Forests beneath the grass

Proceedings of the regional workshop on advancing the application of assisted natural regeneration for effective low-cost forest restoration

RAP PUBLICATION 2010/11

Forests beneath the grass

Proceedings of the Regional Workshop on Advancing the Application of Assisted Natural Regeneration for Effective Low-Cost Restoration

Bohol, Philippines, 19-22 May 2009

Edited by
Patrick B. Durst, Percy Sajise and Robin N. Leslie

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
Bangkok, 2011

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

ISBN 978-92-5-106639-3

All rights reserved. FAO encourages reproduction and dissemination of material in this information product. Non-commercial uses will be authorized free of charge. Reproduction for resale or other commercial purposes, including educational purposes, may incur fees. Applications for permission to reproduce or disseminate FAO copyright materials and all other queries on rights and licences, should be addressed by e-mail to copyright@fao.org or to the Chief, Publishing Policy and Support Branch, Office of Knowledge Exchange, Research and Extension, FAO,Viale delle Terme di Caracalla, 00153 Rome, Italy.

© FAO 2011

For copies write to:

Patrick B. Durst
Senior Forestry Officer
FAO Regional Office for Asia and the Pacific
39 Phra Atit Road
Bangkok 10200, Thailand
Tel: (+66) 2 697 4000
Fax: (+66) 2 697 4445
E-mail: patrick.durst@fao.org>

Food and Agriculture Organization of the United Nations
Regional Office for Asia and the Pacific
Bangkok, Thailand

Contents

Assisted natural regeneration (ANR) is a forest restoration and rehabilitation practice successfully used for converting *Imperata cylindrica* and other grass-dominated areas into productive forests. It is a simple, inexpensive, and effective technique that relies on the natural processes of plant succession. ANR application is based on fire prevention and management, control of grazing, suppression of grasses, and nurturing of seedlings and saplings of indigenous trees.

PREFACE

Although forests have been increasingly recognized for the wide range of environmental and social values essential to our planet's well being, unsustainable forest and land-use practices continue to destroy and degrade millions of hectares of forests in Asia and the Pacific each year. Vast areas of these deforested and degraded lands have been taken over by highly invasive grasses such as *Imperata cylindrica*. These largely unproductive grasslands harbor little biodiversity and provide very few livelihood options for local people.

In various locations across the region, renewed efforts are being made to restore forests to previously degraded sites. Approaches range from large-scale forest plantation development, to agroforestry, to passive natural regeneration. Assisted natural regeneration (ANR) is a forest restoration approach, based on concepts of enhancing ecological succession processes, including regeneration and growth of indigenous species. Experiences with ANR demonstrate that this approach is particularly successful in engaging local communities by addressing some of their basic priorities, reducing the risk of forest fires, and creating new income generating opportunities. ANR also significantly reduces the costs of forest restoration, making it a particularly attractive alternative to costly plantation establishment.

FAO has recognized ANR as an effective forest restoration approach and has been promoting its benefits through various capacity-building efforts for several years. Partnerships for promoting ANR have been particularly successful in the Philippines, where the ANR approach has been piloted and practiced on a limited scale for more then three decades. The regional workshop, organized in Bohol, the Philippines, in May 2009, captured not only the main achievements of the three-year Technical Cooperation Programme Project "Advancing the Application of Assisted Natural Regeneration in the Philippines," but also the key lessons learned over the years from ANR practice in the Philippines and other countries of the region. It was particularly encouraging to witness the commitment from the private sector for investing in ANR and from the Government of the Philippines for integrating ANR in its long-term rural development strategies. The valuable experiences presented by the regional participants and their interest to embrace ANR techniques and adapt them to local conditions gives us even greater hope for forest restoration and rehabilitation throughout the Asia-Pacific region.

Ongoing global efforts to curb climate change provide even greater impetus for forest restoration efforts. The compilation of experiences presented in this publication is one small, but important contribution in support of ANR as one additional tool for the challenges of forest restoration and improved forest management.

Hiroyuki Konuma
Assistant Director-General and Regional Representative
FAO Regional Office for Asia and the Pacific

FOREWORD

The three-year partnership project: “Advancing the Application of Assisted Natural Regeneration [ANR] for Effective Low-Cost Forest Restoration” underscores the potential of this alternative forest restoration and rehabilitation measure in the wake of forest degradation, rapid loss of biodiversity, and poverty alleviation concerns in forest land areas.

ANR is also relevant, now that the effects of climate change loom large in the horizon, for its opportunities for mitigation through carbon sequestration as well as adaptation through enhancement of ecosystems and disaster risk reduction.

Various lessons learned have come to fore from this three-year undertaking opening a wide range of recommendations to make ANR an even more viable approach to restore degraded forests through the natural ecological processes.

It is heartening to note that the move to strengthen participation of local communities, local government units, the private sector and other stakeholders in ANR application runs parallel to DENR’s participatory approach of governance. We adhere to co-management in forest development, conservation and protection as a means to sustainable forest management.

The Project’s concluding activity - a Regional Workshop, has generated a wealth of information on all aspects of ANR implementation and how these could be further improved, putting emphasis not only on institutional interventions but public-private alliances as well, among others. The Regional Workshop also paved the way for an exchange of invaluable knowledge and experiences related to forest rehabilitation efforts with presenters from Asia and the Pacific.

It is with great appreciation that we recognize the efforts of the Food and Agriculture Organization (FAO) to initiate the documentation of the proceedings of the Workshop and all its significant findings through a publication on ANR. The FAO has been a staunch partner in promoting the application of ANR techniques - our sincere thanks!

FOR. MARLO D. MENDOZA
OIC-DIRECTOR
Forest Management Bureau
Republic of the Philippines

ACKNOWLEDGMENTS

The regional Workshop on Advancing the Application of Assisted Natural Regeneration for Effective, Low-Cost Forest Restoration" held in Bohol, the Philippines, 19-22 May 2009, was only one milestone in the long history of ANR activities in the Philippines. Over the past three decades a number of ANR "champions" have emerged from the Philippines, demonstrating immense energy and enthusiasm. The Philippines, the Asia-Pacific region and indeed the world, owe much to their tireless efforts to promote and advance the application of ANR. Several of these individuals were instrumental in the success of the three-year project supported by FAO to promote the application of ANR in the Philippines.

Mr Patrick C. Dugan, Mr Ernesto Cadaweng and other Bagong Pagasa Foundation staff have worked assiduously to pioneer ANR approaches and share them across the country. Local community leaders, in particular the mayors of the three ANR project pilot sites in Bataan, Bohol, and Davao del Norte enthusiastically embraced ANR and made it a reality on the ground. Mr. Leonardo Florece and Mr Dominigo Madulid contributed greatly to our better understanding of the "science of ANR". Through his unique creative approaches and links with the media, Mr Paulino Manalo promoted ANR and helped raise awareness of the potential of ANR among a wide range of people from all walks of life. Mr Percy Sajise – a true pioneering champion on ANR – successfully advised and guided the project and tied all the pieces together in synergy. The ANR story in the Philippines would certainly not have the same positive outcome without the strong support from the Department of Environment and Natural Resources (DENR). In fact, many of the most enthusiastic new ANR promoters are DENR officials, led by DENR Secretary Jose Atienza, Jr., Forest Management Bureau (FMB) Directors Romeo Acosta and Marlo Mendoza, Assistant Director Neria Andin and Forester Nonito Tamayo. The implementation of the FAO-supported project and the organization of the regional workshop would have been impossible without the dedicated support of Foresters Emma Castillo, Roberto Oliveros and the DENR/FMB ANR team at the Regional and Provincial levels of the three pilot sites. The workshop itself benefitted greatly from the expert facilitation skills of Ms Socorro Feliciano who helped participants to crystallize their ideas and maintain their focus.

The list of individuals contributing to the advancement of ANR in the Philippines certainly is extensive. While some of these long-time champions, such as Mr Pedro Walpole, Mr William Granert, Ms Rowena Soriaga, and Mr Patrick Charles Dugan Jr. participated in the workshop, many others have labored behind the scenes to put ANR ideas into practice.

The Bohol workshop was organized with the objective of sharing the experiences from the Philippines and learning from other countries about the needs, opportunities and challenges for ANR application on a wider, regional level. Therefore, to a large extent, the success of the workshop was due to the presence of the experts from different countries. Their views enriched the discussions and opened up new possibilities for wider application of ANR. Their valuable inputs – captured in this publication – are gratefully appreciated.

FAO has actively promoted ANR approaches for over a decade, both in the Asia-Pacific region and in other parts of the world. The recently concluded ANR project in the Philippines benefited greatly from the attention and support of the FAO Office in the Philippines, and we can proudly say that Mr Kazuyuki Tsurumi, FAO Representative in the Philippines, Mr Genaro Castro, Ms Sarah Lacson and the rest of the country office staff are now true "ANR believers". The support received from the team in FAO headquarters, particularly from Ms Linda Rosengren and Mr Jim Carle is very much appreciated.

This publication would not have been possible without the technical revisions by Mr Percy Sajise, and the editing work of Mr Robin Leslie. Sincere gratitude is also extended to Ms Janice Naewboonnien for final proofreading and Mr Christopher Entwistle, Ms Sansiri Visarutwongse and Mr Jeremy Broadhead for the publication layout and cover design.

Introduction

Why assisted natural regeneration?

For decades, foresters, ecologists and policy makers have sought effective, low-cost approaches and techniques to help reverse the continuing loss of forests in Asia and the Pacific. Recent years have been marked by increased recognition of the multiple benefits forests provide, triggering new approaches to address multiple forest management objectives and to effectively involve increasingly diverse stakeholders. "Looking beyond" has indeed become the new paradigm for forest management.

Conventional plantation establishment remains a logical priority for forest managers, particularly where wood production is a primary objective. Currently, forest plantations account for 7 per cent[1] of the global forest area and are a significant contributor to reverse global trends of forest loss. Despite the various benefits of forest plantation development, the magnitude and complexity of the deforestation problem implies the need for diverse approaches to increase forest cover.

Massive deforestation and land-use changes taking place over the last century in the Asia-Pacific region have turned wide areas of formerly forested areas into low-productivity grasslands. *Imperata cylindrica* alone covers over 35 million hectares[2] throughout the region. These grasslands are important to some of the people that live around them and use them for grazing animals or for shifting cultivation, but they generally provide few benefits relative to the potential productivity of the land. Restoration of these degraded areas is therefore a challenge that requires careful consideration of a full range of socio-economic and ecological characteristics of each site.

Assisted natural regeneration (ANR) is a forest restoration technique based on the ecological principles of secondary succession. ANR has been successfully used to enhance local biodiversity and restore ecological processes in many areas, particularly in the Philippines. ANR approaches place strong emphasis on community involvement and offer a variety of opportunities for diversifying livelihoods.

What do we know about ANR?

ANR emphasizes the importance of fire management, protection against destructive grazing, control of invasive grass species and assisting the growth of naturally occurring tree seedlings. Similar principles have been applied in various forms or in combination with other methods in many areas around the world.

In 1989, the Department of Environment and Natural Resources (DENR) formally

1. Key findings, Forest Resource Assessment 2010, FAO
2. Garrity *et al*. (1997)

adopted ANR as a recommended method for restoration of forest cover, but field implementation did not progress significantly for many years. This was primarily due to inadequate capacity and lack of awareness among forestry officials and a dearth of successful field-based ANR examples. In 2006, a three-year project was launched with FAO support to compile and document experiences in implementing ANR, and to mainstream its principles among a variety of stakeholders.

The ANR experiences in the Philippines demonstrate that this approach is best suited for ecologically vulnerable areas such as critical watersheds, where maintenance of the original flora and fauna is important and in areas where communities are supportive of forest restoration[3].

Practical application of ANR revealed some important technical aspects to be considered for establishing a solid ANR foundation: These include: 1) site selection; 2) site-species matching; 3) site modification for catalyzing the growth of preferred species; 4) enrichment or supplemental planting; 5) site protection; and 6) site monitoring. However, the most important ANR lesson emerging from the Philippines is the importance of strong collaboration with local communities and private businesses for successful long-term results.

What are the future prospects for ANR?

At the time of the ANR workshop in Bohol in May 2009, two issues were dominating the headlines – the global financial crisis and climate change. One year later, the headlines remain the same, and the world is still struggling to respond to these challenges. Forestry has emerged at the forefront of discussions on climate change, and new understanding of the roles of forests has created new opportunities for supporting sustainable forest management through various carbon sequestration initiatives and programs. At the same time, in response to the economic crisis, many governments have embraced forestry-related activities as part of their economic stimulus programs.

This newly gained recognition of the importance of the forestry sector has unlocked prospects for various innovative approaches for promoting and funding forest restoration. As one example, in early 2010 a new project that includes ANR techiques was registered under the Clean Development Mechanism (CDM)[4]. Given the difficulties forestry projects have experienced in participating in the CDM, this is a strong encouragement for further up-scaling of ANR activities. In the Philippines, private sector commitment has emerged for supporting future ANR activities through corporate social responsibility initiatives and the DENR plans to use ANR for restoring around 9,000 hectares under its new Upland Development Program. These developments may help generate significant momentum to be further fostered.

---

3. Sajise, (2003)
4. List of registered A/R project, available at: http://cdm.unfccc.int/Projects/DB/TUEV-SUED1245851243.49/view

In addition to climate change concerns, loss of biodiversity is another global issue closely linked to deforestation. Supporting natural regeneration, and fostering the growth of indigenous species that are well adapted to local conditions, is helping to enhance local biodiversity and therefore becoming increasingly important.

As population pressures continue to mount, issues such as ownership and resource tenure rights, income generation, and traditional land-use patterns will increasingly collide with the development visions of policy makers. Lessons from ANR implementation are particularly important in designing approaches that work for the local people and take in consideration the unique ecological and social characteristics of each site targeted for restoration.

Harvesting lessons: overview of the regional workshop

The regional "Workshop on Advancing the Application of Assisted Natural Regeneration for Effective, Low-Cost Forest Restoration" was organized from 19-22 May 2009, in Bohol, the Philippines, as a concluding activity of the three-year FAO-supported project aimed at promoting ANR in the Philippines. Both the project and the workshop were implemented in collaboration with the Philippines Department of Environment and Natural Resources (DENR) and the Bagong Pagasa Foundation.

Key objectives of the workshop were to:

- enhance awareness and understanding of the basic principles, opportunities and challenges of implementing ANR in Asia and the Pacific;
- exchange information and lessons learnt from the three-year FAO-supported project in the Philippines;
- identify key policy, technical, social, financial, and capacity requirements for successful ANR implementation and up-scaling;
- identify and discuss the potential for involving the private sector and establishing public-private partnerships for successful natural forest restoration and rehabilitation; and
- exchange knowledge and experience related to forest restoration efforts in Asia and the Pacific, with a view toward fostering regional cooperation and up-scaling of efforts.

Over 70 participants, representing government, civil society, private sector, academe and development partners involved in ANR and similar practices in the Philippines and the Asia-Pacific region, attended the workshop (Annex 1: List of participants). The workshop received significant interest from senor-level officials. Mr. Antoineto Pernia, Chief of Staff of the Provincial Government of Bohol welcomed the participants; Mr. Kazuyuki Tsurumi, FAO Representative in the Philippines, provided opening remarks; and the Honorable Jeremias Dolino, DENR Assistant Secretary for Visayas and

Mindanao, delivered the key introductory message. A one-day field visit to the project site in Danao, Bohol, was organized as part of the program.

The Bohol workshop dedicated significant attention to the future potential of ANR and focused on identifying new partners and innovative mechanisms for financing and up-scaling. Forest practitioners and researchers from several countries from across the Asia-Pacific region shared a wealth of knowledge and information on different forest restoration approaches applied in their countries – demonstrating a diversity of methods in line with available funding, degrees of forest and land degradation, local socio-economic conditions and specific management objectives.

“Forest beneath the grass” is a compilation of experiences, examples and lessons learned intended to foster sharing of existing knowledge on ANR and to provoke new ideas on how ANR can be further adapted, nurtured, and harnessed in the future. The selected papers present ANR experiences in the Philippines and related forest restoration initiatives throughout the Asia-Pacific region. These, coupled with a synthesis of the workshop observations, discussions and recommendations, are provided to guide and motivate further work in rehabilitating and restoring the region’s degraded forest lands.

Workshop observations, recommendations and conclusions

Given the rapid ongoing loss of biodiversity and the negative global impacts of climate change, there is an urgent need for cost-effective and efficient forest restoration and rehabilitation on a massive scale. The high cost of traditional forest restoration and rehabilitation strategies is a serious constraint to addressing this need, especially for developing countries with limited financial resources. It is in these contexts that assisted natural regeneration (ANR) deserves urgent attention. Although called by various names, ANR provides a low cost approach to forest restoration and rehabilitation. ANR implementation is particularly relevant in restoring biodiversity, enhancing ecosystem services and increasing carbon sequestration for mitigating climate change.

In this regard, the regional workshop generated the following observations:

- The need to identify key elements and enabling conditions for successful implementation of ANR under various biological, ecological and socio-cultural contexts because of the highly diverse conditions in which it can be applied.
- Effective use of information, education and communication materials, including case studies illustrating best practices, which will enhance appreciation and increase understanding of ANR among all segments of society, particularly among the younger generation, educational institutions, local officials, community groups and upland residents.
- Clearly define ANR for audiences at various levels (i.e. communities, local governments, politicians, private sector and government agencies) to improve

the understanding of ANR as a concept and with respect to its application under different socio-cultural and ecological conditions.

- ANR must be seen as one approach among various options available to address forest rehabilitation needs aligned within each country's national forestry programme according to objectives and resources available for implementation.
- ANR offers considerable opportunities to sequester carbon to assist in mitigating climate change, but this potential remains largely unrecognized and underappreciated.
- ANR provides an effective method for communities to enhance local water resources, including contributing to improved downstream water quality and reliability.
- The success of ANR depends on clear recognition and effective involvement of local people in its implementation, underscoring the need to further improve the ways by which communities are provided with incentives and capture the benefits of ANR-based forest rehabilitation.
- The indigenous knowledge of local communities can enhance the sustainability and effectiveness of ANR in many areas.
- Sound research on botanical and wildlife dynamics, water regimes, carbon sequestration rates, soil conditions and socio-economic factors related to ANR implementation is needed to establish a solid foundation upon which to base decisions related to choice of technologies and practices, incentives, ecological requirements of alternative enrichment species, management modalities and others.
- There are clear opportunities to build on and adopt the Philippine experience in ANR to address the forest rehabilitation and restoration needs of many other countries in the Asia-Pacific region.
- Mechanisms are needed to better facilitate the exchange of lessons learned on the successes and failures of ANR implementation and to effectively and widely disseminate such lessons such as through FAO's e-learning platform.

Considering these observations, the regional workshop participants recommended that:

1. Policies and regulations should be revised, as appropriate, to improve the enabling conditions for implementing ANR on a sustainable basis, including incentives and resources from local governments to encourage and strengthen community participation and involvement.
2. Information dissemination, advocacy and extension should be strengthened to more effectively promote ANR application by local communities and the private sector.
3. A systematic effort should be initiated to identify and engage effective community-based ANR efforts that seek to enhance livelihoods and community well-being while restoring ecological processes.
4. Various creative and innovative public-private partnerships should be encouraged to provide more support and resources for ANR implementation and upscaling such

as through corporate social responsibility.

5. Increased support should be provided for research to improve the science-based rationale for effective and efficient implementation of ANR as a means of forest restoration and rehabilitation.
6. Mechanisms should be established to promote linkages and partnerships at national and regional levels while concurrently enhancing the exchange of lessons learned for improving the application of ANR within countries of the Asia-Pacific region.
7. Materials should be developed and various mechanisms used for integrating ANR into the curricula of schools at all levels including the training of teachers on the basic elements of ANR.

There was overall agreement among workshop participants on the importance of ANR as an option for more cost-effective and appropriate forest restoration and rehabilitation primarily for enhancing ecological services and addressing poverty, livelihood needs and climate change mitigation. However, it was recognized that the sustainability of ANR depends on how well it can respond both to the immediate and long-term needs and objectives of various stakeholders across time and space.

Literature cited:

Food and Agriculture Organization of the United Nations (FAO). 2010. Global forest resources assessment 2010. Key findings. Rome, Italy, FAO.

Garrity, D.P., Soekardi, M., van Noordwijk, M., de la Cruz, R., Pathak, P.S., Gunasena, H.P., Van So, M.N., Huijun, G. & Majid, N.M. 1997. The Imperata grasslands of tropical Asia: area, distribution and typology. Agroforestry Systems, 36: 3-29.

Sajise, P. 2003. Advancing Assisted Natural Regeneration (ANR) in Asia and the Pacific. List of registered A/R projects (available at: http://cdm.unfccc.int/Projects/DB/TUEV-SUED1245851243.49/view).

Learning from experience: advancing ANR in the Philippines

Cost comparison analysis of ANR compared to conventional reforestation

Bagong Pagasa Foundation

Introduction

This paper presents information on the average costs per hectare to implement assisted natural regeneration (ANR). It then compares these costs with expenses normally incurred when conventional reforestation methods are applied. The objective is to help facilitate decisions on whether or not to include ANR in forest restoration planning.

ANR costs are derived from records of expenses incurred during implementation of the FAO-assisted Project TCP/PHI/3010 (A) at three sites in the Philippines over three years. The data show average costs in order to take into account the different conditions at the sites. Data on costs to implement conventional reforestation methods are derived from information on the average prevailing costs of projects implemented by the Government of the Philippines and private sector companies. In both cases (ANR and conventional reforestation) the data only present direct costs. The data do not include administrative and other indirect expenses which will vary considerably depending on who and/or what entity manages implementation. Neither do the data include boundary delineation nor fencing. The latter is an option that may be needed in areas threatened by pasturing of stray animals.

An analysis of costs shows that forest restoration via ANR is approximately 50 percent less expensive than conventional reforestation. Results of project experience show an average ANR cost of US$579 per hectare. When conventional reforestation methods are applied, the average cost is about US$1 048 per hectare.

Basic assumptions for cost comparison analysis of ANR vs. conventional reforestation

- ANR sites are dominated by *Imperata cylindrica* but contain an average of approximately 800 suppressed pioneer regenerants per hectare.
- Average area of firelines required per hectare – 1 000 m^2.
- Firelines maintained (reweeded) eight times within three years.
- Three-year implementation timeframe.
- Twelve ringweeding cycles in conventional reforestation:
    - six in year 1; three each in years 2 and 3.
- Nine pressing (lodging) cycles in ANR: 3/year x 3 years.

Table 1. Average forest restoration cost per hectare (US$)

Item	Unit	Unit cost (US$)	No of units		Amount (US$)	
			REF	ANR	REF	ANR
1. Fireline establishment and maintenance	p.d.	3	32	32	96	96
2. Locating and marking regenerants	p.d.	3	-	3.2	-	10
3. Pressing (lodging) Imperata	p.d.	3	-	90	-	270
4. Staking 2 500 planting spots	p.d.	3	6.25	-	19	-
5. Digging 2 500 planting holes	p.d.	3	25	-	75	-
6. Cost of seedlings	slg	0.1	3 000	-	300	-
7. Hauling 3 000 seedlings to the field	p.d.	3	12	-	36	-
8. Planting/re-planting 3 000 seedlings	p.d.	3	30	-	90	-
9. Ringweeding 800 regenerants	p.d.	3	-	36	-	108
10. Ringweeding 2 500 planted seedlings	p.d.	3	113	-	338	-
11. Herbicide to spray firelines	Litre	10	8	8	80	80
12. Labour to spray herbicide	p.d.	3	5	5	15	15
			Total		**1 048**	**579**

Note: p.d. = person day; slg = seedling; REF = conventional reforestation methods.

Explanatory notes for Table 1

1. Average 1 000 m^2 firelines ÷ 250 m^2 accomplishment/p.d. x 8 cycles	32 p.d.
2. Average 800 regenerants/ha ÷ 250 average accomplishment/p.d.	3.2 p.d.
3. 10 000 m^2 ÷ 1 000 m^2 accomplishment/p.d. x 9 (times) within 3 years	90 p.d.
4. 2 500 p.d. ÷ 400 average accomplishment/p.d. (includes gathering of stakes)	6.25 p.d.
5. 2 500 planting spots ÷ average 100 holes accomplishment/p.d.	25 p.d.
6. 3 000 seedlings (includes 20% allowance for culling and replanting)	3 000
7. 3 000 seedlings (incl. 20% allowance) ÷ 250 average accomplishment/p.d.	12 p.d.
8. 3 000 (including 20% allowance) ÷ 100 average accomplishment/p.d.	30 p.d.
9. 800 regenerants ÷ 200 aver. accomplishment/p.d. x 9 (times) in 3 years	36 p.d.
10. 2 500 planting spots ÷ 200 aver. accomplishment/p.d. x 9 (times) in 3 years	113 p.d.
11. Systemic herbicide (e.g. glyphosate) 4 litres per application x 2 applications	8 litres
12. 10 000 m^2 ÷ 2 000 m^2 average accomplishment/p.d	5 p.d.

Average accomplishments

grubbing out grass (e.g *Imperata*) in firelines	m^2	250/p.d.
locating and marking regenerants	regenerant	250/p.d.
pressing (lodging) of *Imperata* and other grasses	m^2	1 000/p.d.
ringweeding of pioneer regenerants or planted seedlings	plant	
staking of planting spots, including gathering of stakes	spot	
digging planting holes	hole	
hauling seedlings to planting spots	slg	
planting and replanting	slg	100/p.d.
spraying herbicide on firelines (including hauling water)	m^2	2 000/p.d.

Factors that impact on costs

To work effectively in forest restoration, it is essential to adapt methods to suit prevailing conditions. These include (among others) climate, soil fertility, existing vegetative cover and topography. These conditions will vary from site to site and will affect the amount of input required to attain forest restoration objectives. For example, there is a high risk of fire in areas with long dry seasons. Thus, it may be necessary to establish more firelines than would be the case in areas with well-distributed rainfall throughout the year.

Similarly, activities on steep terrain will normally require more person days per hectare than on moderately sloping or level terrain. Because labour is a major input in all forest management activities, labour productivity is a major factor to consider. Obviously, the average daily accomplishment rate of workers assigned to the various tasks will impact on total costs. Another important factor is the efficiency of supervisors who oversee implementation and the level of community participation and cooperation that can be enlisted.

In addition, the objectives of forest restoration must also be taken into account. For instance, if the forest restoration objective is to rehabilitate a watershed or improve wildlife habitat, the desired vegetative cover would be a diverse mix of species. ANR is ideal for these purposes. On the other hand, if the ultimate objective is development of a timber plantation, alternative strategies can be formulated to combine ANR and conventional reforestation methods. For instance, ANR can comprise the first phase of plantation development and focus on enhancing the growth of existing pioneer regenerants to serve as nurse trees for the final timber crop. Furthermore, the fire prevention measures taken to protect naturally-growing pioneer species will also benefit the timber crop.

Discussion of cost items

Firelines: Table 1 assumes that (i) approximately 1 000 m^2 of firelines will be established per hectare; i.e. approximately 10 percent of the total area and (ii) the firelines will be maintained through ringweeding eight times during a three-year implementation period. These figures (1 000 m^2 and eight maintenance cycles) may vary considerably depending on conditions. For instance, as noted above, more firelines will usually be required in areas with long dry seasons where there is a relatively high risk of fire. In any case, fireline establishment and maintenance are essential ingredients for success in both ANR and conventional reforestation.

Locating and marking regenerants: In general, if 800 regenerants per hectare are located, marked and conscientiously tended, the resulting canopy cover after three years will be adequate to shade out *Imperata cylindrica* and other fire-prone grasses.

Thus, ANR costs indicated in Table 1 assume location and marking of 800 regenerants. However, it is often possible to find more than 800 per hectare. In such cases, the project implementers may decide to locate and mark more than 800 in order to expedite canopy closure. Conversely, in some sites natural regeneration will be poor and it will not be possible to locate 800. In such cases, enrichment planting may be required. Enrichment planting may be accomplished with seedlings as in conventional reforestation, or via direct seeding.

Pressing (lodging) of Imperata: This activity is explained in the Field Guide Manual developed in the FAO-assisted project in the Philippines from which the data herein were derived. Copies of the Manual may be requested from FAO, Bangkok. ANR promotes pressing (lodging) rather than cutting as a more cost-effective method for inhibiting the growth of *Imperata* and other fire-prone grasses. In general, cutting stimulates the growth of grass, whereas pressing slows down growth.

Staking of 2 500 planting spots and digging 2 500 planting holes (in conventional reforestation): These cost items in Table 1 assume that 2 x 2 metre spacing will be followed in conventional reforestation. If wider spacing is adopted, the number of person days required, and consequently the costs, will be less than the amounts indicated in Table 1.

Cost of seedlings (conventional reforestation): This cost item is highly variable, depending on the species and the type of seedling (i.e. potted or bare root) and the number of seedlings. The amount per seedling indicated in Table 1 (US$0.10) is an average, subject to adjustment based on seedling type and species.

Hauling, planting and replanting 3 000 seedlings (conventional reforestation): This seedling quantity makes allowance for approximately 20 percent mortality and/or culling.

Ringweeding 2 500 planted seedlings (conventional reforestation): Most conventional reforestation projects include nine ringweeding cycles over three years. However, this is a highly variable figure, dependent on how fast the weeds grow and how thoroughly each ringweeding cycle is carried out. If roots of the weeds are grubbed out, nine cycles will normally be sufficient. However, if the weeds are simply cut, but not grubbed out, regrowth of the weeds will be fast and more ringweeding cycles may be required.

Ringweeding 800 regenerants: This figure is based on the average number of regenerants located and marked per hectare. If more regenerants are found and the implementers decide to mark and tend them, costs indicated in Table 1 will increase. Project experience indicates that ringweeding of regenerants should be implemented at least three times each year, or a total of nine times during three years. This is in addition to pressing (lodging) which is also a maintenance activity.

Herbicide and labour to spray herbicide on firelines: The costs indicated in Table 1 are based on project experience. However, costs will be higher if the work is not properly timed. Herbicides are not effective if applied on rainy days and if the *Imperata* and other fire-prone grasses are not in an active stage of growth. Good training and close supervision are essential inputs for effective use of herbicides. Conversely, costs may decrease if the *Imperata* (etc.) have been effectively controlled by ringweeding (maintenance) within the firelines.

Conclusion

Project experience clearly validates that forest restoration can be accomplished at lower costs with ANR than via conventional reforestation. Thus, if the principal objectives of forest restoration are rehabilitation of vegetative cover on watersheds and wildlife habitats, ANR is a logical choice. The principal reasons for lower costs are the elimination of expenses for seedlings, digging of planting holes, planting and replanting. ANR takes full advantage of existing regeneration on site including seedlings of pioneer tree species and woody brush.

The results of project experience also validate that three years of ANR implementation can expedite the growth of a sufficient number of pioneer trees per hectare to establish the first phases of what can eventually develop into a mature forest. This first phase also comprises a nurse crop that can be interplanted with commercially valuable timber species, if the objective is development of a production forest. Additionally, if appropriately thinned, the nurse crop developed via ANR can be interplanted with shade-tolerant agroforestry species such as cacao, coffee, black pepper, pandan, ginger and others.

Hopefully, results of the FAO-assisted project will encourage others to apply ANR wherever feasible and appropriate to expedite the restoration of forest cover on millions of hectares throughout Asia that are currently dominated by *Imperata cylindrica* and similar fire-prone grasses. Rehabilitation of these grasslands will contribute to carbon sequestration and can help address the problems of global warming and climate change.

Assisted natural regeneration and biodiversity in the Philippines

Domingo A. Madulid[1], Danilo N.Tandang[1], Esperanza Maribel G. Agoo[2]

Introduction

A botanical inventory and vegetation survey of assisted natural regeneration (ANR) sites was conducted from August to November 2007 and January to March 2009 to document and describe the status of the vegetation before and during the implementation of the actual assisted regeneration methods.

The inventory included species inventory, vegetation analysis and photo documentation to gather baseline data and monitor the changes in the vegetation at the project sites.

The study sites (Appendix I) were in the major island regions in the Philippines: ANR Site I – Limay, Bataan (Luzon); ANR Site II – San Miguel, Danao, Bohol (Visayas); and ANR Site III – Balagunan, Davao del Norte (Mindanao).

These sites were characterized by different climate types. Based on the Coronas Modified Classification of the Philippine Climate, Site I fell under Type I. This site had two pronounced seasons: the dry season which prevails from November to April and the wet season for the rest of the year. Site II fell under Type IV where rainfall is more or less evenly distributed throughout the year. Site III fell under Type III where the seasons are not very pronounced and it is relatively dry from November to April (Appendix I).

The three sites also differed in climate types based on ratios of dry to wet months. Site I was classified as Type D where it is generally dry with rain insufficiently distributed (at most six dry months). Site II was classified as Type C where it is moist, with rain sufficiently distributed with five dry months. Site III was characterized as Type A which is wet and rainy (Appendix I).

Based on information from the Bureau of Mines and Geo-Sciences (1982) the soils of Site I and its vicinities had Quarternary volcanic cones with ultramafic, coralline, siltstone and shale complexes. Site II soils were interspersed with volcanic and sedimentary rocks. Site III had volcanic, serpentinite, diorite, limestone and alluvium complexes (Appendix I).

1. Philippine National Herbarium, Manila. d.madulid@yahoo.com
2. Biology Department, De La Salle University-Manila.

Materials and methods

Field research was undertaken with the assistance of two botanical researchers, local NGO members and local Department of Environment and Natural Resources (DENR) staff in Limay, Bataan from 25-28 July 2007 and 6-9 January 2009 or 18 months after the initial survey; in San Miguel, Bohol from 5-11 August 2007 and 1-6 February 2009 or 18 months after the initial inventory; and in Balagunan, Davao del Norte from 26 October to 1 November 2007 and 22-27 February 2009, 16 months after the initial survey. Visits to the offices of the local government and the DENR (regional, provincial, municipal branches) were made prior to the actual fieldwork.

Species inventory

A detailed species inventory was conducted in the three ANR sites. Voucher specimens were collected in duplicate. These were pressed in newspaper and soaked in denatured alcohol prior to processing in the Philippine National Herbarium (PNH) in Manila. The specimens were then dried and later identified by comparison with herbarium specimens at the PNH and consulting botanical references.

Local names of the plants were recorded in the field. The equivalent scientific names were cross-referenced with entries in the *Dictionary of Philippine plant names* (Madulid 2001). These were then matched with the identification of the species based on the voucher specimens collected and the specimens deposited at the PNH.

Vegetation analysis

Due to the limited time in the field, purposive sampling of the vegetation in the area was conducted. This was done to obtain samples that appeared to be representative of the population or of the entire vegetation cover to ensure that a range from one extreme to the other was included. The selection of the representative samples is based on the initial ocular assessment of the different vegetation types based on the dominant species found in the area. The positions of the sampling plots, transects or quadrats were recorded using a GPS (Garmin 76™).

An analysis was conducted to describe the physiognomy of the vegetation and forest structure in the area. The plot method for Site I was used because of the patchy nature of the remnant forest there. The point centre quarter method (PCQM), a plotless sampling technique, was used for Sites II and III so a wider area could be covered. This technique was applied because the forest area for sampling at these two sites was larger than at Site I.

The plot method was accomplished by enclosing a 100 m^2 plot, with dimensions of 10 m x 10 m, using a fibreglass meter tape. All the trees with diameter at breast height (dbh) equal to or greater than 10 cm dbh were identified and represented by a voucher specimen. The dbh was measured using a meter tape. The height of the trees was measured using a laser range finder.

The PCQM method was carried out with a 100 metre fibreglass meter tape. Sampling points were designated every 10 metres. In each sampling point, the four trees nearest to the centre tree with a 10 cm dbh were identified and represented by a voucher specimen. The distance to the centre tree and tree height were measured using a handheld laser distance meter (Trimble Spectra Precision Laser HD150). The dbh was also measured with a measuring tape.

The undergrowth and ecotone areas were sampled using quadrats. The quadrats had dimensions of 1 m x 1 m. The species in the quadrat were identified and the number of individuals per species were determined and recorded. Voucher specimens of the species were also collected.

Later, 10 m x 10 m plots were established in grassland areas. One metre high PVC pipes were used to mark the corners of the plot. The different wildlings within the plot were identified and the density of each species was recorded.

Computation of the importance value index was made to determine the dominant species in the area. The Shannon-Weiner Diversity Index and Equitability Index were used to estimate and compare the species diversities of the different sampling areas or vegetation types. 'Species Diversity and Richness' in a Windows© programme (Henderson & Seaby 1997) was used to calculate alpha diversity indices. This was done to compare the species diversities of the different sampling areas or vegetation types within and between sites.

Results and Discussion

Ecosystem and species diversity in the ANR sites

Site I had five vegetation types: grassland, remnant Dipterocarp forest, secondary forest, *Lithocarpus* forest and plantation forest (*Pouteria campechiana*). This was determined in a ground survey and by noting the dominant species and the physiognomy of the vegetation. The grassland was dominated by an introduced forage grass, *Hyparrhenia rufa*, with emergent *Eucalyptus* and other secondary growth plants. The presence of *Eucalyptus* trees in the area indicated that it was formerly a reforestation project site. Mature trees of two Dipterocarp species, namely *Shorea contorta* and *Shorea polysperma* could be found in the remnant primary forest. A third Dipterocarp species, *Anisoptera thurifera* subsp. *thurifera*, stood out in one corner of the site. The three Dipterocarps were mother trees and sources of the wildlings abounded in the forest floor. The secondary forest was dominated by *Ficus* spp. while the Lithocarpus forest was dominated by *Lithocarpus sulitii*.

Site II had three vegetation types, namely grassland, secondary forest and plantation forest (*Gmelina arborea*). The dominant species in the grassland were *Imperata cylindrica, Rottboellia exaltata* and other grass species such as *Chrysopogon, Setaria, Themeda* and *Miscanthus*. The grassland was also characterized by numerous emergent plants such as *Gmelina, Ficus, Syzygium, Melastoma, Antidesma, Evodia* and *Dillenia*, among others. In open grassland at the site, *Dicranopteris linearis* was a co-dominant of *Imperata cylindrica*. In the secondary forest, indicator species such as *Colona serratifolia, Cratoxylon sumatranum* and *Commersonia bartramia*, among others, predominated. *Dipterocarpus grandiflorus,* a prime timber species, was also recorded in the site.

Site III had grasslands, secondary forests and plantation forests (*Gmelina arborea, Leucaena leucocephala* and *Vitex parviflora*). *Imperata cylindrica* and *Saccharum spontaneum* were the dominant species in the grassland and associated with non-grass species such as other weeds and ferns. There were emergent individuals of *Gmelina, Macaranga, Abrus* and *Polyscias* in the grasslands. The secondary forest was dominated by *Piper aduncum, Trema orientalis, Leucaena leucocephala, Macaranga tanarius, Ficus odorata, Ficus septica, Pipturus arborescens* and *Polyscias nodosa* among others. *Piper aduncum* was an invasive alien species.

Site I was the most diverse in terms of types of ecosystem represented. It had grassland, plantation forest and forest patches dominated by different species (Dipterocarp forest, *Lithocarpus* forest, secondary forest). The forest type in Sites II and III was fairly similar even if it occurred in disjunct patches.

Site III had the most species of vascular plants, followed by Site II and Site I.

Site II had the greatest number of trees and most diversity per 100 m^2. It had an average of 26 trees per plot and was represented by 45 different species. This was followed by Site III with an average of 22 trees and 9-22 species and Site I with 12 trees and 2-5 species per 100 m^2.

Site II had the highest tree density and this could account for the smaller trunk diameter of trees which ranged from 10-35.2 cm. Site I had the largest trees with diameters of 10-124.2 cm (10-80 cm in diameter at Site III).

Table 1. Comparison of plant diversity features of the three ANR sites

	Site I	Site II	Site III
Number of species	108	122	152
Number of genera	93	110	138
Number of families	44	50	61
Vegetation types	Grassland, remnant Dipterocarp forest, secondary forest, Lithocarpus forest, plantation forest (*Pouteria campechiana* and *Eucalyptus* spp.)	Grassland, secondary forest, plantation forest (*Gmelina arborea*)	Grassland, plantation forest (mixed), secondary forest
Dominant species in grassland	*Hyparrhenia rufa*	*Imperata cylindrica, Chrysopogon, Setaria, Themeda, Miscanthus, Phragmites, Cyperus, Centrosoma, Lantana, Calopogonium, Fimbristylis, Mimosa, Chromolaena, Sorghum, Scleria, Premna, Urena, Habenaria*	*Imperata cylindrica, Saccharum spontaneum, Mimosa pudica, Pteris, Chromolaena, Fimbristylis, Oplismenus, Desmodium, Sida, Coelorachis, Sorghum, Mikania scandens Lantana, Lygodium, Hyptis, Piper, Macaranga, Cynodon, Flagellaria, Desmodium*
Emergent plants in grassland	*Eucalyptus* sp., *Blumea balsamifera*	*Gmelina, Ficus, Syzygium, Melastoma malabathricum, Antidesma ghaesembilia, Evodia, Pandanus, Dillenia, Uvaria, Maesa, Breynia, Artocarpus*	*Gmelina arborea, Macaranga, Abrus, Polyscias, Piper aduncum, Blumea balsamifera*

Dominant species in plantation forest	*Pouteria campechiana*	*Gmelina arborea*	*Gmelina arborea, Polyscias nodosa, Leucaena leucocephala, Vitex parviflora*
Dominant species in remnant primary forest	*Shorea, Ficus, Voacanga*	*Dipterocarpus grandiflorus*	*Shorea contorta Vatica* sp.
Dominant species in secondary forest	*Ficus, Gyrocarpus, Mallotus, Lithocarpus sulitii*	*Colona serratifolia, Cratoxylon sumatranum, Commersonia bartramia, Ailanthus, Lithocarpus sulitii, Gomphia serrata*	*Piper aduncum, Trema orientalis, Leucaena leucocephala, Macaranga tanarius, Ficus odorata, Ficus septica, Pipturus arborescens, Polyscias nodosa, Mallotus paniculatus, Melanolepis multiglandulosa, Ficus minahassae*
Number of tree species in a 100 m^2 plot	2-5	45	9-22
Number of trees in a 100 m^2 plot	7-16	25-27	15-28
DBH of trees in a 100 m^2 plot (cm)	10-124.2	10-35.2	10-80
Dominant species of ground cover and above	*Pouteria campechiana, Centrosema, Lantana camara, Alpinia, Lycopodium, Abrus precatorius, Melia, Tabernaemontana pandacaqui, Litchi chinensis*	*Nephrolepis, Gmelina, Guioa, Caryota, Wrightia laniti, Miscanthus floridulus, Grewia, Lygodium, Selaginella, Alpinia*	*Glochidion, Alpinia, Lygodium, Pteris, Piper aduncum, Streblus, Scleria, Abrus precatorius, Coffea, Ficus* sp., *Gmelina arborea, Pteridium, Leucaena leucocephala, Gliricidia, Buchanania,*
Dominant species of the ecotone vegetation	*Lantana camara, Chromolaena odorata, Tithonia diversifolia, Urena lobata, Centrosema pubescens, Ipomoea* sp., *Voacanga globosa*	*Dinochloa, Pteris, Miscanthus, Alpinia, Caryota, Stachytarpheta, Pandanus, Gliricidia*	*Bambusa* sp., *Imperata cylindrica, Alpinia, Cynometra, Piper aduncum, Pipturus, Macaranga, Andrographis, Colona serratifolia, Musa, Desmodium, Chromolaena, Leucaena, Glochidion, Psidium, Flagellaria, Stachytarpheta*

Shannon-Weiner Diversity Index (tree vegetation)	0.234 (plantation), 1.82 (remnant forest), 1.332-1.55 (secondary forest), 0.637 (Lithocarpus forest)	0.00 (plantation), 3.328 (secondary forest)	1.604 (plantation), 1.788 (secondary forest)
Shannon-Weiner Diversity Index (grassland)	(0.00) 0.886-1.718	1.55-2.005	0.782-1.959
Equitability Index (tree vegetation)	(0.083) 0.355-0.774	(0.00) 0.874	0.578-0.730
Equitability Index (grassland, ecotone, wildling and ground vegetation)	(0.00) 0.237-0.460	0.408-0.538	0.202-0.609

Forest and grassland species diversity was highest in Site II, followed by Site III and lowest in Site I. This is supported by the Equitability Index of the trees which was highest in Site II and lowest in Site I.

The non-tree species diversity was relatively the same among the three sites.

- *Tree density:* Site II > Site III > Site I
- *Tree species wealth:* Site II > Site III > Site I
- *Tree diameter:* Site I > Site III > Site II
- *Forest species diversity:* Site II > Site III > Site I
- *Grassland species diversity:* Site II > Site III > Site I

Grassland vegetation in Site II was in a more advanced stage of regeneration, with more and diverse emergents. It was apparent that the site was established earlier, allowing for the proliferation and growth of pioneer second-growth species. More uniform grassland vegetation with mainly *Blumea balsamifera* as emergents was observed in Site I. Apparently this was an earlier stage of regeneration and the area had only been converted to an ANR site recently. This underlined the importance of the tree vegetation around the grasslands as it was the source of propagules for the pioneering non-grass species in the grassland areas.

Changes in diversity before and during ANR

In a span of 17-18 months, notable changes have been observed in the biodiversity of the sites which could be attributed to the application of ANR techniques.

In Site I, the extent of the grassland vegetation appeared to be unaltered before and during the ANR project, but the pressing of the grasses allowed the *Eucalyptus* seedlings to grow rapidly from less than 1 metre or lower than the grasses to over 3 metres in height. This could be noted particularly in the grasslands near the road and the firebreak at the lower part of the ANR site. While *Blumea balsamifera* and *Derris* sp. occurred sporadically in the grassland area during the early months, these plants did not survive due to the more aggressive and sturdy grass (*Hyparrhenia rufa*) which dominates the area. *H. rufa*, locally called 'damong-ranchero', which was not recorded by Merrill (1923) to be found in the Philippines in the early 1920s. It is actually a native of Africa which was deliberately introduced as fodder for cattle in Bataan only during the 1950s. It is highly adapted to fire and produces abundant seeds; thus it spreads quickly on hillsides, including the ANR site. Other plants that persist in the grassland but have very slow growth due to competition with *Hyparrhenia rufa* are kasuy (*Anarcardium occidentale*), coconut (*Cocos nucifera*), kakawate (*Gliricidium sepium*), mangga (*Mangifera indica*), avocado (*Persea americana*) and guava (*Psidium guajava*). These are fruit trees that are remnants in the abandoned settlement or farms at the site. Other natural secondary vegetation elements in the grassland which indicate that the area is developing to tree vegetation are *Pittosporum* sp., *Tabernaemontana subglobosa, Trema orientalis, Breynia* sp. and *Melanolepis multiglandulosa.*

The firebreaks, which are maintained by constant brushing, yielded open ground for the growth of Dipterocarp wildlings beside the remnant Dipterocarp forest and *Lithocarpus* and *Parkia* wildlings beside the *Lithocarpus* forest. No wildlings could be found in the ecotone along one side of the remnant Dipterocarp forest which was less brushed over in the period of observation.

The persistence of *Hyparrhenia rufa*, an exotic forage grass in the area, can be attributed to its deep root system and sturdy stems. The grass is also known to be fire-resistant (Randall 2002). Even after the plants have been pressed, the stems of this grass stand and persist over time. The prolific growth of the grass could also be attributed to its reproductive biology whereby it already starts to flower even when the plant is just 20 cm high. This grass can reach 2 metres in height and the plants were in flower during the second visit. In Costa Rica, this species was observed to be intolerant of shade and persists after annual burning unlike other competing woody plants and other grasses such *Cynodon dactylon, Digitaria decumbens*, and *Paspalum notatum* (Daubenmire 1972).

In Site II, the natural regeneration of the vegetation from grassland to forest was more apparent with the emergence of several reforestation species, natural secondary forest species and other indicator species. *Dicranopteris linearis*, a sturdy fern was beginning to co-dominate the landscape in an almost pure grass/sedge-dominated grassland. The growth of herbs and shrubs, in association with grasses and sedges, *Melastoma affine, Desmodium triflorum, Mussaenda philippica, Crotalaria* sp., *Gomphia serrata,* *Ilex brunnea, Neonauclea bartlingii,* and *Trema orientalis,* among others, strongly indicated that the site was in the early stage of development to secondary forest.

While some grassland areas in the site were already characterized by the presence of reforestation species (*Gmelina arborea, Tectona grandis, Leucaena leucocephala*) and secondary tree species (*Antidesma ghaesembilia, Macaranga tanarius, Trema orientalis, Commersonia bartramia, Lagerstroemia speciosa, Colona serratifolia, Cratoxylon sumatranum, Leucosyke capitellata*), the emergence of wildlings of these species indicated successful application of the ANR techniques. This supports the earlier observation that the species dominating the secondary forest have been a constant source of seeds for the regenerating areas that surround it. Species that are indicators of a more advanced state of forest ecosystem like *Lithocarpus sulitii, Palaquium* sp., *Canarium* sp. and *Dipterocarpus grandiflorus* were still conspicuously absent in the regenerating grassland in the area.

In Site III, the wildlings of the nearby secondary forest, such as *Macaranga tanarius, Glochidion rubrum, Polyscias nodosa, Cratoxylum sumatranum* and the highly invasive *Piper aduncum,* were starting to emerge in the grassland area where ANR techniques had been applied. The presence of newly-formed stands of *Piper aduncum* indicated that this species has gained a foothold and may soon spread to larger areas in the site. This species, a native of Southern Mexico, is known to be highly aggressive and can form dense stands to the exclusion of native plants (Siges *et al*. 2005). Other aggressive secondary forest species that were starting to grow in the grassland areas were *Psidium guajava, Leucaena leucocephala* and *Gliricidia sepium.* This indicated that the grassland ecosystem was shifting to pioneer secondary forest. While *Shorea contorta, Vatica* sp., *Lithocarpus sulitii* and *Canarium hirsutum* were among the indicators of an advanced forest in the area, wildlings of these species were not found in the regenerating grassland vegetation signifying that it may take time for the area to reach maturity.

Conservation significance of the biodiversity at the ANR sites

The three ANR sites had elements of high conservation significance with the presence of several threatened species and also alien invasive species.

Dipterocarp species, which are components of lowland evergreen rain forests in the country, were found at the sites although there are a few individuals only. In Site I, large *Shorea contorta, Shorea polysperma* and *Anisoptera thurifera* trees still existed and served as mother trees for wildlings which had successfully emerged in the firebreaks or ecotone maintained at the site. In Site II, a *Dipterocarpus grandiflorus* shed seeds during the first visit in October 2007. In Site III, *Shorea contorta* and *Vatica* sp. were also recorded in the secondary forest. Except for *Vatica* sp., all these species are classified in the *IUCN red list of threatened species* as ‘critically endangered’.

Other species in the IUCN Red List are *Ardisia squamulosa* (Vulnerable), *Diplodiscus paniculatus* (Vulnerable), *Trema orientalis* (Vulnerable) in Site I; *Dillenia philippinensis* (Vulnerable), *Pterocarpus indicus* (Vulnerable), *Artocarpus blancoi* (Vulnerable), *Trema orientalis* (Vulnerable) and *Vitex parviflora* (Vulnerable) in Site II; *Cycas silvestris* (Vulnerable), *Macaranga grandifolia* (Vulnerable), *Pterocarpus indicus* (Vulnerable), *Artocarpus blancoi* (Vulnerable), *Trema orientalis* (Vulnerable) and *Vitex parviflora* (Vulnerable) in Site III.

Invasive alien species are of conservation concern because they aggressively replace indigenous species in their natural habitats. Common examples in all the ANR sites are *Imperata cylindrica, Lantana camara, Chromolaena odorata, Psidium guajava* and *Leucaena leucocephala* among others. They are characterized by persistent root systems or rhizomes and fruits with numerous seeds which easily disperse and germinate even in poor soils. These species are also drought-resistant and can withstand fire.

Hyparrhenia rufa, which is the dominant grass in Limay, Bataan, is a species that despite application of ANR techniques is persistent because of its deep root system and sturdy stem which is resistant to fire and resilient to pressing. The aggressive and persistent characteristic of this grass species is significant in the ecology of the entire area. D'Antonio & Vitousek (1992) noted that exotic grasses, in general, compete effectively with indigenous species over a wide range of ecosystems and at the same time are capable of altering ecosystem processes from nutrient cycling to regional microclimate and can tolerate or even enhance fire.

Piper aduncum, commonly known as bamboo piper, is a small tree native to Central and South America. It is a widespread invasive species and comprises an almost pure stand of forest in Site III. The same species has spread in the forests and open lands of Davao, Bukidnon, and other provinces in Mindanao.

In other countries, the species was observed to invade and establish itself in open unshaded areas, its seeds dispersed by birds, bats and rodents, and can be propagated by suckers or cuttings. The plant has numerous uses for soil-retention structures, fuelwood, house construction material and medicine, among others. Experiments have shown that it accumulates biomass and nutrients (Rogers & Hartemink 2000) and has significant effects on soil productivity providing good planting ground for cash crops like sweet potatoes. However it has soil-drying properties (Siges *et al.* 2005).

Being a notorious invasive species, its spread in Site III must be controlled by uprooting the young plants in the open areas and applying herbicides to the more mature plants.

Conclusion

The three ANR sites exhibit unique geophysical and botanical components. These sites are under different climatic zones and have varying geological complexes. All of the three sites have a mosaic of vegetation types which include grasslands, secondary forests, remnant primary forest and (abandoned) plantation forests. Furthermore, the species composition, species dominance, diversity and structure of these sites are markedly different.

For all the ANR Sites, it is recommended to maintain the firebreaks/ecotones by brushing techniques beside the existing forest stands; ring-weeding of areas around natural regenerants and reforestation species in the grasslands; vigilance in fire detection and fire control; ensuring that the plants inside the plots are monitored and properly cared for; production of a large-scale map of the site where the vegetation can be depicted and the plots marked for monitoring purposes.

Firebreaks should also not be limited to ecotones or vegetation boundaries but should run across the slope or along the contour as well as running up and down the slope (vertically) within vast grasslands.

Firebreaks can also be in the form of green fuelbreaks where tree wildlings can be transplanted at very close intervals.

Research should be continued within the permanent plots. This can be done through the establishment of concrete posts at the corners to guarantee plot perpetuity. Monitoring of changes in species composition in the grassland permanent plots, including wildling/emergent growth within the plots, monitoring of vegetation structure, species diversity, species composition and microclimatic and edaphic conditions must be continued.

Monitoring the introduction and spread of invasive alien species should also be done in order to launch appropriate preventive and mitigation measures when this happens.

Establishment of nurseries for threatened species such as *Shorea polysperma*, *Shorea contorta*, *Anisoptera thurifera* and *Dipterocarpus grandiflorus*. These nurseries will serve as sources of propagules for reforestation.

To further enhance the success of the ANR techniques in the sites, the following activities are also recommended:

Site I

1. Subsequent transfer of some *Shorea*, *Lithocarpus* and *Parkia* wildlings to other sites to limit competition over space in these areas. However, it should be studied whether this will be conducive to the plants' growth.
2. Finding the right method for controlling the spread of *Hyparrhenia rufa* especially in the hillsides and rolling grasslands where the species has already spread. Mechanical pulling of the grasses or applying herbicides can be tried.

3. Establish green fuelbreaks along the contour of the vast grasslands in the site by planting species which are already found in the site like *Gliricidia sepium, Syzygium cuminii,* and *Gmelina arborea*.
4. Physical removal of dry litter and flammable plants like *Chromolaena odorata* and dried ferns.
5. Widen the firebreak around the *Lithocarpus* forest as the litter of these trees are highly flammable.

Site II

1. Planting of economic species such as banana, pineapple, etc., within the multi-purpose firebreaks.
2. Establish green fuelbreaks in hills dominated by *Dicranopteris.* The thick mat of dead leaves of *Dicranopteris* is highly flammable and thus are a fire hazard during the dry season. Pressing of the *Dicranopteris* plants can also help.
3. Establish green fuelbreaks along the contour of the grasslands in the hills by planting species which are already found in the site like *Gliricidia sepium, Acacia mangium, Syzygium cuminii,* and *Gmelina arborea*
4. Physical removal of dry litter and flammable plants like *Chromolaena odorata* and dried ferns.
5. In ecotones where *Dinochloa* and *Pteris* dominate, wider firebreaks should be established as these species are flammable.

Site III

1. Physical removal of young *Piper aduncum* plants.
2. Application of herbicides on more mature trees of *Piper aduncum.*
3. Harvest *Piper aduncum* stems for their commercial value.
4. Survey of the extent of dispersal/distribution of *Piper aduncum* within the site and its vicinities.
5. Determination of the ecological effects of *Piper aduncum* particularly on soil productivity, water retention and soil-binding properties.

For ANR field personnel or NGOs and local people hired in the field:

1. Training in field identification of plants, especially rare, threatened and endemic plants. Knowledge of local plant names should be encouraged.
2. Their local knowledge on the uses of plants in the ANR sites should be harnessed and recorded.

Problems encountered during the botanical inventory:

1. Lack of large-scale reference maps for the ANR sites.

2. Lack of scientific equipment such as laser finders and survey instruments. This equipment was borrowed by the consultant from elsewhere.
3. Instances when fieldwork was done on rainy days.

Acknowledgements

I am grateful to the officials and staff of FAO-Philippines and the Forest Management Bureau, DENR for engaging me in this project. Dr P. Sajise provided valuable review and comments on this paper. I am also grateful to Director Corazon S. Alvina of the National Museum. Mr Patrick Dugan and Charlie Dugan of Bagong Pagasa Foundation, the field staff of the DENR in Bataan, Bohol and Davao and the local government officials and NGOs working in the ANR sites are also acknowledged.

Literature cited

Bureau of Mines and Geo-Sciences. 1982. *Geology and mineral resources of the Philippines.* Manila, Ministry of Natural Resources.

D'Antonio, C. & Vitousek, P. 1992. Biological invasions by exotic grasses, the grass/fire cycle and global change. **Annual Review of Ecology and Systematics,** 23: 63-87.

Daubenmire, R. 1972. Ecology of *Hyparrhenia rufa* Nees in derived savanna in North-Western Costa-Rica. *Journal of Applied Ecology,* 9(1):11-23.

Henderson, P. & Seaby, R. 1997. Species diversity and richness ver. 1.2. Pisces Conservation Ltd., U.K.

Kintanar, R. 1984. *Coronas modified classification of Philippine climate.*

Madulid, D.A. 2001. *A dictionary of Philippine plant names.* 2 vols. Manila, Bookmark, Inc.

Merrill, E.D. 1923-1926. *An enumeration of Philippine flowering plants.* Manila, Bureau of Printing.

Randall, R. 2002. *The global compendium of weeds. Hyparrhenia rufa.* Western Australia, Department of Agriculture.

Rogers, H. & Hartemink, A. 2000. Soil seed bank and growth rates of an invasive species, *Piper aduncum*, in the lowlands of Papua New Guinea. *Journal of Tropical Ecology,* 16(2):243-251

Siges, T., Hartemink, A.E., Hebink, P. & Allen, B.J. 2005. The invasive shrub *Piper aduncum* and rural livelihoods in the Finschafen area of Papua New Guinea. *Human Ecology,* 33 (6) 875-893.

Appendix I

Geophysical characteristics of the three ANR sites in the Philippines surveyed in 2007 and 2009

	Limay, Bataan (Site I)	San Miguel, Bohol (Site II)	Balagunan, Davao (Site III)
Geographical coordinates			
Grassland	***Near the road with Eucalyptus seedlings (Permanent Plot 1)*** North 14.52499, East 120.54558, 375 masl North 14.52395, East 120.54385 North 14.52414, East 120.54377 North 14.52415, East 120.54392 370-376 masl ***Near the hut (Permanent Plot 2)*** North 14.52392, East 120.54152 North 14.52376, East 120.54152 North 14.52389, East 120.54170 North 14.52373, East 120.54160 400-410 masl ***Open area near Lithocarpus forest (Permanent Plot 3)*** North 14.52462 East 120.54140 430 masl	***Plot 1 (before)*** North 14.52499, East 120.54559	***Plot 1, Site A (before)*** North 07.47779, East 125.55959 ***Plot 1, Site B (before)*** North 07.47766, East 125.56665 ***Plot 2, Site A (before)*** North 07.47800, East 125.56401 ***Lower elevation (Permanent Plot 1)*** North 07.28364, East 125.33572 87.6 masl, North 07.28368, East 125.33568, 95.9 masl North 07.28374, East 125.33572 91.3 masl, North 07.28369,East 125.33576 85.8 masl ***Mid-elevation (Permanent Plot 2)*** North 07.28401, East 125.33527,118 masl North 07.28395, East 125.33524 113 masl, North 07.28396, East 125.33518 114 masl, North 07.28402, East 125.33521, 117 masl ***High elevation (Permanent Plot 3)*** North 07.28432, East 125.33480 128 masl North 07.28426, East 125.33479, 130 masl North 07.28426, East 125.33472 133 masl North 07.28432, East 125.33473 133 masl

Ecotone	***Near remnant Dipterocarp forest (Plot 2b, during)*** North 14.31500, East 120.32624 North 14.31482, East 120.32628 North 14.31488, East 120.32635 North 14.31493, East 120.32639 400-450 masl ***Near Lithocarpus forest (Plot 4a and 4b)*** North 14.52372, East 120.54130 413 masl		***Plot 1, Site A (before)*** North 07.47668, East 125.56279 ***Plot 2, Site A (before)*** North 07.47652, East 125.56111 ***Plot 3, Site A (before)*** North 07.47876, East 125.56041 ***Plot 1, Site B (before)*** North 07.47601, East 125.56284 ***Plot 2, Site B (before)*** North 07.47693, East 125.56540 ***Plot 3, Site B (before)*** North 07.47787, East 125.56466 ***Plot 4, Site B (before)*** North 07.47965, East 125.56185 ***Plot 1 (during)*** North 07.28410, East 125.33510 123 masl North 07.28408, East 125.33504 120 masl North 07.28413, East 125.33501 119 masl North 07.28416, East 125.33508 119 masl
Remnant Dipterocarp Forest	***Plot 2 (before)*** North 14.0798, East 120.86870	-	-
Secondary Forest	***Plot 3 (before)*** North 14.52656, East 120.53925, 493 masl	***Plot 1 – Transects 1-4 (before)*** North 09.95653, East 124.26844 264 masl	***Plot 1, Site A – Transect 3 (before)*** North 07.47729, East 125.55997 ***Plot 1, Site A – Transects 4-5 (before)*** North 07.47777, East 125.55959
Other Types of Forest	***Plot 1 – Tiesa stand (before)*** North 14.52371, East 120.54352 ***Plot 4 – Lithocarpus forest (during)*** North 14.52652 East 120.54100	***Plot 2 – Transect 5 (before)*** North 09.95967; East 124.26837 at about 237 masl	***Plot 1, Site B (before)*** North 07.47778, East 125.56340 ***Plot 2, Site B (before)*** North 07.47896, East 125.56242

Climate type			
Coronas Modified Classification of Philippine Climate (Kintanar 1984)	Type 1: two pronounced seasons: dry from Nov. to Apr., wet for the rest of the year	Type IV: rainfall more or less evenly distributed throughout the year	Type III: seasons not very pronounced; relatively dry from Nov. to Apr., wet for the rest of the year
Hernandez Climate type based on ratios of dry to wet months (Kintanar 1984)	Type D: dry; rain not sufficiently distributed with at most 6 dry months	Type C: moist; rain sufficiently distributed with 5 dry months	Type A: wet and rainy
Geology/soil type			
Bureau of Mines and Geo-Sciences 1982	Zambales ultramafic complex; massive coralline limestone with siltstone and shale interbeds; Quarternary volcanic cones	Pre-Tertiary volcanic and sedimentary rocks	Basement rocks of alicia schists on volcanics, serpentinite and diorite; limestone and alluvium soils

Note: masl = metres above sea level.

Plant diversity, soil chemical changes and carbon stock assessment of a marginal ANR site in the Philippines

Leonardo M. Florece and Jesusita Coladilla[1]

Introduction

The growing concern for the development of marginal lands demands a cost-effective rehabilitation strategy in the face of poverty and environmental degradation. Most marginal lands or grasslands are characterized to be low in biodiversity and soil infertility generated by continuous burning for pasture improvement and hillside farming. Therefore, restoring the lost forest cover will not only improve biodiversity and physical conditions but also enhance the land's capacity to support local people's sources of livelihood in the uplands. Land rehabilitation will likewise contribute to mitigating climate change and environmental security.

Marginal lands, as defined by the Department of Environment and Natural Resources (DENR), are "areas once covered with tropical forest, converted to plantation forests, fire-climax *Imperata* grassland, and reproduction brush". These areas have the general characteristics of low productivity, inability to support extensive lowland-type agriculture and high in-migration rates. Falling under the category of marginal lands are open lands, grasslands, rangelands, grazing lands and pasturelands. These lands are very important ecosystem types both in terms of extent and value, and the fact that they have varied ecological and economic importance also requires immediate attention. Considerable tracts of watersheds in the country today are vegetated with grasslands and brush that support water for irrigation, hydropower and other domestic uses. Economically, about one-third of our people rely on these ecosystems for livelihoods or additional sources of fibre, timber and fuel supply. Because of low productivity, upland dwellers remain poor and the practices they are using also lead to further deterioration.

Very recently, these lands are being eyed as potential areas for biofuel production due to increasing prices of fossil fuel in the world market. Improving the productivity of marginal lands, however, remains a daunting challenge. This is because, from experience, their rehabilitation has always been futile because of poor soil condition, tenure problems and regular fire events. For instance, the DENR has already spent an estimated US$22.4 million for the reforestation of marginal lands only for them to be destroyed by fire subsequently (Table 1). Hence, if the government is keen on

1. School of Environmental Science and Management (SESAM), University of the Philippines at Los Baños (UPLB), College, Laguna, and University Researcher, SESAM, UPLB. Email: lmflorece@gmail.com

developing these areas as possible sites for biofuel, a thorough assessment of the area and a workable strategy must be developed for plantations to succeed. Proponents of biofuel assert that only lands not suited for agriculture are the subject for development in order to avoid competing with national food security. If this is true, then marginal lands are the most likely sites for biofuel production. Grasslands, barren areas and wooded grasslands are estimated to cover about 2.2 million hectares (DENR 2005).

Assisted natural regeneration (ANR) is a technique that may be utilized for the rehabilitation or development of marginal areas. The DENR has had this technology for some time. In fact, Memorandum Circular No. 17 was issued in late 1989 for DENR staff to implement the strategy in their reforestation activities. But, until today, it appears as if this approach has been underutilized despite the following advantages: (a) it is cheaper or cost effective, (b) it is ecologically desirable, (c) it promotes biological diversity, (d) it maintains hydrological integrity and (e) it can source local communities' familiarity with indigenous plant species of value to them (Sajise 1989).

Table 1. Fire occurrences and area burned from 1992 to 2004

Year	Fire events	Area burned (ha)				Total Cost $US	Size (ha/ event)
		Natural forest	Grassland	Plantation	Total		
1992***	1 106	5 064	14 404	31 842	51 310	4 091 639	46.39
1993	595	312	415	14 603	15 330	3 659 484	25.76
1994	218	648	2 509	4 564	7 721	456 385	35.42
1995	280	1 370	2 055	7 285	10 710	1 117 891	38.25
1996	194	5	891	4 568	5 463	2 454 792	28.16
1997	147	410	372	2 780	3 561	1 236 999	24.23
1998***	941	17 044	18,894	18 894	54 832	4 777 659	58.27
1999	36	257	3 500	2 344	6 102	720 109	169.49
2000	38	829	1 123	1 186	3 137	120 284	82.56
2001	26	129	700	753	1 582	418 615	60.83
2002*	180	1 971	2 238	16	4 224	1 056 385	23.47
2002**	227	1 983	2 619	4 147	8 749	1 303 421	38.54
2003	208	58	507	5 236	5 800	664 419	27.89
2004	46	20	764	656	1 440	330 852	31.31
Total	**4 242**	**30 098**	**50 990**	**98 873**	**179 961**	**22 408 935**	

*Statistics from 1992 to 2002 are sourced from data submitted by regional offices compiled and consolidated by the Special Action and Information Division (SAID).
** Statistics from 2002 to 2004 are sourced from submitted reports by regional offices in compliance with the Office of the Undersecretary for Field Operations (OUFO) Memo dated 27 April 2004. Data for 2004 cover January to April 2004 only.
***El Niño years.
Source: USAID, Special Concerns Office; DENR (2004).

The concept of plant succession is the fundamental basis of ANR. Sajise (1989) described ecological succession as an "orderly process of community changes, which is directional and often predictable. If it is described in terms of plant community changes, then it is referred to as plant succession”. The basic ecological processes of species replacement through time as a result of modification of the environment by pioneer plant species that are favourable for the recruitment of climax species are central to ANR.

ANR as a rehabilitation process is defined by Sajise (1989) as a “reforestation strategy that makes use of advanced stages of plant succession characterized by the presence of sufficient numbers of tree seedlings, mother trees, favorable soil and microclimatic conditions as a starting point by which enhancement activities of seedling ‘liberation’, protection, and enrichment planting is conducted”.

As a science it could be defined as a systematic integration of biophysical, technological, socio-economic and cultural information to meet the objectives of forest rehabilitation. This definition implies that successful attainment of ANR objectives requires a thorough understanding of the prevailing biophysical characteristics of the site, the prevailing socio-economic and cultural traditions or indigenous knowledge of the local people to be involved and the acceptability of the technology that will be introduced in the area. Therefore, ANR is site-specific and requires some modifications of the current implementing guidelines or policies to make it suitable to ranges of conditions prevailing in the country.

Since the concept evolved, not much research has been conducted to test the effectiveness of the strategy. Because of the need to improve knowledge on ANR, such research was implemented with the objectives of: (a) analysing the effectiveness of *Gliricidia sepium* cuttings as planting material for grassland rehabilitation by quantifying its survival and growth performance after planting and burning; (b) quantifying plant diversity (plant species composition) and physical (soil chemical) changes under the established stand of *Gliricidia*; and (c) assessing the carbon stock of the 20-year-old ANR site planted with *Gliricidia.*

The Research Site

The research site was formerly the fire ecology study area of the Upland Hydroecology Program (UHP) of the University of the Philippines at Los Baños in 1979. It is situated at an elevation of between 390 and 400 metres and was believed to be a Dipterocarp forest that had been subjected to swidden farming after the Second World War. It had been abandoned for almost 20 years and with regular burning every year, grass dominance had been maintained. The soil in the area is Macolod Clay Loam (UHP 1979). It is under the Type 1 climate of the Corona classification system, with almost 94 percent of the total annual rainfall occurring in May to October. The fire ecology research team under the UHP conducted the following studies in the area: (a) effects of fire on soil temperature at two depths (2.5 and 6 cm); (b) effects of fire on soil temperature; (c) effects of fire on some soil chemical properties; (d) effects of fire on the Acarine fauna of the grassland; (e) influence of fire on soil fungal populations in the grassland; (f) effects of fire on grassland vegetation; (g) effects of grass management on the bacterial and actinomycete populations and on nitrogen availability; (h) runoff and sediment load; and (i) chemical composition of the runoff water from grass-covered plots subjected to different types of grass management and times of burning. The size of the study site is about 2 500 m^2 bounded by secondary forest and fallow kaingin (a shifting cultivation area). The secondary forest here could serve as source of propagules for plant succession (Plate 1).

Materials and methods

Vegetation and soil sampling

Initial vegetation composition was determined by the harvesting method in a 1 m^2 quadrat on 6 April 1989. Twelve 1 m^2 quadrats were randomly chosen along the ridge and another 12 below the ridge. The harvested above-ground biomass was placed in plastic bags and later brought to the School of Environmental Science and Management's analytical laboratory for segregation by species; it was then placed in paper bags for oven drying for 48 hours at 105^0C. The Importance Value (IV) for each species was determined using the dry weight as basis for computation..

Twelve composite soil samples were also taken randomly for soil pH, nitrogen, phosphorus, potassium and organic matter determination. These processes were then repeated in August 1996 and February 2009 or seven and 20 years after, respectively.

Land preparation and planting material

Burning was used for clearing the whole site. This was done on 10 April 1989 or after the vegetation sampling was completed. Before burning, the grasses were lodged to achieve a good burn or complete removal of above-ground biomass. Stems of talahib (*Saccharum spontaneun*) constituted most of the unburned material because of its high moisture content and the woody nature of its stem.

Gliricidia sepium (kakawate) cuttings were used considering the good sprouting ability of the species when used as pegs or posts for fences. Cuttings as planting stock are advantageous over seedlings because of larger diameter size compared to potted seedlings, they eliminate the need for nursery operation, they are easy to haul (about 100 cuttings per person) and have a faster rate of planting (about 150 cuttings per person). Moreover, *Gliricidia*: (a) is a socially acceptable among farmers; (b) although exotic, it has already adapted to local conditions; (c) is a multipurpose species; and (d) it coppices readily. The cuttings were 0.5 m in length and were planted at 1 x 1 m at a depth of 0.25 m. Cuttings were sharpened (like sharpening a pencil) using a machete and care was observed not to split the bark. This was done by digging a hole using a rounded iron bar at a depth of 0.25 m before inserting the stem cutting.

Experimental design and treatments

The study occupied a total area of 2 500 m^2. The experiment was laid out in a completely randomized design with diameter class as the main plots and length of storage of cuttings as subplots. The following treatments were used:

T_1 or 2A: Cutting diameter class 1.5-2.99 cm and cuttings stored for 1 week, and site burned the following year;
T_2 or 2B: Cutting diameter class 1.5-2.99 cm and cuttings stored for 2 weeks, and site burned the following year;
T_3 or control: Cutting diameter class 1.5-2.99 cm, cuttings not stored, and no site burning;
T_4 or 4A: Cutting diameter class 3.0-4.99 cm, cuttings stored for 1 week, and burned the following year;
T_5 or 4B: Cutting diameter class 3.0-4.99 cm, cuttings stored for 2 weeks, and site burned the following year;
T_6 or control: Cutting diameter class 3.0-4.99, not stored, and no site burning.

The cuttings were sharpened at the base at the time of collection; then they were immediately stored in the shade. The treatment that needed no storage was planted the following day. Length of storage for one treatment was assessed to determine the effect of storage on survival for the practical reason that collection and hauling will require some time to accomplish under actual field conditions. Similarly, diameter size indicates the age or maturity, and therefore is a critical variable in the survival of cuttings. Planting commenced on 5 May 1989, then 12 May and 19 May for no storage, 1 week storage and 2 weeks' storage, respectively. There were 20 sample plants per treatment replicated six times. Survival was monitored quarterly during the first two years and the final determination of survival was conducted in August 1996.

A multifactor analysis of variance (ANOVA) was used to determine the effects of fire treatment, diameter size and length of storage on survival of cuttings; significant differences were analysed using the Tukey test. A one-factor ANOVA was used to analyse the initial and final sampling of soil variables.

Measurement of carbon stock

The field methods used by Banaticla (2003) in estimating the C pools for various land-use types in Putting Lupa, Mt. Makiling Forest Reserve were adopted in this study. The C stock in the following pools was measured:

- Above-ground biomass – all vegetation in the understorey layer.
- Below-ground biomass – coarse and fine roots found at depths of up to 5 cm.
- Necromass – coarse woody debris and standing litter (fallen leaves, twigs and branches, fruits and flowers on the forest floor).
- Soil organic C – up to 30 cm depth.

The method of estimating biomass and necromass was expressed in terms of dry matter per unit area (megatons per hectare) (Mg/ha) and was determined by obtaining the dry weights of the vegetation. Dry matter was then converted to the equivalent amount of C by multiplying the dry matter weight by 45 percent which is the average content of plant tissue samples taken from different areas in the Philippines (Lasco *et al.* 2002).

The total system C stock of each land cover type was calculated based on the following equation:

$$\text{Total system C stock (Mg/ha)} = \frac{\text{Biomass C + necromass C+ soil C}}{\text{Area of land (ha)}}$$

Sampling procedure

Three rectangular plots measuring 5 x 30 m (150 m2) were established from the ridge down the lower slope of the ANR site. Within each plot, a 30 m central transect line with 2.5 m perpendicular lines on both sides were established and a 1 x 1 m square plot was determined for sampling of understorey vegetation, litter, underground roots and soil for analysis (Figure 1).

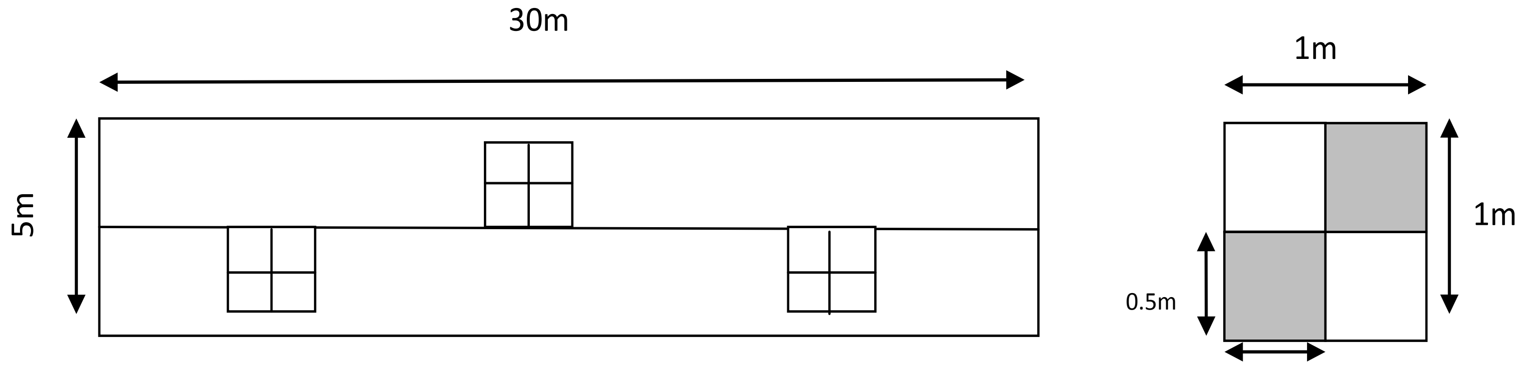


Figure 1. a. The main 150 m² plot for sampling trees. Within the plot are randomly located sampling quadrats for understorey vegetation, litter, roots and soil. b. Sampling quadrats for understorey vegetation (1 x 1 m) and litter/soil/roots (0.5 x 0.5 m). The shaded quadrats are for sampling litter. There were 3 samples for understorey vegetation and 6 samples for litter, roots and soil.

All trees within the 5 x 30 m rectangular plot with diameter at breast height (dbh) of ≥10 cm and palms live or dead were identified and their dbh was measured using a digital caliper. Tree height was measured using a Haga altimeter.

In estimating individual above-ground tree biomass the regression equations shown in Table 2 were used (Banaticla 2003). For sampling understorey biomass and the litter layer, a quadrat measuring 1 x 1 m and subdivided into four equal sections was established. All plants with less than 5 cm in diameter found inside the quadrat were clipped, weighed and brought to the laboratory for oven-drying at 60ºC until constant weight was achieved.

Table 2. Biomass regression equations for estimating individual above-ground tree biomass

Species	Equation (biomass in kg)	n	r^2	dbh range (cm)	Height range (m)	Source
Palms	Biomass = 0.3999+7.907 *total height	-	0.75	-	1-33	Teopolo *et al.* (2002)
Ipil-ipil	Biomass = 0.08771*dbh2.13 * total height$^{0.36}$	18	0.98	5.40-21.0	5.70-16.30	Tandug (1986)
General	Biomass = 0.068xdbh2.5	39	0.99	4.10-36.1	-	Banaticla (2003)

Note: n = number of tree samples; r^2 = correlation coefficient; ρ = wood density in g/cm^3).

For the necromass, all undecomposed materials or crop residues from the randomly chosen 0.5 x 0.5 m quadrats within the understorey quadrats were collected, sieved, weighed and oven-dried in the laboratory at 60ºC until constant weight was achieved.

The biomass/necromass and equivalent C stored in the understorey vegetation and litter were calculated using the following equations (Banaticla 2003) as follows:

$$\text{Total dry weight (kg/m2)} = \frac{\text{Oven-dry weight (g)/1 000(g/kg)}}{\text{Area of quadrat } (m^2)}$$

$$\text{Biomass/necromass dry weight } (Mg/m^2) = 10 \times \text{total dry weight } (kg/m^2)$$

$$\text{C stock} = \text{biomass/necromass dry weight (Mg/ha)} \times 45\% \text{ C content}/100$$

For the below-ground C pools, the live and dead roots in the upper 5 cm soil layer and soil up to a 30 cm depth were collected. Then, from the 0.5 x 0.5 m sampling site for necromass/biomass, a 0-5 cm soil layer was excavated, coarse-sieved for roots and soil samples, transferred to a plastic bag and brought to the laboratory for air-drying and dry-sieving of roots. Digging was continued for sampling of roots and soil at depths of 5-15 cm and 15-30 cm (Banaticla 2003).

The collected soil samples with roots were air-dried in the laboratory and dry-sieved with a 2 mm sieve. The collected roots with soil particles were washed to get rid of the adhering soil particles, air-dried, weighed and oven-dried at 60ºC until constant weight was attained. Total root dry matter and C were calculated using the same formula used for the understorey and litter pools.

Composite air-dried soil samples that passed through the sieve during the processing of roots for the 0-5 cm, 5-15 cm and 15-30 cm layers were later sent to the UPLB-ASC Soil Analytical Laboratory for pH and organic matter analysis using the Walkley-Black method.

Results and discussion

Survival of stem cuttings

The initial mean survival of *G. sepium* cuttings six months after planting (November 1989) for all treatments was 64 percent (Table 3). This may be low because planting was delayed for two weeks. The best time for planting of *G. sepium* stem cuttings as experienced by many farmers in the uplands is before the onset of the rainy season or in mid-April. Although the highest survival rate (78.33 percent) was observed in Treatment 4B or diameter size of 4 cm stored for two weeks and the lowest was in Treatment 1 or 2A at 48.33 percent, their differences were not significantly different. This implies that either sizes may be utilized as planting material and that planting may be delayed for two weeks as long as the cuttings are stored under shade and abrasions on the bark at the base are avoided.

Table 3. Mean survival (%) of *G. sepium* stem cuttings for two sampling periods

Treatment	22 November 1989* % survival	17 July 1996* % survival
T1 or 2A	48.33a	18.33a
T2 or 2B	63.33a	33.33ab
T3 or 2 control	56.67a	38.33ab
T4 or 4A	65.00a	40.83ab
T5 or 4B	78.33a	41.67ab
T6 or 4 control	71.67a	50.00b
Mean	**64.00a****	**37.00b****

*Mean survival rates along columns with the same superscripts are not significantly different at the 5 percent level by the Tukey test.

**Survival rates across columns are significantly different at 5 percent.

The mean survival rate in August 1996 or after about seven years was 37 percent (Table 3), which is significantly different ($p<0.05$) from that of the initial survival rate. The very low survival rate after seven years was attributed to the fire generated in the second year (April 1990). The relatively higher survival rate of cuttings in the bigger size class implies that diameter size is indeed an important factor of survival. Therefore, for the plantation to be successful, fire prevention, control and maintenance activities must continue until such time that the diameter of seedlings or stocks has reached a ground-line diameter (gld) of at least 5 cm. To attain this size, would require about five years or more. The current project reforestation budget allotment is only good for three years, and therefore seedlings will only be about 2-3 cm gld; thus they could still be easily killed by wildfire. Survival, however, is dependent also on species. Fire-intolerant species (e.g. *Acacia auriculiformis*) would still be killed by fire at 10 cm gld while fire-tolerant species at 5 cm gld would survive high fire intensity levels either through basal or epicormic sprouting (Florece and Methven 1996).

Vegetation composition

The initial vegetation sampling in April 1989 showed a total of 16 plant species with *Saccharum spontaneum* and *Imperata cylindrica* being the two most dominant grasses – an IV of 47.1 and 41.5 percent, respectively (Table 4). There were no wildlings of trees recorded despite the secondary forest that surrounds the site. The regular fire set every year by farmers surrounding the site might have eliminated the wildlings of broadleaved plants since the time of its abandonment by the UHP in 1979.

Table 4. Vegetation composition of the site during initial and second samplings

6 April 1989 (Initial)			August 1996 (second)		
Species	**O.D. wt.(g/m²)**	**IV (%)**	**Species**	**O.D. wt.(g/m²)**	**IV (%)**
*S. spontaneum**	1 472	47.1			
O. corniculata	0.4	0.01			
*D. triflorum**	15.4	0.49			
*A. mutica**	39.6	1.27			
Cyperus sp.	1.2	0.04			
*I. cylindrica**	1 296	41.48			
*D. bulbifera**	0.2	0.006			
E. oryzoides	100.8	3.23			
C. pubescens	0.4	0.01			
*L. circinatum**	5.2	0.17			
Ipomoea sp.	9.6	0.31			
*M. cordata**	18.7	0.59	*M. cordata*	29.6	4.82
*E. tomentosus**	3.1	0.09	*E. tomentosus*	13.2	2.15
P. conjugatum	105.8	4.83	*P. conjugatum*	225.5	36.7
C. patens	9.2	0.294	*C. patens*	206.7	33.64
C. acrescens	1.8	0.064	*C. acrescens*	4.1	0.67
			S. nodiflora	2.1	0.34
			N. cordifolia	32.6	5.3
			L. camara	7.5	1.22
			C. odorata	56.2	9.13
			C. asiatica	0.1	0.02
			A. conyzoides	0.5	0.08
			Trees/shrubs		
			L. leucocephala	19.8	3.22
			F. hauili	4.3	0.7
			F. ulmifolia	11	1.79
			C. philippensis	0.2	0.03
			B. javanica	1.2	0.19
Total	**3 124.4**	**100**		**614.6**	**150.49**

*Species present during the Fire Ecology Study of the UHP in 1979.

The result of the sampling conducted in August 1996 or seven years later showed a completely different vegetation type dominated by *Paspalum conjugatum* and *Cyrtococcum patens* with IVs of 36.7 and 33.6 percent, respectively (Table 4). It is surprising that the two most dominant species encountered in the initial sampling no longer existed. Out of the 16 species recorded in 1989, only five were encountered in the August 1996 sampling. These were: *Mikania cordata*, *Elephantopus tomentosus, Paspalum conjugatum, Cyrtococcum patens* and *C. acrescens*. New species have emerged such as *Synedrella nodiflora, Lantana camara, Chromolaena odorata, Centella asiatica* and *Ageratum conyzoides.* The dominant grasses in the August 1996 sampling such as *P. conjugatum* and *C. patens* had a very low IV during the initial sampling but became the dominant species after seven years, which indicated that these species were shade-loving (Table 5). It is notable that during the initial sampling the total above-ground biomass was 3 124 g/m2 with almost 88 percent of the biomass contributed by *S. spontaneum* and *I. cylindrica* as against the second sampling of only 615 g/m2 mostly from the biomass of *P. conjugatum* and *C. patens* or a marked decrease of 80 percent above-ground biomass (Table 4).

Table 5. Other tree species present in the area during the August 1996 sampling or species not captured by the sampling method used

Common name	Scientific name	Family
Paguringon	*Cratoxylum sumatranum* (Jack) Blume	Clusiaceae
Tibig	*Ficus nota* (Blanco) Merr.	Moraceae
Banaba	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae
Salago	*Phaleria capitata* Jack	Thymelaeaceae
Matang-araw	*Melicope triphylla* (Lam.) Merr.	Rutaceae
Mamalis	*Pittosporum pentandrum* (Blanco) Merr.	Pittosporaceae
Hamindang	*Macaranga bicolor* Muell-Arg.	Euphorbiaceae
Bogus	*Acalypha stipulacea* Klotz.	Euphorbiaceae
Kalingag	*Cinnamomum mercadoi* Vid.	Lauraceae
Tangisang bayawak	*Ficus variagata* Blume	Moraceae
Bignay pugo	*Antidesma pentandrum* (Blanco) Merr.	Euphorbiaceae
Tirukan	*Beilschmiedia glomerata* Merr.	Lauraceae
Matang hipon	*Breynia rhamnoides* (Retz.) Muell-Arg.	Euphorbiaceae
Putat	*Barringtonia racemosa* (L.) Blume ex DC	Lecythidaceae

Moreover, a complete enumeration in 1996 of tree species within the site or those that were not captured by the sampling method used revealed 14 species, which indicated that the site had shifted into an advanced stage equivalent to a secondary forest ecosystem (Table 5). This could be explained by the following conditions: (a) *G. sepium* plantation provided a conducive microclimate for the recruitment of tree species; (b) the exclusion of fire allowed for the entry of fire-sensitive species; and (c) the presence of mother trees surrounding the site as sources of seeds.

Recently, a complete enumeration of plants contained in the ANR site revealed a total of 29 species of trees, palms and shrubs and eight species of grasses, herbs and vines (Table 6), which is considerably different and more diverse compared with the initial vegetation where grasses dominated (Plate 1).

Plate 1. The ANR site in 2009 or about 20 years after establishment (courtesy Leonardo M Florece)

Table 6. Plants at the ANR site as of June 2009

Local name	Scientific name	Family
Grasses/herbs/vines		
Bikal babui	*Dinochloa luconiae* (Munro) Merr.	Poaceae
Bikal	*Dinochloa acutiflora* (Munro) S. Dransf.	Poaceae
None	*Cyrtococcum patens* (L.) A. Camus	Poaceae
Cyperus sp.	*Cyperus* sp.	Cyperaceae
Devil's grandmother	*Elephantopus tomentosus* L.	Astraceae
Uoko	*Mikania cordata* (Burm. F.) B.L. Rob.	Asteraceae
Litlit	*Piper interruptum* Opiz var. loheri (C.DC.) Quis	Piperaceae
Bamban	*Donax cannaeformis* (G. Forst.) K. Schum.	Maranthceae
Trees/palms and shrubs		
Subiang	*Bridelia insulana* Hance	Phyllanthaceae
Paguringon	*Cratoxlum sumatranum* (Jack) Blume	Clusiaceae
Kaong	*Arenga pinnata* (Wurmb) Merr.	Arecaceae
Amugis	*Koordersiodendron pinnatum* (Blanco) Merr.	Anacardiaceae
TibigIpil-ipil	*Ficus nota* (Blnco) Merr.	Moraceae
Hauili	*Leucaena leucocephala* (Lam) de Wit	Fabaceae
Matang araw	*Ficus septica* Burm. F.	Moraceae

Bayanti	*Melicope triphylla* (Lam.) Merr.	Rutaceae
Tagbak	*Aglaia rimosa* (Blnco) Merr.	Meliaceae
Coronitas	*Alpinia elegans* (Presl.) K. Schum.	Zingiberaceae
Hagimit	*Lantana camara* L.	Verbenaceae
Takipan	*Ficus minahassae* (Teysm & de Vriese) Miq.	Moraceae
Lago	*Caryota rumphiana* Mart. var *philippinensis* Becc.	Arecaceae
Tamayuan	*Prunus grisea* (C. Muell.) Klkm.	Rosaceae
Balingayo	*Strombosia philippinensis* (Baill.) Rolfe	Olacaceae
Kayumanis	*Erythropalum scandens* Blume	Olacaceae
Alasiis	*Clausena anisum-olens* (Blanco) Merr.	Rutaceae
Lamog	*Aphananthe philippinensis*	Ulmaceae
Putat	*Planchonia spectabilis* Merr.	Lecythidaceae
Namot	*Barringtonia racemosa* (L.) Blume ex DC.	Lecythidaceae
Kalingag	*Cynometra bijuga*	Fabaceae
Ligas	*Cinnamomum mercadoi*	Lauraceae
Strophanthus sp.	*Semecarpus cuneiformis*	Anacardiaceae
Duyok-duyok	*Strophanthus* sp.	?
Matang-hipon	*Manilkara fasciculata*	Sapotaceae
	Breynia rhamnoides (Retz.) Muell-Arg.	Euphorbiaceae

Soil chemical changes

Soil chemical analyses of samples taken on 6 April 1989 (initial) and the sampling conducted on 12 March 1997, revealed higher values in the later sampling in all variables, except for organic matter percentage and nitrogen where no significant differences were detected (Table 7). Phosphorus, potassium and pH values during the initial and second sampling were significantly different at the 5 percent level of significance (by the Tukey test). Though nitrogen was not significantly different after seven years, the increase in the levels of soil chemical properties indicated that *G. sepium* could be a good fallow crop for marginal lands or swidden agriculture. Grist *et al.* (undated) also observed an increasing fertility over time when *G. sepium* was used as a fallow crop. Simons and Stewart (1994) revealed that the leaves of *G. sepium* when used as mulch decomposed in 40 days, hence allowing for rapid recycling of soil nutrients.

Soil analysis after about 20 years showed a slight improvement in soil chemical properties compared with the initial soil analysis especially in terms of soil organic matter and nitrogen content except for pH where the sampling in June 2009 showed a much lower value of 5.3 (Table 7).

Table 7. Results of chemical analysis of soils taken on 6 April 989 (initial), 12 March 1997 and 30 June 2009 sampling in the area.

Variables	6 April 1989	3 March 1997	30 June 2009
pH	5.34 a	5.86 b	5.3
%OM	5.72 a	5.93 a	6.73
Nitrogen	0.243 a	0.276 a	0.337
Phosphorus	0.219a	1.311b	
Potassium	1.78a	2.86b	

Superscripted values with different letters between columns are significantly different at the 5 percent level of significance (Tukey test).

Estimated C stocks

Results of carbon stock estimation in the ANR site 20 years after the initial activity in the area are shown in Table 8. Initial carbon stock was not estimated prior to ANR activities in the area, but as the area was formerly grassland dominated by *Imperata cylindrica* and *Saccharum spontaneum*, the estimated C stocks would not differ greatly with the study of Lasco and Pulhin (2000) or other authors for this type of vegetation.

Table 8. Estimated C stocks in the ANR site

Plot no.	Estimated C stored in live trees (Mg/ha)	Estimated C from above-ground biomass (Mg/ha)	Estimated C from necro-mass (Mg/ha)	Estimated C from soil (Mg/ha)	Estimated total C stock (Mg/ha)
Plot 1	807.70	0	4.58	115.03	119.61
Plot 2	576.48	5.13	5.64	115.03	125.8
Plot 3	105.43	3.81	4.70	115.03	123.54
Mean	496.54	2.98	4.97	115.03	122.98
SD	357.89	2.66	0.58	0.0	3.13
CV (%)	128 087	7.09	0.34	0	9.81

The mean C stock of live trees is 496 Mg/ha, 2.98, 4.97 and 115 Mg/ha for above-ground biomass, necromass and C from the soil, respectively. The ANR system today as a whole has a mean C stock of 123 Mg/ha (Table 8).

The mean C stock (123 Mg/ha) of the ANR site today is much higher compared with the study of Banaticla in 2003 (Table 9) in the same area under abandoned shifting cultivation with only about 56 Mg/ha. This means that ANR has the potential to increase C stock when properly managed and protected from human activities. Differences in C stock values of the ANR site and that of Banaticla (2003) were not statistically analysed due to differences in sampling size.

Table 9. Comparison of estimated average C stock Banaticla (2003)

	C stock (Mg/ha) for the 22-year abandoned *kaingin*	This study C stock (Mg/ha) for the 20-year ANR site	Banaticla (2003) C stock (Mg/ha) for open *kaingin*
Tree biomass	84.44	496.54	89.17
Above-ground biomass	2.01	2.98	0.05
Necromass	3.038	4.97	1.352
Soil C	50.74	115.03	42.11
Estimated total C stock	55.788	122.98	43.512

Conclusion and recommendations

Rehabilitation of degraded forest lands through conventional and ANR approaches is a complex matter that needs a thorough understanding of the biophysical, technological, socio-economic and cultural conditions prevailing in the area. There are no short cuts to forest rehabilitation work as evidenced by the long process that occurred in Mt. Makiling. Although the socio-economic and cultural dimensions of ANR were not taken into account, it is still possible to test the technology in some parts of the country by asking people whether they are willing to try the technique. With the ailing economy, a cheaper version of rehabilitation must be developed. And the use of stem cuttings as described deserves a second look if it is possible in some other sites similar to the conditions at Mt. Makiling. We must endeavour to properly set up ANR sites and to document the process from the beginning to the end. Allowing an area to become marginal, such as a grassland, will entail more resources to reforest and will be more difficult because of the recurrent fire that inhibits the growth and survival of trees. But if tree species planted are fire-resistant and fast growing, grassland species will be gradually eliminated because they are shade-intolerant.

The following actions are recommended: (a) identification and characterization of ANR sites under various climatic zones in the country; (b) revision of MC No. 17 to suit the varying conditions of ANR sites; (c) research-based implementation of ANR in various sites; (d) graduate student support for those interested in research on ANR; and (e) local government participation in the implementation of ANR.

Imperata–Saccharum–Themeda-dominated grasslands abound in the country. Grasslands and marginal areas in the country are estimated to cover about 2 million hectares, all of which need immediate rehabilitation to relieve rural poverty and enhance environmental stability. As fire is the limiting factor in the rehabilitation of fire-dominated ecosystems, the following actions are recommended: (a) development of a fire management system for regions (Cordillera Administrative Region, Regions 2 and 3) and its institutionalization at all levels; (b) fabrication of fire-fighting tools and equipment to avoid relying on imported products that are often expensive; (c) support for research on fire ecology/fire management, especially on fire effects on forests at the margins of grassland areas; (d) regular monitoring and evaluation of fuel moisture under forest ecosystems during times of drought and an information, education and communication campaign in rural communities on the effects of fire on biodiversity; (e) development of a fire database system and fire-risk maps using GIS for fire-prone ecosystems; (f) formulation of a workable incentive system to encourage rural people to participate in forest fire prevention and control; and (g) regular training on fire management among DENR field staff and volunteers in villages that host fire-prone ecosystems.

Literature cited

Banaticla, M.R.N. 2003. Carbon storage of land cover types in the Western Margin of Mt. Makiling, College, Laguna, UPLB. (Unpublished MS thesis).

Department of Environment and Natural Resources (DENR). 2005. *Philippine forestry statistics*.

Florece, L.M. & Methven, I.R. 1996. Fire behavior, fire effects, and survival responses of trees. *SYLVATROP, The Technical Journal of Philippine Ecosystems and Natural Resources,* 4(2): 41-63.

Grist, P., Menz, K. & Nelson, R. Undated. *Gliricidia as improved fallow*. Australian Centre for International Agricultural Research (ACIAR), Monograph No. 52. pp. 133-147.

Lasco, R. D. & Pulhin, F. B. 2000. Forest land-use change in the Philippines and Climate change mitigation. *Mitigation and Adaptation to Global Climate Change Journal* 5:81-97.

Lasco, R.D., Pulhin, F.B., Sales, R.F. & Guillermo, I.Q. 2002. Carbon stocks assessment of secondary forest and tree plantations in the Philippines: towards improving GHG inventory. *In* D.M. Macandog, R.D. Lasco, R. Boer & P. Chittachumnonk, eds. *Highlights of the research project for the Southeast Asian Region-LUCF Sector.* College, Laguna, UPLB, UPLB Foundation Inc., Institute for Global Environmental Studies, National Institute for Environmental Studies.

Sajise, P.E. 1989. Assisted Natural Regeneration as an Approach to Reforestation. *In* Assisted Natural Regeneration: Working with Nature Reforestation Strategy. Rainfed Resources Development Program, DENR and Institute of Environmental Science and Management, UPLB, College, Laguna.

Simons, A.J. & Stewart, J.L. 1994. *Gliricidia sepium* - a multipurpose forage tree legume. *In* R.C. Gutteridge & H.M. Shelton. *Forage tree legumes in tropical agriculture.* Wallingford, Oxon, CAB International.

Tandug, L.V. 1986. Biomass prediction equation for giant ipil-ipil (*Leucaena leucocephala* Lam. De wit.). College, Laguna, College of Forestry, UPLB. (Unpublished MS thesis).

Teopolo, O.G., Calmon, M. & Rocha Feretti, A. 2002. Measuring and monitoring carbon stocks at the Guarquecaba climate action project, Parana, Brazil. *In* K. Liu & J. Li, eds. *Proceedings of the international symposium on forest carbon sequestration and monitoring, 11-15 November 2002*, pp. 28-36. Taipei, Taiwan, Forestry Research Institute and Winrock.

Upland Hydroecology Program (UHP). 1979. *Fire ecology.* Annual Report. College, Laguna, UHP, UPLB.

Overcoming bracken climax to assist forest regeneration in Mindanao

Lucy Linantad,[1] Rufino Sagula,[2] Eric Bruno[3] and Pedro Walpole[3]

Introduction

Mindanao's tropical rain forest lies below the typhoon belt with rainfall ranging from a distinctly dry season to rain throughout the year. The greatest area and range of forest cover are found on the slopes of the different mountain ranges that are habitats for unique species of fauna. The northern part of Mindanao has been predominantly 'Manobo', a loosely related polyglot culture of over 20 languages. The Pulangiyen, one of these communities, live along the upper reaches of the Pulangi River in Bukidnon Province and they have traditionally been associated with the local river systems. Bendum, their main village, is located at 650 metres above sea level (masl) on the western slopes of the Pantaron Range which experiences drier months from March to May.

The Pulangiyen community has an ancestral domain of 2 600 hectares that reaches the mountain ridge. There are about 80 households in the village, 20 percent being migrants. A council of elders leads the community; there are *sitio* (small settlement) leaders, some being Pulangiyen, connected to the *barangay* (village) of Busdi across the Pulangi. Helping the tribal council in the management of the domain are several committees. The Water Committee was established in 1995 and is tasked with managing the water system and its source. The committee encourages forest regeneration activities in areas of concern especially above the source. The Livelihood Committee is the trading arm of the community. The committee links the community to markets by facilitating the trading of abaca fibres and basic commodities that are not locally produced such as salt, dried fish, cooking oil, canned goods and snack foods. The committee also initiates planting of abaca to ensure the sustainability of the resource base for trade and for weaving.

Land use

Traditionally people have hunted and practiced swidden agriculture while gathering *alamay* (wild abaca) and rattan. Logging was heaviest in the area in the 1980s but has now stopped leaving the difficult forested slopes and higher elevation mossy forest unlogged. The rattan stock is now exhausted after extraction was exacerbated by many outsiders. People tried to cultivate coffee for a while and intensive maize cultivation

1. Panginabuhian hu Kumitiba, Nabantaw Pulangi Organization (NPO), Bendum, Malaybalay City, Philippines.
2. Wahig hu Kumitiba, (NPO) Bendum, Malaybalay City, Philippines.
3. Apu Palamguwan Cultural Education Center (APC), Bendum, Malaybalay City, Philippines.

was introduced by the migrants, but in the last ten years abaca has been planted and provides a variable income for many people along with less intensive farming that involves a rotation of fallow lands. Abaca is a banana-like plant (*Musa textilis*) and fibres obtained from its stalks are used to make cordage, fabric and paper.

The community has harvested forest products for a long time and has maintained much of the forest abandoned by logging companies. Young people take a particularly active role in monitoring activities in the area. The community understands that forest cover is responsible for clean water in the area. Basically, this is a community that wants to secure its domain and central to the present discussion is the water source and its system of management. The community has had to struggle with its own needs for food, for cash during emergencies and for supporting children's education. Decisions were made over a decade ago when there were external pressures to cut the forest to find other ways to support their needs other than timber extraction and forfeiting their children's inheritance. The community sought greater security in resources by establishing agreements with neighbouring communities and a formal agreement with the government regarding their ancestral domain. Their affiliation with the land and importance given to cultural identity and language has strengthened their approach to area management.

Abaca

The Pulangiyen have cultivated abaca traditionally; the women dye and weave it into *kumuyut* (cloth). *Kumuyut* is culturally important as gifts for visitors and as tokens during conflict resolution. It is also entwined into rope. With the onset of commercialization, abaca as a basic fibre is now sold and has become a reliable source of cash for the community.

To strengthen the quality of existing wild abaca stocks, new corms have been brought from Agusan. The Pulangiyen plant abaca in semi-open canopy forest; this also protects it from mosaic disease that aphids bring from the maize. In 2004, as part of a land management strategy, the committees, in cooperation with the Apu Palamguwan Cultural Education Center, started to plant abaca. Quarterly maintenance of the area is carried out via weeding and cutting of dead leaves along with the maintenance of the spring box. Planting is becoming an annual activity and is extending the original area. Abaca fibres can be extracted within three to four years after planting. The current practice employs manual stripping although a mechanized stripping machine would be more efficient. However this has not been realized yet as it may overexploit the existing resource.

Bracken climax

The natural vegetation at 600 to 700 masl is submontane forest with a significant presence of upilon or salumayag (*Agathis philippensis*) lawaan (*Shorea* sp.) and dangulog (*Dipterocarpacea*). When this land is cleared and then eroded by intensive logging activities or intensive maize production by migrants, soil nutrients are depleted and agsam or bracken (*Pteridium* sp.) dominates the vegetation more than cogon grass (*Imperata cylindrica*) or boyo-boyo (*Piper arborecens*) found at lower elevations. The bracken grows to 3 metres in height and may burn during dry periods. With such thick growth it is very hard for other species such as labagti (*Macaranga* spp.) to compete. Bracken becomes the false climax, while the true Dipterocarp climax is lost.

Forest regeneration

Formerly, water to Bendum village was delivered by split bamboo conduits but with frequent sickness and interruption of supply a safer and more permanent source was identified. A spring box was built around an exposed source adjoining cultivated land and the water was piped to the community 0.75 kilometre away on the opposite slope. The area around the spring box – about half a hectare – has since been planted with giant bamboo (*Dendrocalamus asper*) and mahogany (*Swietenia macrophylla*), both non-native species to the area as well as *Shorea*; exposed soil is now no longer found. The committee clears the spring box, mainly of roots, every three months and is also responsible for distribution and maintenance of pipes and collection of a small fee.

Above the spring box the initial cutting of some abaca and clearing of bracken in a small area allowed the growth of labagti and other noted pioneer species. Under the emerging shade of this growth, after four years new abaca corms were planted in 2006. Every school year, students collect salumayag and lawaan seedlings from the forest and plant them in the area. The livelihood and water committees along with the younger generation now want to establish more permanent cover on a neighbouring area previously cleared for agriculture and left fallow. The initial one hectare is now being extended to approximately four hectares.

Meanwhile, the lower stream banks towards the village are maintained with natural vegetation of about one hectare. A further three hectares between the village and the water source is naturally regenerating and the original vegetation is creeping back, dominated by tree ferns (*Cyathea* sp.) and some self-seeding falcata (*Albizia falcataria*). The wet area has not been successfully managed as a fishpond and has been planted with a rush (*Fimbrystilis globulosa*) that is cut and woven into soft mats. The degraded old forest is being rehabilitated and the school has about half a hectare of recently replanted *lawaan*. Burning is prevented in the area due to general awareness of the disastrous results this wrought during the drought of 1997.

The regeneration efforts are patchy with different reasons for different areas but there is an awareness of assisting natural regeneration as a strategy of particular importance to the culture. In total 12 hectares under various forms of utilization assist natural regeneration. In this way basic resources, while being productive in terms of people's livelihoods, are self-sustaining – in this case through abaca growth and water security.

This regenerating corridor links the higher tangile-oak (*Shorea polysperma* and *Lithocarpus* sp.) and mossy forests with the village and is becoming a learning ground for the education center that uses the language and culture of the Pulangiyen to strengthen their identity and negotiation powers in the valley.

Charting partnerships and possibilities for upscaling assisted natural regeneration

Rowena Soriaga[1]

Getting humans to assist natural regeneration needs to happen 'naturally'. The forest will come back if the land is not perceived as government-owned, but as a locally managed resource. The activities will continue if they are viewed as part of the stakeholders' way of life and not belonging to a project, a government programme or an NGO.

One example of upscaling assisted natural regeneration (ANR) is the 'No-Fire Bonus' Scheme in Mountain Province, the Philippines. The scheme was a provincially funded initiative from 1996 to 1998 that tapped 'natural' motivations and relationships. The Community Environment and Natural Resources Office (CENRO) desperately wanted to address the intense fires after the 1993-1994 El Niño but did not have the funds. The *barangay* (village) governments had village development plans but did not have funds for implementation. The *dap-ay* (tribal council) had a cultural system to care for forests (including fire protection) but was concerned that the system was breaking down as the sense of ancestral domain and cultural cohesion faded away. The congressman had the Countryside Development Fund that was mainly used for infrastructure projects that contributed to their political visibility. Combining all of these factors, the scheme involved the congressman awarding a PHP100 000 infrastructure project to each *barangay* government that had not incurred any fire (or made efforts to suppress escaped fires). *Barangays* that obtained a 'certificate of no-fire occurrence' from CENRO based on fire monitoring reports could claim their award from the Department of Public Works and Highways. Some municipal governments helped the *barangays* to claim the awards by covering transaction costs. The governor promised to contribute funds to the scheme, but he was not able to deliver on his promise.

The incentive scheme successfully prevented fires in 97 percent of the 124 target *barangays*. A recent impact study found a declining trend in fire occurrence even after the scheme stopped. The scheme prompted speculative behaviour among communities – they continued fire protection in anticipation of another round. In the subsequent elections, the congressman won and the governor lost. Village infrastructure projects funded through the scheme are still operational and continue to be maintained by the communities. This scheme may be likened to payment for an environmental service. Partnerships and collaboration in society happen when people are clear about each other's motivations, i.e. what's in it for them.

Another example is an effort by an urban family that owns an abandoned fishpond in Batangas to revert the area back to mangrove forest. The family sees the mangrove

1. Asia Forest Network

planting effort as a way to get families and friends together. Monitoring happens 'naturally' as the family and their friends now have a reason to frequently visit the area.

Several ANR examples exist in Bohol of families who obtained Certificates of Stewardship contracts in the 1980s under the Integrated Social Forestry Program, of people's organizations who obtained Community-based Forest Management Agreements and of households who now depend on income not from farming but from overseas remittances.

Trust in the partnership is maintained when expectations of the collaborating parties are met. Previous reforestation projects of the Department of Environment and Natural Resources raised expectations among local people that they would become millionaires if they planted falcata, mangium and mahogany, only to find when the trees had grown that either they were not allowed to harvest them or the transaction costs were very high. It takes more effort to win back trust once broken, especially when broken many times.

If policies are tools for applying the carrot and stick approach to make things work in society, then Philippine forestry policies have more sticks than carrots. The continuous decline in forest cover indicates that this does not work. Moreover, policy-makers are presently weak at using the 'delete function' for outdated policies that provide more sticks than carrots.

The most viable way to upscale ANR is to allow space for diversity. This diversity should occur not just in the species allowed to regenerate on the land, but also in the people who are given the opportunity to benefit from the land. As yet, policies and programmes in the Philippines do not provide enough space for these diversities to occur and lead to synergy among different sectors of society and line agencies of the government. Payment for environmental services will have a better chance of getting off the ground when this synergy happens.

When talking about forest rehabilitation in many parts of Asia, water is a more practical and tangible entry point than carbon. Local governments know the strain when disasters strike as a result of extreme weather events. Under pressure to contribute to the Millennium Development Goals, their concern about delivery of basic services, including water, has increased. ANR as an approach to forest rehabilitation has a better chance of getting public attention if it is tied first to water issues. Expectations may be better managed if carbon is only introduced later on as an added value.

Who are the most viable partners to upscale ANR?

- Community-based organizations and small-scale farmers favour land diverse in species and adapt well to diverse sources of livelihoods. The Philippines has over 4 800 community-based forest management organizations and several more holders of certificates of ancestral domain claims/titles. Thailand has over 10 000 community forestry networks. Viet Nam has over 2 000 village forest communities. Cambodia has over 700 community forestry committees. The cost of getting them to assist natural regeneration depends not only on the strength of the organization but also on their level of trust in the institution selling the idea. The stronger the organization, the lesser the cost. The lesser the trust, the greater the cost. As the Vietnamese 5 Million Hectares Reforestation Programme case shows, villagers needed to believe that they would benefit not only in terms of labour employment, but also in terms of forest by-products.

- Owners of abandoned fishponds who seek psychological and social rewards from caring for the environment by restoring mangrove forests.
- Families who now rely on overseas remittances and do not have time for farming but need ways to make their land more productive without much labour involved.
- ‘Gentlemen farmers’ – retired people who want to reconnect with the land (e.g. those who bought shares in Leisure Farms in Batangas).

Where best to apply ANR?

- The Vietnamese experience and inputs from the commercial forestry sector indicate that the most viable and appropriate option is on lands allocated for protection and conservation forests where diversity is appreciated and trees are more valued when left standing (national parks, watershed areas).

Who are possible supporters to mainstream ANR?

- Local governments (mayors, governors, councillors, congressional representatives) who have access to development funds and can use them as incentives for communities and villages assisting natural regeneration, e.g. through fire protection and/or overcoming species hindering succession.
- Industries using forest by-products who are interested in having a stable supply of raw materials (e.g. handicraft industries, designers of native fashion accessories, abaca processors).
- Socially and environmentally responsible corporations who have tree planting projects or subscribe to adopt-a-watershed or adopt-a-mountain programmes.
- Local and national media that have historically featured socio-environmental stories in their environment, lifestyle or business sections.

Looking forward and looking further - regional and global perspectives for ANR application

Assisted natural regeneration: global opportunities and challenges

Patrick B. Durst and Marija Spirovska-Kono[1]

Ultimately, the future of the natural ecosystem depends not on protection from humans but on its relationship with the people who inhabit it or share the landscape with it. William R. Jordan III (founder of ecological restoration)

Introduction

Forests are increasingly recognized for the ecological services and economic opportunities they provide, as well as for their social and cultural values. More than ever before, forests are seen as being intricately linked with many of the world's most pressing global environmental and social concerns, such as climate change, loss of biodiversity, water issues and rural poverty.

Despite increased recognition and appreciation of forest values, deforestation rates remain high, estimated at 13 million hectares per year, according to the latest Global Forest Resource Assessment in 2005. In aggregate numbers, the Asia-Pacific region has recently registered a positive reversal of trends related to forest area, reflected by a three million hectare net gain in forest cover from 2000 to 2005. This apparent regional turnaround, however, is due primarily to the large reforestation achievements of the People's Republic of China and Viet Nam, which mask the otherwise rather disappointing performance of much of the rest of the region. Collectively, the other countries of Asia and the Pacific lost about 3.7 million hectares of natural forest during the same period (FAO 2006).

Rising concerns over forest loss and enhanced appreciation of forest values are giving new impetus to forest restoration and rehabilitation initiatives throughout the world. Although monocultures of exotic timber species continue to be favoured for commercial plantations, there is increased recognition of the need to integrate and complement commercial plantations with enhanced biodiversity conservation and landscape restoration (Shono *et al.* 2007; Chazdon, 2008). Reforestation efforts throughout the world are therefore increasingly focusing on restoring forests' ecological functions and providing the means for sustainable rural livelihoods.

Given the scale of reforestation and forest rehabilitation needs around the world, a range of low-cost approaches needs to be considered. Assisted natural regeneration

1. FAO Regional Office for Asia and the Pacific. Email: Patrick.Durst@fao.org; Marija.SpirovskaKono@fao.org

(ANR) is one such approach. As practised and promoted in the Philippines over the past 30 years on a limited scale, ANR emphasizes fire management, protection against destructive grazing, control of invasive grass species and assisting the growth of naturally occurring tree seedlings. Similar principles have been applied in various forms or in combination with other methods elsewhere in the world (Chazdon, 2008).

ANR has demonstrated promising results when applied at small scales, as in the case of pilot sites in the Philippines. For ANR to deliver substantial contributions toward global efforts in combating deforestation and enhancing environmental and social conditions, however, opportunities for replicating, up-scaling and mainstreaming ANR must be identified and promoted at many levels. Although local, site-specific conditions will inevitably be most critical in determining the success or failure of ANR approaches, it will be increasingly important to relate local forest rehabilitation efforts to pressing global concerns and the support mechanisms that are emerging to address these issues.

Global opportunities and challenges

Deforestation and forest degradation are undeniably interlinked with various problems extending far beyond the immediate sites where tree felling occurs. Clearing of large areas of forests and failing to substitute for the loss of their functions has led to devastating environmental, social and economic consequences, thus exacerbating some of the most pressing concerns of modern society.

Climate change is currently at the highest levels of the international environmental agenda. The recognition of the vital roles that forests play in the global carbon cycle has driven efforts to include forestry in various climate mitigation measures, including Reducing Emissions from Deforestation and Forest Degradation (REDD) and enhancing the role of forests as carbon sinks.

Forest ecosystems are estimated to contain about 80 percent of the world's above-ground terrestrial carbon and about 40 percent of below-ground carbon. At present, approximately 50 percent more carbon is stored in the world's forests than in the Earth's atmosphere (FAO 2006). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007) indicated that deforestation and forest degradation contribute about 20 percent of global greenhouse gas emissions. Approximately 90 percent of this is accounted for by the conversion and degradation of tropical forests.

Natural regeneration of forests, including ANR approaches, can play a significant role in mitigating climate change, especially by promoting growth of long-lived shrubs and tree species with dense wood and slow turnover of woody tissue (Chazdon 2008). Restoring degraded forests can increase carbon storage on land by 120 tonnes per hectare or more (DiNicola *et al.* 1998). A clear advantage of ANR is the steady accumulation of carbon, while simultaneously generating a wide range of other forest benefits and values.

Biodiversity loss is a second area of major global concern. Some estimates suggest that overall species extinction is now occurring at 1 000 times the historical rates indicated by fossils records (CBD 2006). Habitat destruction and fragmentation are clearly among the most important contributing factors.

The complexity involved in identifying and reporting on biological diversity loss remains challenging for many countries. However, available data indicate unsettling developments, beginning with the alarming loss of 6 million hectares of primary forest each year due to deforestation and as a result of modification of forests from logging and other disturbances. In responding to surveys conducted by the Global Forest Resources Assessment, countries have classified an average of 5 percent of the tree species native to their countries as 'vulnerable', 'endangered' or 'critically endangered' (FAO 2006). There is little doubt that the loss and major modification of forest ecosystems are taking a serious toll on species and terrestrial biodiversity.

By enhancing the regeneration of native vegetation already growing and adapted to local sites, ANR offers considerable potential for restoring some of the lost biodiversity values. From a biodiversity perspective, ANR offers strong biodiversity benefits relative to conventional single-species plantation forestry.

Although ANR is sometimes criticized for producing forests that are initially dominated by a few pioneer species (Shono *et al.* 2007), it is important to recognize that the secondary forest established through ANR can be further managed for specific objectives, according to available resources, including for promotion of increased species diversity. Enrichment planting is a commonly used method to augment basic ANR techniques.

Water resources and their relation to forests have long been shrouded in misunderstanding and misinformation, especially with regard to water availability and mitigation of macrolevel floods and droughts. The importance of forest cover in regulating hydrological flows has often been overestimated (FAO and CIFOR 2005; FAO 2008). However, at local levels, forest cover undeniably plays a crucial role in preventing or reducing local downstream flooding. More importantly, forest cover has significant influence on water quality and is therefore an essential element for maintaining the hydrological balance of watershed ecosystems.

Watershed management encompasses a complex set of measures and actions that are necessary to address the interlinked ecological and social processes occurring in water catchment areas. Forest restoration in degraded watersheds needs to consider the complexity of each site and work to provide long-term solutions for maintaining and restoring ecological services and people's livelihoods.

ANR offers great potential for restoring watershed functions because it places heavy emphasis on restoration of natural processes and steady improvement of soil productivity and water quality.

Sustainable livelihoods and the role of forests in contributing to the income and well-being of local people have gained global prominence in recent years as forest policy-makers broaden their expectations and demands on forests. Nevertheless, adequately addressing the rights and responsibilities of forest-dependent people remains a significant challenge.

The current economic crisis vividly demonstrates the interconnected nature of today's society. The collapse of the housing sector in many developed countries has greatly reduced demand for wood products. The reduced ability and willingness of buyers to pay has negatively affected the demand for environmental services. Markets for carbon and environmental services have witnessed a plunge in prices and demand similar to other commodities. Forestry jobs have been slashed and investment in the forestry sector has declined dramatically.

At the same time, the crisis has opened new opportunities for 'greener' paths of development, with some countries (e.g. Japan, the United States of America, the Republic of Korea) including forestry-related measures in their economic stimulus programmes. Incentives and opportunities for forest communities to engage in sustainable forest management will hopefully be a lasting legacy of the 'green development' approaches emerging from the current economic crisis.

Local communities are at the core of successful ANR application. Initial experience with ANR in the Philippines demonstrated a wide variety of ways for effectively involving and empowering local people. However, up-scaling of ANR requires the identification of additional innovative approaches for up-scaling and strengthening community involvement (Table 1).

Table 1. Incentives for community involvement in ANR activities

Examples of observed incentives	Possible incentives for future ANR up-scaling
Contributing to local pride and sense of accomplishment	Strengthening the security of land and resource tenure
Fire management (demonstrating zero fire occurrence on formerly fire-prone sites and witnessing resulting regrowth of vegetation)	Zero-fire cash bonuses
Income opportunities through salaries for ANR work	Payment for environmental services (PES), including carbon financing
Approval to grow cash crops and trees producing non-wood forest products (NWFPs) in fire breaks	Improved market access for cash crops and NWFPs

Land and resource tenure are the central issues for ensuring local commitment to sustainable land management beyond the duration of finite projects. Policies need to be developed or revised accordingly, to provide a secure sense of ownership of restored forest areas and ensure sustainable long-term resource management.

Secure land and resource tenure is a necessary prerequisite for local communities to access innovative new sources of financing such as PES and emerging carbon markets (Leimona *et al.* 2009). However, many other elements also need to be addressed before communities practising ANR will be able to fully tap the potential of PES and carbon-trading schemes. Among the priorities is generating more detailed documentation of the long-term impacts of ANR practices *vis-à-vis* local biodiversity, water quality and carbon sequestration. To advance this agenda, there is a strong need for developing simple, practical and low-cost community-based monitoring tools.

Experience from the Philippines demonstrates that there are various private companies seriously committed to offsetting their negative environmental impacts by supporting forest rehabilitation and restoration. Social corporate responsibility is becoming increasingly important for many companies. At the same time, many governments in the region are also developing schemes for remunerating communities for providing various environmental services. These developments offer potential for attracting greater support for ANR activities from both the private and public sectors in the future.

ANR's niche in restoring degraded lands

Given the scale of reforestation and forest rehabilitation needs around the world, it is necessary to consider all available opportunities and approaches for addressing the challenges. The costs are daunting. Conventional reforestation can easily cost US$1 000 per hectare, suggesting a hefty bill of up to US$13 billion per year just to offset current forest losses, using conventional plantation reforestation methods (Dugan 2009).

Plantations currently comprise about 4 percent of the total global forest area, with a steady expansion of about 2.8 million hectares per year globally, much of it in Asia (FAO 2006). Data on the areas where forests are regenerated naturally are far less certain, but many of the more successful techniques are evident. These include 'mountain closure' in China, the inclusion of natural regeneration as a key element of the Five Million Hectare Reforestation Program in Viet Nam, natural regeneration in community forests in Nepal and ANR in the Philippines. There are also important opportunities to rehabilitate lands using agroforestry, farm forestry and other approaches.

It is not appropriate to blindly advocate one approach over others, but rather to carefully assess the costs and benefits of different options against desired objectives and local conditions.

The case of grasslands dominated by *Imperata cylindrica* is a particular challenge for much of the Asia-Pacific region. Sheet *Imperata* (meaning very large expanses of *Imperata*-dominated grasslands) covers 35 million hectares across the region – an area larger than all of the Philippines. When other areas where *Imperata* is mixed with various low-productivity species are included, the total affected area exceeds 57 million hectares (Table 2). Due to frequent and repeated burning and progressive degradation, these areas are generally unproductive, harbour relatively little biological diversity and offer few opportunities for local livelihoods.

Table 2. Estimates for Imperata areas in Asia

Country	Area (million ha)
Indonesia	13.5
India	12.0
Philippines	6.0
Viet Nam	5.0
South China	5.0
Thailand	4.0
Myanmar	3.0
Lao PDR	2.0
Sri Lanka	2.0
Malaysia	0.5
Cambodia	0.3
TOTAL	**57.2**

Source: Garrity *et al*. (1997).

The scale of the *Imperata*-dominated areas represents both a challenge and an opportunity for forest restoration. ANR – as practised in the Philippines – has developed specific approaches for rehabilitating *Imperata* areas (especially with respect to fire management and control); they offer excellent potential for application in other countries with large areas of *Imperata*.

Conclusions

Despite ongoing and intensified efforts to restore forests, ecosystem services and biodiversity throughout the world, a massive area of degraded land and forests remains, particularly in the tropics. Policy-makers – even when they are sympathetic to the problems – are generally constrained by a lack of funding and resources to fulfil ambitious forest restoration goals.

Restoration of degraded lands and forests is evolving to increasingly consider the complex ecological, economic and social values of each locale. Different approaches are being applied with varying degrees of success around the world, but an unbalanced emphasis on single-species plantation development in many areas remains.

It is therefore important to strengthen awareness-raising efforts to highlight the potential of simple, low-cost alternatives for forest restoration, such as ANR. At the same time, it is critically important to identify conditions and factors necessary for successful application of ANR, and to be realistic about the expectations and potential for ANR to meet management objectives. The costs and benefits of various forest restoration methods must be assessed in more detail to help policy-makers in identifying the most effective methods for achieving desired objectives.

Detailed documentation of the effects on local biodiversity, water quality and carbon storage capacities is also required if ANR is to seize emerging opportunities for capturing innovative new financing through carbon markets and PES.

Forest restoration is a long and complex process, which needs to take into account a wide array of environmental, economic and social factors. ANR offers practical options for complementing large-scale conventional reforestation efforts and provides effective low-cost solutions for increasing the social values of formerly degraded areas.

Literature cited

Chazdon, R. 2008. Beyond deforestation: restoring forests and ecosystem services on degraded lands. *Science*, 320(5882): 1458-1460.

Convention on Biological Diversity (CBD). 2006. *Global biodiversity outlook 2*. Montreal, Canada, Secretariat of the Convention on Biological Diversity. 81 pp.

DiNicola, A., Jones, D.J. & Gray, G. 1998. *Carbon dioxide offset investment in the Asia-Pacific forestry sector: opportunities and constraints.* RAP Publication 1998/9. Bangkok, Thailand, FAO. 48 pp.

Dugan, P. 2009. *Cost comparison analysis: ANR versus conventional reforestation.* Paper presented at the Regional Workshop on Advancing Application of Assisted Natural Regeneration for Effective Low-cost Forest Restoration, Bohol, Philippines, 19-22 May 2009.

Food and Agriculture Organization of the United Nations (FAO). 2008. *Forests and water.* FAO Forestry Paper 155. Rome, Italy, FAO.

FAO. 2006. *Global forest resources assessment 2005*. FAO Forestry Paper 147. Rome, Italy, FAO.

FAO & Centre for International Forestry Research (CIFOR). 2005. *Forests and floods: drowning in fiction or thriving on facts?* RAP Publication 2005/03. Bangkok, Thailand, FAO. 30 pp.

Garrity, D.P., Soekardi, M., van Noordwijk, M., de la Cruz, R., Pathak, P.S., Gunasena, H.P., Van So, M.N., Huijun, G. & Majid, N.M. 1997. The *Imperata* grasslands of tropical Asia: area, distribution and typology. *Agroforestry Systems*, 36: 3-29.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Fourth assessment report climate change 2007*. Geneva, Switzerland, IPCC.

Leimona, B., Joshi, L. & van Noordwijk, M. 2009. Can rewards for environmental services benefit the poor? Lessons from Asia. *International Journal of the Commons,* 3(1): 82-107.

Shono, K., Cadaweng, E. & Durst, P. 2007. Application of assisted natural regeneration to restore degraded tropical forestlands. *Restoration Ecology,* 15(4): 620-626.

Capturing the value of forest carbon: C sequestration through ANR practices

Rodel D. Lasco[1]

Introduction

The last century has witnessed massive deforestation in the tropics and the Philippines has been no exception. When the Spanish colonizers first set foot in the Philippines in 1521, 90 percent of the country was covered with lush tropical rain forest (approximately 27 million hectares out of 30 million hectares of total land area). By 1900, there was still 70 percent or 21 million hectares of forest cover (Garrity *et al.* 1993; Liu *et al.* 1993). However, by 1996 there were only 6.1 million hectares (20 percent) of forest remaining (FMB 1997). Thus, in the last century alone, the Philippines lost 14.9 million hectares of tropical forests or an average of about 150 000 hectares/year (Table 1).

Table 1. Deforestation rates in the Philippines in the twentieth century

Period	Years	Forest loss (ha)	Rate (ha/yr)
1900-1934	35	4 000 000	114 286
1935-1988	54	9 700 000	179 630
1989-1996	8	1 200 000	150 000
Mean			147 972

Source: Forest loss data adapted from various Forest Management Bureau (FMB) statistics.

Reforestation work in the Philippines started during the first decade of the twentieth century. A recent review of reforestation in the Philippines showed that the reforestation rate significantly lagged behind the deforestation rate (Carandang *et al.* 2004). From 1960 to 2002, the annual average area planted was about 41 000 hectares per year, which is less than 50 percent of the annual deforestation rate for the same period. More importantly, the actual success rate of the reforestation effort could be less than 30 percent in many cases. Official statistics report the area planted for the year but do not track what portion still exists. This is validated by the fact that available maps do not show where the reforested areas are.

The cost of reforestation is not cheap. Between 1988 and 1992 the Asian Development Bank (ADB), the World Bank and the Japanese Government lent US$731 million for forestry projects in the Philippines (Korten 1995). With such a low rate of success, much of these funds have been wasted. In future, reforestation of the country’s 8.4 million hectares of denuded forests could cost the government some PHP361 billion (US$6.6 billion).

1. World Agroforestry Centre (ICRAF), Philippines. Email: rlasco@cgiar.org

There have been attempts to find more cost-effective alternatives to conventional reforestation approaches, one of which is assisted natural regeneration (ANR). ANR is a flexible approach to reforestation that uses natural regeneration of forest trees (wildlings or natural seedlings, and sprouts). It 'assists' natural regeneration by preventing fire, 'pressing' *Imperata*, helping trees to grow faster and planting additional trees when needed (Friday *et al.* 1999). By the end of 1995, about 2 500 hectares of ANR areas had been developed, mostly in the Bicol region (FMB 1996).

Experience in the Philippines has shown that if grassland areas are protected from fires and other disturbances, they can regenerate back to tropical forest. ANR seeks to hasten the process of succession by protecting the area from disturbance and by planting additional trees. The success of ANR largely depends on how well the community is able to protect the growing seedlings from fires and other damaging agents (such as grazing). Firebreaks may also need to be constructed. After fire prevention, suppressing cogon and other weeds is the most important activity in ANR. This is done through 'pressing'. The grass is pressed low to the ground by trampling or by rolling a weight over it. Pressing bends the base of the cogon culm (stem) in the same way as folding a plastic water hose. The weight of the grass helps to keep it bent down and grass in the lower layers dies.

More recently, there has been a rising interest in the role of forest ecosystems to mitigate climate change through carbon (C) sequestration. A number of studies have explored the potential of forest lands in the Philippines to store and sequester carbon, including accessing the rising carbon market (Lasco *et al.* 2008; Lasco *et al.* 2007; Villamor and Lasco 2006).

This paper has two main sections. The first presents key findings of the Intergovernmental Panel on Climate Change (IPCC) report on the role of forestry in mitigating climate change. The second presents research results on carbon sequestration through reforestation activities in the Philippines.

The mitigation potential of reforestation and forest regeneration

Deforestation, degradation and poor forest management reduce carbon storage in forests, but sustainable forest management, planting and rehabilitation can increase carbon sequestration (FAO 2006). It is estimated that the world's forests store 283 Gigatonnes (Gt) of carbon in their biomass alone. The carbon stored in forest biomass, deadwood, litter and soil together, is about 50 percent more than the amount of carbon in the atmosphere.

The tropical region has the greatest potential for climate change mitigation through its beneficial forestry activities. It is difficult to quantify the total potential of the world's tropical forest to mitigate climate change. According to the IPCC's Fourth Assessment Report, available studies about mitigation options differ widely in basic assumptions on carbon accounting, costs, land areas, baselines and other major parameters (Nabuurs *et al.* 2007). There is still a need for more detailed estimates of economic or market potential for mitigation options by region or country in order for policy-makers to make realistic estimates of mitigation potential under various eligibility-rule scenarios for policy, carbon price and mitigation programmes. Initial studies indicate that the largest potential is in avoiding deforestation and enhancing afforestation and reforestation (A/R), including bioenergy.

In spite of the different approaches and methods, recent studies estimate that future deforestation will remain high in the tropics. For example, Sathaye *et al.* (2007) estimated that deforestation rates will continue in all regions. Africa and South America have high rates of loss, cumulatively about 600 million hectares by 2050. Thus, reducing deforestation is a high-priority mitigation option within the tropical region. In addition to the significant carbon gains, substantive environmental and other benefits could be obtained from this option. To counteract the loss of tropical forests, successful implementation of mitigation activities requires understanding of the underlying and direct causes of deforestation, which are multiple and locally based (Chomitz *et al.* 2006).

In the short term (2008-2012), it is estimated that 93 percent of the total mitigation potential in the tropics will be through avoided deforestation (Jung 2005). In the long term, it is estimated that US$27.2/t$CO_2$ is needed to virtually eliminate potential deforestation (Sohngen and Sedjo 2006). Over 50 years, this could mean a net cumulative gain of 278 000 MtCO_2 relative to the baseline and 422 million hectares of additional forests. The largest gains in carbon would occur in Southeast Asia, which gains nearly 109 000 MtCO_2 for US$27.2/t$CO_2$, followed by South America, Africa and Central America, which would gain 80 000, 70 000 and 22 000 MtCO_2 for US$27.2/t$CO_2$, respectively (Figure 1).[2]

Next to avoided deforestation, establishment of new forests through reforestation and afforestation offers the second largest potential to mitigate climate change through enhanced carbon sequestration. The assumed land availability for afforestation options depends on the price of carbon and how it competes with existing or other land-use financial returns, barriers to changing land uses, land tenure patterns and legal status, commodity price support and other social and policy factors.

2. tCO2 = tonnes of carbon dioxide. MtCO2 = Mega (or million) tons of carbon dioxide.

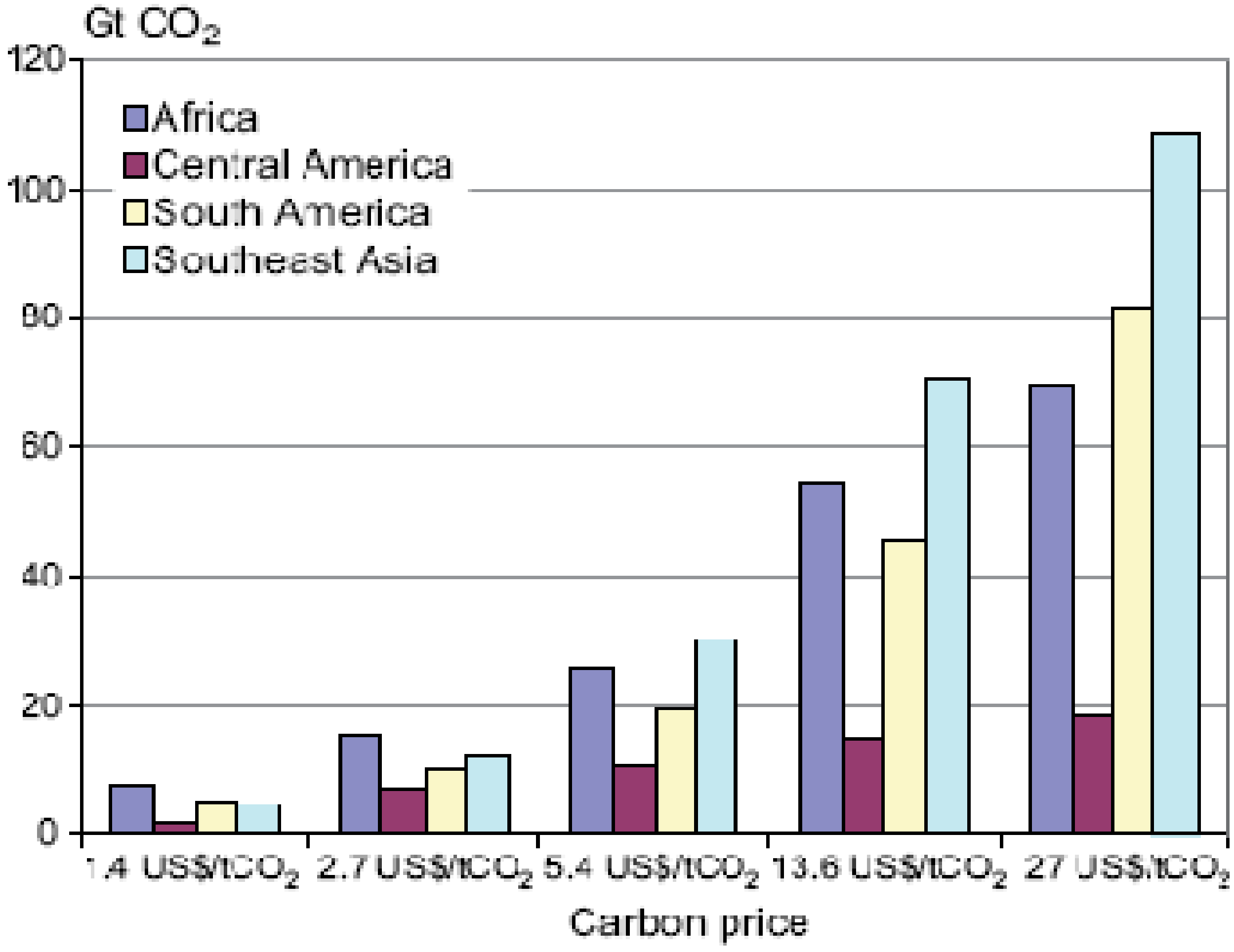


Figure 1. Cumulative carbon gained through avoided deforestation by 2055 over the reference case by tropical regions under various carbon price scenarios.
Source: Sohngen and Sedjo (2006) from Nabuurs *et al.* 2007

Cost estimates for carbon sequestration projects for different regions vary widely. For forestry projects in developing countries, the cost ranges from US$0.5 to US$7/tCO_2, compared to US$1.4 to US$22/tCO_2 for forestry projects in industrialized countries (Cacho *et al.* 2003; Richards and Stokes 2004). In the short term (2008-2012), an estimate of economic potential area available for afforestation/reforestation under the Clean Development Mechanism (CDM) would be 5.3 million hectares, an aggregate total in Africa, Asia and Latin America, with Asia accounting for 4.4 million hectares (Waterloo *et al.* 2003).

In total, the cumulative carbon mitigation benefits by 2050 for a scenario of US$2.7/t$CO_2$ plus a 5 percent annual carbon price increment for one model are estimated to be 91 400 MtCO_2; where 59 percent comes from avoided deforestation (Figure 2). From 2000 to 2050, avoided deforestation dominates in South America and Asia, accounting for 49 percent and 21 percent, respectively, of the total mitigation potential. When afforestation is considered, Asia predominates.

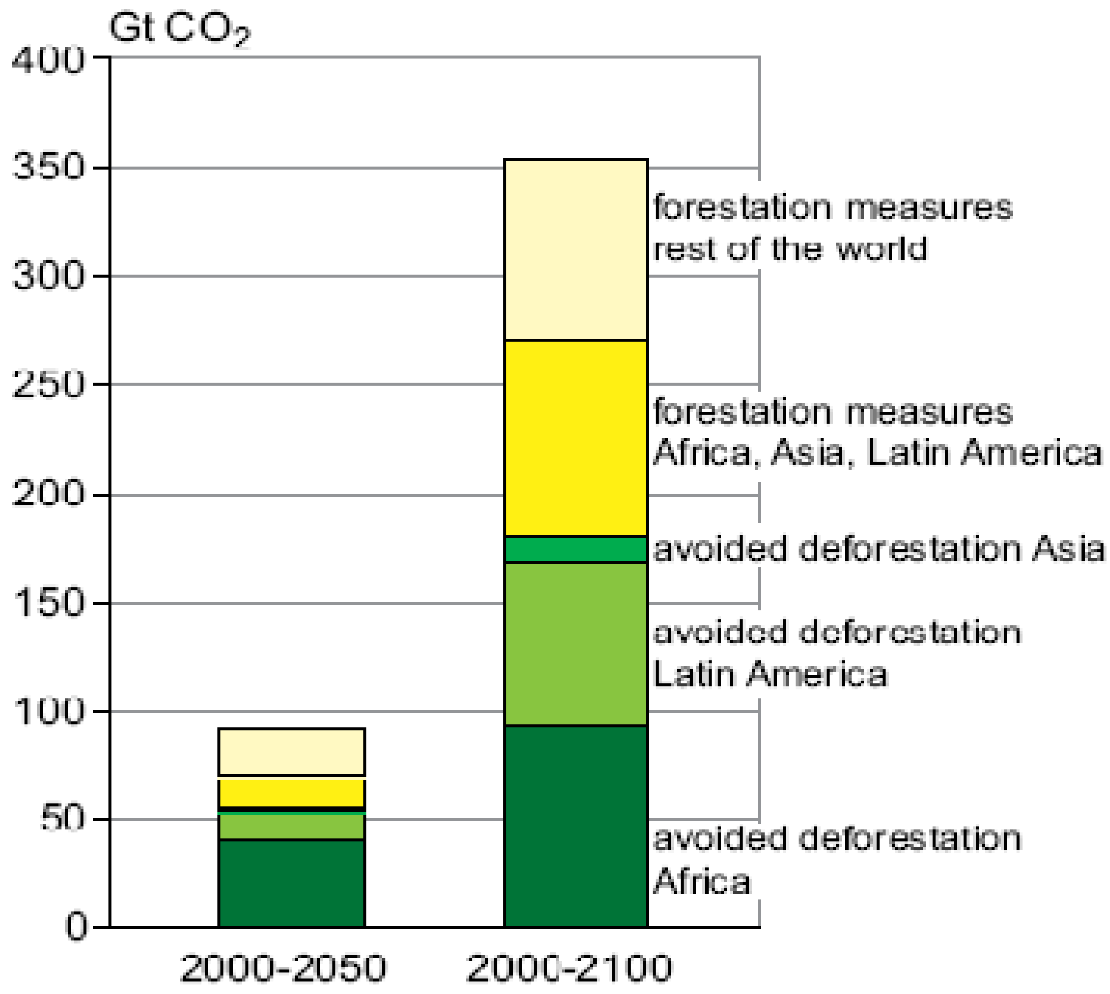


Figure 2. Cumulative mitigation potential (2000-2050 and 2000-2100) according to mitigation options under the US$2.7/t$CO_2$ +5 percent/year annual carbon price increment.

Source: Sathaye *et al.* (2007) from Nabuurs *et al.* (2007)

The IPCC 2007 report did not include the specific mitigation potential of ANR that can fall under two categories depending on the initial forest cover. If the initial tree crown cover is below the threshold forest definition (from 10 to 30 percent minimum crown cover), then ANR is a reforestation activity. However, if the initial crown cover is more than the minimum, then it becomes a forest management (regeneration) activity.

According to the IPCC special report on land-use change and forestry (IPCC 2000), forest regeneration includes activities such as changing tree density through 'human-assisted natural regeneration'; enrichment planting; reduced grazing of savannah woodlands; and better matching of tree provenances, genetic strains, or species to soils and sites. Human-assisted natural regeneration is the establishment of a forest age class from natural seeding or sprouting after activities such as selection cutting, shelter (or seed-tree) harvest, soil preparation, or restricting the size of a clear-felling stand to secure natural regeneration from surrounding trees.

Forest regeneration influences on-site carbon stocks by accelerating the return of a growing forest after harvest, altering growth rates of above- and below-ground tree biomass through better species selection and changing the potential mix of final wood products. The accumulation time of above- and below-ground biomass ranges from 5 years (for the shortest rotation times in tropical plantations) to 150 years or more in low-potential sites in boreal forests. The tree biomass carbon accumulation process is not difficult to quantify and predict where well-developed forest growth and yield models are available. However, only a few studies exist on the relationship between forest regeneration and carbon sequestration.

Potential carbon sequestration of ANR

The rapid loss of forests in many Southeast Asian countries has left millions of hectares of denuded and degraded land. In the Philippines, at least 2 million hectares of former forested lands are now grasslands. Deforested lands have much lower carbon stocks than the forests they replace. In response, countries in the region have launched massive reforestation programmes. There are very limited data in the literature on carbon sequestration rates of reforestation species in Southeast Asia. However, there is much literature on the growth performance of species planted in reforestation areas. Typically, diameter at breast height (dbh) and height are the main variables measured and reported. Through the use of allometric equations, primarily from the FAO handbook by Brown (1997), we attempted to estimate biomass and carbon stocks and their rate of accumulation based on data from existing literature. Selected results are presented below. Actual carbon sequestration rates for ANR projects may not be too far from those in reforestation projects.

In the Philippines, a reforestation project in highly degraded soil conditions using fast-growing exotic species has carbon stocks of 3.5-48.5 MgC/hectare six to 13 years after planting (Table 2). On the other hand, the rate of carbon sequestration was 0.3-3.7 MgC/hectare/year (as measured by mean annual increment [MAI]). These values are very low compared to other Philippine tree plantations because of the poor site conditions in the area that is predominantly covered with *Imperata* and *Sacharum* spp. grasses (Sakurai *et al.* 1994).

Table 2. Biomass/carbon density and MAI in Nueva Ecija, Philippines

Species	Age (yr)	Ave dbh (cm)	Biomass Mg/ha	MAI Mg/ha/yr	C density MgC/ha	MAI MgC/ha/yr
Acacia auriculiformis 1	6	5.68	7.4	1.2	3.3	0.6
A. auriculiformis 2	6	6.46	10.0	1.7	4.5	0.8
A. auriculiformis 3	9	9.62	42.5	4.7	19.1	2.1
A. auriculiformis 4	9	8.71	32.0	3.6	14.4	1.6
A. auriculiformis 5	9	10.47	46.1	5.1	20.8	2.3
A. auriculiformis 6	9	8.73	39.7	4.4	17.9	2.0
Tectona grandis 1	13	5.50	8.7	0.7	3.9	0.3
T. grandis 2	13	7.36	22.3	1.7	10.0	0.8
Gmelina arborea 1	6	7.33	17.2	2.9	7.8	1.3
G. arborea 2	6	6.80	7.7	1.3	3.5	0.6
Pinus kesiya	13	12.53	107.8	8.3	48.5	3.7
P. kesiya + broadleaf spp.	13	10.10	83.2	6.4	37.5	2.9

Note: Age and dbh data from Sakurai *et al*. (1994); biomass computed using the equation Biomass/tree in kg= 21.297-6.953*dbh+0.74dbh^2 for broadleaf species and Biomass/tree = EXP-1.17+ 2.119*LN(dbh) for conifers (from Brown 1997); %C in biomass = 45 percent (based on Lasco and Pulhin 2000).

In another part of the Philippines with similar vegetative cover but higher rainfall, carbon MAI was 6.4-7.9 MgC/hectare (Table 3). The carbon sequestration in this site was higher than the previous site most likely because of the more abundant rainwater supply. This study is also unique in that the biomass was determined directly by destructive sampling (Buante 1997). In the same island, three fast-growing species have a carbon density and MAI of 8-88 MgC/hectare and 0.7-8.0 MgC/hectare/year, respectively (Table 4).

Table 3. Biomass/carbon density and MAI in Leyte, Philippines

Species	Biomass Mg/ha	MAI biomass Mg/ha/yr	C density MgC/ha	C MAI MgC/ha/yr
Acacia mangium	56.9	14.2	25.6	6.4
Gmelina arborea	70.2	17.6	31.6	7.9
A. auriculiformis	64.0	15.9	28.6	7.1

Note: Biomass data from Buante (1997); %C in biomass assumed to be 45 percent. Tree age = 4 years.

Table 4. Carbon density and MAI of reforestation species in Leyte, Philippines (Lasco *et al.* 1999)

Species	Biomass Mg/ha	MAI biomass Mg/ha/yr	C density MgC/ha	C MAI MgC/ha/yr
S. macrophylla				
1	22.6	2.1	10.2	0.9
2	19.9	1.8	9.0	0.8
3	8.5	0.8	3.8	0.4
Mean	***17.0***	***1.6***	***7.7***	***0.7***
A. mangium				
1	220.9	20.1	99.4	9.0
2	162.9	14.8	73.3	6.7
3	203.6	18.5	91.6	8.3
Mean	***195.8***	***17.8***	***88.1***	***8.0***
G. arborea				
1	165.1	10.3	74.3	4.6
2	117.0	7.3	52.7	3.3
3	89.9	5.6	40.5	2.5
Mean	***124.0***	***7.8***	***55.8***	***3.5***

Planting trials of species not commonly growing in the Philippines but with potential for reforestation were conducted in Iloilo Province with similar grass cover as the above sites (Lachica-Lustica 1997). After four years, carbon density ranged from 0.30-70.11 MgC/hectare, while carbon MAI was generally less than 10 MgC/hectare/year (Table 5). In contrast, adjacent grassland area has only 1.68 MgC/hectare.

Table 5. Biomass/carbon density and MAI in Iloilo Province, Philippines

Species	Mean dbhcm	Biomass Mg/ha	MAI biomass Mg/ha/yr	C density MgC/ha	C MAI MgC/ha/yr
Acacia neriifolia	17.5	87.1	21.8	39.2	9.8
A. holosericea	11.9	34.4	8.6	15.58	3.9
A. crassicarpa	18.9	155.8	39.0	70.1	17.5
A. aulacocarpa	13.0	56.4	14.1	25.4	6.3
Leucaena diversifolia	3.3	0.7	0.2	0.3	0.1
Casuarina cuminghiana	3.8	3.2	0.8	1.4	0.4
C. equisitifolia	7.8	15.6	3.9	7.0	1.8
Eucalyptus citrodora	12.1	52.4	13.1	23.6	5.9
E. cloeziana	11.6	48.3	12.1	21.7	5.4
E. pellita	10.4	34.0	8.5	15.3	3.8
E. tereticornis	11.8	49.9	12.5	22.4	5.6

Note: dbh data from Lachica-Lustica (1997); tree age = 4 years; biomass computed using the equation Biomass/tree in kg = 21.297-6.953*dbh+0.74dbh^2 for broadleaf species and for conifers Biomass/tree = EXP-1.17+ 2.119*LN(dbh) (from Brown 1997); %C in biomass = 45 percent (based on Lasco and Pulhin 2000).

In terms of long-term carbon stocks after reforestation, mahogany and dipterocarp trees planted about 80 years ago are estimated to contain 126-286 MgC/hectare with an MAI of 1.6-3.6 MgC/hectare/year (Table 6). These densities and MAI are lower than the above results because mahogany and dipterocarp trees are relatively slow growing.

Table 6. Carbon density and MAI of reforestation areas 80 years after planting in Mt. Makiling, Philippines

Species	Age (yrs)	Tree/ ha	Biomass (Mg/ha)	MAI (Mg/ha/yr)	C density Mg/ha	MAI Mg/ha/yr
Swietenia macrophylla 1	80	802	565	7.1	254	3.2
Swietenia macrophylla 2	80	405	635	8.0	286	3.6
Parashorea malaanonan + *Anisoptera thurifera*	80	569	536	6.7	241	3.0
Parashorea malaanonan + *Dipterocarpus grandiflorus*	80	701	279	3.5	126	1.6

Note: Age and dbh data from Sakurai *et al*. (1994); biomass computed using the equation Biomass/tree in kg = EXP{-2.134+(2.53*LNdbh)} (from Brown 1997); %C in biomass = 45 percent (based on Lasco and Pulhin 2000).

Silvicultural treatments, such as fertilization, weeding and mycorrhizal inoculation, increase the growth of trees and thus enhance the rate of carbon sequestration.
In degraded areas in Surigao del Sur, Philippines, the inoculation of mycorrhizae increased carbon density by 32 to 237 percent compared to uninoculated treatments (Table 7). In another area of the country, mycorrhizal inoculation increased carbon density and MAI by 43 to 169 percent (Table 8).

Table 7. Effects of mycorrhizal inoculation on carbon density and MAI of tree plantations in Surigao del Sur, Philippines

Species/Treatment	Age (yr)	Diameter cm	Biomass Mg/ha	MAI Biomass	C density	C MAI
Pinus caribaea						
Uninoc	2	6.11	15.97	7.98	7.18	3.59
Inoc	2	9.17	37.74	18.87	16.98	8.49
% difference				136		
Eucalyptus deglupta						
Uninoc	2	4.15	5.76	2.88	2.59	1.30
Inoc	2	6.3	7.63	3.81	3.43	1.72
% difference				32		
Eucalyptus deglupta						
Uninoc	3	9.435	23.96	7.99	10.78	3.59
Inoc	3	14.26	80.69	26.90	36.31	12.10
% difference				237		

Note: Diameter data from dela Cruz (1999); no. of trees = 1 111/hectare. Allometric equation for *P. caribaea*: Y (kg) = exp{-1.170+2.119*ln(D)} range 2-52 cm; for *E. deglupta*: Y (kg)= EXP{-2.134+(2.53*LNdbh)} (from Brown 1997)

Table 8. Effect of mycorrhizal inoculation on carbon density and MAI of tree plantations in Tarlac, Philippines

Species/treatment	Age (yr)	Diameter cm	Biomass Mg/ha	MAI Mg/ha/yr	C density (MgC/ha)	MAI C MgC/ha/yr
Acacia auriculiformis						
Uninoc	2	6	6.91	3.45	3.11	1.55
Inoc	2	7	9.87	4.94	4.44	2.22
% difference			43			
Casuarina equisitifolia						
Uninoc	2	2.7	2.83	1.41	1.27	0.64
Inoc	2	4.3	7.58	3.79	3.41	1.71
% difference			169			

Note: Allometric equation for C. equisitifolia: Y (kg) = exp{-1.170+2.119*ln(D)} range 2-52 cm; adj r2=0.98 (from Brown 1997). Allometric equation for A. auriculiformis: Y (kg) = 21.297-6.953(D)+0.740(D2) range 4-112 cm; adj r2=0.92 (from Brown 1997).

In Indonesia, a reforestation project in Sumatra produced carbon stocks of 39-76 MgC/hectare/year and a carbon sequestration rate of 4.9-6.9 MgC/hectare/year (Table 9). On the other hand, a reforestation project in Bogor produced a carbon density and MAI of 162-256 MgC/hectare/year and 3.6-8.0 MgC/hectare/year (Table 10). This carbon density is much higher than the site in Sumatra because the former is much older. However, the rate of carbon accumulation is comparable.

Table 9. Carbon density and MAI of reforestation species in Sumatra, Indonesia

Species	Age (yr)	Tree/ha	Biomass Mg/ha	MAI Mg/ha/yr	C density MgC/ha	MAI MgC/ha/yr
Swietenia macrophylla	11	940	169.24	15.39	76.16	6.92
Acacia mangium	11	912	157.34	14.30	70.80	6.44
Peronema canescens	8	1 016	87.49	10.94	39.37	4.92

Note: Age, dbh and tree/ha data from Sakurai *et al*. (1995). Allometric equation used to estimate biomass: Biomass per tree (kg)= EXP{-2.134+(2.53*LN(dbh)} (from Brown 1997).

Table 10.C density and MAI of reforestation species in Bogor, Indonesia

Species	Age (yr)	Tree/ha	Biomass Mg/ha	MAI Mg/ha/yr	C density MgC/ha	MAI MgC/ha/yr
Swietenia macrophylla	45	666	359.02	7.98	161.56	3.59
Dipterocarpus retusus	33	428	413.69	12.54	186.16	5.64
Shorea selanica	32	244	567.83	17.74	255.52	7.99

Note: Age, dbh and tree/ha data from Sakurai *et al*. (1995). Allometric equation used to estimate biomass: Biomass per tree (kg) = EXP{-2.134+(2.53*LN(dbh)} (from Brown 1997).

In Malaysia, afforestation projects have been conducted in two degraded soils: BRIS (162 000 hectares) and tin tailings (113 000 hectares) (Amir *et al*. 1994). Beach ridges interspersed with swales (BRIS) soils form an almost continuous belt in the east coast of peninsular Malaysia. Tin tailing soil is a waste product of tin mining. Soil composition is mainly sandy, with low nutrient status, inferior water and nutrient-holding capacity and poor structure. Growth rates are expected to be lower under such soils. Results of afforestation trials showed that most species accumulate less than 5 MgC/hectare/year while carbon density ranged from 7-261 MgC/hectare depending on the species and age (Table 11).

Table 11. Estimated above-ground biomass of afforestation sites in Malaysia

Species	Stand age	MAI dbhcm	dbh cm	Biomass Mg/ha	C density MgC/ha	Biomass MAI Mg/ha/yr	C MAI MgC/ha/ yr
Tin tailings							
1. Sandy							
Acacia aulocarpa	27	0.85	22.95	100.6	45.3	3.8	1.7
A. auriculiformis	32	0.78	24.96	123.5	55.6	3.9	1.7
A. mangium	4	2.87	11.48	15.6	7.0	3.9	1.8
Pinus caribaea	26	0.76	19.76	69.1	31.1	2.7	1.2
P. elliotii	33	0.59	19.47	67.0	30.2	2.0	0.9
Casuarina equisitifolia	30	0.78	23.4	98.9	44.5	3.3	1.5
2. Sandy slime							
A. auriculiformis	30	1.24	37.2	314.7	141.6	10.5	4.7
A. richii	28	1.02	28.56	170.5	76.7	6.1	2.7
P. merkusii	32	0.87	27.84	143.0	64.3	4.5	2.0
P. caribaea	30	1.22	36.6	255.2	114.9	8.5	3.8
3. Slime							
A. auriculiformis	32	0.99	31.68	217.5	97.9	6.8	3.1
Paraserianthes falcataria	30	1.63	48.9	580.3	261.1	19.3	8.7
Fagraea fragrans	30	0.47	14.1	28.2	12.7	0.9	0.4
BRIS soils							
A. mangium	8	2.6	20.8	78.7	35.4	9.8	4.4
Hopea odorata	6.5	0.72	4.68	2.0	0.9	0.3	0.1
Araucaria cunninghamii	29	0.65	18.85	62.6	28.2	2.2	1.0
P. caribaea	30	0.92	27.6	140.4	63.2	4.7	2.1
P. merkusii	24	0.92	22.08	87.5	39.4	3.6	1.6
P. oocarpa	24	0.91	21.84	85.5	38.5	3.6	1.6
C. equisitifolia	8	2.74	21.92	86.1	38.8	10.8	4.9

Note: Age and dbh MAI data from Amir *et al*. (1994). Spacing assumed to be 5x5 m (400 trees/ha). Biomass C content = 45 percent. Allometric equation used to estimate biomass: Biomass per tree (kg) = EXP{-2.134+(2.53*LN(dbh)} (from Brown 1997).

Potential of ANR to generate carbon credits

The Clean Development Mechanism (CDM)

The Kyoto Protocol sets emission limits for six greenhouse gases (GHGs) for developed nations, mostly industrialized countries and economies in transition, known as ‘Annex 1’ or ‘Annex B’ countries. These countries committed to collectively reduce GHG emissions by at least 5 percent relative to their 1990 emissions. To enter into force, 55 countries were required to ratify the Protocol, including at least 55 percent of emissions of Annex 1 Parties for 1990. On the ninetieth day after the ratification by the Russian

Federation, the Kyoto Protocol entered into force on 16 February 2005. The Philippines ratified the protocol in November 2003.

The Clean Development Mechanism (CDM) is one of the three flexible mechanisms established to meet the goals of the Kyoto Protocol. The dual goal of the CDM is to assist Parties not included in Annex I to achieve sustainable development, and to assist Parties included in Annex I to achieve compliance with their quantified emission limitation and reduction commitments through projects in developing countries. The CDM essentially offers opportunities for financing sustainable development projects in developing countries that could generate Certificates of Emission Reduction (CERs). It specifically presents opportunities for a developing country to host projects that rehabilitate degraded lands, among others.

Under the CDM, forestry projects are limited to A/R. A key output of COP-9[3] in December 2003 was the modalities and procedures for A/R CDM projects (Decision 19/CP9) that could serve as a workable basis for project development. Reforestation and afforestation are officially defined by the United Nations Framework Convention on Climate Change as follows (Decision 11/CP7, 2001):

- 'Afforestation' is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.
- 'Reforestation' is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but was converted to non-forested land. For the first commitment period, reforestation activities would be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989.

It should be noted that how a country defines a forest is very important in determining which activities qualify. Under the CDM, a 'forest' is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 percent with trees with the potential to reach a minimum height of 2-5 metres at maturity *in situ*. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations that have yet to reach a crown density of 10-30 percent or tree height of 2-5 metres are included under forest, as are areas normally forming part of the forest area that are temporarily unstocked as a result of such human intervention as harvesting or natural causes, but which are expected to revert to forest. Depending on how a party chooses its definition, certain type of agroforestry systems may not be eligible for CDM. For example, if a low cover is selected (e.g., 10 percent), then many agroforestry systems, such as tree farms, will be classified as forest already and are thus not eligible for 'reforestation or afforestation'.

3. Ninth Meeting of the Conference of the Parties.

For the first commitment period, credits from CDM Land use, Land-use Change and Forestry (LULUCF) projects cannot exceed 1 percent of the total commitments of Annex 1 parties.

Our initial estimates showed that the life-cycle cost of potential forestry projects (not necessarily Kyoto Protocol compliant) in the Philippines ranged from about US$0.12/tC to US$7.60/tC (Lasco and Pulhin 2001). On the other hand, the cost of protecting a Philippines National Oil Company-Energy Development Corporation geothermal forest reservation in the island of Leyte was US$2.94/tC (Lasco *et al.* 2002). In contrast, a systematic comparison of sequestration supply estimates from national studies in the USA produced a range of US$25 to US$75/ton for a programme size of 300 million tons of annual carbon sequestration (Stavins and Richards 2005).

Areas suitable for CDM in the Philippines, which include those that need to be permanently forested for legal, ecological, or social reasons, are the most likely candidate areas for climate mitigation projects. These include:

- Critical watersheds;
- Forest reserves (including those under the management of other government agencies and government-controlled corporations, such as the Philippine National Oil Company and National Power Corporation, academic institutions and the military); and
- Forest lands under the National Integrated Protected Area System, including those with 50 percent slope and 1 000 masl elevation.

The total area of the aforesaid forest lands is about 5 million hectares (FMB 2001), a large portion of which needs to be either protected or rehabilitated.

Once new financing schemes are available, property rights issues may become important (Lasco and Pulhin 2003). Competition over who will control forest lands may intensify. In the Philippines, many upland areas are being claimed by indigenous peoples. Such claims may be ignored in favour of establishing climate-change forests. Thus, the guidelines should have adequate provisions for respecting the rights of local users. This is more easily said than done in many developing countries. These issues could be adequately addressed, however, through public consultation and participation in project planning and implementation. The environmental impact assessment system is the main mechanism for facilitating this in the Philippines. Existing policies and procedures embodied in the Indigenous People’s Rights Act should also ensure that the rights of indigenous peoples are fully safeguarded.

ANR potential for CDM and other carbon markets

For the CDM market, the selected forest definition of a country will play a critical role in whether ANR will qualify or not. ANR projects are eligible only if the project area is not forested (i.e., it does not have tree cover greater than the minimum cover for a forest as defined by the host country, which could range from 10 to 30 percent tree cover). If a country chooses 10 percent as the minimum cover for a forest, it is likely that ANR activities will not qualify. This is because one prerequisite for ANR to succeed is the presence of natural regeneration, which some recommend to be at least 200 trees/hectare (Friday *et al*. 1999). The coverage of these natural regeneration stands may exceed the threshold, making the potential project sites already 'forested'. The Philippines uses 10 percent crown cover in its forest definition, although this has not been officially submitted to the CDM Executive Board. If it sticks to this definition, there may be a very limited number of forestry projects that could be eligible. Projects such as those on ANR will be excluded. In contrast, Indonesia has chosen 30 percent as its minimum crown cover for forests, thereby allowing a greater variety of eligible forestry projects.

In any case, there are still a very limited number of approved forestry projects under the CDM, partly because of its complicated rules. To date, there are only four approved forestry CDM projects comprising about 0.2 percent of all approved CDM projects (Figure 3).

The situation in the voluntary carbon market (non-Kyoto) is slightly more encouraging. The voluntary over-the-counter markets are currently the only source of carbon finance for avoided deforestation and they have a higher proportion of forestry-based credits out of total market transactions than the CDM (36 percent vs. 1 percent for CDM) (Hamilton *et al*. 2007). Indeed, forest projects are the largest component of the voluntary carbon market, which in 2006 amounted to 23.7 million tCO_2 equivalent valued at US$91 million. This is partly because voluntary carbon markets have historically served as sources of experimentation and innovation.

Another potential barrier to the implementation of ANR carbon sequestration projects is the transaction cost. For forestry projects, it is estimated that up to US$200 000 are needed to design and register a regular-sized CDM project. This amount does not include the cost of actual tree planting and maintenance. This means that an area of several thousand hectares is needed just to break even. In most cases, the financial return from the sale of carbon credits will not be enough to offset the expenses incurred. Thus, the carbon market should be viewed as an added income stream to forestry projects.

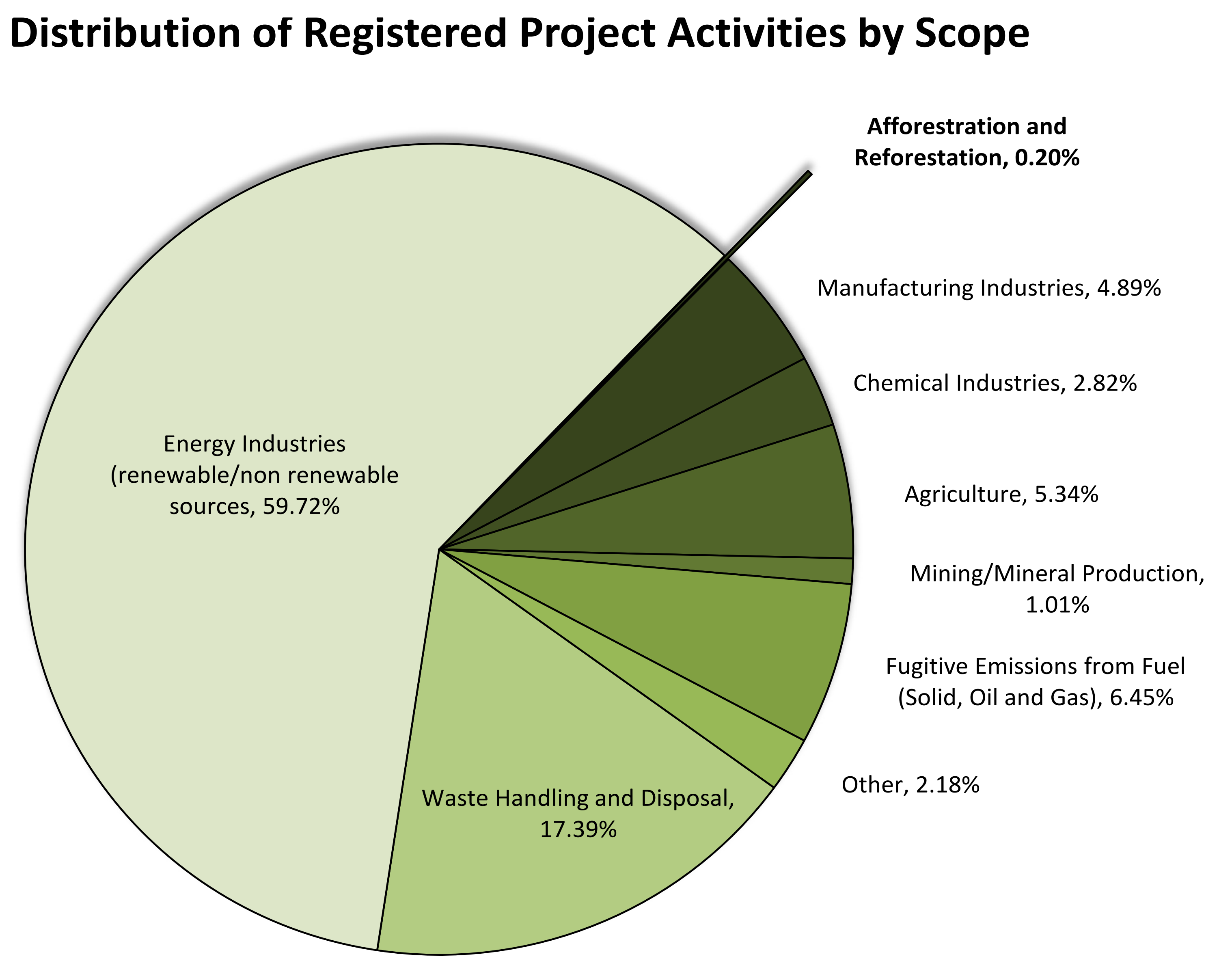


Figure 3. Forestry projects comprised less than 1 percent of all registered CDM projects as of 14 May 2009
Source: http://cdm.unfccc.int/Statistics/Registration/RegisteredProjByScopePieChart.html

Closing remarks

Climate change is one of the most pressing concerns today. One of the leading causes of GHG emissions is deforestation. Conversely, forest conservation, restoration and sustainable management are critical to mitigating climate change.

Assisted natural regeneration is one of the most effective ways to restore forest cover. One of its many ancillary benefits is increased carbon sequestration as trees grow. While this is not disputed, accessing the carbon market may be hindered by legal and financial reasons.

Several research gaps remain. Carbon sequestration rates of ANR projects in the Philippines are still lacking. Financial and economic cost and benefit data of ANR carbon sequestration projects are also missing.

Literature cited

Amir, H.M.S., Ang, L.H., Suhaimi, W.C., Mohd, H. & Azian, A. 1994. Plantation trials on BRIS soils and tin tailings in Peninsular Malaysia. *In Rehabilitation of degraded lands in the tropics,* pp 147-157. Tsukuba, Japan, JIRCAS International Symposium Series No. 1, Japan International Research Center for Agricultural Sciences (JIRCAS).

Brown, S. 1997. *Estimating biomass and biomass change of tropical forest: A primer.* Forestry Paper 134. Rome, FAO.

Buante, C.R. 1997. Biomass production of *Acacia mangium* Willd., *Gmelina arborea* Roxb., and *Acacia auriculiformis* A. Cunn. Ex Benth. as fuelwood species in Leyte. *In developments in agroforestry research,* pp. 224-246. Book Series No. 160/1997. Los Baños, Laguna, Philippines, Philippine Council for Agriculture, Forestry and Natural Resources Research and Development.

Cacho, O.J., Hean, R.L. & Wise, R.M. 2003. Carbon-accounting methods and reforestation incentives. *The Australian Journal of Agricultural and Resource Economics,* 47: 153-179.

Carandang, A.P., Pulhin, J.M., Acosta, R.T., Chokalinggam, U., Lasco, R.D., Razal, R.A., Natividad, M.Q. & Peras, R.J.J. 2004. *Forest rehabilitation initiatives in the Philippines: lessons learned*. Final report submitted to CIFOR. College, Laguna, Philippines.

Chomitz, K.M., Buys, P., DeLuca, G., Thomas, T.S. & Wertz-Kanounnikoff, S. 2006. *At Loggerheads? Agricultural expansion, poverty reduction, and the environment in the tropics.* Washington, DC, the World Bank. 284 pp.

Dela Cruz, L.U. 1999. The potentials of mycorrhizal technology in mitigating climate change. *In Proc. international conference on tropical forests and climate change,* pp 95-106. Environmental Forestry Programme, College of Forestry and Natural Resources, University of the Philippines, College, Laguna, Philippines.

Food and Agriculture Organization of the United Nations (FAO). 2006. *Global forest resources assessment 2005.* Forestry Paper No 147. Rome, FAO.

Forest Management Bureau (FMB).2001. *Forestry statistics (2000).* Quezon City, Philippines, FMB.

FMB. 1997. *Forestry statistics (1996).* Quezon City, Philippines, FMB.

FMB. 1996**.** *Forestry statistics (1995).* Quezon City, Philippines, FMB.

Friday, K., Drilling, M.E. & Garrity D.P. 1999. *Imperata grassland rehabilitation using agroforestry and assisted natural regeneration.* Bogor, Indonesia, International Centre for Research in Agroforestry. p.167.

Garrity, D.P., Kummer, D.M. & Guiang, E.S. 1993. *The upland ecosystem in the Philippines: alternatives for sustainable farming and forestry.* Washington, DC, National Academy Press.

Hamilton, K., Bayon, R., Turner, G. & Higgins, D. 2007. *State of the voluntary carbon market 2007: picking up steam.* UK, New Carbon Finance. 59 pp.

Intergovernmental Panel on Climate Change (IPCC). 2000. *Land use, land-use change and forestry.* Special report of the IPCC. Cambridge, Cambridge University Press, 377 pp.

Korten, F. 1995. Environmental lending may be harmful to the environment. PCDF Forum Article No. 14. July 10, 1995.

Lachica-Lustica, A. 1997. Trial planting of introduced reforestation species in Dumarao, Capiz. *In Developments in agroforestry research*, pp. 270-281. Book Series No. 160/1997. Los Baños, Laguna, Philippine Council for Agriculture, Forestry and Natural Resources Research and Development.

Lasco, R.D., Pulhin, F.B. & Cruz, R.V.O. 2008. Carbon stocks assessment of forest land uses in the Kaliwa Watershed, Philippines. *Journal of Environmental Science and Management,* 11: 1-14.

Lasco, R.D, Pulhin, F.B. & Sales, R.F. 2007. Analysis of leakage in carbon sequestration projects in forestry: a case study of upper Magat watershed, Philippines. *Mitigation and Adaptation Strategies for Global Change,* 12: 1189-1211.

Lasco, R.D., Lales, J.S., Arnuevo, M.T., Guillermo, I.Q., de Jesus, A.C., Medrano, R., Bajar, O.F. & Mendoza, C.V. 2002. Carbon dioxide (CO_2) storage and sequstration of land cover in the Leyte Geothermal Reservation. *Renewable Energy,* 25: 307-315.

Lasco, R.D. & Pulhin, F.B. 2003. Philippine forest ecosystems and climate change: Carbon stocks, rate of sequestration and the Kyoto Protocol. *Annals of Tropical Research,* 25(2): 37-51.

Lasco, R.D. & Pulhin, F.B. 2001. Forestry mitigation options in the Philippines: application of the COMAP model. *Mitigation and Adaptation Strategies to Global Change,* 6: 313-334.

Lasco, R.D. & Pulhin, F.B. 2000. Forest land-use change in the Philippines and climate change mitigation. *Mitigation and Adaptation Strategies to Global Change,* 5: 81-97.

Lasco, R.D. & Pulhin, F.B. 1999. Mitigating climate change through forestry options in the Philippines. *In Proc. of the international conference on tropical forests and climate change*. Philippines, CFNR, UPLB.

Liu, D.S., Iverson, L.R. & Brown, S. 1993. Rates and patterns of deforestation in the Philippines: application of geographic information system analysis. *Forest Ecology and Management,* 57: 1-16.

Nabuurs, G.J., Masera, O., Andrasko, K., Benitez-Ponce, P., Boer, R., Dutschke, M., Elsiddig, E., Ford-Robertson, J., Frumhoff, P., Karjalainen, T., Krankina, O., Kurz, W.A., Matsumoto, M., Oyhantcabal, W., Ravindranath, N.H., Sanz Sanchez, M.J. & Zhang, X. 2007. Forestry. *In* B. Metz, O.R. Davidson, P.R. Bosch, R. Dave & L.A. Meyer, eds. *Climate change 2007: mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* pp. 541-584. Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press.

Sakurai, S., Ragil, R.S.B. & de la Cruz, L.U. 1994. Tree growth and productivity in degraded forest land. *In Rehabilitation of degraded lands in the tropics,* pp.64-71. JIRCAS International Symposium Series No. 1. Tsukuba, Japan, Japan International Research Center for Agricultural Sciences (JIRCAS).

Sathaye, J.A., Makundi, W., Dale, L., Chan, P. & Andrasko, K. 2007. GHG mitigation potential, costs and beneûts in global forests: A dynamic partial equilibrium approach. *Energy Journal,* Special Issue 3: 127-172.

Sohngen, B. & Sedjo, R. 2006. Carbon sequestration costs in global forests. *Energy Journal,* Special Issue: 109-126.

Stavins, R.N. & Richards, K.R. 2005. *The cost of U.S. forest-based carbon sequestration.* Arlington, VA, USA, Pew Center on Global Climate Change. 52 pp.

Villamor, G.B. & Lasco, R.D. 2006. Case study 7. The Ikalahan ancestral domain, the Philippines. *In* D Murdiyarso & M. Skutsch, eds. *Community forest management as a carbon mitigation option: case studies,* pp. 43-50. Bogor Barat, Indonesia, Center for International Forestry Research, Bogor Barat, Indonesia.

Waterloo, M.J., Spiertz, P.H., Diemont, H., Emmer, I., Aalders, E., Wichink-Kruit, R. & Kabat, P. 2003. *Criteria potentials and costs of forestry activities to sequester carbon within the framework of the Clean Development Mechanism.* Wageningen, Alterra Rapport 777. 136 pp.

Restoration of degraded forest ecosystems in Southeast Asia

Kikang Bae,[1] Don Koo Lee[1] and Su Young Woo[2]

Background

Problem analysis

The geophysical and climatic conditions of the Association of Southeast Asian Nations (ASEAN) region have allowed a rich endowment of natural resources. The judicious use of these resources would contribute to the continued well-being of its people. ASEAN member countries are committed to achieving the Millennium Development Goals (MDGs). Although it is the responsibility of national governments to take proper action to address and manage environment and associated problems such as poverty and health, regional collaborative partnerships such as the ASEAN-Korea Environmental Cooperation Project (AKECOP) could effectively provide synergistic benefits in addressing common problems on environmental issues to improve the quality of life in the region as well as in the rest of the world.

Total forest cover in the ASEAN Countries in 2005 was 203 million hectares which is 45 percent of the region's total land area (FAO 2006). ASEAN's forests are important not only for their rich biological diversity but for their economic value in timber and non-wood forest products as well. In many ASEAN countries, however, resources in terrestrial and coastal ecosystems are under increasing stress due to the growing population and the extension of agricultural lands into forest and other ecologically sensitive areas. In 1990, about 55 percent of the land area of the region was still covered by forests but this decreased to only 45 percent in 2005. The average annual rate of deforestation in the region from 2000 to 2005 was 2.75 million hectares or 1.35 percent, compared to the world average of 0.2 percent.

Mangrove forests are found in all ASEAN member countries except for Lao PDR and play important ecological functions by preventing coastal erosion and saltwater intrusion; they also support economically important fisheries by providing habitats and food for the conservation of biological diversity. Despite the socio-economic and ecological importance of mangroves, it was only in the last several decades that concern for them began to emerge and their sustainability was widely discussed. However, mangrove forests in many ASEAN member countries have decreased and some species are in danger of extinction due to coastal development.

---

1. Seoul National University.
2. University of Seoul.

Justification

ASEAN countries continue to cope with the challenge of balancing environmental concerns with the imperatives of development. Successful management of the forest environment in the ASEAN region depends heavily on the capacity of concerned countries to tackle various complex problems on policy, economy, institutional capacity, technology and human resources associated with forest management. Thus, one key component for the sustainable management of the forest environment is to strengthen the human and/or institutional capacity of forest ecosystem management in ASEAN member countries.

The project Restoration of Degraded Forest Ecosystems in the Southeast Asian Tropical Region was a flagship ASEAN project supported by the Republic of Korea (ROK). AKECOP accumulated significant knowledge and sufficient experience through its cordial and firm partnership among key ASEAN and ROK forest research organizations during Phase 1 (1 July 2000 to 30 June 2005), Phase 2 (1 July 2005 to 30 June 2008) and will continue to do so in Phase 3 (1 July 2008 to 30 June 2011). Its research findings have led to an effective and efficient restoration of degraded tropical forests in ASEAN member countries.

Project goals and strategies

AKECOP's main goal is to enhance the capacity of member countries in the ASEAN region in managing their forest ecosystems in a sustainable manner for an improved regional and global environment. AKECOP has implemented appropriate activities related to sustainable forest ecosystems, which are intended to:

- Enhance the capacities of ASEAN member countries, institutions and people to manage existing and emerging issues on sustainable forest ecosystems in terrestrial and coastal environments.
- Produce high impact knowledge, information and technology and generate lessons that could improve sustainable management policy, extension and practices.
- Enrich biodiversity and restore forest ecosystems.
- Alleviate the poverty of community forests, thus leading to food security.

To maximize the impact of the project, the following strategies and tactics have been adopted in formulating and implementing details of the activities. Figure 1 provides a schematic diagram of project strategies and goals.

Strategy 1: A multisectoral, multidisciplinary and holistic approach for national programmes on sustainable forest management with special emphasis on people's well-being

Tactic 1 — Critical and strategic assessment of national programmes on sustainable forest management to extract lessons and establish guidelines for future programmes. This process identifies gaps in information, technology and policies that help in formulating improved national programme activities.

Tactic 2 — Conduct multisectoral forums involving policy-makers, administrators, scientists, academics, NGOs, the private sector and forest dwellers to address and discuss key national issues on sustainable forest management.

Tactic 3 — Publication of a state-of-the-art review report on the assessment of national programmes on sustainable forest management and the proceedings of multisectoral forums on related issues.

Tactic 4 — Development of general guidelines for policy and practice in sustainable forest landscape restoration.

Tactic 5 — Participatory planning and evaluation of supplementary research project activities. This has been done by holding consultative visits and onsite review and evaluation of projects by multisectoral committee members.

Strategy 2: Enhancement of national capacity in dealing with existing and emerging issues on sustainable forest ecosystem management

Tactic 1 — Conduct complementary research and development activities in model forests to best strengthen the ongoing high priority national project. These R&D activities will fill information, technology and policy gaps in national programmes. They could also include *ex-post* analysis on the sustainability of national programmes.

Tactic 2 — Conduct common research on regional concern such as the valuation of mangrove forests using a uniform research methodology.

Tactic 3 — Provide short-term training on major or priority topics and graduate study including research grants for theses in respective countries.

Tactic 4 — Organize conferences or workshops to enhance the technical communication and research management skills of the participating countries.

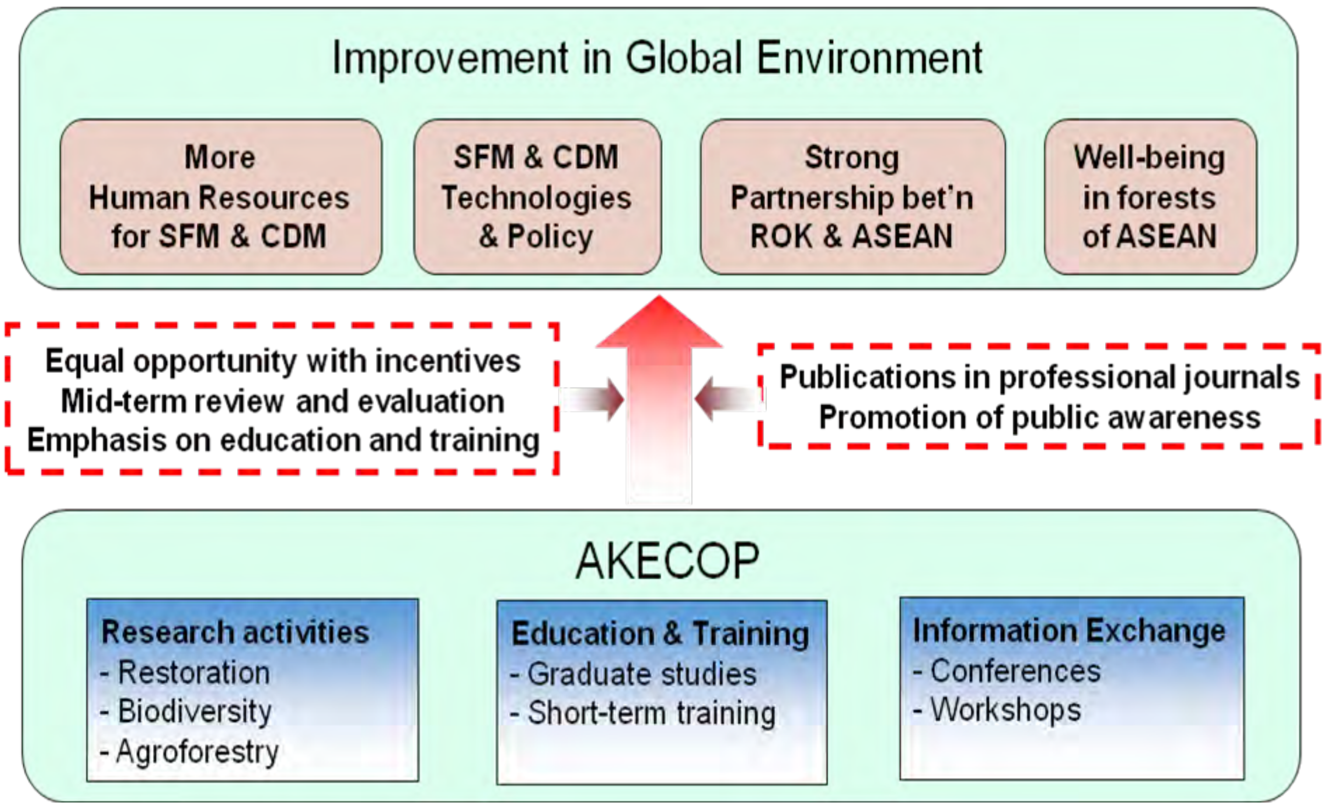


Figure 1. Schematic diagram of project goals and strategies

Main achievements of the AKECOP project

Selected countries with an adequate infrastructure and technical capacity carry out regional research on relevant issues, which complement national programmes of high priority. *Ex-post* research in model forests where national programmes have been conducted in the past is preferred. The onsite field research is carried out by ROK scientists in the Philippines. Research results and findings from the basic and applied research are utilized for ecological restoration of degraded forests, sustainable forest management and agroforestry techniques in needed areas as well as for formulating policies and extension activities.

The education and training component of the project consists of short-term training activities and graduate study for master or doctoral degrees in forestry or other related fields in ROK and some leading ASEAN forestry institutions. The short-term training programme provides hands-on experience, practical information and skills necessary for the immediate needs of individual research and development organizations. Advanced techniques and new areas of science and technology are introduced using modern equipment and facilities at the National Instrumentation Center for Environmental Management (NICEM) and other research institutes in ROK. A total of 152 applicants from 9 countries have participated in the short-term training. Research grants for master or doctoral theses are expected to be available in some countries. Nineteen graduate students (5 doctoral and 13 masters) have already finished or are pursuing their degrees. The yearly financial support for graduate study includes stipends, tuition fees and research support.

The project organizes conferences or workshops to provide a forum for interaction among participating scientists. Two conferences (90 participants from 12 countries) and five workshops (216 participants from 10 countries) have been held. They allowed participating researchers to improve specific research skills and to share knowledge on tropical forests through exchange of experiences and field visits. The meetings were organized by the ASEAN-Korea Environmental Cooperation Unit (AKECU) in close collaboration with the participating institutions in ASEAN member countries. The workshops dealt with specific issues related to tropical forests in order to introduce new concepts and to share in-depth knowledge on specific fields of science.

Assisted natural regeneration in the AKECOP project

In 1989, the concept of assisted natural regeneration (ANR) was formally instituted through the Department of Environment and Natural Resources of the Philippines (DENR). As a part of AKECOP projects, ANR has been conducted in the Mt. Makiling Forest Reserve of Los Baños and the La Mesa Dam Watershed of Rizal in the Philippines in 2004 and 2005 (AKECU 2005). The focus of ANR is restricted to rehabilitation of grasslands, brushlands, scrublands, or barren areas because potentially different management interventions are called for in these areas as opposed to rehabilitation of degraded forest areas. Bringing back forests on grasslands, brushlands, scrublands, or barren areas could be important in helping to reduce degradation pressures on existing forests. Usually, the reasons for failure in reforestation efforts are legion, ranging from the technical to the social. Poor species-site matching, inadequate maintenance, corruption and social conflict are just some of the major reasons. As ANR is based on natural resources, it can present an attractive alternative to conventional reforestation techniques. However, at present, there is still no evaluation of the success or failure of ANR in the limited area where it has been tried. Therefore, further efforts for appropriate evaluations of ANR should be conducted as part of future AKECOP activities.

Expected outputs

AKECOP as a catalyst for attaining sustainable forest management in the region has become prominent and relevant. Being a regional collaborative partnership, it has supported ASEAN member countries in generating scientific knowledge, sharing information and experiences and enhancing human and institutional capacity during Phase 1 and Phase 2.

The major research and development activities of the project will focus on a critical and strategic assessment of national programmes on sustainable forest management in the past and present in order to extract lessons and identify gaps in information, technology and policies for forest restoration in ASEAN member countries. This will produce a state-of-the-art national report on forest restoration in ASEAN member countries, and will serve as a basis for formulating improved and effective mid- and long-term national plans. The project will establish and operate a viable multisectoral forum on forest consisting of key policy-makers and administrators, researchers, NGOs and local community leaders of forest dwellers to address jointly key national issues on the sustainable management of forest. The project will also conduct complementary research in model forests that will fill technical gaps as well as serve as a venue for extension and training activities. Regional research on mangrove forests in coastal environments will be conducted using a uniform research format. The project will also continue various forms of training activities related to human resource development.

Literature cited

ASEAN-Korea Environmental Cooperation Unit (AKECU). 2005. Restoration of degraded forest ecosystem in the Southeast Asian Tropical region, Annual Report for Year 2004 - 2005, ASEAN-Korea Environmental Cooperation Project (AKECOP). pp. 111 – 114.

Food and Agriculture Organization of the United Nations (FAO). 2006. *Global forest resources assessment 2005.* Rome, FAO.

Lee, D.K. 2008. ASEAN-Korea Environmental Cooperation Project. Restoration of degraded terrestrial forest and mangrove forest ecosystems in ASEAN region. Proposal to the Ministry of Foreign Affairs and Trade, Republic of Korea.

The rehabilitation of degraded tropical forest based on secondary succession

Shigeo Kobayashi[1]

Forest condition and rehabilitation of degraded land

The two major factors that have induced decreasing and degraded forest area are forest harvesting and land-use changes. Commercial and large-scale illegal logging as well as human-induced fire hazards have also seriously threatened forest conditions. Forest degradation and decrease of forest area impact negatively on cultural aspects, ecological services and socio-economic conditions (Kobayashi 2007). Degraded and decreasing forest areas need to be rehabilitated to recover lost benefits. Natural secondary succession processes provide important information for the application of techniques to rehabilitate degraded tropical forests. The influence and role of vegetation types on secondary succession in the contexts of facilitation or competition processes have been described by Holmgren *et al.* (1997) and Li and Wilson (1998); Callaway and Walker (1997) reported on their interaction.

This study aims to clarify the initial phase of vegetation recovery through facilitation or competition processes for secondary succession and to discuss the final rehabilitation outputs.

Survey locations and methods

Species composition and the biomass of undergrowth plant populations were examined in relation to logging intensity, land form and soil conditions at one and several months after forest harvesting, fire events, enrichment planting and mixed planting. Surveys were carried out in mixed dipterocarp forest in Samarinda, East Kalimantan, Indonesia; mixed dipterocarp forest in Pasoh, Malaysia**;** mixed deciduous forest in Maeklong, Thailand**;** peat swamp forest in Belait, Brunei Darussalam; abandoned pasture in Pucallpa, Peru; subtropical moist forest in Misiones, Argentina; and a teak plantation in Thom Pha Phun, Thailand. Fixed quadrates were set ranging from 2x2 metres to 10x10 metres and vegetation changes were monitored using the methods of Braun-Blanquet (1964).

The secondary succession process

The study examined the initial phases of vegetation recovery 2 and 14 months after gap and line planting in mixed dipterocarp forest in Pasoh, Malaysia (Figure 1).

---

1. Graduate School of Asian and African Area Studies, Kyoto University, Japan.

Species composition of the undergrowth was measured using quadrats of 2x2 metres at 5 quadrats/hectare. Dominance and height were measured using the Braun-Blanquet method. Intensive forest clearing for enrichment significantly affected vegetation recovery at the initial phase. Vegetation types were classified into grasses and ferns, *Melastoma*-dominated woody shrubs and *Dipterocarpacea* during the initial phase, based on species composition and dominance value. Grasses and ferns were associated with the competition process because they had the smallest species number without tree species. Vegetation suppressed in the competition process will require rehabilitation treatment (enrichment and planting). *Dipterocarpacea* belonged to the facilitation process because of their high species number and considerable recruitment of woody shrubs and *Dipterocarpacea*. Under the facilitation process, vegetation is expected to follow its natural course of secondary succession but may sometimes need treatment to accelerate natural regeneration.

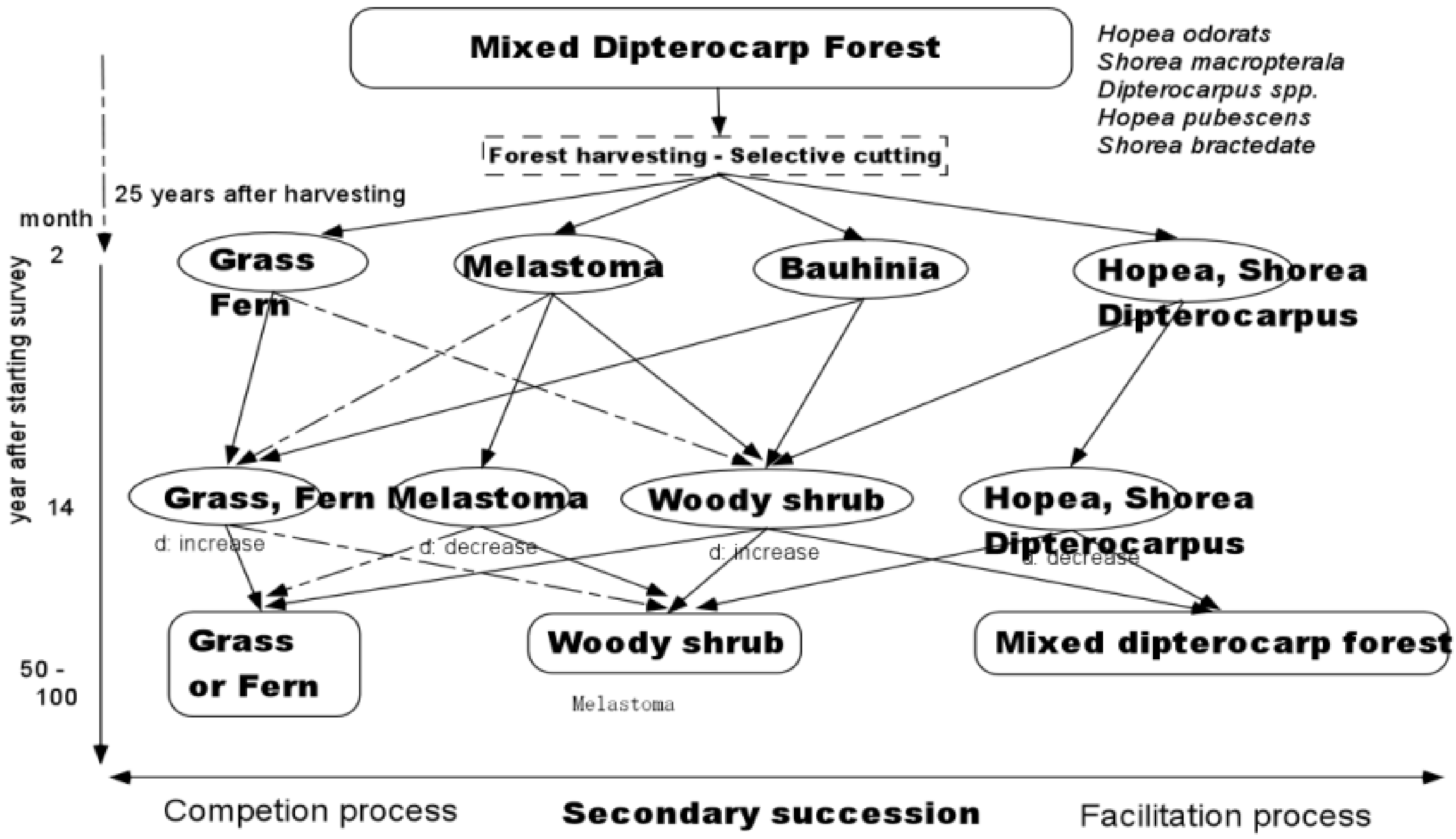


Figure 1. Secondary succession in mixed dipterocarp forest of Pasoh, Malaysia

Similar processes were also observed in mixed dipterocarp forest in Samarinda, East Kalimantan, Indonesia; mixed dipterocarp forest in Pasoh, Malaysia**;** mixed deciduous forest in Maeklong, Thailand**;** peat swamp forest in Belait, Brunei Darussalam; abandoned pasture in Pucallpa, Peru; subtropical moist forest in Misiones, Argentina; and a teak plantation in Thom Pha Phun, Thailand (Kobayashi *et al.* 2001; Kobayashi 2004; Kobayashi 2007). Figure 2 summarizes factors analysed at all study sites. The facilitation process must be applied to accelerate natural regeneration and enrichment planting (Kobayashi 2004). The competition process can be introduced in large-scale and catalytic plantations (Nambiar and Brown 1997).

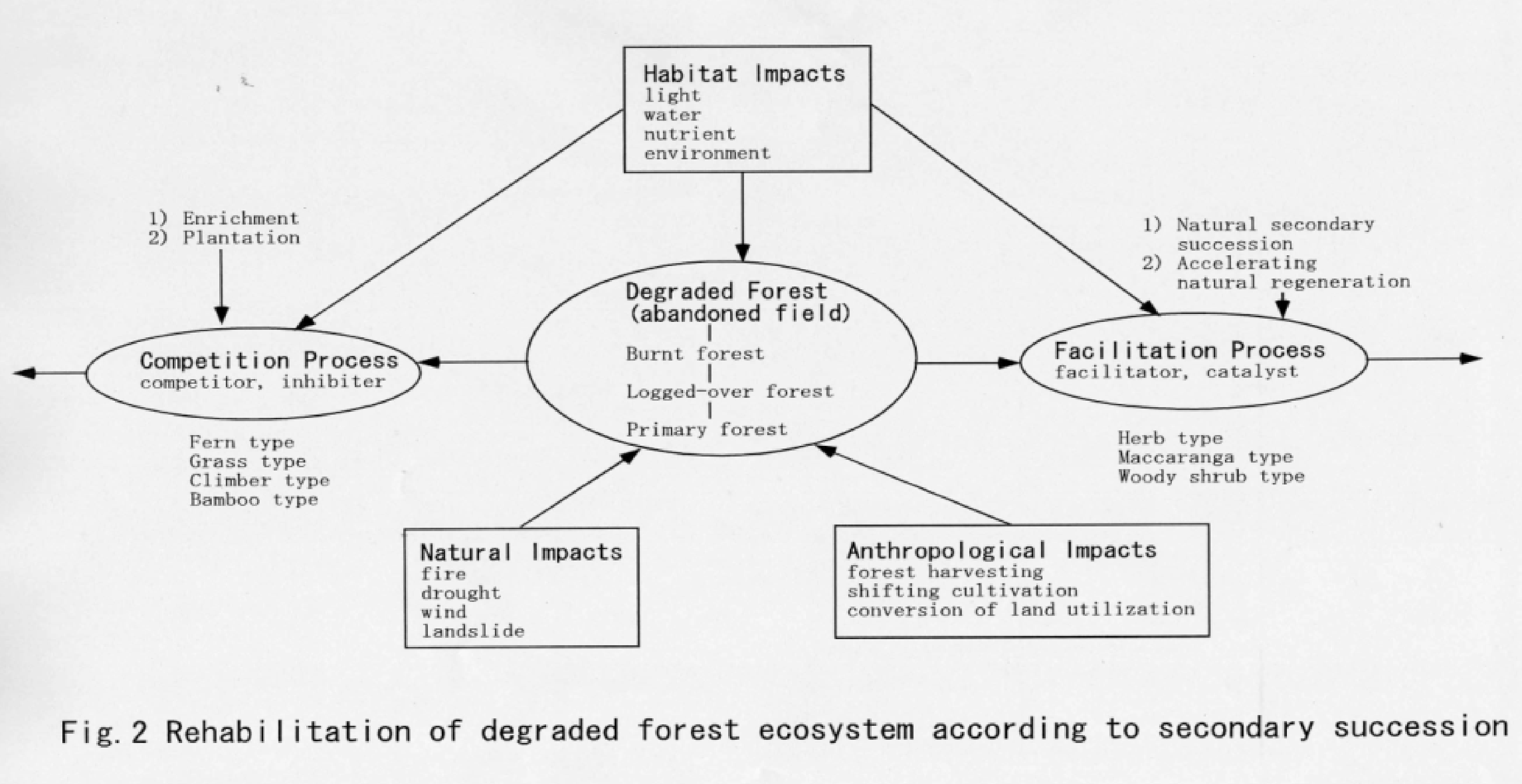


Figure 2. Rehabilitation of degraded forest ecosystems according to secondary succession (Kobayashi 2004)

Rehabilitation of degraded forest using secondary succession related to assisted natural regeneration

We classified undergrowth vegetation types in logged-over tropical lowland mixed dipterocarp forest and for evaluating the influences and roles of vegetation types on secondary succession. Grasses and ferns were associated with the competition process because they retained 100 percent composition of their type, the smallest species number and the smallest recruitment of woody shrubs 14 months after fire events (fern cover was thick and the soil was dry).

Dipterocarpacea were associated with the facilitation process because of higher species number and the highest recruitment of woody shrubs (relatively light cover and wet soil). This supports the diversity–productivity hypothesis (Tilman *et al.* 1996), but does not support the statement “species-rich sites were more resistant to invasion” (Tilman 1997). Woody shrubs and ferns will be classified into lower criteria after further monitoring. For rehabilitation, vegetation associated with the facilitation process can be applied to accelerate natural regeneration or for monitoring purposes. Conversely, vegetation associated with the competition process must be applied for enrichment planting, mixed plantation and catalytic plantation.

Accelerated natural regeneration methods have been developed such as ‘umbrella’ natural regeneration, ‘side-effect’ natural regeneration and forest patch improvement; these are closely related with assisted natural regeneration (FAO-RAP 2003). Enrichment planting techniques such as line planting and gap planting have been studied (Kobayashi 2003; Chan *et al.* 2008). The catalytic effects of large-scale planting using site matching, direct sowing and mixed planting can be anticipated.

We addressed not only technique development but also local community incentives. Forest recovery takes a long time and fires and illegal logging will occur during this period. Local community incentives should focus on forest ecological resources (fallow products and non-wood forest products) on which forest dwellers depend (Figure 3). Local communities can utilize these resources during the facilitation process in secondary succession.

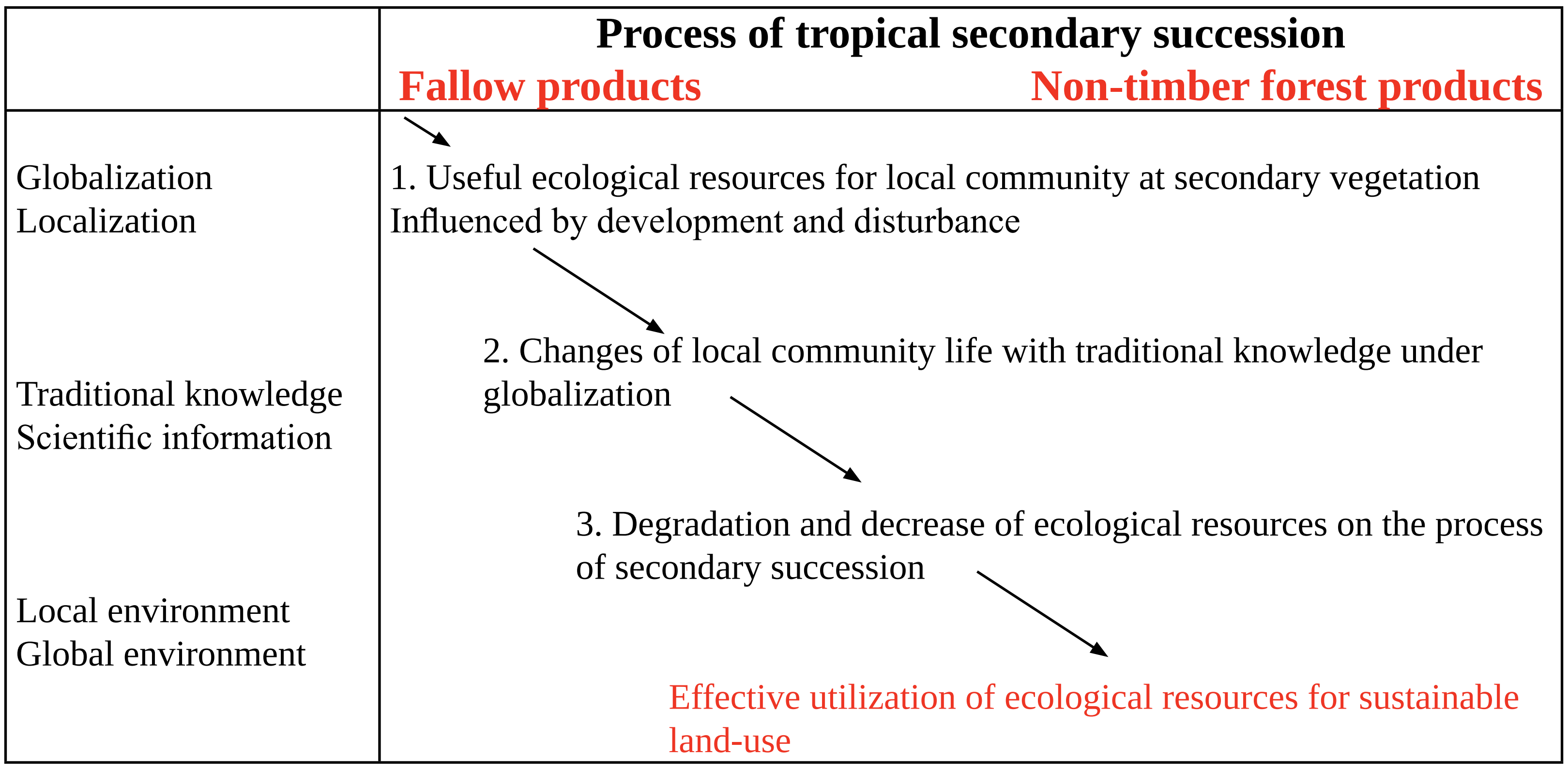


Figure 3. Relationship between secondary succession process and factors affecting forest management.

Concluding remarks

Secondary forests comprise diverse species and structures that, if disturbed, can be replenished by secondary succession, either via facilitation or competition processes. The rehabilitation site must be determined based on secondary succession that employs these processes and be managed with adequate rehabilitation techniques. Sustainability is more important than productivity; after evaluation of ecological resources, management techniques that conserve biodiversity and non- timber forest products during secondary succession will provide local communities with incentives for sustainable land use.

Acknowledgement

I would like to thank the Japanese International Cooperation Agency; Center for International Forestry Research; Ministry of Foreign Affairs, Japan; Ministry of Agriculture, Forestry and Fisheries, Japan; Ministry of Education, Culture and Sports, Japan; and the Environmental Foundation of Mitsui Bussan for financial support for this study.

Literature cited

Braun-Blanquet, J. 1964. *Pflanzensoziologie.* Wien.

Callaway, R.M. & Walker, L.R. 1997. Competition and facilitation: a synthetic approach to interaction in plant communities. *Ecology,* 78: 1958-1965.

Chan, H.T., Shamsudin, I. & Ismail, P. eds. 2008. *An in-depth look at enrichment planting.* Malayan Forest Records 47. 194 pp.

Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific (FAO-RAP). 2003. *Advancing assisted natural regeneration (ANR) in Asia and the Pacific.* RAP Publication 2003/19, 44 pp.

Holmgren, M., Scheffer, M. & Huston, M.A. 1997. The interplay of facilitation and competition in plant communities. *Ecology,* 78: 1966-1975.

Kobayashi, S., Turnbull, J.W., Toma, T., Mori, T. & Majid, N.M.N.A. 2001. *Rehabilitation of degraded tropical forest ecosystems.* Workshop proceedings. Bogor, Indonesia, CIFOR. 226 pp.

Kobayashi, S. 2003. Silviculture management of natural Dipterocarp forests: The rehabilitation of logged-over forests. In Frim, Apafri *et al.* Proceedings of the Seventh Round-Table Conference on Dipterocarps. (KL, Malaysia) 95-116.

Kobayashi, S. 2004. Landscape rehabilitation of degraded tropical forest ecosystems, Case study of the CIFOR/Japan project in Indonesia and Peru. *Forest Ecology and Management,* 201: 13-22.

Kobayashi, S. 2007. An overview of techniques for the rehabilitation of degraded tropical forests and biodiversity conservation. *Current Science,* 93: 59-66.

Li, X. & Wilson, S.D. 1998. Facilitation among woody plants establishing in an old field. *Ecology,* 79: 2964-2705.

Nambiar, E.K.S. & Brown, A.G. 1997. *Management of soil, nutrients and water in tropical plantation forests.* CSIRO, ACIAR, CIFOR. 571 pp.

Tilman, D. 1997. Community invisibility, recruitment limitation, and grassland biodiversity. *Ecology,* 78: 81-92.

Tilman, D., Wedin, D. & Knops, J. 1996. Productivity and sustainability influenced by biodiversity in grassland ecosystems. *Nature*, 379: 718-720.

FORRU: bringing back the forest in northern Thailand

Tidarat T. Chuprapatthasri[1]

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

Introduction

Deforestation is a serious environmental problem, particularly in the tropics, causing poverty, loss of biodiversity, floods and drought. Natural tropical forests are declining at a rate of 14.2 million hectares annually (approximately 0.7 percent per year), approximately the same rate of decline during 1980 to 1990 (FAO 2001). Thailand has lost more than half of its natural forest cover since 1961; existing cover is about 24 percent. Despite a ban on commercial logging since 1989, forest area continues to diminish and large areas of forest within existing national parks and wildlife sanctuaries have been degraded. Overall, since 1961, Thailand has lost nearly two-thirds of its forests (Bhumibamon 1986).

Forest has a natural capacity for self-recovery. This can take centuries under natural conditions, but by understanding and enhancing the natural processes of forest regeneration, it can be completed in just a few years. The Forest Restoration Research Unit (FORRU) was founded to develop effective methods to accelerate natural forest growth and research was initiated to develop these methods in the conservation area of Doi Suthep-Pui National Park (DNP) in northern Thailand.

FORRU was established in 1994 in collaboration with the DNP and the Biology Department of Chiang Mai University (CMU) by Dr Vilaiwan Anusarnsutorn and Dr Stephen Elliott. FORRU aims to restore original levels of species diversity, ecosystem structure and ecosystem function by planting tree species that were present before deforestation was manifested. The planted trees are the drivers for restoring natural forest ecosystems and their associated biodiversity. They also encourage wildlife to return which facilitates forest restoration. The basic principle is to harness the natural mechanisms of forest regeneration, recreating the complex webs of relationships

1. Forest Restoration Research Unit (FORRU), Biology Department, Science Faculty, Chiang Mai University, Thailand. Email: tidarach@gmail.com, www.forru.org

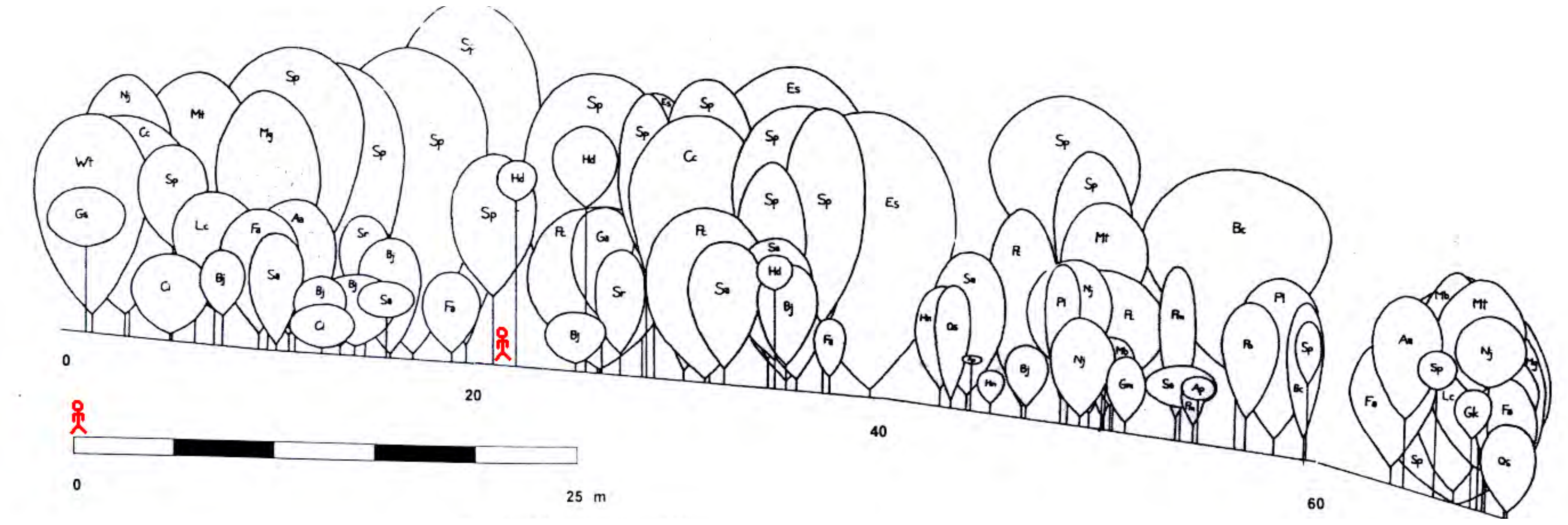
among species that are essential for the recovery of biodiversity.

One of the most fundamental constraints to forest ecosystem restoration is lack of knowledge on how to ensure and integrate the natural diversity of tree species that comprise most tropical forest ecosystems. The need to complement forest protection with forest restoration is now widely acknowledged, but how can this be achieved?

Plate 1. Left, a degraded site after burning before planting of framework tree species; right, the non-planted site in the same area after six years, dominated by grasses and herbaceous weed cover

The 'framework tree species' method involves planting a minimum number of indigenous forest tree species during a single planting event for maximum ecological benefit. Framework species are selected for their potential to accelerate biodiversity recovery and enhance natural regeneration, creating a self-sustaining forest ecosystem for wildlife conservation and environmental protection within protected areas. The framework species method has been adapted to local conditions on degraded sites in northern Thailand. The method was first conceived in northern Queensland, Australia to repair damaged tropical rain forest (Goosem and Tucker 1995; Tucker and Murphy 1997); a mixture of 20 to 30 indigenous pioneer and climax forest tree species were planted. Framework tree species are successful in arresting weed problems in deforested sites after clearing, where grasses and herbaceous weeds can predominate. Planted trees 'recapture' the site by shading out herbaceous weeds, re-establish a multilayered forest canopy and restore forest productivity and nutrient recovery. In addition, framework tree species flower and fruit soon after planting, thus providing food to attract wild animals that disperse the seeds of diverse non-planted tree species throughout the planted site; this creates excellent competition-and free conditions for tree seedlings to germinate. Conditions are also enhanced by the nutrient cycle in the carpet of leaf litter as well as cooler, more humid and weed-free areas.

FORRU now has an office and a research tree nursery at the park's headquarters, a community nursery and field plots at the Hmong village of Ban Mae Sa Mai and an education unit in the herbarium building of CMU's Biology Department. FORRU's primary task is to carry out scientific research to develop effective techniques for restoring biodiversity on degraded land that are not expensive and acceptable for the local people. An education unit disseminates and interprets this research to those who are interested in forest restoration such as students, teachers, ecotourism guides, villagers, NGOs, forestry staff and university researchers. The education unit is responsible for disseminating FORRU's information both in Thai and English and inside and outside of Thailand.



A six-year-old planted site with framework trees species, showing a multilayered canopy of pioneer and climax tree species planted at the same time in the rainy season of 1998. The diagram was created by FORRU students

Research work

Much research has been devoted to answering the question **How can forest be replanted according to its original state before degradation occurred?** The FORRU approach started by screening more than 660 indigenous tree species in the DNP (Maxwell and Elliott 2001) for their ability to act as framework species; tree phenology was observed to reveal seasonal patterns of fruiting and a seed collection schedule was developed for planning of nursery and planting work. The nursery research continued to determine which treatments resulted in the healthiest seedlings and those that were cost effective (Incomserb 1994; Kopachon 1995; Zangkum 1998; Jitlam 2001; Philachanh 2003). Field trials followed at the Hmong village to determine the survival and growth rates of each species, as well as their ability to shade out weeds and recover after a (preset) fire; they revealed varieties that could serve as framework species (Elliott *et al*. 2003). The sites recaptured 70 percent of canopy closure and shaded out weeds within four years. Planted trees were checked regularly for production of any resources that might attract birds or mammals (e.g. fruit, flowers, nectar etc.). Fourteen trees species out of 29 framework trees species produced flowers and fruit that tempted wildlife to return to FORRU's plots within three years after planting. Various silvicultural treatments to maximize field performance of the planted trees were also tested, such as different weeding methods, mulching and fertilizer regimes (Elliott *et al*. 2000); new methods were tested to improve and to reduce the cost of forest restoration such as perching (Scott *et al.* 2000; Gale *et al.* 2002), use of wildlings (Kuarak 2002) and direct seeding (Woods and Elliott 2004; Tunjai *et al.* 2005).

Biodiversity recovery is the most important outcome of FORRU's activities. Wildlife use the 44 framework tree species for food sources, nesting or perching sites, roosting or for sleeping.

The seed disperser helped to increase the recruitment of 72 non-planted seedling species eight years after planting (Sinahseni 2008). Bird varieties rose from 34 to 88 species after six years; bird population density was concentrated more in the oldest plots that resembled their former forest habitats rather than younger planted or non-planted control plots (Chantong 1999; Toktang 2005). Mycorrhizal fungi varieties increased from six to 21 species and both mychorrhizae and lichen were twice as abundant as those in the secondary forest nearby. Small mammals (Thaiying 2003) and signs of medium-sized mammals including the hog badger, pangolin, barking deer, wild pig and red jungle fowl as well as other bird species were recorded at the planted site. These results demonstrate the effectiveness of framework tree species in restoring biodiversity.

Plate 2. Aquilaria crassna, one of the non-planted tree species dispersed by animals over >8 km from the forest near to the planted site

Education work

The five years of research that FORRU-CMU has been conducting for establishing the best methods and tree species for forest restoration has generated a wealth of information that must be disseminated so people can implement them properly. An education unit was set up under a grant from the United Kingdom's Darwin Initiative to implement a three-year project called Education and Training for Restoring Tropical Forest Biodiversity, with British partner East Malling Research (EMR, formerly known as Horticulture Research International) in 2002.

Community outreach work was continued with funds from the Eden Project (by the Trees for Thailand Project) until the middle of 2008 via technical assistance and seed grants; this motivated 12 communities in northern Thailand to establish framework tree nurseries and initiate forest restoration projects in their own villages. International outreach, within the Indochina region, includes work with the People's Republic of China, Cambodia and Lao PDR, with support from the Darwin Initiative. Under this project, the book *How to plant the forest?* was translated into Thai, English, Chinese, Lao, Khmer and Vietnamese to help these countries understand this method easily. The new book *Research for restoring tropical forest ecosystems – a practical guide* that incorporates FORRU-CMU's 15 years of experience is also available in English, Thai, Chinese, Lao, Khmer and Indonesian. All FORRU-CMU information can be downloaded on PDF files through FORRU's Web site at www.forru.org; books, proceedings, research papers, student abstracts, newsletters, images and teaching modules to promote and disseminate the knowledge and ideas generated by FORRU-CMU are available.

Recent work

Currently, FORRU is continuing both research and education by collaborating with many organizations and expanding forest restoration work. FORRU-CMU is studying how to restore the lowland forest at Huay Tung Tao, Chiang Mai Province under a grant from Biodiversity Research Thailand. Lowland forests have very different conditions compared to upland forests because of higher degradation. They are more densely populated resulting in more intense human impact. Field trials and propagation of threatened species are being carried out under another research grant from the International Foundation for Science to increase the potential to conserve threatened species by integrating them among framework species for planting in forest restoration projects.

FORRU-CMU is collaborating with different organizations in western and southern Thailand to provide technical assistance for establishing local forest units in different types of forest. FORRU-CMU is working with the Elephant Conservation Network to establish a community nursery and restore the Asian elephant's habitat in Kanchanaburi Province, western Thailand; this project is supported by the Keidenaren Nature Conservation Foundation of Japan. In southern Thailand, FORRU-CMU is working with the UK's Royal Society for the Protection of Birds and the Oriental Bird Club, to develop effective methods to restore lowland tropical rain forest in Krabi Province, the habitat of Gurney's Pitta, the most endangered bird species of Thailand. Suitable framework tree species were selected to restore the area and a small assisted natural regeneration (ANR) experimental plot has been established to test the technique; the site has many natural regeneration sources such as tree stumps, seedlings, saplings and natural seed banks; fertilizer application and weeding encourage their growth. Plate 3 shows how the site has been transformed through canopy closure.

Plate 3. Tropical lowland evergreen forest, Krabi Province, southern Thailand. Left, the ANR experimental plot in May 2007 after mulching, weeding and fertilizer application; right, the same area in November 2007 six months later – canopy closure is well underway

The education unit continuously works with communities to provide technical training and support. In Doi Mae Salong, Chiang Rai Province, 13 communities are involved in restoring an area of 1 440 hectares near the Thai-Myanmar border, in partnership with the Plant a Tree Today Foundation, the World Conservation Union (IUCN) and Thailand's Supreme Command. FORRU-CMU has also hosted workshops on nursery techniques and forest tree seedling propagation – the Trees Bank Project – for local people who are members of the Bank for Agriculture and Agricultural Cooperatives. The concept of this project was to increase the number of trees in Thailand by stimulating farmers to plant trees who would then be refunded each year depending on tree species and tree age. FORRU-CMU also works on ecotourism development with different tour agencies by transferring knowledge to tour guides on topics such as forest ecology, forest tree species, nursery work to produce indigenous tree species for forest restoration projects and plant/wildlife association. Most ecotourism guides involved in the training are local people from many villages in northern Thailand. FORRU-CMU has also collaborated with the conservation club of Ban Mae Sa Mai of the Hmong hilltribe for more than ten years to help plant and take care of demonstration plots, carry out weeding and prevent fires locally. The villagers plan to develop ecotourism projects in their natural forest and FORRU-CMU's planted plots; they are willing to use ecotourism to protect their forest. The FORRU-CMU partnership with the DNP and the Ching-Cha volunteer group provides training to children and adults to become ecotourism guides in their own villages.

FORRU-CMU has also established successful collaboration with a private company in Chiang Mai, Trisila Company Ltd., of the City Life Magazine, to develop a 'Go Carbon Neutral' carbon offset campaign; the sum of 240 000 baht was allocated for planting 1 625 indigenous trees at FORRU's site in 2008.

Literature cited

Bhumibamon, S. 1986. *The environmental and socio-economic aspects of tropical deforestation: a case study of Thailand.* Department of Silviculture, Faculty of Forestry, Kasetsart University. 102 pp.

Chantong, W. 1999. *Effects of forest restoration activities on the bird community of a degraded upland watershed.* Chiang Mai Province, Biology Department, Faculty of Science, Chiang Mai University, Thailand. (BSc thesis)

Elliott, S., Navakitbumrung, P., Zangkum, S., Kurak, C., Kerby, J., Blakesley, D. & Anusarnsunthorn, V. 2000. Performance of six native tree species, planted to restore degraded forestland in northern Thailand and their response to fertiliser. *In* S. Elliott, J. Kerby, D. Blakesley, K. Hardwick, K. Woods & V. Anusarnsunthorn, eds. *Forest restoration for wildlife conservation,* pp 244-255. Chiang Mai University.

Elliott, S., Navakitbumrung, P., Kurak, C., Zangkum, S., Anusarnsunthorn, V. & Blakesley, D. 2003. Selecting framework tree species for restoring seasonally dry tropical forests in northern Thailand based on field performance. *Forest Ecology and Management,* 184: 177-191.

Food and Agriculture Organization of the United Nations. 2001. *State of the world's forest 2001*. Rome, FAO. 200 pp.

Gale, G., Pattanakeaw, P., Maxwell, J.F., Scott, R. & Elliott, S. 2002. *Do bird perches increase seedling recruitment in deforested tropical landscapes?* Paper presented at 16th Annual Meeting of the Society for Conservation Biology, Cambridge, UK 2002.

Goosem, S.P. & Tucker, N.I.J. 1995. *Repairing the rainforest-theory and practice of rainforest re-establishment in North Queensland's wet tropics.* Cairns, Wet Tropics Management Authority. 71 pp.

Incomserb, P. 1994. *Effect of mycorrhizae on germination and seedling growth rate of native tree species at Doi Suthep-Pui National Park and Chiang Mai University.* Chiang Mai Province, Biology Department, Faculty of Science, Chiang Mai University, Thailand. (BSc thesis)

Jitlam, N. 2001. *Effects of container type, air pruning and fertilizer on the propagation of tree seedlings for forest restoration.* Chiang Mai Province, Graduate School, Chiang Mai University, Thailand. (MSc thesis)

Kopachon, S. 1995. *Effects of heat treatment (60-70^{o}C) on seed germination of some native trees on Doi Suthep.* Chiang Mai Province, Biology Department, Faculty of Science, Chiang Mai University, Thailand. (BSc thesis)

Kuarak, C. 2002. *Factors affecting growth of wildlings in the forest and nurturing methods in nursery.* Chiang Mai Province, Graduate School, Chiang Mai University, Thailand. (MSc thesis)

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

Philachanh, B. 2003. *Effects of presowing treatments and mycorrhizal inoculum on the germination and early seedling growth of tree species for forest restoration.* Chiang Mai Province, Graduate School, Chiang Mai University, Thailand. (MSc thesis)

Scott, R., Pattnakaew, P., Maxwell, J.F., Elliott, S. & Gale, G. 2000. The effect of artificial perches and local vegetation on bird-dispersed seed deposition into regenerating sites. *In* S. Elliott, J. Kerby, D. Blakesley, K. Hardwick, K. Woods & V. Anusarnsunthorn, eds. *Forest restoration for wildlife conservation,* pp 326-337. Chiang Mai University.

Sinhaseni, K. 2008. *Natural establishment of tree seedlings in forest restoration trials at Ban Mae Sa Mai*. Chiang Mai Province, Graduate School, Chiang Mai University, Thailand. (MSc thesis)

Thaiying, J., 2003. *Effects of forest restoration on small mammal communities.* Chiang Mai Province. Biology Department, Faculty of Science, Chiang Mai University, Thailand. (BSc thesis)

Toktang, T. 2005. *The effects of forest restoration on the species diversity and composition of a bird community in northern Thailand.* Chiang Mai Province. Graduate School, Chiang Mai University, Thailand. (MSc thesis)

Tucker, N.I.J. and Murphy, T.M. 1997. "*The effects of ecological rehabilitation on vegetation recruitment: some observation from the Wet Tropics of North Queensland*", Journal of Forest Ecology Management, 99: 133-152.

Tunjai, P., Kuarak, S. Elliott and S. Suwanarattana, 2005. *Direct seeding for forest restoration in northern Thailand* Nat. Hist Bull. Siam Soc. 53(2): 175-76 (abstract).

Woods, K. & Elliott, S. 2004. Direct seeding for forest restoration on abandoned agricultural land in northern Thailand. *J. Trop. For. Sci.*, 16(2): 248-259.

Zangkum, S. 1998. *Growing tree seedlings to restore forests: effects of container type and media on seedling growth and morphology.* Chiang Mai Province, Biology Department, Faculty of Science, Chiang Mai University, Thailand. (BSc thesis)

Strategy and challenges for natural forest restoration in Lao PDR

Saysamone Phothisat[1]

Introduction

Lao PDR is landlocked country with the People's Republic of China to the north, Cambodia to the south, Viet Nam to the east, Thailand to the west and Myanmar to the northwest. The total land area is 236 800 km^2. Seventy percent of the total land area is mountainous terrain, forest cover is 41.5 percent nationwide and the population totals 5.5 million people (2008 estimate). Lao PDR's climate is tropical monsoon with the rainy season extending from May to October and the dry season from November to April.

Developmental goals have often taken precedence over forestry, particularly in relation to revenue-generating activities such as mining, hydropower generation and logging. The direct impacts of economic development on forests include deforestation and land conversion as well as forest depletion due to poorly regulated legal and illegal logging[2]. The future forestry situation in Lao PDR is likely to be mixed, with grounds for both optimism and pessimism in relation to economic development and sustainable natural resource management.

In response to the Lao Government's realization of the alarming forestry situation and its commitments to sustainable forest management, the Forestry Strategy 2020 (FS 2020) has been developed and launched. This official guiding document is an effort by the Lao Government and international donors to comprehensively assess forestry-related status, issues and policy and also matters associated with implementation as well as monitoring and evaluation.

The government is promoting collaboration with domestic and international players in several focal areas including plantation development, wood processing, non-wood forest products (NWFPs), forest resource conservation and ecotourism.[3]

Trends in forest resources

Lao PDR's terrain is characterized by three distinct formations: mountains, plateaus and plains. Mountains, at an average height of 1 500 meters, dominate the northern region. The Phou Luang or Annamite Range cuts through Indochina forming a spine

1. Department of Forestry, Ministry of Agriculture and Forestry, Lao PDR. Email: saiphothisat@yahoo.com
2. Forestry Sector Country Outlook for Lao PDR, 2008.
3. National Socio-Economic Development Plan, 2006-2010.

adjacent to the Lao PDR and Viet Nam border and claiming a small area in northern Cambodia. The plains region consists of large and small plain areas distributed along the Mekong River. Three plateaus comprise the Xiengkhouang Plateau in the north, the Nakai Plateau in the central region and the Bolivens Plateau in the south.[4]
The main forest types in Lao PDR are:

- Dry evergreen in the northern region;
- Tropical montage evergreen along highland areas of the Annamite Mountains and Bolivens Plateau;
- Lowland semi-evergreen Dipterocarp on the Mekong River Plain;
- Tropical montage deciduous scattered in the northern region.
- Dry Dipterocarp in the southern region;
- Mixed deciduous in the southern region;
- Pine forest in the Annamite Mountains, Xiengkhouang and Nakai Plateau; and
- Subtropical montane in the northern region.

Figure 1. Topographical map of Lao PDR and surrounding countries

Source: GLOBE (2008).

4. Forestry Sector Country Outlook for Lao PDR, 2008.

Forest land-use change

Three forest categories were established under the Forestry Law No. 06/NA, 24 December 2007 – protection forest, conservation forest and production forest. A high rate of forest loss has seen forest cover figures fall from 70 percent in 1940 to 64 percent in the 1960s, 49 percent in 1982 and 47 percent or 11.2 million hectares in 1992. In 2002, the forest area was 9.8 million hectares or 41.2 percent. It is estimated that about 134 000 hectares[5] of forest *per annum* are being lost or 0.6 percent of the total land area. The government acknowledges that deforestation attributable to unsustainable shifting cultivation, uncontrolled logging, conversion to agricultural land and other land, weak law enforcement and rapid population increase is responsible for widespread poverty.

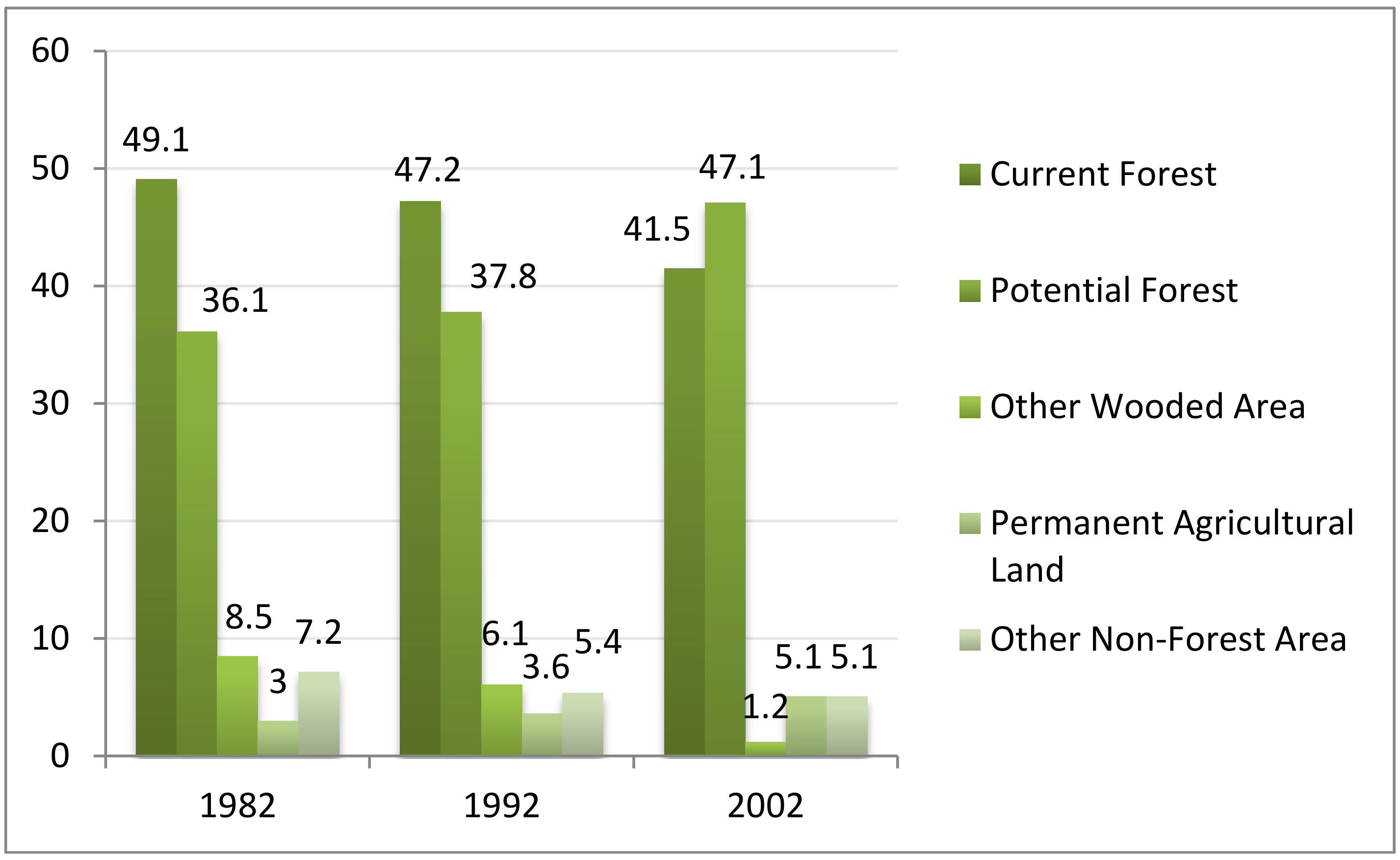


Figure 2. Changes in forest and land use during 1982, 1992 and 2002

Rubber plantations began as a modest way for northern upland Lao farmers to supplement their incomes and they have blossomed into a fast-expanding agro-industry. Major expansion of the crop began around 2002, with substantial foreign commercial interest making inroads into northern Lao PDR. Forest areas across the country are being cleared in ever-increasing volumes to make way for new plantations.

The main drivers of deforestation are:

- Encroachment into the forest for permanent cultivation;
- Shifting cultivation (northern region);
- Commercial timber logging (central and southern regions);
- Forest fires (uplands); and
- Large infrastructure development projects (southern region).

5. Report on the Assessment of Forest Cover and Land Use during 1992-2020, July 2005.

National forest policy

Lao has a short history of implementing its 1996 Forest Law (renewed in 2007) and the 2007 Wildlife and Aquatic Law. The FS 2020, which is endorsed by the government, is the official document guiding development of the forestry sector in line with overall national plans and strategies for socio-economic development and environmental conservation, including the National Growth and Poverty Eradication Strategy.

The Ministry of Agriculture and Forestry (MAF) has adopted a 5-year Agriculture and Forestry Development Plan (AFDP) 2006-2010, which has four targets and 13 measures. Concrete targets for forestry include:

- Forest management programme:
    - Increase forest cover from 9 million hectares (42 percent) to 12 million hectares (53 percent) by 2010;
    - Increase forest cover to 70 percent of the total land area or 16.5 million hectares through management of existing forest and restoration of forest by 6 million hectares by 2020;
    - Restoration of forest by 2.55 million hectares by 2010 and 3.9 million hectares by 2015;
    - Continue detailed forest survey and classification for management according to scientific principles, available technology and current policy and regulations;
    - Ground-level identification of water resource protection and a protection forest management plan of around 8.2 million hectares;
    - Systematic establishment of management plans for 4.7 million hectares of National Biodiversity Conservation Areas (NBCAs) or conservation forest;
    - Acceleration of ground-level identification of production forests with an area of around 3.09 million hectares;
    - Environmental protection for other sectors.
- A shifting cultivation stabilization programme.
- Land-use planning and land allocation programmes.
- Forest law enforcement and governance.

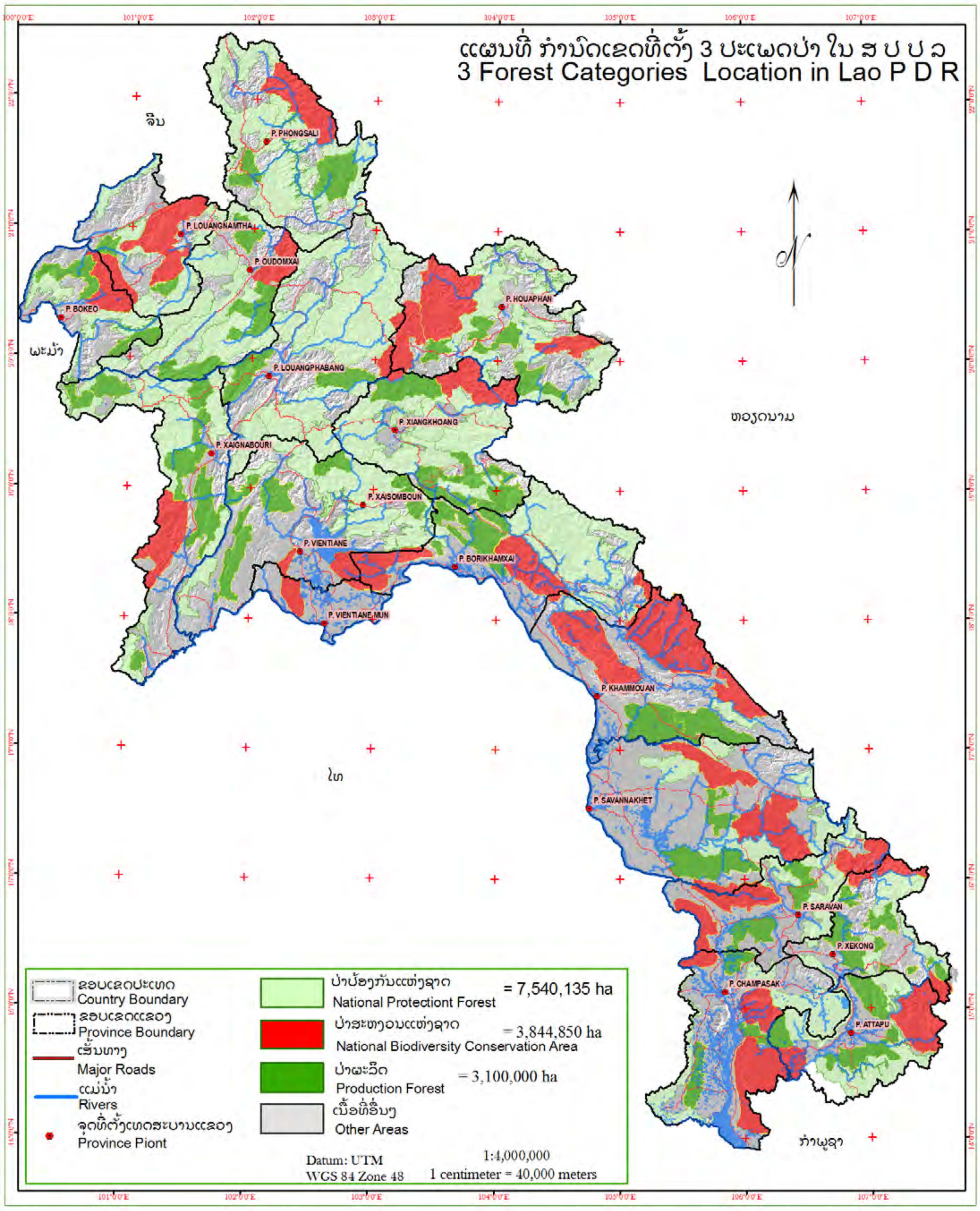


Figure 3. Three types of forest cover in Lao PDR. Protection Forest (blue and brown), Conservation Forest (red and yellow) and Production Forest (green)

Source: PSFM Description (2008).

Forest regeneration

Regeneration Forest is the term for forest areas in a degraded condition that have been designated for regeneration such as young secondary forest regenerating from old fallow forest.

Forests in Lao PDR are important for supplying clean water, supporting conservation, preserving biodiversity and acting as buffers against natural disasters. Water is particularly important for irrigation and hydropower in Lao PDR. Developing a competitive irrigation system is a major government objective to guarantee subsistence in rice production and food security for rural households. In recent years, public investment in the irrigation sector has equaled between 40 and 50 percent of total public investment in the agriculture and forestry sectors. Potential protection forests for 51 watershed areas along main Mekong tributaries and 25 existing and proposed hydropower dams have been preliminarily identified on maps. Water supply is closely linked to forest area.[6]

A forest regeneration policy shall be promoted for individual households and organizations via incentives to regenerate degraded natural forest and young fallow forest areas through supplementary tree planting to increase forest density.

Main objectives

- To preserve and develop national forest resources to meet the demand for timber and other forest products in a sustainable manner.
- To preserve water resources, soil, aquatic life, wildlife and maintain environmental equilibrium.
- To rehabilitate forest and forest land areas to their former natural condition.

Work implementation

1. Regeneration through natural means: This is natural regeneration of vegetation via seeds of various tree species growing in the forest regeneration zone after ground clearing and thinning.
2. Regeneration through supplementary planting: This is supplementary planting of tree species that are suitable for forest regeneration in natural forest areas, especially in areas with low tree density where natural distribution of various tree species is scattered and irregular, or some of the original species are close to extinction or disappearing.
3. Seed planting: Planting of quality seeds in barren forest lands.

Forest regeneration activities

Forest regeneration activities have been implemented irregularly on an annual basis but have been unable to meet set targets (Table 1).

6. Forestry Strategy to the Year 2020 of the Lao PDR, 2005

Table 1. Forest regeneration activities, 1998 to 2008

Year	Action plan (ha)	Activities (ha)
1998-2000		21 600
2000-2001		8 596
2001-2002	161 000	4 083
2002-2003	161 000	155 319
2003-2004	161 000	89 941
2004-2005	161 000	60 687
2005-2006	200 000	62 090
2006-2007	629 000	84 500
2007-2008	629 000	127 000
Total	**2 102 000**	**613 816**

Source: Final Report on Forest Rehabilitation of Department of Forestry, 2008.

The implementation of natural forest rehabilitation in Lao PDR has not gone according to plan because government funding is limited and operational costs are not sufficient to implement activities at local levels. In this context, natural forest rehabilitation/reforestation needs support from international organizations, especially with regard to protection forest management.

Implementation of forestry policy

There are two major actors:

The Department of Forestry (DOF)

The DOF is responsible for the management of forest resources, rehabilitation of degraded forest and plantations.

The FS 2020 is the guiding document for Lao forests and forestry. The government realizes the current inadequacy of forestry laws and policy implementation. The government has therefore made efforts to address outstanding issues in order to continue with its commitment to sustainable forest management. The government has adopted strategies, set targets and made ground measurements to help deliver targets contained in the FS 2020. To reflect the government's commitment to implementing sustainable forest management, progress on implementation of the FS 2020 is reported annually through stakeholder consultation.

Forestry is expected to continue to provide a range of benefits to national economic development as well as to maintenance and improvement of rural livelihoods. However, forest resources are not sustainably managed due to limited human and financial resources for enforcing laws and regulations. There is relatively weak awareness that forestry is of a social character, cutting across the geographical and legal demarcations which frame the social and economic relationships between individuals, organizations and states.

Community forest management is considered as an important, and possibly the only, path to sustainable forest management and poverty alleviation by the government. Hence, it is crucial that an integrated management approach, incorporating links and enhancing understanding between food security, forestry and resource conservation is implemented.

Department of Forestry Inspection (DOFI)

The DOFI addresses forest law enforcement and governance (FLEG) and inspection of forests and rehabilitation efforts.

Challenges

- Lack of alternative livelihood or production systems to replace shifting cultivation in remote areas and access to markets together with lack of social services such as education and health care.
- Incomplete land-use planning including forest zoning and village-level land-use planning and land titling and insufficient resources for management of each land area or forest zone.
- Unclear resource and land tenure.
- Weak coordination between sectors.
- Weak law enforcement and governance.
- Insufficient understanding or ignorance of existing laws and regulations by entrepreneurs and local people.
- Limited human resources and limited financial support.

Assistance needed

- Capacity building at central, local and community levels.
- Information technology development (linkage between the DOF and other sectors).
- Support to the production forest management system including sustainable financial management.
- Strengthening forest ecosystem services, e.g., ecotourism, carbon market negotiation, protection forest and water resource management of hydropower projects, biodiversity conservation, etc.
- Financial support to the forest regeneration and restoration project and tree seed improvement both in terms of capacity and quality.

Conclusion

The implementation of natural forest rehabilitation in Lao PDR has not gone according to plan because government funding is limited and operational costs are not sufficient to implement activities at local levels. In this context, natural forest rehabilitation and reforestation need support from international organizations, especially with regard to protection forest management. A forest regeneration policy shall be promoted for individual households and organizations via incentives to regenerate degraded natural forest and young fallow forest areas through supplementary tree planting to increase forest density.

The Lao Government has attempted to address deforestation with policy initiatives and annual logging quotas among other thrusts. These initiatives have, however, had poor results on the ground. Lack of clarity in procedures, including those related to plantation establishment, together with limited financial resources and human capacity and weak law enforcement are major obstacles. The direct impacts of economic development on forests in Lao PDR include deforestation and land conversion as well as forest depletion due to poorly regulated legal and illegal logging. In response to the Lao Government's realization of the alarming forestry situation and its commitments to sustainable forest management, the Forestry Strategy 2020 has been developed and launched. The government is also promoting collaboration with domestic and international players in several focal areas including plantation development, wood processing, NWFPs, forest resource conservation and ecotourism.

Literature cited

Lao Forestry Law, No. 06/NA, dated 24 December 2007.

Forestry Strategy to the Year 2020 of the Lao PDR, No. 22-/PM, dated 9 August 2005.

Report on the Assessment of Forest Cover and Land Use during 1992-2002.

Forestry Sector Country Outlook for Lao PDR, 2008.

Roles of Department of Forestry, 2007.

Roles of Department of Forestry Inspection, 2008.

Operation Manual for Participatory Sustainable Forest Management in Production Forest areas, Volume 1. Participatory Sustainable Forestry Management Model (PSFM) Description, 2008.

The National Movement on Forest and Land Rehabilitation in Indonesia

Noviar[1]

The National Movement on Forest and Land Rehabilitation

Indonesia is endowed with 17 000 small, medium and large islands, spread along the equator. The land area encompasses 189.15 million hectares (Indonesia's Statistical Bureau BPS, 2007). Forest occupies 120.35 million hectares or 63.44 percent of the total land area. Indonesia's tropical rain forest, a greater portion of the forest area, serves as the world's lung; it absorbs greenhouse gas emissions and assists in balancing global ecosystems. From the domestic standpoint, the rain forest has economic, social and environmental roles for communities within and outside the forest area.

Forest utilization and industrialization have resulted in deforestation and forest degradation. The Directorate General of Land Rehabilitation and Social Forestry has indicated that critical land areas cover about 77.8 million hectares, of which roughly 47.6 million hectares is lightly critical, 23.3 million hectares is regarded as medium rate critical and about 7 million hectares are severely critical.

These critical land areas have difficulty in supporting productive economic and environmental functions, including capacity to absorb greenhouse gases, in particular CO_2. In this context, tropical forests should be returned to their original natural state through rehabilitation and pristine forests should be maintained and conserved.

In the not too distant past, Indonesian forestry culture was dominated by large-scale forest harvesting. This resulted in substantial depletion of forest quality and quantity, and generated critical land areas on a wide scale via forest degradation and deforestation. When the government formally limited the degree of forest exploitation by setting a forest-harvesting threshold, illegal exploitation took place. Thus forest degradation and destruction could not be mitigated by enacting laws and regulations, especially those that limited the exploitation rate. To overcome the problem, the government adopted a cultural approach to empower community forest management. The Government of Indonesia promulgated the Program of National Movement to Rehabilitate Forest and Critical Lands in 2003, which continues today. The target for 2003-2008 was 3 million hectares in Indonesian watersheds nationwide.

The National Movement on Forest and Land Rehabilitation was mandated by the Forestry Law of 1999. The law stated that forested area should encompass a minimum of 30 percent of the total land area. In particular, forest should protect watershed

1. Directorate General of Land Rehabilitation and Social Forestry, Ministry of Forestry. fx_noviar@yahoo.com

areas because they are important for agriculture and provision of potable water for communities. The rest of the forest should function well to develop economic, social and enviromental benefits. However field observation has indicated that in some cases, what is formally called forest, is 'barren' land, or savannah-type land where unproductive forest grows sparsely or is infested with *Imperata cylindrica*.

The National Movement specified that forest benefits should spread to other economic sectors. The multidimensional benefits of rehabilitation and rehabilitation programmes should be reaped by the parties that promote such activities. Thus, programmes are executed through closer cooperation between the government (central, provincial and district levels) and local communities. The reasons for such cooperation are based on the origins of forest loss: (1) geomorphological properties – geology, soil type, topography that determine the degree of erosion, landslides and drought; (2) climate, especially rainfall intensity; and (3) human activities (more important) including encroachment, excessive logging, setting of forest fire and land utilization that neglects conservation measures.

There are three forest and land rehabilitation systems under the National Movement program: (1) activities induced by incentives, (2) the full cost type and (3) model development, described below.

- The first system is adopted by communities outside forest areas. The community participates in rehabilitation activities. The government provides high quality seeds and funds for conservation structures. The main attributes are stakeholder participation, provision of adequate supplies of high quality seeds and established organizations that can run the project independently. The system is used for the rehabilitation of community forests as well as environmental enhancement such as the creation of urban forests, trees along highways and soil conservation.
- The second system is used for forest under the management of the Ministry of Forestry – conservation, protection and production forest areas. The activities are fully funded by the government, including the provision of seeds and seedlings, planting, maintenance of juvenile plants and construction of conservation structures; it involves communities within and adjacent to forest areas.
- The third system is a movement to increase forest productivity and participation of the community. It is basically an endeavour to find techniques for land management and community participation. This is fully funded by the government. The funds are channeled to the stakeholders through block grants to farmers' groups for the conservation of rare species and the application of intensive silviculture, rehabilitation of critical lands using the potting system, the development of seed production areas, social forestry and community business partnerships.

Given current problems, these systems should be adopted by future forestry programmes to address forestry development holistically. Forestry development needs to create a favourable investment climate that enables the business sector to stimulate economic growth (Pro-growth).

Directly or otherwise, high economic growth created by the National Movement on Forest and Land Rehabilitation is a safety valve for high unemployment in Indonesia. The National Movement, as a forestry programme, is not only capital-intensive but also very suitable in the context of Indonesian demographics that constantly require job opportunities. The National Movement has been a buffer for the Indonesian economy (Pro-job).

The National Movement needs to enhance people's prosperity further. Lessons learned from 1965 to 1997 indicated that economic growth and job creation failed to improve people's lives due to the absence of distribution effects. Trickle-down effects created better conditions for only a limited number of people. The National Movement needs to ensure that benefits are distributed evenly, especially for the poor (Pro-poor).

To evaluate National Movement performance vis-à-vis Pro-growth, Pro-job and Pro-poor, a review was conducted in 31 watersheds throughout Indonesia. Based on 2003-2007 data, the review revealed:

1. Pro-job: The National Movement could absorb on average 35,785 persons/year for 31 watersheds; Indonesia's overall absorption is 1,109,335 persons/year.
2. Pro-poor: The National Movement improved family income on average by 16.91 percent (from Rp.4.32 million/family/year to Rp.5.09 million/family/year).
3. The National Movement also achieved participation of 30,721 forest farmers' groups (1.54 million families). At four people per family on average, the National Movement recruited 6.1 million people.
4. The absorption of labor and development of institutions are expected to support economical growth of people (Pro-growth)

To increase its success, the future trend of the National Movement should consider the following options:

1. Optimizing the National Movement by creating multiyear contracts, incorporating state and private forestry companies especially in forest and land rehabilitation.
2. Utilizing global tools for rehabilitation such as the Clean Development Mechanism and Reducing Emissions from Deforestation and Forest Degradation.
3. Providing credit for communities that create plantations inside forest areas.
4. Direct investment in industrial forest plantation.
5. Developing partnerships between the private sector and communities (that own lands) as well as partnerships between estate holders, local governments and the forestry sector.
6. Rehabilitation by expanding community forest activities.

BirdLife Indonesia's Forest Restoration Program[1]

In 2004, the Ministry of Forestry issued a policy decision (No. 159/Menhut-II/2004) which allowed degraded forests to be managed for ecological restoration. After three years, the Forestry Minister issued the first ever 'License for Management of a Production Forest for Ecosystem Restoration' in August 2007.

The restoration policy does not just open up a new way of managing forests, it has attracted a whole new type of investor into the forestry sector. Conservation and environmental funds have until now been used in trying to persuade or force the government and logging companies to do a better, more responsible job of managing the forest estate. Now there is a tantalizing prospect of doing something much more concrete with scarce conservation funding – getting hold of a concession and proving how management for restoration can be good for the forest and good for local communities and economies.

The Ministerial Decision on Ecosystem Restoration in Production Forests defines restoration as management with the objective of returning the biological (trees, wildlife) and non-biological (water cycling, carbon recycling) elements of the forest to their natural balance. According to the policy, any production forest reserve can be designated for restoration. Forest restoration can be as simple as protecting the forest from further damage, or it can include planting native species or management to encourage regeneration. It may include returning watercourses to their natural state and management to nurture specific habitats required by endangered, forest-dependent species. It allows for use of non-wood forest products by local communities, but forbids the commercial extraction of timber.

The area identified for restoration was a production forest covering 101 000 hectares on the border between Jambi and South Sumatra. The licence was presented to PT Restorasi Ekosistem Indonesia, a company created to hold the licence by the BirdLife consortium – Burung Indonesia, the Royal Society for the Protection of Birds and BirdLife International.

The first action of the new management was to stop the logging that had been conducted in the forest. This action will be continued until the natural balance of the ecosystem has been restored. Otherwise, to accelerate natural regeration in the restoration areas, more than 37 000 endemic seedlings were planted, such as meranti, bulian, durian hutan and dan merpayang tree species.

---

1 Sourced from interviews and Indonesia Forestry Magazine, 2008, XI Edition, Jakarta. Also: www.burung.org/detail_txt.php?op=news&id=259; www.burung.org/detail_txt.php?op=news&id=257; www.burung.org/detail_txt.php?op=news&id=255; www.burung.org/detail_txt.php?op=news&id=247

In the future, BirdLife Indonesia has a plan to expand forest restoration throughout Indonesia's production forest. It will develop 1 million hectares of forest restoration until 2020.

From the lessons learn by PT Restorasi Ekosistem Indonesia, next year the Ministry of Forestry will develop 100 000 hectares throughout Indonesia's conservation forest. The Ministry of Forestry believes that forest restoration is the best choice to overcome forestry problems in Indonesia.

Recent forest restoration initiatives in Sabah, Malaysia

Robert C. Ong[1]

Introduction

The forest industry

Throughout the 1970s and 1980s, revenue generated from forests consistently accounted for more than 50 percent of the annual state government revenue. The emergence of the industry to such prominence was nurtured by abundant timber supplies from the natural forests in the past. Despite the gradual decline of this contribution in the 1990s, forestry remains a significant sector of Sabah's economy, contributing 22 percent (or RM510 million) of the total government revenue in 2008 (Sabah Forestry Department 2009). Ironically, the heavy dependence and tremendous capacity of the industry to generate individual wealth and government revenue has led to the rapid decline and degradation of forest resources. Today, the future of the industry is shrouded with uncertainty, due to drastically declining domestic timber supplies, particularly from the natural forests. But despite declining timber output, forestry remains a dominant land use in Sabah.

Forest resource administration

A noteworthy feature of forest resource administration in Malaysia is that all matters pertaining to land, including forestry, fall under the jurisdiction of the respective states. As such, the states maintain full rights over the management of their forest lands, and are empowered to enact laws and form forestry policies independently. The three principal agencies entrusted with forest resource management in Sabah are the Forestry Department, the State Parks and the Wildlife Department.

Forested lands, including both natural and planted forests, are found mainly within areas designated by law as Forest Reserve, State Park, or Wildlife Sanctuary. Together, these three classes of forest lands account for 52 percent (3.87 million hectares) of Sabah's landmass and are collectively referred to as Permanent Forest Estate (PFE) (Sabah Forestry Department 2005). Few native forests are left outside the boundaries of the PFE.

Management

The PFE is managed for multiple uses, i.e., timber production, recreation, biodiversity conservation and ecosystem services. In terms of management, Sabah's PFE can be broadly categorized according to two management functions (Table 1).

---

1. Senior Research Officer, Sabah Forestry Department, Malaysia. Email: Robert.Ong@sabah.gov.my

Table 1. Permanent Forest Estate according to management function in Sabah

	Area (ha)	% of total land area
Conservation		
- with legal status: 1 182 208 ha	1 377 208	18.6
- production forests designated for		
- conservation: 195 000 ha		
Production		
- natural forest management: 2 039 480 ha	2 489 480	33.6
- tree plantations: 450 000 ha		
Total	**3 866 688**	**52.2**

Forest restoration/rehabilitation initiatives

More than 90 percent of Sabah's production forests have been logged or burned, leaving behind residual forests with varying levels of disturbance to regenerate. In addition, some 35 000 hectares throughout the state have been illegally occupied for agricultural crop cultivation. Over the last three years, the Forestry Department has taken drastic action to reclaim encroached lands. Today, forest restoration is a key agenda of the Sabah Forestry Department. Generally, forest restoration and rehabilitation efforts take two forms: 1) for commercial production of timber; and 2) for conservation.

Restoration for commercial production

As timber resources from natural forests decline, tree plantations are expected to become increasingly important as a source of raw material supply for the wood-based industry. About 450 000 hectares within the PFE have been designated for timber production by the intensive cultivation of short-rotation (<15 years) timber trees (Ong and Sinajin 2003). Areas approved for tree plantations are mainly areas where the forest has been determined to be degraded or poorly-stocked. As of December 2008, the total area of established tree plantations was about 200 000 hectares (Sulaiman *et al.* 2007). Such restoration efforts are largely undertaken by private companies as commercial ventures on a relatively large scale (usually exceeding 1 000 hectares). Therefore, they are also funded privately. These companies have concession rights ranging from 50 to 100 years. Commonly planted species are:

Facaltaria moluccana	Batai
Acacia spp.	Acacia
Hevea brasiliensis	Rubber
Anthocephalus cadamba	Laran
Octomeles sumatrana	Binuang

Assisted natural regeneration (ANR)/timber stand improvement: This activity is largely carried out in areas managed directly by the Forestry Department. Since 2006, the department has consistently treated about 10 000 hectares a year. ANR in this respect entails the cutting of vines (particularly climbing bamboo) and the selective liberation of potential crop trees. The cost of ANR ranges from RM250-350 (US$70-100) per hectare.

Restoration for conservation

Over the last two years, there has been increasing interest in restoring forest for conservation purposes. Such efforts largely receive external funding (Table 2). They mostly focus on the restoration of critical wildlife habitat, particularly for orangutans. Forest restoration in this respect involves the planting of a mix of native species, including the planting of selected native fruit trees that may later serve as a source of food for wildlife. Such plantings cost about RM3 500 (US$1 000) per hectare. The government has also taken bold measures to destroy structures and crops established illegally within forest reserves. Here, reforestation activities are promptly conducted to deter any further encroachment.

The catastrophic Indian Ocean tsunami of December 2004 triggered renewed interests in the protection and management of mangroves. The federal government subsequently allocated substantial funds for the restoration of mangroves (Ong and Petol 2007). However, Sabah's mangroves are largely intact. Not more than 1 500 hectares have been identified for restoration. Therefore, the restoration of mangroves is not considered a critical issue in forestry.

Table 2. Financial allocation for restoration purposes, 2003-2008

Funding agency	US$ million
Sime Darby	6.0
NewForest	5.0
World Wide Fund for Nature	1.0
HSBC	0.6
IKEA	2.0
Innoprise-FACE Foundation	2.5
Government funding	6.0
Others	0.5
Total	**23.6**

Constraints and opportunities

Political support

Political support, as well as support from the highest levels of government administration, is seen as an important determinant of success for any forestry projects. Politicians are key decision-makers, particularly in the approval or allocation of large parcels of land for restoration, as well as the approval of funds. In order to get this support, the Forestry

Department has to be seen as a highly credible and relevant government agency that reflects government policy in action. For example, engaging local communities in restoration contracts is a positive way of rallying political support.

Procurement of planting material

The procurement of planting material, both in terms of quantity and quality, can be a limiting factor in large-scale restoration projects, particularly for native species. In an effort to promote and support the planting of native species, the Sabah Forestry Department has initiated the establishment of seed orchards of native trees. In addition, the fruiting of trees in the wild is also being continuously monitored. Where possible, the Forestry Department buys seedlings from nurseries operated by rural communities. The department also gives special permission to local communities to collect seeds and wildlings from selected forest reserves.

Supervision

Most planting failures can be traced to poor field supervision. Therefore, good supervision is perhaps one of the most important factors in determining the success of any restoration efforts. Supervision at all levels is necessary, from the hardening and selection of seedlings, through to the planting and tending stages.

Establish and maintain good models

Models serve to showcase good forest management and are useful tools for demonstrating the viability of forest restoration projects, especially to policy-makers and prospective financiers. Models should be developed to demonstrate the various technical and functional aspects of forest restoration in an operational scale, e.g., timber stand improvement, enrichment planting, forest plantations and local community participation.

Funding

Forest restoration is a costly endeavour and funding can be a crucial factor in determining the success of any restoration project. Before embarking on any restoration projects, it is important to ensure that there are sufficient funds to tend and maintain plantings until they are fully established. The Forestry Department continues to explore innovative means of financing forest restoration. One recent initiative is an agreement with a USA-based company, NewForest, to establish the ‘Malua Bio-Bank’ covering the entire Malua Forest Reserve. The idea is to sell so-called biodiversity credits (expressed in units of 100 m^2) over the entire reserve.

Fires

Fires can be a serious threat to forest rehabilitation efforts, particularly in *Acacia* plantations. Since most fires are induced by humans, public awareness and enforcement measures during periods of drought are important. Since the last El Niño event in 1998, the department has run an active training programme in fire prevention and control. At the same time, most forestry districts are equipped with the necessary firefighting equipment.

Conclusion

The tasks of restoring degraded forests are confronted by many challenges. However, the fact that trees are renewable resources, presents a basis and an opportunity for sustainable management. For any restoration project to be successful, security of land tenure is imperative, especially because this aspect is also a key criterion for forest certification. Therefore, for permanent land use, there must be a firm government resolve to recognize forestry as a legitimate and permanent use of land, either by legislative decree or through strict forest policies, thereby removing the option for conversion. But amidst the mounting pressure for land, the challenge will be to convince the public, as well as policy-makers, to maintain the status quo in the area of forest reserves designated for forestry use (particularly timber production), and to recognize that this particular class of land as an asset will remain more valuable under forest cover as opposed to other forms of land use.

Funding forest restoration is a central issue for forestry in Sabah today. Should funds be made available, timber-related activities in natural forests would best focus on timber stand improvement and restoration. For purely economic reasons, it appears more than likely that forest plantations will eventually replace natural forests as the principal source of commercial timber in Sabah. Given sufficient time, natural forests can still be expected to contribute to timber production as their timber productivity is gradually restored. However, production from natural forests will probably be best managed for high value timber crops on long cutting cycles of not less than 35 years, and any timber stand improvement activities in logged forests would best be considered as a restorative measure rather than an economic venture. For timber production, the forest management model most likely to succeed in the future would be a combination of intensively cultivated forest plantations and extensively managed natural forests. In addition, provisions for environmental services, as well as recreational use, are expected to become a more prominent aspect of integrated forest management.

How to add socio-economic value to degraded forests, even during a prolonged cessation of timber production, is the challenge confronting forestry in Sabah. The importance of a highly innovative and effective forestry department in surmounting such a challenge cannot be overemphasized. The ultimate test of competency for the

Forestry Department in Sabah will include influencing land-use policy and public opinion in support of forestry, sourcing of badly needed funds for forest restoration and adapting to the changing values of a society that is becoming increasingly influential in decision-making.

Literature cited

Ong, R.C. & Petol, H. 2007. *Sabah's mangrove forests: towards conservation and sustainable use.* Sabah Forestry Department. 38 pp.

Ong, R.C. & Sinajin, J. 2003. The status and management of production forests in Sabah. *In Proceedings of the conference of forestry and forest products research 2003: forestry for society*, 6-8 October, 2003, Kuala Lumpur, Malaysia.

Sabah Forestry Department. 2005. *Forestry in Sabah*. 176 pp.

Sabah Forest Department. 2009. *Annual report 2008*. 315 pp.

Sulaiman, R., Mohammad, A., Lapongan, J. & Ajik, M. 2007. Revitalizing forest plantation development in Malaysia, with special reference to Sabah. *In Proceedings of the 14th Malaysian forestry conference, Kota Kinabalu. 12-16 September, 2005*, pp. 297-316.

Forest resources and regeneration in the People's Republic of China

Wushe Cui[1]

Basic forest resource information

Vast in area, China is endowed with favourable geographical and climatic conditions. Its territory extends from north to south crossing many types of climatic zones. Distributed from north to south are coniferous forest, mixed coniferous and broadleaf forest, deciduous broadleaf forest, evergreen broadleaf forest, monsoon rain forest and rain forest. The rich varieties of plants and forests have formed unique, diversified and colourful forest landscapes.

The country has 169.02 million hectares of forested land, including 142.79 million hectares of forest stand, 21.39 million hectares of economic forest and 4.84 million hectares of bamboo forest.

The area of natural forest totals 115.76 million hectares, of which forest stand covers 110.49 million hectares, economic forest 2.08 million hectares and bamboo forest 3.19 million hectares. Human-induced forest covers an area of 53.26 million hectares, of which forest stand is 32.30 million hectares, economic forest 19.31 million hectares and bamboo forest 1.65 million hectares.

The forest stand's timber volume is 84.73 m^3 per hectare; natural forest stand timber volume is 95.87 m^3 per hectare; and in plantations it is 46.59 m^3 per hectare. The average yearly growth of forest stand comes to 3.55 m^3 per hectare, the average crown closure is 0.54 and the average diameter at breast height (DBH) is 13.8 cm.

The geographical distribution of forest is closely related to natural conditions, social and economic development. As a result of human activities and natural calamities over a long period of time and unbalanced economic development among different regions, the geographical distribution of forest is extremely uneven in China.

The drainage area of the seven major rivers constitutes nearly 50 percent of the total national land area. The total forest area and stocking volume account for more than 70 and 60 percent of the country's total respectively. The area and stocking volume of the forest in the drainage areas of the Heilongjiang River and Yangtzi River constitute about 50 percent of China's total forest area respectively (Table 1).

1. Department of Forest Resources Management, State Forestry Administration, PR China. Email: c.wushe@263.net

Table 1. Forest distribution by river valleys

Unit	Forest coverage (%)	Forest area (10 000 ha)	Forest stocking volume (100 M m³)
Yangtzi River	30.53	5 495	31.68
Helongjiang River	45.29	3 866	32.06
Zhujiang River	39.91	1 765	6.96
Yellow River	13.62	1 025	4.10
Liaohe River	23.50	516	1.37
Haihe River	11.40	299	0.50
Huaihe River	11.41	307	0.87

The land area covered by the five major forest regions makes up 40 percent of the country's total, the forest area accounts for nearly 80 percent of the country's total forest area and the stocking volume more than 90 percent of China's total (Table 2).

Table 2. Forest distribution by five major forest regions

Unit	Forest coverage (%)	Forest area (10 000 ha)	Forest stocking volume (100 M m³)
Northeast Inner Mongolia Forest Region	62.17	3 778	31.56
Southeast Low Mountain and Hilly Forest Region	48.18	5 358	21.03
Southwest Mountains Forest Region	20.69	3 911	49.13
Northwest Mountains Forest Region	36.81	479	4.90
Tropical Forest Region	38.91	1 030	9.03

The Sixth National Forest Inventory results show that great changes have taken place in China's forestry. The forest area and stocking volume have presented an increasing trend, the coverage of forest has steadily increased, the forest structure has further improved and forest quality has also been enhanced. Forest conservation and development have now entered a new historical stage.

Forest regeneration in China

In the National Standard Code of Forest Harvesting, there are three kinds of forest regeneration as follows:

Artificial regeneration

Artificial regeneration is used in the following situations:

- Changing species composition.
- Clear-felling of sites.

- Renovation of low-yield (low-benefit) forest after clear-felling.
- Where there are skid tracks, landings, temporary camps and quarries after clearing for forest rehabilitation.
- In areas for regeneration of industrial raw material plantations and economic forests.
- At sites damaged by improper or illegal harvesting.
- At sites relatively difficult to regenerate by natural means, or difficult to regenerate to the required standard in a specified period.

Artificial assisted natural regeneration

At the following sites where the regeneration standard cannot be reached by natural means in a specified period, artificial supplementary measures should be taken to promote natural regeneration:

- Shelter-wood harvested sites.
- Low-yield (low-benefit) forest land for enrichment or integrated renovation.
- Harvested areas with many reserved natural seedlings and young trees of target species, which are unevenly distributed or difficult to regenerate to the required standard within the specified period.

Natural regeneration

Natural regeneration is used where there is:

- A harvested area after selection cutting and shelter-wood cutting.
- Low yield (low-benefit) forest land after selection cutting.
- A harvested area with many reserved natural seedlings and young trees of the target species, which are evenly distributed and can reach the regeneration standard within the specified period.
- A harvested area with many reserved, evenly distributed seed trees for natural seedlings, or with trees of good sprouting capacity, which can reach the regeneration standard in the specified period.
- A harvested area to be kept as a natural stand, in good condition, with sufficient rainfall and capacity for natural seedlings and sprouting.

At sites where the regeneration standard cannot be reached by natural means in a specified period, artificial supplementary measures should be taken to promote natural regeneration, i.e., in:

- Harvested areas with many reserved natural seedlings and young trees of the target species, which are unevenly distributed.
- Other harvesting areas that suit natural regeneration.
- Low-yield (low-benefit) forest land for enrichment or integrated renovation.

Regeneration requirements

- Forest management units (enterprises) should plan for regeneration of unregenerated cut-over areas, burnt-over areas, open land in forest and barren areas suitable for afforestation. These areas should be regenerated within a specified period.
- The survival rate is generally more than or equal to 85 percent of the same year for artificial regeneration; in northwest China and areas with annual mean precipitation of 400 mm or less it is more than or equal to 70 percent; for promoted natural regeneration it is more than or equal to 85 percent.
- The survival rate in clear-felling harvested areas is more than or equal to 80 percent; in northwest China and areas with annual mean precipitation of 400 mm or less it is more than or equal to 65 percent.
- The regeneration frequency should be more than or equal to 60 percent in harvested areas of selection cutting, and more than or equal to 80 percent for the shelter-wood cutting area.
- The regenerated area with a qualified survival rate in the first year should reach 95 percent of the total harvested area. The regenerated area with a qualified preservation rate in the third year should reach 80 percent of the total harvested area.
- Appropriate regeneration methods should be selected for forest regeneration by scientific selection of tree species, mixture of suitable sites, use of superior seeds and seedlings, good site preparation, proper density, careful stewardship and timely tending. For details, refer to the National Norms GB/T15776, GB/T15163 and GB/T18337.3.

Forest management policies in China

China is a country deficient in forest resources. To increase them, improved afforestation and forest maintenance nationwide are proceeding at an accelerated pace. At the same time, a series of measures have been taken to reduce the consumption of forest, mainly based on the annual allowable cut. China's forest management system includes forest harvesting, timber transportation and timber processing.

Management system for forest harvesting

According to the provisions of the Forest Law and Regulations on Implementation of Forest Law, the management system for forest harvesting includes the annual allowable forest cut system, the licence-based harvest system and the annual timber production planning system.

Annual allowable forest cut system

Article 29 of the Forest Law stipulates that in compliance with the principle that the consumption of timber shall be lower than growth, the state shall impose strict controls over the annual forest cutting volume. In the formulation of annual cutting quotas, state-owned enterprises, institutions, farmland, factories or mines shall be calculated as units for state-owned forests and trees, and the county as a unit for collectively used forests and trees and privately owned trees. The competent forestry authorities at the provincial, autonomous region and directly administered municipality levels shall compile a summary sheet, which shall be submitted to the State Council for approval after examination by the people's government at the same level.

Article 28 of the Regulations on Implementation of Forest Law stipulates that the annual cutting quotas approved by the State Council shall be verified every five years.

Since its implementation in 1987, the annual allowable forest cutting quota system has played a significant role in protecting forest resources, curbing consumption of forest resources and cracking down on illegal logging; it has been improved through practice. During the 8th Five-year Plan period commercial timber, farmers' timber for private use, timber for the cultivation industry and fuelwood were all included in the annual forest cutting quota; thus, management of the gross volume of forest cutting and control over each subquota are undertaken for forest resource consumption and its structure. During the 9th, 10th and 11th Five-year Plan periods, a subquota based on the category of harvest was added, thus making the annual forest cutting system more scientific and standardized.

Licence-based forest harvest system

This is an important measure to ensure the implementation of the annual forest cut quota system and an effective way to curb unwise consumption of forest resources, sustain their growth and prevent deforestation.

The Regulation on Protecting Forest and Developing Forestry issued by the State Council makes it clear that the licence-based forest harvest system shall be implemented across the country. According to the Forest Law, to cut trees, it shall be necessary to apply for a cutting licence and conduct the cutting according to the provisions of the licence. The issuing authorities for cutting licences include competent forestry authorities or other authorized sectors or institutions. Cutting licences cannot be issued for the following situations:

- Harvest of shelterbelts and forests for special use for non-tending or non-regenerating purposes; or cutting of trees during mountain closure of trees during mountain closure periods or in closed mountains.
- Reforestation tasks have not been fulfilled following harvest in the previous year.
- Preventive and remedial measures have not been taken when significant deforestation, forest fires or pests and diseases have occurred in the previous year.

Management system for timber production planning

Article 30 of the Forest Law provides that the national government develops the annual production plan, which shall not exceed the approved annual allowable cut. Article 29 of the Forest Law provides that cutting of forest and trees for sale must be included in the national annual timber production plan.

Article 39 of the Forest Law provides that cutting of forest and trees in excess of the timber production plan shall be punished as is done for deforestation.

The management system is in line with the reality and forest situation of China. It is among the legal means for the government to control and regulate the annual volume of commercial timber and to ensure that the annual cutting of commercial timber shall not exceed the cutting quota. The annual timber production plan as well as the legal criteria for timber production are developed by the State Council.

Management system for licence-based timber transportation

This is a management system for forest resources, in parallel with the annual allowable cut and the licence-based timber harvest system. It is an important measure to maintain discipline in normal timber transportation and prevent illegally cut timber from entering circulation.

Article 37 of the Forest Law provides that transportation licences issued by forestry authorities are mandatory for transporting timber out of the forest, except for timber allocated by the national government. Article 35 of the Regulations on Implementation of the Forest Law provides that the timber transportation licence shall be valid from the source to the destination and must accompany the timber. No institution or individual can be a carrier without a timber transportation licence.

There are two categories of timber transportation licences: (1) between provinces; and (2) within a province. The timber transportation licence between provinces shall be designed and printed out by the forestry authority of the State Council. The timber transportation licence shall be issued by the forestry authority at the provincial level or by other authorized institutions.

The timber transportation licence within a province shall be issued and printed out by the provincial forestry authority at or above the county level.

Management system for timber processing

All of the aforementioned systems have given rise to an integrated management system. Article 34 of the Regulations on Implementation of the Forest Law provides that timber processing in forest areas must gain the approval of forestry authorities of the people's government at or above the county level. No institutions or individuals are allowed to purchase timber logged without cutting licences or from other illegal sources. The licence-based system for timber processing is implemented across most provinces. Institutions or individuals engaged in timber processing must apply for and receive the timber-processing licence from forestry authorities at or above the county level before applying for the business licence from industrial and commercial authorities. Otherwise the industrial and commercial authorities shall not issue the business licence.

Opportunities for including ANR in reforestation in China

Before the 1990s, most of the plantations in China comprised one-species forest and were human-induced. Now, with more and more attention being paid to ecological benefits and the environment, natural forest, semi-natural forest or unevenly aged and mixed-species forest are receiving more and more attention. In this context, the Chinese Government is revising old or devising new administration policies, technical standards or related regulations. This will motivate forest managers to use natural elements to build or rebuild forests. Consequently, ANR will become increasingly more important in forestry production and will play a greater role in reforestation schemes.

Literature cited

State Forestry Administration. 2005. *7th Forest inventory report in China.* Janu, P.R. China, State Forestry Administration.

Bureau Quality and Technical Supervision in China. 2005. *Code of forest harvesting.*

Bureau Quality and Technical Supervision in China. 1995. *Technical regulations for afforestation.*

Advancing the application of assisted natural regeneration for low-cost forest restoration in Viet Nam

Vo Dinh Tuyen[1]

Forest status and forest degradation in Viet Nam

The forests of Viet Nam have dramatically decreased during the last 60 years, even though there has been an increase in their area recently. Before 1945, when Viet Nam was under French colonial rule, forests had been harvested heavily for timber and poles as well as for rubber and coffee production. However, at that time the forest area was still considerable as it covered around 43 percent of the country. From the early 1960s to 1975, the forests of Viet Nam were severely damaged by the long war with the United States, overexploitation and shifting cultivation. By 1976, the total area of forests had been reduced to 11.2 million hectares (covering 33.8 percent the country), of which only 10 percent remained intact. Since 1976, forests have continued to be destroyed for many reasons. As a result, forest cover had declined to an estimated 30 percent in 1985, and 27.7 percent in 1995.

In 1998, the 5 Million Hectare Reforestation Programme (5 MHRP) was launched with a target to plant 5 million hectares of forests by 2010, restoring the forest cover to 43 percent. The programme has aimed not only to reforest, but also to protect existing natural forests. As a result, the forest cover of Viet Nam has gradually increased. In 2008, the forest area of Viet Nam was over 13 million hectares, of which over 10 million hectares were natural forests and over 2.5 million hectares were plantation forests, resulting in forest cover of 38.7 percent.

Planted forests in Viet Nam are distributed unequally, due to the different land conditions. The Red River Delta Region and Central Highlands have less planted forest compared to other regions of the country. The Northeastern Region, the Northern Central Region and the Coastal Plains Region have numerous plantation forests. In these areas, the wood-processing sector has developed and made a notable contribution to the local economy.

Overview of policy-level instruments for forest restoration and rehabilitation

The National Assembly of Vietnam has ratified the Law of Forest Protection and Development. This law has concretized the allocation of forest-planting land to organizations, individuals, households and communities in the form of leasing the forest and forest land over a long-term period to make good profits from forestry production.

1. General Forestry Department. Email: tuyendof@gmail.com

The state gives priority to the allocation of land and forest to local communities, cooperatives and householders for management purposes and to derive long-term benefits from definitive planning by jurisdictional levels from central to provincial areas. This encourages the establishment of intensive plantations in many forms, for example households and individuals lease or merge their own stocks, including forest and forest land under their tenure after leasing from the government. These changes have informed public opinion and enhanced local awareness on the value of planting forests. The Government of Viet Nam (GoV) acknowledges the role of different economic sectors in forest protection and development. This facilitates the policy of developing a multisector commodity economy and fosters a market-oriented mechanism under the management of the GoV. It has generated many good results. The National Forest Strategy, 2006-2010 has been approved to help development of the forest sector and has mobilized overseas investment in this context.

There are also several policies related to landownership, forest management, finance, science and technology that help to encourage stakeholders to invest in the forest sector.

Recent efforts at the national level for promoting natural forest restoration and rehabilitation

From 1992 to 1998, the GoV initiated two forest planting programmes to address environmental problems related to deforestation: Programme 327 and the 5 MHRP. Programme 327 was launched for watershed protection. The 5 MHRP has wider scope aiming at establishing forests of every category.

Programme 327 – Watershed Protection Programme (1992-1997)

A precursor of the 5 MHRP – Greening the Barren Hills, also known as Programme 327 – was initiated in 1992. Originally the programme had a wide range of objectives ranging from “re-greening the major part of the degraded hills” to “creating incomes to the State and consolidating the national security”. Later, in 1996, the programme was re-emphasized to concentrate on the protection and re-establishment of watershed and special-use forests.

The programme had a strong top-down and state control emphasis. All financing took place through state farms and enterprises. In areas where such institutions did not exist, they were formed for the sole purpose of obtaining financing for plantation projects. Project approval was also a complex process initiated at the district level. Final decisions were, however, always made at the central level. Neither were there specific practical project-planning guidelines – project planning was carried out based on an ad hoc interpretation of various decrees and circulars. However, the recipient communities were not involved in the planning processes.

The areas where project money was to be used included:

- Infrastructure, scientific and technical facilities.;
- Public welfare;
- Reforestation and seed production;
- Subsidies to families wishing to reclaim unused land; and
- 40 percent of the financing could be used for interest-free loans to project area households.

Revenue originating from project support was shared between individual households (50 percent in planted forests, 25 percent in the case of protecting existing forest) and the GoV (50 and 75 percent respectively).

Large-scale plantation programmes such as Programme 327 and possibly the 5 MHRP tend to have notable problems in their implementation. The ones specific to Programme 327 were identified in a World Bank review:

Top-down approach, bureaucracy and lack of participatory approaches

- Constantly changing objectives, and insufficient and erratic financing.
- Problems in land allocation.
- Many projects were developed purely to support ailing state forest enterprises.
- Poor quality in seeds, seedlings and implementation work.
- Lack of knowledge on species selection and silvicultural methods and approaches.
- No market orientation in commercial activities.
- Many projects were considered alien by the local communities; poor households give higher priority to food security than to wood production.
- Long-term viability of the plantations remains to be seen.

The review concluded that the shortcomings identified jeopardize achieving the broad objectives of the programme.

The 5 MHRP is viewed as a continuation of Programme 327. Some, but by far not all, problems identified in 327 have been corrected in the new design. However, the top-down approach and the lack of community participation as well as inadequate social and biological knowledge – the most notable issues – have not been tackled. The most apparent modification in project approach is the switch from protection to production forests. The households will also be entitled to a higher share of logging revenues (up to 100 percent).

Five Million Hectare Reforestation Programme (1998-2010)

After this programme has been completed in 2010, most natural forests will be 'closed', i.e. logging will be disallowed. The programme includes both reforestation and 'active protection' of existing forests. The objective is that by 2010, forests will cover 14.3 million hectares.

Sixty percent of the plantations were established for production purposes, one-third for watershed protection and the remainder for the protection of coastlines, flood control, etc. The production plantations are classified by the end-use of the wood; most of them use fast-growing exotic species for pulp production including some bamboo plantations. The furniture wood plantation category also includes 120 000 hectares of rubber plantations, rubber often being classified as an agricultural product.

Participatory approach to involve all stakeholders including indigenous people

Land-use planning is carried out with the full participation of different stakeholders who are entitled to allocated land and who live in local villages or communes. Participatory and rapid rural appraisal approaches need to be used to encourage local people's participation. Land-/forest land-use planning and allocation have strong cooperation from state officers and technicians from various levels who visit villages and communes for allocation purposes.

There is a need to ensure specialized cooperation among agroforestry, land administration and other relevant units. District and management officers need to support people in communes or villages in preparing land-/forest land-use planning and allocation plans, to assist them in understanding relevant policies and mechanisms, to provide them with technical guidance and to facilitate administrative procedures during the implementation process.

The GoV has initiated plantation programmes to replace the closed forests. Based on previous experiences from plantation programmes, the 5 MHRP may possibly not meet all, or even most, of the expectations. There is need for a detailed analysis of the demand–supply projections and redesigning parts of the wood supply strategy, particularly in view of declining imports from neighbouring countries.

The following issues should be addressed in the development of a national wood supply strategy:

- Redrafting the 5 MHRP taking into consideration the problems identified in Programme 327, and re-analyse the wood supply potential.
- Assessing the feasibility and need for 'closing the forests'; will the logging ban

be respected and would strict, but feasible, management provide better results with lower economic costs?

- Curtailing illegal logging by both effective on-site and transport control, and chain-of-custody monitoring.
- Rural communities both as suppliers and consumers of wood.

Main opportunities and challenges at national, regional and community levels for forest restoration and rehabilitation

Perceived strengths in planted forest management

The GoV has striven to develop planted forests in the country, for example the 5 MHRP. Recently, it has introduced the Forest Development Strategy for 2006 to 2020, in which planted forest development will play a very important role in the forest sector. Otherwise, the GoV has launched many programmes and projects aiming to increase planted forest area nationwide and to improve living standards and infrastructure in rural areas for local people. Planted forest plays an important role in terms of protecting the environment and improving local livelihoods. Silviculture has also been introduced with new and suitable species as well as innovative techniques. The media network is helping local people to acquire and apply knowledge and techniques. The market for planted forest products has developed considerably putting greater demand on the development of planted forests at the moment and in coming years.

Many foreign and private companies and enterprises are very interested in finding suitable forest land for establishing new plantations. A number of international customers are now requiring that products from planted forest should have international certificates. This is forcing central and provincial governments and also many large forestry companies who own forest plantations to improve their forest management techniques in order to meet international standards.

Perceived weaknesses in planted forest management

There are several weaknesses in planted forest management:

- Investment in planted forests is low, especially funding to protect forests. This hinders the establishment of quality forest in terms of seedling selection, thinning/pruning and other necessary silvicultural practices.
- The minimum rotation for a planted forest to provide a better yield is more than eight years; but due to financial stringencies, some plantation owners or local farmers are cutting at years 6-8 or even earlier to get some return from their investment because of high interest rates from the bank. They cannot afford to wait longer even if they realize that they will achieve greater benefits from their plantations. At this stage the young and small diameter logs are only suitable for

pulp and paper production. This is a common situation in all plantations owned by local farmers who used their own money to establish their plantations; the GoV has little control in terms of area, species and the time for harvesting. There is little information at the provincial level for the planted area owned by local people, species composition, annual yield and what volume to be extracted per hectare due to the poor reporting system at the provincial level.

- There is a limited understanding, especially among local farmers, on planning the density of their plantations and how to conduct activities such as thinning during the rotation.
- There is lack of information on the market both for domestic and export purposes, especially for local farmers who live in rural areas with no access to useful information.
- The markets are open, but not very stable for local people. In many areas such as the Southeastern Region, planted forests have to compete with species such as rubber and pepper. It is difficult for planted forests to develop without suitable policies from the GoV.

Potential threats in planted forest management

- There is intense competition between wood chip and paper production in the national furniture industry. This has a significant influence on how stakeholders decide to cultivate their land. For example, only a few species from planted forests have market demand such as *Acacia*, *Eucalyptus* and *Pinus*. Native species such as *Styrax* and *Manglietia* in plantations are now gradually being replaced by *Acacia*, mostly in the northern provinces, due to less demand.
- New and exotic tree species that are being explored will run the risk of diseases and pests.
- As planted forest areas are developing very quickly, owners do not pay much attention to protecting the environment. This leads to soil erosion and degraded land, which impede cultivation.

Potentials for other forms of forest restoration

In order to supplement forest plantation establishment, especially in those areas that have important biodiversity or are watershed areas, other forms of silvicultural techniques could be applied, which focus on supporting natural succession and local species.

One successful example is planting multipurpose trees around schools, villages, offices and different public areas; in the past 50 years this has shown significant results. These types of activities could help in the increased involvement of local people and especially can contribute to fire prevention.

However, the main objective of reforestation needs to be considered as well as the available funding. It is important to learn more about the benefits of forest restoration and to invest more in research that will promote different aspects in order to make forest restoration activities applicable at a large-scale level.

Appendix 1: List of Participants

Academe, Non-Government Organizations (NGO), And People's Organizations (POS)

Dr. Leonardo Florece
School of Environmental Science and Management, University of the Philippines, College, Laguna
Tel.: +63 49 536-3080
E-mail: lmflorece@gmail.com

Mr. Patrick Dugan
President
Bagong Pagasa Foundation
445 Bulusan Drive, Marian Lakeview Subd., Paranaque, Metro Manila
Tel.: +63 2 823 3010
E-mail: patdugan@mozcom.com

Mr. Ernesto Cadaweng
Bagong Pagasa Foundation
445 Bulusan Drive, Marian Lakeview Subd., Paranaque, Metro Manila
Tel.: +63 2 823 3010
E-mail: boycadaweng@yahoo.com

Mr. William Granert
Executive Director
Soil and Water Conservation Foundation
169-6 Maria Cristina Extesion, Cebu City 6000
Tel.: +63 32 254 7570
E-mail: wggranert@yahoo.com.ph,

Ms. Rowena L. Soriaga
Regional Operations Director
Asia Forest Network
Rizal St. Sacred Heart Village, Tagbilaran, Bohol
Tel.: +63 38 5018947
E-mail: Rowenasoriaga@asiaforestnetwork.org

Mr. Pedro Walpole
Executive
Asia Forestry Network (AFN)
1st Floor Manila Observatory Building
Ateneo de Manila University Campus
Katipunan Road, Loyola Heights, Quezon City
Tel.: +63 2 926 0452
Fax: +63 2 425 0554
E-mail: afn@asiaforstnetwork.org

Ms. Myra Colis
GIS Specilist
Asia Forestry Network (AFN)
1st Floor Manila Observatory Building
Ateneo de Manila University Campus
Katipunan Road, Loyola Heights, Quezon City
Tel.: +63 2 926 0452
E-mail: afn@asiaforstnetwork.org

Mr. James W. Gaongen
Indigenous People
Sagada, Mountain Province
E-mail: c/o mlppenro@yahoo.com

Mr. Alberto Padilla
Member, San Miguel Association Resource Team (SMART) and Kagawad, Danao, Bohol

Department Of Environment And Natural Resources (DENR)

Hon. Jeremias Dolino
Assistant Secretary for Visayas and Mindanao
DENR
Tel.: 426 385

For. Marlo D. Mendoza
OIC, Director
Forest Management Bureau
Visayas Avenue, Quezon City
Tel.: +63 2 928-9313

For. Neria A. Andin
Assistant Director
Forest Management Bureau
Visayas Avenue, Quezon City
Tel.: +63 2 927-4784
E-mail: neria_andin2003@yahoo.com

Dr. Sofio B. Quintana
Regional Technical Director for Forestry
DENR-Region 3, City of San Fernando, Pampanga
Tel.: +63 928 5221 240
E-mail: rtdquintana@yahoo.com

Dir. Leonardo Sibbaluca
Regional Executive Director
DENR-Region 7, Banilad, Mandaue City
Tel.: (032) 346-0661
Fax: (032) 345-3966

Dr. Isabelo Montejo
Regional Technical Director for Forestry
DENR-Region 7, Banilad, Mandaue City
Tel.: (032) 345-3966
Dir. Hardinado V. Patnugot, Jr.
Regional Technical Director for Forestry
DENR-Region 11, Davao City
Tel.: +63 82 234 6606, 234 7788
E-mail: rtdfmsdavao@yahoo.com

For. Nonito M. Tamayo
In-Charge, Natural Forest Management Division
Forest Management Bureau
Visayas Avenue, Quezon City
Tel.: +63 2 927 6229
E-mail: noni_tamayo@yahoo.com

For. Roberto A. Oliveros
Supervising Forest Management Specialist
Forest Management Bureau
Visayas Avenue, Quezon City
Tel.: +63 2 927 6229

For. Emma N. Castillo
Senior Forest Management Specialist
Forest Management Bureau
Visayas Avenue, Quezon City
Tel.: +63 2 927 6229
E-mail: emma_castillo23@yahoo.com

For. Visitacion A. Zaño
Senior Forest Management Specialist
Forest Management Bureau
Visayas Avenue, Quezon, City
Tel.: +63 2 927 6229

For. Emerito M. Evangelista
Forest Management Specialist II
Forest Management Bureau
Visayas Avenue, Quezon, City
Tel.: +63 2 927 6229

For. Jesus DL. Posadas, Jr.
Forest Management Specialist II
Forest Management Bureau
Visayas Avenue, Quezon, City
Tel.: +63 2 928 2891
E-mail: jdlp518@yahoo.com

Ms. Venesa D. delos Reyes
FMB, Visayas Avenue, Quezon, City
Fax: +63 2 928 2891
E-mail: van_da22@yahoo.com

For. Elena B. America
Forester III
DENR-CENRO Limay, Bataan
Tel.: +63 47 237 6639

For. Eufemio Abaniel
Forester
DENR-CENRO Talibon, Bohol
Tel.: +63 38 515 0086

For. Camilo Victoria
Forester II / Chief of Watershed Section
DENR, Region 11, Davao City
Tel.: +63 82 234 6194
E-mail: meldpag@yahoo.com

For. Jovencio D. Taer
Forester III
DENR-PENRO Bohol
Tel.: +63 38 411 2278, 235 6157
E-mail: penrobohol@yahoo.com

Mr. Manuel Pogeyed
PENRO
DENR-Cordillera Autonomous Region
Benguet, Nursery Compound, Pacdal,
Baguio City
Tel.: +63 928 7872673
E-mail: mlppenro@yahoo.com

Mr. Richard Abella
Forester
DENR Region 7 Mandaue City
Tel.: +63 32 3466102, 3461000

Development Partners

Mr. Oliver Agoncillo
Natural Resources Policy Advisor
USAID Philippines
Tel.: +63 2 552 9828
E-mail: oagoncillo@usaid.gov

Mr. Patrick Charlie Dugan, Jr.
Consultant
UNDP
Tel.: +63 917 702 2316
E-mail: pckdju@yahoo.com

Dr. Rodel Lasco
Philippines Coordinator
ICRAF Los Baños, Laguna
Tel.: +63 2 845-0563 local 2544
E-mail: rlasco@cigiar.org,
rdlasco@yahoo.com

Food and Agriculture Organization of the United Nations

Mr. Patrick Durst
Senior Forestry Officer
FAO Regional Office for Asia and the Pacific
39 Phra Atit Road, Bangkok 10200, Thailand
Tel.: +66 2 697 4139
E-mail: Patrick.durst@fao.org

Mr. Kazuyuki Tsurumi
FAO Representative in the Philippines
29/F, Yuchengco Tower, RCBC Plaza, 6819 Ayala Ave., Makati City

Ms. Linda Rosengren
FAO-APO
Tel.: +39 06 57055135
E-mail: linda.rosengren@fao.org

Ms. Marija Spirovska-Kono
Consultant
FAO, Regional Office for Asia and the Pacific, 39 Phra Atit Road, Bangkok 102000, Thailand
Tel.: +66 8 49092450
E-mail: marija.Spirovskakono@fao.org

Ms. Sarah Lacson
Assistant FAO Representative (Administration)
29/F, Yuchengco Tower, RCBC Plaza, 6819 Ayala Ave., Makati City
Tel.: +63 2 9010357
E-mail: sarah.lacson@fao.org

Mr. Genaro Castro
Programme Officer
29/F, Yuchengco Tower, RCBC Plaza, 6819 Ayala Ave., Makati City
Tel.: +63 2 901 0354
E-mail: gnaro.castro@fao.org

Dr. Percy E. Sajise
Regional Director
Biodiversity International Regional Office for Asia, Pacific and Oceania and International Consultant for ANR Project
Tel.: +63 49 5362380
E-mail: p.sajise@cgiar.org

Dr. Domingo Madulid
Scientist IV, Botany Division of Philippine National Museum and
National Consultant on Botany/Biology for the ANR Project
Tel.: +63 2 527 1218
E-mail: dwadulid@info.com.ph

Mr. Paulino Manalo
National Consultant on Documentation and Media Relations, ANR Project
Tel.: +63 919 6068228
E-mail: pl_manalo@yahoo.com

International Presenters

Dr. Cui Wushe
Department of Forest Resources Management of State Forestry Administration
People's Republic of China
Tel.: +86 10 8423 9808
E-mail: c.wushe@263.net

Dr. Robert Ong
Senior Research Officer
Sabah Forestry Department
Malaysia
Tel.: +60 89 537533
E-mail: Robert.ong@sabah.gov.my

Mr. Tuyen Dinh Vo
Deputy Head
Forest Development Division
Viet Nam
Tel.: 84 38 438803
E-mail: tuyendof@gmail.com

Ms. Tidarach Toktang Chupoaphatthasri
Extension and Education
Forest Restoration Research Unit
Tel.: +66 87 3057093
E-mail: tidarach@gmail.com

Mr. Noviar
Director General
Land Rehabilitation and Social Forestry
Indonesia
Tel.: +62 21 5730106
E-mail: fx_noviar@yahoo.com

Mr. Saysamone Phothisat
Director
Protection Forest Management and Forest Restoration Division
Lao PDR
Tel.: +856 21 215000
E-mail: saiphothisat@yahoo.com

Ms. Kikang Bae
Korea Forest Research Institute /AKECOP Project
South Korea
Tel.: +82 10 41517142
E-mail: namu0302@nate.com

Mr. Shigeo Kobayashi
Professor
Kyoto University
Japan
Tel.: +81 75 7537832
E-mail: ksige@asafas.kyoto-uac.jp

Local Government Units (LGUs) and the Private Sector

Atty. Tomas Abapo , Jr.
Provincial Administrator
Province of Bohol
Capitol Building, Tagbilaran City

Mr. Antonieto Pernia
Chief of Staff
Province of Bohol
Capitol Building, Tagbilaran City

Hon. Louis Thomas Gonzaga
Mayor
Municipality of Danao, Bohol
Fax: +63 38 507 3106 loc. 187

Mr. Leonilo Lafuente
Bohol Environment Management Office
Tel.: +63 38 5018858, 5019912
Fax: +63 38 5019912
E-mail: bemo_phil@yahoo.com

Mr. Gualberto Cenabre
Councilor
Danao, Bohol
Tel.: +63 38 5073106 loc. 187

For. Bernard Sinues
Forestry/Planning Manager
Surigao Development Corp. (SUDECOR)
Tel.: +63 2 8909697, (63) 921 7525848

For. Bernardo D. Agaloos, Jr.
Executive Vice President and Project Manager
Sustainable Ecosystems International Corp. (SUSTEC)
Tel.: +63 917 5375293

Engr. Cielito Establecida
Division Manager
Local Water Utilities Administration
Tel.: +63 2 9205441

Fax: +63 2 9223434
E-mail: litoestablecida@yahoo.com

Mr. Victor Francisco
Vice President
Corporate Environment and Community Relations
Philex Mining Corporation
Philex Bldg., 27 Brixton St., Pasig City

For. Vicente L. Servidad
Department Manager
Philex Mining Corporation
Philex Bldg., 27 Brixton St., Pasig City
Tel.: +63 920 9285844
E-mail: vicservidad@yahoo.com

Mr. Erlito del Rosario
Department Manager
Environmental Management Department
Energy Development Corporation
4th Flr. Bldg. 4B, Energy Center Merritt Road, Fort Bonifacio, 1201 Taguig City, Philippines
Tel.: +63 2 8931320 loc. 4351
E-mail: delrosario@energy.com.ph

For. Jose Ruben Chagas
Senior Supervisor
Environmental Management Department
Energy Development Corporation
4th Flr. Bldg. 4B, Energy Center Merritt Road, Fort Bonifacio, 1201 Taguig City, Philippines
Tel.: +63 2 8127465 loc. 147
E-mail: chagas.jrm@energy.com.ph

Media

Mr. Willy Rodolfo
Business Mirror
Tel.: +63 0919-8404008
E-mail: wrodolfo3@yahoo.com

Ms Mediatrix P. Cristobal
Philippine News Agency
Tel.: +63 0918-3249323
Tel.: +63 2 9815050
E-mail: chie_cristobal@yahoo.com

Ms Elisabeth Baumgart
Sun.Star
Tel.: +63 0917-6649216
E-mail: e.baumgart@yahoo.com

Ms Ainjeliz de la Torre
Freeman
Tel.: +63 0928-4210724
E-mail: jelai_6288@yahoo.com

Ms Priscilla Richards
Bohol Standard
Tel.: +63 0928-2326707
E-mail: precious_asastone@yahoo.com

Ms Aida Tanghal
Provincial Government Media Affairs (PGMA)/Radio Station DYDL

Mr Rey Anthony H. Chiu
Philippine Information Agency
Tel.: +63 0918-3231583
E-mail: tsinoy_na_singgkit@yahoo.com

Mr Ric Obedencio
Bohol Chronicle/Freeman
Tel.: +63 0921-4911419
E-mail: ricobedencio@yahoo.com

Mr. Bruce Zabala
PGMA

Mr. Danny Reyes
Radio Station DYRD

Mr. Ramonito B. Lustre
Videography

Facilitators

Ms. Ma. Socorro Feliciano
Ms. Jackie Bacal
E-mail: sukijack@gmail.com

Ms. Amelia Hernandez Esteban
E-mail: ameme25@yahoo.com

Assisted natural regeneration (ANR) is a forest restoration and rehabilitation practice successfully used for converting *Imperata cylindrica* and other grass-dominated areas into productive forests. It is a simple, inexpensive, and effective technique that relies on the natural processes of plant succession. ANR application is based on fire prevention and management, control of grazing, suppression of grasses, and nurturing of seedlings and saplings of indigenous trees.

ISBN 978-92-5-106639-3
9 789251 066393
I1734E/1/08.10