WELCOME

Prof.Dr. K.J. Beek
President of the Board of the Tropenbos Foundation

Your Excellency,
Distinguished Participants,
Ladies and Gentlemen,

It gives me great pleasure, on behalf of the Tropenbos Foundation, to welcome you all at our Seminar on ›Research in Tropical Rain Forests: Its Challenges for the Future‹. It is a great honour and stimulus for our debate that the Minister for Development Cooperation will introduce the subject this morning.

When discussing with Minister Pronk last year the external review of the Tropenbos programme and our plans for the future, the Minister proposed the organisation of this seminar and also offered to finance it, which we gratefully accepted.

Although each of us present at this interesting exchange of views had a different interpretation of the kind of seminar which the Minister had in mind, I believe that the objectives stated in the programme are not far from his intentions: we should provide an overview of the ongoing research, its past achievements and the present research capacity in the Netherlands. We should also identify gaps crucial to achieve sustainable forest management, suggest challenging recommendations to improve the communication between researchers and policy-makers in both directions and improve the pre-conditions for effective research, which in forestry is synonymous with long term commitment. We should also consider measures to enhance the incorporation of research output in policy, management and decision making while aiming at the greatest possible impact on development objectives. Education and training at all levels in developing countries have a key-function to achieve this in order to make them less dependent on foreign research.

The seminar should stimulate the participants when facing the immense challenges of sustainable forest management not to be discouraged by the overwhelming magnitude of deforestation and forest degradation that is taking place, but to formulate the right research questions that contribute to improvements in a foreseeable future.

Fortunately, researchers, policy makers, NGOs, public institutions, local communities and the private sector are increasingly aware that they need each other when tackling the challenges that lie ahead. It is quite evident that on our spaceship Earth there are no passengers, only crew members.

We have to be ambitious, but also realistic in our goals: when debating this year's forest fires in Indonesia, for example, let us not forget that in Europe each year 550,000 hectares are burnt, mostly during the dry summers in the Mediterranean region. This despite all the technology in place for prevention and combatting of forest fires.

When we refer to tropical rain forests, we know that the prime cause of deforestation is the basic need for food, fibre and energy for poor people. Therefore, our challenges lie basically in finding ways to mitigate poverty, taking into account what is taking place in the rural areas and the role which forests play in the management of water basins.

Having had the privilege to look at some of the papers to be presented during the next two days, including the insights stemming from both fundamental- and development oriented research, I am convinced of the relevance of the seminar. I think that it can contribute to strengthening the local capacities to manage forests in a sustainable way, while emphasising the respect for the value of the indigenous species and their natural regeneration, both timber- and non-timber products. After all, many of these species have millions of years of experience in maintaining themselves in their specific dynamic environments, while the time horizon of our research has to be counted in mere decades.

In commercial timber production also the prospects of rapidly returning forests to a near-natural state through a new technique called reduced-impact logging will be compared with ordinary logging.

An interesting research topic is the perspective of the manipulation of light in tropical rain forests to influence the natural stratification and diversity of species, in consultation with the local people. In general, the indigenous knowledge of local people is an important source of information to be matched with the output of innovative research.

For the monitoring of silvicultural techniques exciting international standards are emerging for the application of criteria and indicators of sustainable forest management, parallel to what is going on in the introduction of land quality indicators for the evaluation of sustainable land management in rural areas, in which the World Bank and the FAO have taken a leading role. Remote sensing and geographical information systems will be useful, not only in a controlling function, but also for land use planning and management support.

Such tools which are common in top-down planning should also be placed in the hands of local communities to make top-down and bottom-up planning processes meet, and to ensure that the fascinating potential of an emerging information society will include information highways which inclusively cover the last miles to the concessions, farms and villages.

During this seminar strategic directions for biodiversity conservation will be proposed and linked to policy development. Attention will also be given to the possible effects of certification of sustainably produced forest products.

Benefiting from the participation of Professor Sayer, Director General of the CGIAR Center for International Forest Research (CIFOR), and from our colleagues from the developing countries, we will discuss the specific contributions which the Dutch scientific community could make and the modes of international cooperation. One of our strengths lies in the modelling of forest ecosystems and their response to a variety of management interventions, according to Professor Sayer.

Several years ago, also at the initiative of Minister Pronk, we discussed in Groningen the contribution of research to development processes. Tropenbos was presented as an example of international cooperation in environmental research. At that time much of our attention was drawn to the so-called ›greenhouse effect‹, leading to global warming and climatic change. One of our Latin American colleagues then remarked that for his country the ›white house‹ effect was more important.

This year much attention is drawn by the ›El Niño‹ effect, a disturbing natural phenomenon affecting rainfall patterns world-wide. I expect that when recognising the beneficial effects of this seminar, and in recognition of our Minister for Development Cooperation who gave us the opportunity to meet these two days, we should introduce the term ›Jan Pronk effect‹ for his stimulating influence on tropical rain forest research for sustainable forest management.

I would now like to invite Minister Pronk to present his opening address.

OPENING

Mr. J.P. Pronk
Minister for Development Cooperation

Ladies and gentlemen,

I greatly appreciate being invited to open this seminar today, since it puts me in the company of people who share my commitment to the conservation and sustainable use of the tropical rain forests.

Such a commitment is essential if we are to achieve sustainable development and maintain the world's biological diversity. Efforts will need to be made at local and global level alike. For maintaining biodiversity is vital not only to the survival strategies of local populations, but also to the ecological balance of the entire world.

But from the fact that an asset is crucial, it does not automatically follow that it is treated with care. For even though economic reasons have also been identified for safeguarding the tropical rain forests, many different factors are at work that pose an enormous threat to their very existence.

We all know that severe degradation threatens practically every forest in the world, and between 15 and 20 million hectares of forest land are lost each year. The recent fires in Indonesia rightly attracted widespread media attention. But ongoing degradation and conversion seldom reach the front pages, though their effects are equally devastating.

The primary forests are shrinking fast and there is little virgin forest left. But these forests are part of our common heritage, and we are morally obliged to do all in our power to conserve them.

Local populations are also under threat. Up to now, they have had no say in plans for the forests, and they have benefited very little from their exploitation. At the same time, they are often the first to feel the impact of degradation and deforestation.

Development and the environment figure high on the list of the Netherlands' international priorities. Policy on tropical rain forests thus plays an important role.

As early as 1991, the Policy Document on Tropical Rainforests was drafted with the assistance of the then State Secretary for Agriculture, Mr. Gabor. The main objectives were to achieve the best possible protection for primary rain forests and the sustainable management and exploitation of the remainder. An annual 50 million guilders were allocated for the conservation of tropical rain forests, in addition to the 100 million guilders allocated to tropical forests in general.

Many activities have been funded. At grass roots level, local development needs are linked with the need to conserve unspoilt areas of rain forests. At all other levels, efforts are being made to enhance the capacity to plan, use, manage and control natural resources, including forests. Support is being given to the development of proper policies, and adequate mechanisms to implement them.

The Netherlands is a member of many international fora, including the Intergovernmental Forest Forum and the forest programme of the Convention on Biological Diversity. And, as our presence here today shows, research in the field of conservation and the sustainable use of tropical rain forests occupies a prominent place on the agenda.

During this two-day seminar, attention will largely focus on research. Research both enhances our knowledge and understanding of development-related issues, and contributes to efforts to build capacity in developing countries.

The research we are discussing now will need to focus on the ecological, social, cultural and economic significance of tropical rain forests. It will need to examine the relationship between people and the resource base, the ecosystem. What we are seeking is a better understanding of the complex nature of this relationship, and the influence exerted by external factors. We need to know more about ecological relationships within the forest. For the concept of biodiversity, the new star in the firmament, is far from being fully understood.

Up to now, the value of forests to national economies has not been fully appreciated. The role they play in relation to, for example, biological diversity, climate, carbon sink, water catchment, water regulation and indigenous and local peoples has been given little recognition. Timber production has long been regarded as their main economic function. And once the trees have been felled, the land can be used for other purposes, such as agriculture, livestock farming and rubber plantations. The forest always loses.

Forestry research is currently broadening its scope with studies of, for example, non-timber forest products. Traditional knowledge systems are now regarded as essential to conservation and sustainable use.

Research on forests and forestry is vital to conservation. It is for this reason that the Netherlands supports a wide variety of research programmes, through its contributions to numerous international institutes.

But we cannot delay. We must take action even though the mysteries of the tropical rain forest have not yet been fully revealed to us.

Tropenbos occupies its own place within the world of research. It was established to coordinate Dutch research on tropical rain forests and to train and assist partner organisations in developing countries. It also provides the scientific basis for the Dutch input in international fora. It is the aim of Tropenbos to broaden our knowledge base.

The aim of the Dutch government is to assist developing countries in building the capacity and knowledge they need to conserve the forests and achieve sustainable forest management. The training of local staff plays a key role.

Tropenbos should consider assisting the various actors in developing countries by providing the capacity and know-how to conduct research on forests. Its main objective should be to build the research capacity of developing countries. Only when the countries concerned are the owners of such research, can we expect effective conservation and sustainable management of virgin forest.

The developing countries themselves should therefore be closely involved in Tropenbos: future programming and strategic planning. Today I hope to hear what has been achieved to date and to find

out what lessons you have learned. I hope too that you will be able to inform me of the impact your efforts have had - and will have in the future.

It is the link between ecology and development that is most important to development cooperation efforts. It is up to Tropenbos to seek the link between scientific research and its impact on degradation and deforestation.

Tropenbos has done a good job so far. But now it must set its sights on the future. I wish you every success with your seminar.

Thank you.

INTRODUCTION

Prof.Dr. R. Rabbinge
Chairman of the Seminar

Ladies and gentlemen,

It is a pleasure for me to welcome you to this seminar organised by the Tropenbos Foundation. The reason for this seminar is a question raised some time ago by the Dutch Minister for Development Cooperation, Jan Pronk. He requested clarification of the integration of research results on tropical rain forests in the development process and, more specifically, what facts, insight and expertise resulting from intensive research programmes have contributed to policy making in development cooperation. An answer to this fundamental question is very difficult. It is nearly impossible to demonstrate an immediate relation between scientific analysis done by Tropenbos and decisions or strategic choices taken by policy makers. There is no simple answer to this question or a reaction such as: »all knowledge and insight helps to strengthen the arguments that determine the final decisions«.

However, there are other possibilities which this seminar will demonstrate, and that is exactly our intention. The seminar has five explicit objectives:

1. To present an overview of the role of Dutch research on tropical rain forests in an international context.
2. To identify crucial gaps in research on sustainable forest management and conservation.
3. To develop policy recommendations for improving the link between research and policy.
4. To develop recommendations for improving pre-conditions for effective research.
5. To motivate and inspire participants to continue their work in research and policy development.

These objectives require some explanation. During the last decade Dutch research on tropical rain forests has been promoted and stimulated through the Tropenbos Foundation that received its major contribution from the Ministry for Development Cooperation. The intention of that stimulus was to strengthen the scientific basis for policy decision making. It is important to see how that programme has stimulated the research and the impact of the results on policy making.

It will be clear that there are still gaps and insight lacking that are crucial for any decision making. These gaps should be identified and it should be made clear what efforts and research are needed to fill them. The gap between scientific activities and policy makers is often large. Many policy makers ask questions that can't be answered by scientific research alone. The normative basis for many policy decisions should be made explicit to see how and why choices are made. The survival of humankind is, in many cases, not at stake and it may be advisable to point out that many arguments are of a cultural rather than a scientific nature. Many scientists tend to give answers to questions that have not even been raised by policy makers. During this seminar the dialogue between policy makers and the scientific world will be stimulated. There are not only policy makers asking questions; many non-governmental organisations and private companies ask questions on tropical rain forests with various objectives in mind. Those questions should be addressed by the scientific community.
It should be clear that much research in order to maintain tropical rain forests requires knowledge of the pre-conditions for identifying the questions which should be asked. In addition, clear identification of the issues which require research and the questions which cannot be answered through research is

essential.

Finally, this meeting and the many discussions that will take place will stimulate scientists to continue and strengthen their research activities. The communication between scientists, policy makers and other stakeholders may stimulate further discussions on research subjects. Prioritisation of the research agenda may be very helpful for the future and help to justify the continuation of Tropenbos.

I am convinced that by the end of this meeting we will have good presentations, stimulating discussions and the identification of well-motivated recommendations for the future.

I wish you all a good seminar.

EXPECTATIONS OF RESEARCH

SUSTAINABLE MANAGEMENT AND FORESTRY RESEARCH IN CAMEROON

Mr. S. Nguiffo
Centre pour l'Environnement et le Développement, Cameroon

Lecture presented by **Dr. O. Eyog Matig** (*Institut de Recherche Agricole pour le Développement - IRAD, Cameroon*)

1. INTRODUCTION

1.1. The forestry sector in Cameroon

The forestry sector in Cameroon is highly complex. It involves various actors with different interests and motivations. The forest constitutes one of Cameroon's major resources. It covers more than 60% of the national territory and is characterised by a wide variety of flora and fauna. Inventories made by State institutions on 14 million hectares of humid forest show a timber potential of about 1,517 thousand million m^3 belonging to 600 exploitable species. To date, only 300 species are marketable, of which only about 60 are exploited on a regular basis. With the present market conditions, the exploitable potential stands at about 750 million m^3. Timber can thus be regarded as one of the potential sources of wealth for the country.

Forests have been exploited under licence for many years. Exploitation started in the coastal region and, with the development of road and railway transport, gradually extended to other regions. The distribution of surface areas under licence shows that there are three major forest regions: Centre and South; East; Littoral and South West, which account for about 80% of the total production. Timber production by the formal sector is about 3 million m^3. Five species, namely Ayous, Iroko, Sapelli, Azobe, and Frake, account for more than 70% of this production. There are 64 processing units made up of 58 sawmills, 4 veneer units, 1 cutting unit, and 1 manufacturer of matches, which represent a processing capacity of about 1.7 million m^3 of logs. The secondary and tertiary processing industries have remained in their early stages. Very few industries are interested in industrial carpentry. The three operational companies prefer furniture-making and building-carpentry for the local market.

Mass production of good-quality products for export is almost non-existent. In the past decades, very little effort has been made to undertake truly sound management. It consisted mostly of collecting revenue from logging operations. The revenue was used by the Forestry Department to preserve the protected areas, or to create some forest plantations. At the same time, the Forestry Department was very inadequate and poorly equipped. Its staff were not trained, and earned very little.

In the late 1980s, a conjunction of dramatic events totally changed the face of the forestry sector in Cameroon. These were:

- The signing of the Structural Adjustment Programme with the IMF;
- The drop in national oil production;
- The financial crisis in the country.

As a result, the Forestry Sector is now regarded as an important source of income by the Government. It was decided that, by the year 2000, Cameroon should become the biggest timber exporter in Africa. This target was reached in 1992.

The people living in the forest are excluded from the management of the forest. They have no (or very few) benefits from logging, and they suffer the most from the social and ecological upheavals. Based on studies pointing out this dramatic situation, the Centre pour l=Environnement et le Développement (CED) came into being in 1994.

1.2. Presentation of the CED

The CED is a young Cameroonian NGO which was set up in response to problems encountered in the management of forest resources in Cameroon. CED's main objective is to promote the involvement of local communities in sustainable forest management and in benefit-sharing. CED is involved in forest management at two different levels:

- The local level, and
- The regional level.

1.2.1 At the local level

CED action aims at:

1. Providing assistance to local communities willing to reduce their pressure on the forest;
2. Promoting traditional knowledge on the use of the forest;
3. Empowering local groups with a view to reinforcing their capacity to manage their community forests;
4. Disseminating information on the content of the forestry law.

CED is conducting a number of activities aimed at improving the participation of local communities in the sustainable management of tropical forests while improving their living conditions. We achieve these objectives through:

1. Empowerment of the Baka (an indigenous group of people from the Cameroonian forest). The objectives of that programme are:
   - To establish food self-sufficiency in the Baka community;
   - To develop income-generating activities in the communities;
   - To valorise the traditional know-how of the Baka in the management of forest resources, especially Non-Timber Forest Products (NTFP).
2. Experimentation with biological farming:
   - To reduce the actual rate of deforestation and land degradation as a result of shifting cultivation;
   - To reduce pollution by the use of natural fertilisers and biological techniques in agriculture;
   - To increase agricultural yields;
   - To reduce the dependency of local farmers on producers and dealers of chemical pesticides.
3. Research on traditional practices and local technologies aimed at:
   - Making an inventory of local technologies that can be disseminated for the sustainable management of forests;
   - Setting up a data bank of small-scale technologies and knowledge;
   - Testing small technologies and disseminating the best through trials at the local level.

1.2.2 At the regional level

Following-up and monitoring policy and practices in forest management in Cameroon and in Central Africa. These policies and practices strongly affect people living in the forest. CED is deeply concerned with key issues related to forest management in the Congo Basin. These include timber certification, mainly with the Forest Stewardship Council (FSC); involvement of Asian logging companies in Africa; the difficult implementation of community forestry, etc.

CED target groups are communities living in the forest. Particular attention is being given to the Baka. CED employs six persons working full-time, and specialists in various fields (agronomist, specialist in soil management, environmentalist, and social scientists). CED also works in collaboration with about twenty part-time local assistants.

Project area

CED field activities are located in the south of Cameroon, in the areas of Djoum, Nkongmekak, and Zoetele. In these areas, CED is conducting the following activities:

- The dissemination of information on biological farming to reduce dependency on shifting cultivation and to promoting the use of local knowledge in fertilisation and the fight against pests;
- The dissemination of information on the use of NTFP as a way to reduce villagers'expenses and, if possible, as a way to generate income;
- To provide training in group management and in the implementation of group activities;
- Experimentation in the field of game breeding and apiculture using local species.

2. INFORMATION NEEDS

At the beginning, CEDs activities were based on:

- The joint identification of needs with the target groups in the project area, focusing on possible solutions to problems that were identified on the basis of data available to CED, or short studies conducted by our small team;
- Exchange of experience with other organisations and experts involved in the same issues.

This method was very difficult, because of the lack of specialists capable of providing support to communities in the field of forest management, as opposed to Sahelian areas, for example, where support activities have been going on for many years. It is relatively easy to point out the problems, but it is much more difficult to provide solutions.

CED requires immediate information to further its activities, including:

- Information on small-scale equipment for the processing and conservation of forest products;
- Information on the market for the NTFP, both at the national and international levels;
- Information on the regeneration of threatened tree species with high commercial and traditional values (Bubinga, Moabi, etc...);
- Knowledge on the non-chemical regeneration of soils.

3. HOW AND TO WHAT EXTENT DID CED BENEFIT FROM RESEARCH?

The results of research were used by CED in two different ways:
- By exchanging experience with other research centres;
- By using research documents.

3.1. Exchange of experience with other research centres

CED shared experiences with IITA, CIFOR, ICRAF, ECOFAC, and the Catholic University. The main areas of exchange were NTFP and methods of regenerating Moabi trees. Experiments are currently being performed in our project area. Field trips have been organised for farmers from our project area to experimental plots of ICRAF and IITA. These trips aim at teaching the farmers various techniques of agroforestry and soil conservation.

3.2. Use of research documents

The more frequently used documents were *Nature and Fauna*, the FAO review, and documents prepared by the German GTZ, for the implementation of a micro-project on game breeding.

4. CED INVOLVEMENT IN RESEARCH

In the area of research, we have conducted a number of specific studies to increase our understanding of the forest conservation problem in Cameroon, but also to improve the efficiency of our actions in the field. Some of the topics were:
- The management of the commons in Cameroon;
- Study of the regional environment of Dja et Lobo;
- Study on local forest practices in Cameroon: case study of the Mfouladja region;
- A survey on local/traditional practices in the management of the rain forest: case study of Cameroon;
- Integration of customary rights in forest management in Cameroon;
- Detailed map of Baka camps in the Djoum, Oveng, Mintom regions.

We have also conducted a number of studies on timber certification.

5. WHAT TYPE OF INFORMATION IS CED STILL LACKING FOR DECISION- MAKING ON SUSTAINABLE FOREST MANAGEMENT?

CED lacks two types of information that hinders its effective functioning. They are:
- Social and anthropological data;
- Data on forest resources and on NTFP.

The social and anthropological data include the following themes:
- The traditional value system of the forest;
- The knowledge of indigenous people, particularly that of the Baka (studies of acculturation process, systems of communication, traditional use of the forest, etc.);
- Is it possible (and if so, how?) to promote community forestry even in horizontal societies?

As for the forest resources data, they include the following:

- An exhaustive and scientific answer to the following question: is logging in primary forest possible without resulting in conversion (i.e. is it possible to implement sustainable forest management and certify logging in primary forest)?
- The systematic identification of exploitable forest resources, mainly NTFP;
- Are there alternatives to shifting cultivation that can be implemented at low cost in forest areas?

SUSTAINABLE MANAGEMENT AND FORESTRY RESEARCH IN CAMEROON

Challenges and Problems; Information Needs

- Small scale methods for the processing and conservation of forest products.
- Information concerning the national and international markets for NTFP.
- Information on the regeneration of threatened trees species.
- Knowledge on non-chemical regeneration of soils.

Points for Future Research

- Social and anthropological studies: traditional value systems; traditional forest use.
- Knowledge of forest resources: NTFP and sustainable logging systems.

INFORMATION FOR SUSTAINABLE LAND USE PLANNING AND CONSERVATION IN THE GUAVIARE DEPARTMENT, COLOMBIAN AMAZONIA

L.J. Martínez M.
The Tropenbos-Colombia programme

INTRODUCTION

For administrative and planning purposes, the Amazon region of Colombia is divided into six departments: Guaviare, Guainia, Vaupés, Amazonas, Caquetá and Putumayo (Figure 1). The Guaviare department was created in 1991 and is divided into four municipalities covering an area of 5,484,700 hectares, or 15 % of the total area of the Amazon region.

Figure 1 Location of the study area

The total population of Guaviare was estimated at 80,000 inhabitants in 1995, most of whom are colonists from the Andean region. Colonisation of the Amazonian forest implies the introduction of land use types characterised by instability and low productivity, leading to intensive degradation of the ecosystem. These uses are based mainly on pastures for livestock raising and on illegal crop cultivation.

In 1991, as a strategy to determine and apply solutions to these problems, the Guaviare department began a planning process with participation of the community, official and private organisations, and the Departmental and Municipal Governments. A first product of this process was the development plan for a 6-year period from 1994 to 2000. The main objective of the development plan was to promote a gradual change in the present economic condition of the Department by identifying and introducing sustainable production alternatives as a substitute for illegal crop cultivation and to preserve the natural resources (Gobernación del Guaviare, 1993). Some characteristics of the planning process are:

- Participatory approach aiming to increase popular participation in decision-making, which is

achieved by involving the community at various stages of the planning process;
- Introduction of additional criteria to make decisions and a proposal for the definition of priorities to invest the scarce financial resources of the budget;
- Emphasis on the execution of participatory research focused on identifying solutions for specific problems;
- Focus on planning and management of natural resources defining priority areas.

1. LAND USE PLANNING AS A STRATEGY FOR THE WISE USE AND CONSERVATION OF NATURAL RESOURCES

In Guaviare, land use planning is one component of the entire spatial planning strategy. The process encompasses a wide range of actions related to identifying problems, assessing alternatives and applying solutions towards the conservation and sustainable use of natural resources. The implementation of this process has some favourable factors:
- The precepts of the new National Constitution, new laws and rules about planning, community participation and environment have generated needs for changing traditional planning methods;
- An institutional structure with specific functions related to environmental policies, definition, research, planning and natural resources management;
- Increased concern about conservation of Amazonian forests among the colonists, the governmental agencies, NGOs, the private sector, and also about the present problems and the need to improve the situation;
- Availability of nearly 4,500,000 ha still covered by natural forest with a low degree of intervention, and 1,000,000 ha which have already been affected to some degree by intervention in the ecosystem.

To support the land use planning process, a problem-oriented project was carried out to develop and apply methods and tools for sustainable land use planning and conservation. The project was executed by Tropenbos, the international Institute for Aerospace Survey and Earth Sciences (ITC), the former Corporación Araracuara (today SINCHI institute) and the Departmental Government of Guaviare.

After finalising the project and publishing the results in May 1997, the outputs obtained are being used by local government and local organisations for specific purposes. In this article, I will present the main benefits of the research results for local users and identify gaps in information and research needed to continue supporting the land use planning and conservation process.

II. MAIN OUTPUTS OF THE RESEARCH CONDUCTED

- The main output included a method for sustainable land use planning and conservation (Figure 2). This method integrates planning concepts, local policies and rules, existing research results and local needs. It is supported by tools such as GIS, remote sensing and modelling techniques to produce and manage the information required.
  Specific research topics such as landscape ecology, land evaluation, farming system analysis and environmental impact assessment, which are usually carried out and used in a isolated way, were integrated in the land use planning approach. The integration of biophysical and social/economic components is another important feature of this approach.
- An important achievement of the project was a model to evaluate land suitability. It included biophysical and social/economic criteria to define suitability. Based on the results, a plan with specific activities for production, conservation, and land restoration was established to increase sustainability and profitability of existing farm systems and to stabilise the colonisation area that

decreases the rate of forest destruction.

- A GIS tool including spatial and non-spatial databases for soil, climate and socio-economic aspects was developed and implemented.
- A publication with the results of the project was done in the Tropenbos-Colombia Series.

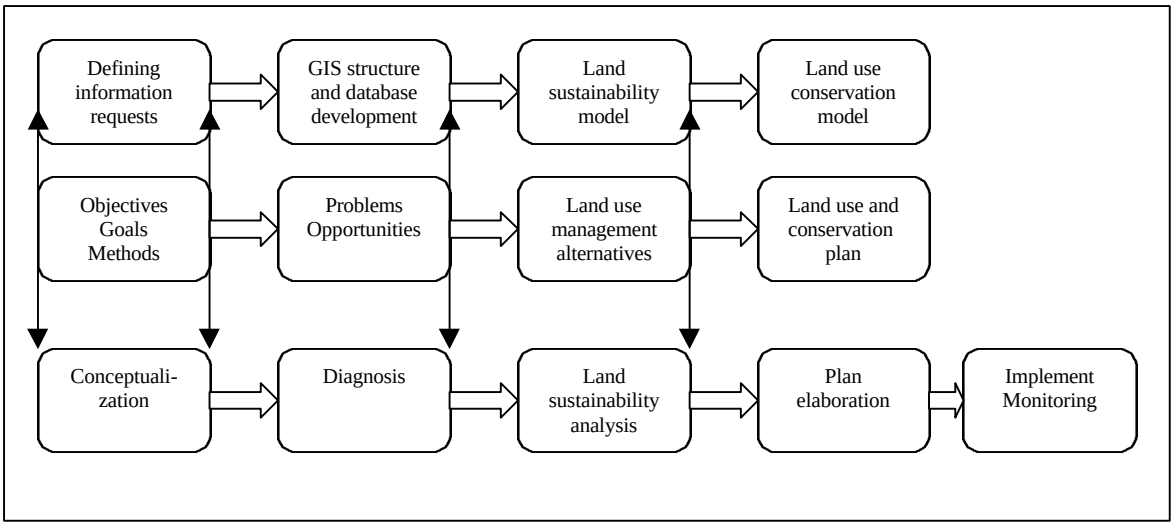

Figure 2 Main component of land use planning method

III. MAIN BENEFITS OF RESEARCH RESULTS

Although the process of using and applying the outputs of the project is still in its early stages, there are already important and positive achievements to be noted. I will present the main benefits obtained so far and specific applications that are being conducted by local government together with research, management and planning organisations.

(a) Awareness

An important benefit is the change in attitude of people in local government and organisations. At the moment, there is great interest to continue improving the decision making process by using geographic information. Tools such as GIS, databases and modelling techniques are now part of institutional structures. Methods such as land evaluation and spatial analysis of farming systems were incorporated in research and planning processes. Three important achievements are:

- Planning is perceived as an efficient way to identify and apply activities for the wise use and conservation of forests and natural resources, as well as to improve the present situation of local people;
- Information is considered to be an important support for the planning and decision-making process. GIS techniques are basic tools for data storage, management and analysis to produce the geographic information required;
- The approach to land use planning and geographically developed information appears to be an important strategy to direct the research process. It allows the identification of needs and priorities for research and will permit assessment of the impact of research. This approach constitutes an important link between demand (local problems) and supply of research.

(b) Institutional development and personnel training

As part of the project, personnel of local institutions were trained in basic aspects of land use planning,

land evaluation, farming system analysis and database development. Most of them are working in applying or improving the methods and tools developed within their institutions.

Databases containing maps, satellite images, non-spatial data of soils, climate, and social/economic aspects were transferred to the Department and are being used and improved for new applications. It is the first set of digital data available in Guaviare for local institutions.

An important step towards the integration of institutional actions was the creation of a framework for the production, use and management of information. It will avoid the duplication of efforts for collecting and storing data and will contribute to improving the efficiency and use of information.

(c) Institutional structure to produce, manage and use geographic information

A working group of local institutions co-ordinated by the Departmental Government is designing and implementing a GIS for storing, managing and analysing data and producing information related to 7 main subjects: environmental, social, cultural, economic, infrastructure, institutional and political aspects.

The first outputs of this working group are the creation of an institutional structure, defining information objectives, improvement of database design and institutional functions.

The objective of GIS is to provide adequate and updated information to support the regional planning process (*ordenamiento territorial*) which must be conducted in the Guaviare territory. For this purpose, a first version of a database was defined and the structure and content of the tables established.
Institutions working on this issue are the Departmental Government (Planning Division and Secretariat of Agriculture and Environment), SINCHI Institute (responsible for research), CDA Corporation (natural resources management) and INCORA (agrarian reform institute).

(d) New applications for development

Developed methods and tools are being applied by local institutions for new applications. Since these processes are not yet finished, I will present some progress made thus far:

1. Land use and conservation plans for small watersheds

The land use planning method developed was applied in a project carried out by the Departmental Government, the Fund for Rural Development (DRI) and a local NGO. The objective was to define and agree with communities a management plan for six small watersheds (90,000 ha of total area). GIS, and other geographic databases developed, were used to support phases in diagnosing and evaluating land use and management alternatives, and the elaboration of plans.

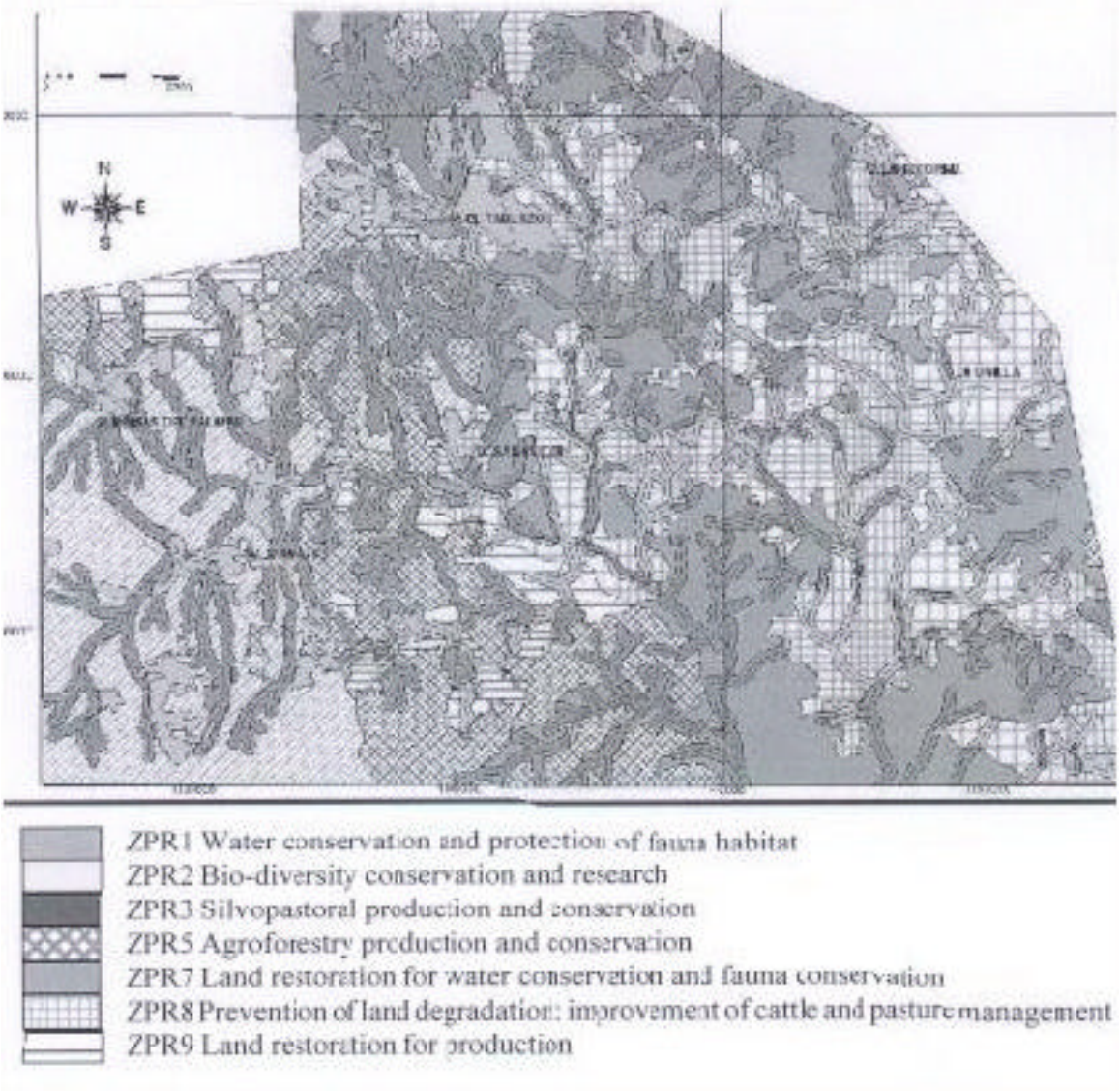

Figure 3 Zoning for land use, management, conservation and restoration - La Unilla Watershed

The main outputs are the zoning of each catchment (Figure 3) showing areas for production, forest and water conservation and for restoration of degraded lands. Specific projects were elaborated to improve the present land use systems with forestry and agroforestry, soils and forest restoration, education, pasture and livestock management.

These plans are in the stage of evaluation for later implementation. Financial problems are the main limiting factor for implementation.

2. Spatial study of farming systems

The objective of this project, conducted by the SINCHI Institute with participation of local government and other institutions, is to identify and characterise the present farm systems, their spatial trends and their environmental impact as a basis for defining improvements in the present situation. Methods, tools and geographic databases developed are being used as inputs into the study process. The study covers about 2,000,000 ha in Guaviare and will extend into new areas in other departments of Amazonia.

(e) Dissemination of results

Results of the project were published in the Tropenbos-Colombia Series and an automated demonstration (DEMO) was done with a summary of the method and procedures developed. These are important tools that are being used to support training and the diffusion of activities not only in Guaviare but also for other organisations and universities.

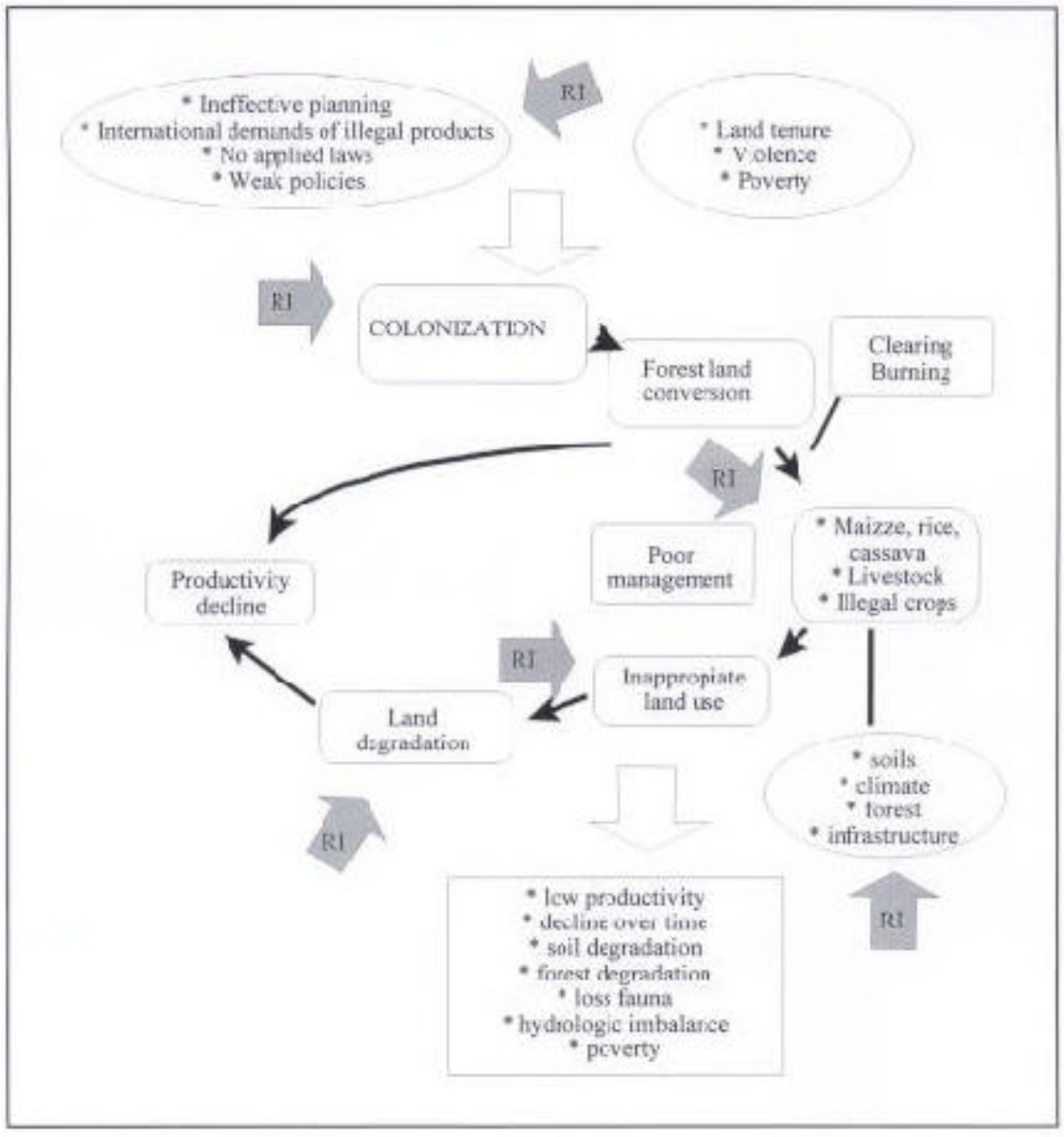

Figure 4 Cause and effect model of present land use situation in Guaviare

IV. LACK OF INFORMATION AND RESEARCH

(a) Main problems to be addressed by research

The model in Figure 4 presents the main causes and effects related to use, management and conservation of natural resources in Guaviare. This model offers points for introducing changes and for the identification of research needs to improve the present situation.

1. Limited impact of research on local problems

Most research projects conducted in Guaviare have considered the conservation and appropriate utilisation of tropical rain forests as its main objectives. However, the question that often arises is: how much has research contributed to reaching the objectives?

It is clear that the knowledge of the Amazonia ecosystem has improved as a result of the research conducted. However, an important application of these results has not taken place and therefore no influence or improvement in the conservation and management of tropical rain forests has occurred.

In the developed method an attempt was made to integrate results of existing research and local knowledge for producing useful information for planning. This method seems to be a suitable and efficient approach and allows us to make some recommendations:

- Research must be linked to local management and conservation policies, programmes and objectives;
- Research must contribute to solving specific problems; therefore, these should be important criteria in order to decide what to investigate;
- Local organisations and communities must be involved in the research process. It is important to consider them not only as sources of data and information but as part of the decision-making process in defining research priorities and how to execute the research.

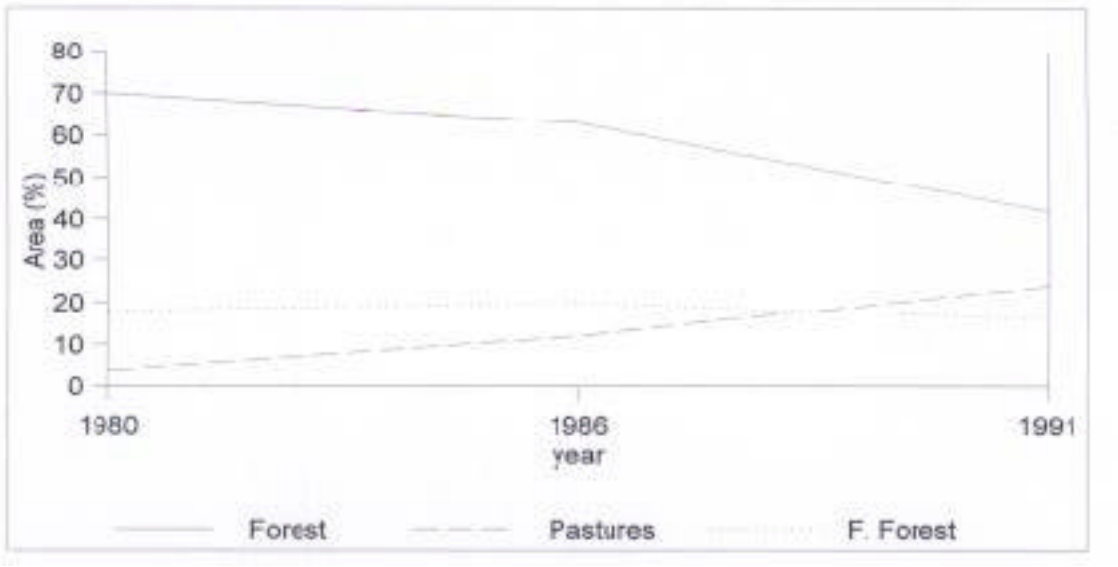

Figure 5 Rate of forest land conversion

2. The forest land conversion process

A pilot area (237,000 hectares) and the dynamics of converting forest land to pasture over a 10-year period were analysed by comparing maps of different years. From the results shown in Figure 5, during the period 1980-1991 there was an important decrease in the forest area and increase in pasture area. In 1980, about 73% of the area was covered by natural forest, by 1986 this had decreased to 61% and by 1991 to 43%. On the other hand, pasture area increased from 4% in 1980 to 12% in 1986 and to 25.3% in 1991. These data demonstrating the rate of deforestation permits us to assess the future situation if present trends continue.

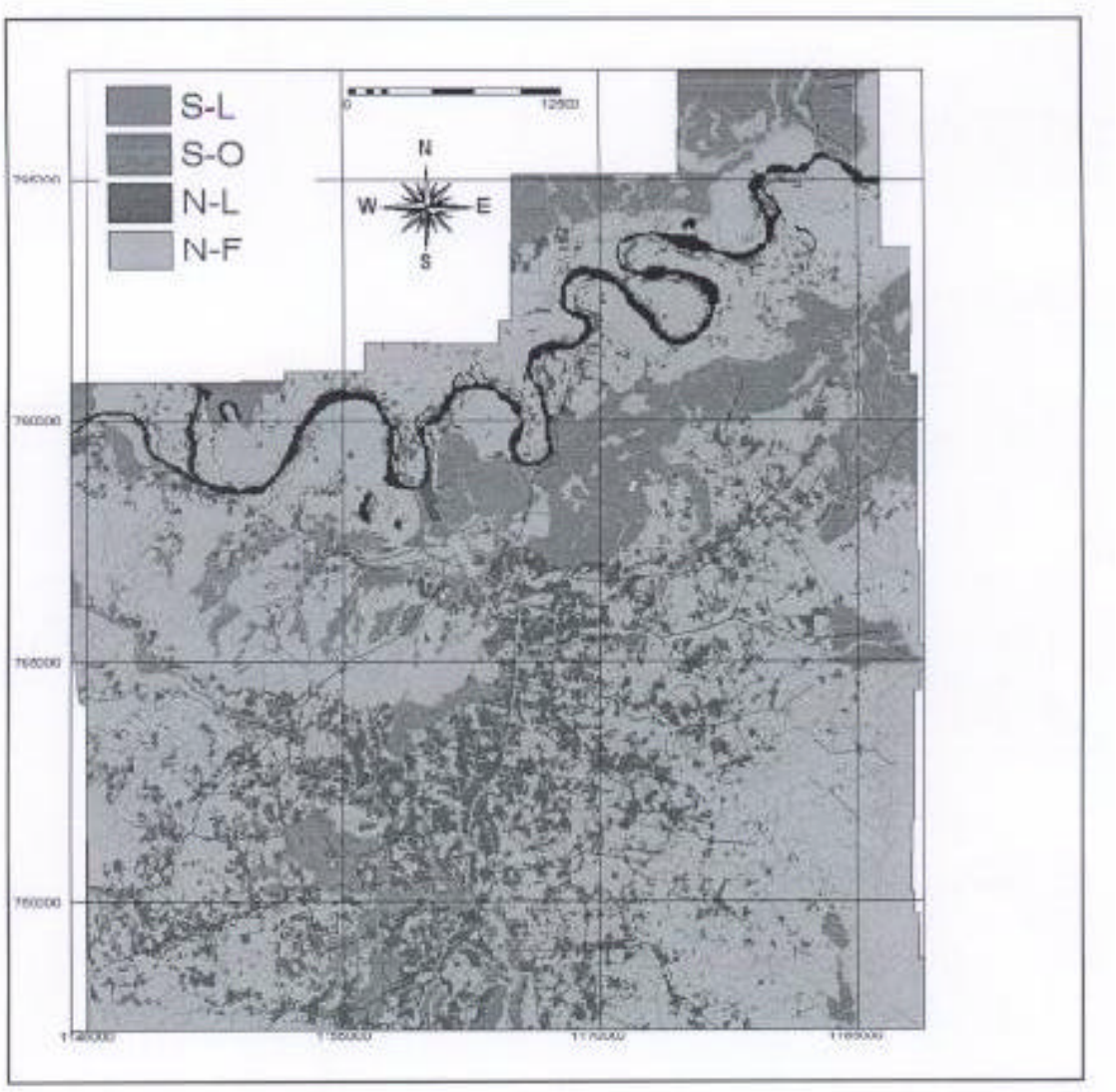

Figure 6 Inappropriate land uses
Land suitability for cattle: S = Suitable; N = Unsuitable
Present land use: L = Cattle; F = Forest; O = Other

3. Inappropriate land uses

Inappropriate land use results from the discrepancy between present land use and land suitability. In Figure 6, the present area occupied by livestock is compared to land suitability for the same system. The data analysis demonstrates that 19.5% of the area is used for livestock although the land is not suitable for that use.

Another aspect is the potential inappropriate use of land. These include unsuitable areas not yet converted to livestock production, which occupy 60% of the area. If the present trends continue, pastures will gradually occupy these areas.

4. Lack of sustainable land use options

Colonisation implies the introduction of land use systems characterised by instability and low productivity, leading to intensive degradation of the ecosystem. After the initial cutting and burning of the forest, colonists plant crops, such as maize, cassava or rice, for one or two years. Thereafter, most of the holding is converted to pasture and cattle are introduced. Initially, the pastures support relatively high cattle densities, but the productivity is difficult to sustain and the carrying capacity falls.

The instability of the present land use systems and the lack of alternative sustainable land uses result in continuous intervention in forest areas. As a result of soil and pasture degradation processes, land productivity declines and more forested areas must be converted into pastures for breeding cattle.

5. Soil degradation and productivity decline

If a specific use is implemented in an unsuitable area several problems will occur. In our case soil and pasture degradation processes are taking place in the cattle pastures and consequently land productivity is declining. The degraded lands are abandoned and new forest areas are incorporated into the production frontier.

6. *Financial constraints*

The low amount of financial resources assigned to research, planning, management and conservation of natural resources is one of the most limiting factors. Many research and conservation projects have to wait a long time for a budget, others are finalised without having fulfilled their objectives, and several projects never begin.

(b) Specific demands of research

1. Efficient methods to produce, manage and use information

Results of the project are in the process of implementation by local government and by local institutions and, therefore, no specific changes in natural resources policies or in land use and management rules have been noted yet. However, there are good perspectives for positive impacts in the future and more support is needed while taking account of the following aspects:

- Introducing changes in land use policies and rules, and applying them to practical cases, is not an easy issue. This is a challenge that needs time, financial, technical and human resources.
- The present stage is critical for a successful introduction of changes. The approach developed is important but is not finished and improvements and more developments are needed.

Based on these aspects it is essential to continue working on a more complete strategy to ensure: the supply of good quality information at the lowest possible cost; the optimum role of information in planning and in the decision making process; and maximum impact of information and research.

Specific topics to be addressed in the future regarding this matter are:

1.1 Conceptualisation

It is essential to continue promoting conceptualisation and the strengthening of issues such as planning, information requirements and functions of information in the decision making process. It is also important to continue analysing and developing GIS as a tool to support the planning process whilst considering not only the technical issues, but also institutional, financial and human factors.

1.2 Data and information quality

Inadequate information could result in incorrect decisions and poor data quality may result in useless or incorrect information. Research is needed to develop clear and operational procedures to evaluate data and information quality; to determine the effect of data and information quality on decisions, and to define a minimum or acceptable quality of data and information for land use planning.

1.3 Data and information quantity

In Guaviare, data collection and data capture are the most expensive stages in information production. No clear procedures are in place for sampling or defining the amount of data required for a specific purpose. Updating of developed databases and collecting additional data are now points of interest.

It is important to establish criteria for defining a minimum quantity of information required for adequate and reliable planning and for establishing the minimum set of data essential for generating the required information.

1.4 Access to and dissemination of information

One of the most important factors limiting the use of information in planning and decision-making processes is the problem of access to information. A general situation is the lack of a mechanism to exchange information between researchers, planners, farmers and decision-makers. If this problem is not solved, research and information will never have an important effect on the wise use and conservation of natural resources. Some needs are:

- Methods to support the present technology transfer process carried out by the UMATAS (Municipal Units for Technology Transfer);
- Methods to support the formal education process. The existing education laws allow the introduction of regional subjects as part of the curriculum.

2. Basic surveys of natural resources

To continue with the land use planning process geographic information of the whole territory is required. At the moment only 10% of the Guaviare area has adequate spatial and non-spatial data, the remaining 90% presents only very general maps (1:500,000) supported with very few field data. Research is needed on identification, mapping and characterisation of land units at the appropriate scale considering:

- Identification and distribution patterns of forest and soil types, and fauna population and dynamics;
- Characteristics of each land unit in terms of forest (structure, biodiversity indicators, species of potential use), soil characteristics (physical, chemical, morphological properties).

3. Sustainable land use options to improve the present farming systems

Conservation of natural forests will be possible only if there are sustainable land use options. In Guaviare, alternative land uses are being investigated but few of them are available for implementation by the farmers. Some priorities for research are:

- Non-conventional uses of forest;
- Technologies for restoration of degraded soils;
- Methods for monitoring soil degradation and its impact on production;
- Agroforestry and forestry systems;
- Uses based on adequate management of fauna and hydro-biological resources;
- Marketing of non-conventional products.

4. Land evaluation methods for natural forest areas

As stated before, in Guaviare more than 4,500,000 ha still remain covered by natural forests that will form part of the planning process. The main aspects of research are:

- Identification and description of forest land uses and functions;
- Definition and quantification of inputs and outputs;
- Establishment of criteria to define suitability.

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INFORMATION FOR SUSTAINABLE LAND USE PLANNING AND CONSERVATION IN THE GUAVIARE DEPARTMENT, COLOMBIAN AMAZONIA

Achievements

- Development of a method for planning of sustainable land use and conservation using planning concepts, GIS, remote sensing and modelling techniques.
- Integration of different disciplines, such as landscape ecology, land evaluation, farming system analysis and environmental impact assessment; and of biophysical and socio-economic components.

Challenges and Problems; Information Needs

- Lack of sustainable land use options, leading to intervention in forest.
- Soil and pasture degradation leading to low productivity of the land.
- Low amount of financial resources assigned to research, planning, management and conservation of natural resources.
- Poor mechanisms to exchange information between researchers, planners, farmers and decision-makers.

Points for Future Research

- Description of natural forest areas including the spatial component.
- Identification and description of forest land uses and functions; establishment of criteria to define suitability of land use.
- Methods and procedures for analysis in land use planning; environmental assessment of measuring soil degradation; restoration of degraded soils.
- Sustainable land use options to improve the present farming systems

Impact of research

- A change in attitudes of people in local organisations, an increased use of analytical methods such as GIS and land evaluation; a great interest in improving the decision making process by using and applying information.
- Application of advanced methods for land-use planning at catchment level; farming systems; for definition of priority areas for social investment.
- The creation of a institutional framework for information use, production and management.
- Dissemination in local publications.

Conclusions

- Research must be linked to local policies, programs and objectives of management and conservation.
- Research must contribute to solve specific problems, therefore, these should be important criteria to decide on what to investigate.
- One of the most important factors limiting the use of information in planning and decision making processes is the lack of mechanism to exchange information between researchers, planners, farmers and decision-makers.

RESEARCH NEEDS FOR A LOW IMPACT LOGGING OPERATION IN THE BRAZILIAN AMAZON: THE CASE OF PRECIOUS WOODS/MIL MADEREIRA ITACOATIARA

Dr. R. de Camino V.
Precious Woods, Costa Rica

1. MIL MADEREIRA AND FOREST MANAGEMENT IN THE BRAZILIAN AMAZON

'Precious Woods' was created to promote sustainable development through forest management of plantations and primary forest. The company intends to demonstrate the profitability of producing multiple goods from the tropical forest, according to the sustainable development paradigm, for the benefit of the company's shareholders, employees and workers in the local communities in the area of influence of its projects, the consumer, and the environment. In practical terms, Precious Woods wants to produce hardwood and other forest products in tropical countries by means of proper reforestation and the sustainable management of natural forests. Perhaps the exception that makes Precious Woods different is that its sustainable management of natural forest considers all dimensions of the concept: the social, economic, and environmental dimensions.

The company is making great efforts to guarantee an efficient management, oriented towards the quality of its corporate activities. It wants to accomplish the economic and social integration of its companies in the environment and with the local population. To do so, it employs highly qualified mainly national and occasionally international personnel in the activities of the countries to transfer technology and know-how to the environment where it works, to develop a forest economy feasible and close to nature and people, and to add significant value to the regions and possibly to the countries where it works.

Through its Brazilian company 'Mil Madereira Itacoatiara' (MMI), Precious Woods owns a farm in Amazonia. Located 200 km east of the city of Manaus, capital of the State of Amazon, its area is 80,000 ha. The property's name is 'Fazenda Dois Mil', or F2M. The present land use for forest management at F2M is shown in Table 1.

Table 1 Present land use at F2M forest concession, Brazilian Amazon. Guerreiro, 1996

Present Use	**Area (ha)**	**Percentage (%)**
Forest Area for Wood Production	50,000	63
Conservation Area	24,726	30
(Absolute Conservation Unit)	(5,164)	
(Conservation Areas in Production Compartments)	(19,844)	
Deforested Area before 1993 (year of purchase by PW)	5,845	7
TOTAL	80,571	100

complete
to the main river. Within the wood production compartments, 18,200 ha on the lowlands and deep

be preserved.

IBAMA, the Brazilian Authority for the

requirements of
the current operations, certification of good forest management was requested from Rain Forest
FSC. The certification team included
group of highly qualified scientists and technicians. The selection of the certification group was based

and possibly more important, for the Brazilian forestry and
approved in July 1997.

Principal guidelines for forest management applied at F2M by Precious Woods. 1996.

	Activity
harvest	General Forest Inventory (0.1 % intensity).
3 years before the first	Topographical measurement of the area.
2 years before the first	Analysis of the topography and establishment of the harvest Delimitation of the planning units (10 ha) in the first compartment. diameter in the compartment to be harvested of the trees. up of harvesting impact on the remaining forest. Construction of roads. computerised
harvest	Planning of the harvesting activities. Opening of the systematic network of logging roads.
1 year after the first harvest	the remaining forest. Measurement of permanent plots: impact recovery, survey of future measurement of regeneration. silvicultural treatments: cutting of the growth of desired species and individuals.

CELOS system (de ,1986; Poels,

1987; Hendrison, 1990), developed in Suriname by a team of scientists from the University of Wageningen (among whom Dr. de Graaf is a permanent adviser to Precious Woods). The system was adapted by INCA to the conditions of the Brazilian Amazon (Higuchi *et al*.,1991), and adapted again to the specific conditions of the F2M=s forests by the foresters' group of the company.

Table 2 shows the concept of sustainable management being applied.

The management concept contains the following elements:

- The forest's inventory yields a volume of 290 m^3/ha of all species of wood with a diameter of more than 5 cm;
- The volume of commercial species with a diameter of more than 50 cm is 80 m^3/ha;
- The average planned logging volume is 35 m^3/ha, with a maximum of 40 m^3/ha. The limit for individual species is 80% of the commercial volume, to avoid excessive logging and without endangering the biodiversity. Research information from EMBRAPA/CPATU determines a yearly average growth for the logged species of 1.6 m^3/ha/year, which would allow a maximum of 43 m^3 to be logged every 25 years. Estimates are that, with forest management, the volume growth of commercial species could increase to 5.2 m^3/ha/year, but in the long term (75 to 100 years; Silva *et al*., 1995).
- At present, there is a list of 65 species with a potential for export and for national markets; 45 species already have export and/or national markets, and 28 have an export market. The larger the number of commercial species, the greater the possibilities for flexible silviculture, while maintaining the cyclical allowable harvest. In fact, it is now possible to sell only 28 species. In these forests, there are no fine species, as in other areas of the Brazilian Amazon. Completely lacking are *Swietenia*, *Cedrela*, and *Carapa*, which make the commercialisation and sale of the products more difficult.
- The cutting cycle was fixed at 25 years, which is the term estimated for a forest area to recover its original volume after being logged. The cutting cycle determines the repetition of logging in the same area.
- The forest is divided into 25 compartments of 2,700 ha, each with an average of 700 ha for preservation (buffer zones of water courses and similar areas) and 2,000 ha for wood production.

The most important forest activities are programmed as follows:

- Operational inventory in the next compartment to be harvested: a survey of all commercial trees with a diameter in excess of 50 cm. A map with UTM co-ordinates (4 x 4 km) is used. In the area, blocks of 10 ha (250 x 400 m) are marked with strips every 50 m. All the commercial trees within these blocks are measured. For every tree, the diameter at breast height is measured (DBH at 1.3 m height). The species is identified, located on the map, and marked with a number. The data are processed with software that generates an inventory list and a map. The computer makes a pre-selection of the trees to be harvested, according to the maximum volume to be logged, the species abundance, and the distribution of the logging in the block and in the compartment. With this information, a prospecting map and then a logging map are generated, which the harvest crews use in the field.

- Opening of roads: a systematic network of logging tracks is made, 100 m apart, which yields a road density of 80 linear m per ha. The network is permanent; the logging tracks will be in the same place in every logging cycle. About 14 km of main roads are constructed for each compartment of 2,000 ha and one log yard is made for each 60 ha of forest. The road network represents about 4.5% of the total area.

Table 3 Main differences between the Precious Woods model and the traditional model for using primary tropical forests.

Precious Woods Model	**Traditional Model**
• To take advantage of business for making sustainable development in its economic, social and environmental dimensions.	• To take advantage of business for basically earning money. Sustainable development is only considered when expressed in the laws.
• The Forest Management Plan is a tool for carrying out the activities in the field.	• The Forest Management Plan is just a legal requirement for cutting wood.
• The planning of activities is essential. The same amount of money is invested in planning as in the purchase of land and forest.	• There is basically no planning of the activities in the field, further than extracting the maximum possible volume at the lower cost.
• The harvest is limited by the growth of the forest and by the requirement that not one species in the forest goes extinct.	• The harvest is concentrated in just the most valuable species, without consideration of their possible extinction.
• The cutting and extraction system causes a limited impact in the forest.	• The cutting and extraction system causes a great impact in the forest.
• Personnel is previously trained in their job to improve efficiency as well as to reduce impacts on the forest, and they use safety equipment.	• Personnel learn while they do their job, and under the philosophy of obtaining the highest yields, without consideration of the impacts. Personnel safety is very poor.
• Forestry management includes silviculture, by cutting the vines, refining and liberation, in order to favour the trees of the most valuable species.	• There is no silvicultural concept.
• Follow-up of the method through research.	• There is no research.
• Transparency and active promotion of the model: training and technical assistance to third parties.	• The personnel is not trained, nor are third parties. Criteria of competition prevail over the criteria of transmitting appropriate techniques.
• Good possibilities of certification because of high management standards.	• No big interest in certification, which is considered as a cost.
• Intention of a permanent social outreach program, transfer of technologies to forest-based communities that improve their livelihood.	• Social issues limited to the legal requirements.

- Tree felling: crews go over the area with the logging maps in hand, to locate the trees to be logged. The felling starts by verifying whether the tree is hollow. If there is a big cavity, the tree is not felled, since it would destroy other trees and it would not be used. Then, other criteria are verified, such as proximity to other trees, species, and the size of the gap in the forest due to the felling of the tree. If the tree is rejected, it is replaced by another non-marked commercial tree located nearby. If the tree is selected, a directional felling is done with power saws and wedges in order to fell the tree, if possible, in a herring-bone position according to the roads and in a direction that causes the least damage to the remaining trees. The yield of this operation is 17 trees/crew/day.
- Pre-hauling: this is done with a track skidder, especially designed for low-impact extraction in the forest. Extraction is done from the logging track. Logging machinery does not go inside the forest; instead, logs are pulled out with winches to a maximum distance of 50 m. The impact of the logging operations on the regeneration and future trees is minimal. The yield of this operation is 35 logs/machine/day.
- Hauling: this does not have any great impact on the forest, and the trees pre-hauled to the side of the road are transported to the log yard in the forest. This is done with a skidder with low pressure tyres to avoid excessive compacting of the soil. The yield is 45 logs/machine/day.

Additionally, permanent plots are delimited and measured before and after the felling. This will allow the measurement of volumes, the felling and logging impacts, and the forest growth, as well as the planning of silvicultural activities.

A sawmill was installed with a processing capacity of 70,000 m^3 logs and a production of 35,000 m^3 sawn wood a year. The target transformation coefficient for the beginning stage is 45%, but the goal is to increase it to 60%, with which the yearly production could also increase to 42,000 m^3. Additionally, there are kiln dryers, and a wood-processing plant for the production of semi-finished and finished products (e.g. doors, windows, finger joints) will be finished by the end of 1997. Processed wood fetches higher prices than just sawn wood. Expectations are that 85% of the wood will be exported and 15% will be sold on the local market.

The main differences between the system of Precious Woods and that of traditional loggers are described in Table 3. Table 4 shows the big difference in impact that the Precious Woods system provokes in the forest in comparison with the traditional logging system (FAO, 1997).

Table 4 Differences in impact between the Precious Woods model and the traditional logging system in Amazonia. Results of a trial by FAO. Adapted from FAO (1997).

Variable	Precious Woods Model	Traditional Model
Harvest (m^3/ha)	38.50	114.60
Time for felling a tree (min)	21.41	17.59
Volume per tree felled (m^3)	7.08	5.57
Productivity (m^3/hour)	19.76	17.92
PCTs with damage after felling[1] (%)	28.30	52.40
Area occupied by skid trails (%)	4.53	19.87
Timber losses in harvesting (%)	3.90	8.50
Sum of canopy gaps of felled trees (%)	10.80	24.70

[1] PCT is Potential Crop Tree.

2. THE INFORMATION NEEDS FOR FOREST MANAGEMENT

A model like the one of Precious Woods requires:

- Precise information on the volumes and volume distribution by species, and information on defects in the volume (e.g. hollow trees), which translates into higher costs for the planning of logging;
- Information on the response of the forest ecosystem to logging and subsequent silvicultural intervention. This includes changes in species composition in preserved and in intervened areas and in growth rates of all species in response to canopy opening;
- Information on the additional cost of silvicultural intervention in comparison with traditional non-management;
- Precise information on the yields of forest operations and the safety of the logging system;
- Information on the markets (e.g. prices, species, trends, products) for a greater number of species (including lesser-known species) and about potential clients for products from well-managed forests;
- Information about the surrounding institutional environment. There is a need to face pressure from the environmental community, and sometimes even its lack of understanding of the model. Nevertheless, the company adopts a policy of transparency and free access, and is looking for contact and collaborative work with institutions and groups that can be powerful partners in implementing and disseminating the philosophy and methods of sustainable forest management of primary forests;
- Information about the policy environment to face the lack of cooperation mechanisms of the international financing institutions, which do not support commercial projects in primary tropical forests. A greater involvement of regional and multilateral institutions is also expected, since the Precious Woods model could be considered a pilot activity.

3. THE ROLE OF RESEARCH FOR THE SUCCESSFUL IMPLEMENTATION OF THE PROJECT

The project finds its existence in research:

- In 1990, I was one of the opponents for the dissertation of J. Hendrison (1990) in Wageningen. This gave me the opportunity to become familiar with the CELOS System and also to get to know Dr de Graaf and his views about sustainable forest management.
- In 1991, as a member of the Editorial Committee of *Forest Ecology and Management*, I had to review an article by Verissimo *et al*. (1992), which was also an inspiring element for the conceptual structure of the project, because it permitted me to have a look into the economy of forestry in Amazonia.

From its incipience, the company did not go directly into research, but to universities and research institutions to get advice from researchers for the development of the project, as indicated above. The starting points were existing research experiences such as the experiments in Suriname (the CELOS System) and near Manaus (the S.E.L. system, a modified version of CELOS for the Brazilian Amazon).

In the region, there is a lack of information from permanent plots that could inform us about the composition and extent of the forests in Amazonia and about stand dynamics (regeneration strategies and growth rates). It was only possible to find isolated points of information, which made the first selection of the project site difficult.

Some direct benefits of research for the implementation of the project are:

- CPATU, Centro de Pesquisas Agronomicas del Tropico Umido of EMBRAPA, provided the methodology and the software for the installation, measurement, and processing of information for the permanent sample plots that MMI is laying out every year. About 10 permanent plots of 1 ha

are installed every year for studies of growth, yield, regeneration, and logging impact;
- FAO conducted a study to compare the impact of the PW and traditional logging systems in the Brazilian Amazon. The study has helped us to refine the logging system (FAO, 1997);
- Students of different universities have conducted thesis studies in Itacoatiara: the sustainability of seed dispersal by animals (Spierings and Koning, 1996); a study in progress about the frequency and causes of the presence of rotten and hollow trees in the forest (Brockhoff ,1996); the spatial distribution of commercial species as a useful advance for ecological and management modelling (Breugel, 1996);
- MMI has tried to complete the information about wood characteristics of the species, because the company needs to provide their key features to the markets. A report was produced (Guereiro *et al*., 1996), but afterwards was enhanced by the work of a forestry student of the ETH from Zürich, which contains the botanical description, the silvicultural features of the species, a description of the wood, the physical and mechanical properties of wood, the values of durability and impregnation possibilities, the drying conditions, the workability of wood, the local and commercial use of wood, similar species and particular properties of the species (Gambetta, 1997).
- Another study is in progress to measure the conversion rate of logs to sawn wood for different species, and to seek ways of improving the yield in the sawmill.

An important study is now being set up to evaluate the impacts of logging and forest management as practised traditionally and by MMI. The study will cover the ecological, social, and economic dimensions of sustainable management. The research will be a major test conducted in an area of about 700 ha. Four different logging systems will be compared, concentrating on the structure of the forest and regeneration, the impacts on soils, the impacts on fauna, and the impacts on non-timber forest products. The study is being proposed by EMBRAPA in Manaus and is now looking for funding.

As is evident, research efforts in the area are now:
- Only opportunistic and not structured by a research organisation;
- Trying to take advantage of the interest of researchers and undergraduate and graduate students;
- Following, to a certain extent, the interest of researchers rather than the company.

Research is an investment for the long term, but before going too intensively into research, the company needs to prosper economically.

4. NEEDS FOR FURTHER RESEARCH

Research is an important tool for sustainable forest management. The response of the forest to harvesting is not well known, and many of the decisions related to forest management are at present based on ecological and silvicultural common sense (harvesting volume, cutting cycle, percentage of trees to be left after harvest, etc.). It will be important to continue collecting information, knowledge, and insights throughout the cutting cycle.

The managed forest of MMI offers great opportunities to monitor and evaluate developments in the ecosystem caused by the management activities. Besides subjects directly related to forest management, the sawmill and MMI's other timber-processing departments should also be considered in the design of a research programme, because a private company needs not only forestry research, but also logging, sawmilling, marketing, and economic research.

Research will be needed to improve the established techniques in harvesting as well as in silviculture.

In these fields, cooperation may be sought with various interested institutes, national as well as international. Preference should be given to subjects of research clearly related to the company's interest.

A clear distinction should be made between operational research and scientific research. Operational research will help MMI to establish and improve its operations, and is largely practical in nature (e.g. to support short-term management decisions). Scientific research is needed to establish a scientific base for long-term management, especially in a long-term business as forestry is. Scientific research, however, cannot be given priority during the first years of establishing MMI as an economically sound enterprise.

In the following, the main research issues that are important for the practical management of a private company are briefly outlined. The information is taken from Appendix IV of the forest management plan of MMI, as prepared by de Camino and de Graaf.

Ecology

Ecology

The presence of permanent preservation areas will permit comparative studies of ecological dynamics in preserved and harvested areas. A comparative study on system dynamics will contribute to determining the impact of harvest on biodiversity.

- Research on the regeneration strategies of the main commercial tree species will contribute to a more sophisticated definition of the silvicultural treatments;
- Research on the ecology of potential non-timber forest products is a basic requirement for the design of sustainable management strategies for the various products (e.g. Bromeliaceae, vines, fruits, and extractives).

Forest management for carbon sequestration

Nowadays, there is much discussion about the potential of a tropical forest for carbon storage and fixation. The differences between a managed forest, a traditionally logged forest, and an untouched forest are not clear, especially considering that the last two are subject to deforestation.

Silviculture

Analysis of permanent sample plots

Permanent sample plots are installed at a frequency of one sample plot of one hectare for each 200 hectares of forest production area. The plots are measured one year before and one year after harvest, and every three to five years afterwards. The permanent sample plots are an important source of information on the dynamics of the forest under management. Different kinds of research can be conducted based on this information:

- The effects of harvesting and silvicultural intervention on the remaining trees, on regeneration, on the soil, and on water sources and courses;

- Studies on tree growth following harvest and silvicultural interventions will establish the length of the cutting cycle with increased precision;
- Studies on the various methods of tree elimination as part of silvicultural treatment of the forest: the efficiency of different girdling methods, the use of different kinds of arboricides, and their residual effect;
- Phenological studies of the main commercial tree species, with an emphasis on age and size of first reproduction of trees and fruiting intervals;
- A subject of future studies (of less priority now) may be research on the sustainability of forest management as done by MMI, so as to develop criteria and indicators for monitoring the sustainability of systems that can be used practically and without high costs.

Harvest intensity

It is known that the intensity of harvesting has clear impacts on the remaining forest. A higher intensity will provoke higher damages. There is a limit to the intensity of harvesting above which the damage is too high and the future development of the forest will be compromised. On the other hand, higher harvesting intensities will improve the profitability of harvesting. It is therefore important to conduct research on:

- The response of the forest (along the lines described above) with different initial basal areas and to harvesting with different intensities. The combination of growth studies and harvesting-impact studies will help to define the planning of cutting cycles and harvest intensity with more precision. These are now determined tentatively, on the basis of available information.

Species trials

There are different ways of growing trees besides the normal forest management system. These alternatives can be interesting options for the already existing cleared areas, the secondary forest, or as an addition to the current forest management system. In this context the following trials can be mentioned:

- Species trials for reforestation under the cover of secondary vegetation. There are about 5,000 hectares of deforested land in the MMI area. This area will gradually transform into secondary forests. In the future, different trials of enrichment planting will be done. Enrichment can make sense in an open secondary forest.
- Species trials for enrichment planting in the managed forest area. In the compartments already harvested, different trials can be done with the most valuable commercial tree species now present in the forest and other tree species representing a high commercial value (e.g. *Swietenia*, *Cedrela*, *Carapa*, and others). The trials should be small-scale, since the success of enrichment has been very limited and expensive.

Harvest planning and implementation

Refinement of inventory criteria

Inventory is the basis for the proper planning of harvesting activities and a key issue in the economics of sustainable forest management. In this context, the following research items are of interest:

- Volume estimate improvement. In the first compartment, the accuracy of the volume equation applied was very low. Improvements were already made with the second compartment. Until now, MMI has used a volume equation that aggregates all species. By the time more information becomes available, the volume equation can be further improved and different equations for different species or groups of species could become available;

- The occurrence of different kinds of defects according to different variables (e.g. species, size of trees, site condition). It is important to gain more insight into the probabilities and external features that reveal the occurrence of defects on trees.

Damage reduction
To secure the future production of the forest stand, logging impacts need to be minimised:
- Methods need to be developed to determine and reduce the damage of felling to the remaining trees of different size. Felling damage can be expressed in number of trees, basal area, and volume;
- Methods need to be developed to determine and reduce the impact of winching and skidding of the logs. The principal impacts are removal of the top soil, construction of roads, skid trails, and log landing areas, as well as damage to the remaining stand.

Organisation of activities
The increased availability of specific information on forest management will improve the organisation of activities:
- Cost-benefit analysis of forest operations (e.g. harvesting and silvicultural operations, road construction, and the processing of management data and information). Results can be rapidly obtained, and will lead to important reductions in cost;
- Skid trail layout and winching distance. Skid trails are located 100 m apart. If the winching distance can be increased to more than 50 m, the distance between skid trails can also be increased to more than 100 m. The practical impact of different trail distances needs to be studied in terms of productivity and the economic consequences;
- Log landings. Trials to improve the design of the log landing areas in the forest for a better preservation of the logs;.
- Maintaining a special data base on specific considerations to be taken into account for each tree species harvested. Considerations like how to avoid splits during and/or after felling, fungus and insect attacks, etc.;
- Start working on the development of a Geographic Information System (GIS) for forest management purposes.

Sawmilling, industrialisation, and marketing
Conversion factors
With time, the progress of the sawmill operations will provide the information, now lacking, but needed to take proper production decisions:
- Possibilities for wood-waste processing. A proportion of at least 30% of the volume of a tree remains in the forest. There is a need to measure the volume of wood that can be utilised and to develop operational methodologies for improving the yield. What is needed is to identify and test ways of producing wood from short logs and large branches, and the possibilities of charcoal production with harvest residues and wood felled during road and skid trail construction;
- Sawmill production yield of logs. Studies are needed to obtain the conversion factors for the production yield of the sawmill as a function of species, diameter, length, time between harvest and processing, etc. Strategies must be developed for improving the yield through further processing;

- Finished and half-finished products. A control system is needed for the amount of >waste= material coming out of the sawmill and the kind of yield this brings in the industrialisation process. The vertical integration of the production process into half-finished and finished products is a key issue for the efficiency and profitability of MMI.

Productivity improvement

There is a need to improve the productivity in the production process. The percentage of raw material processed into marketable products and the costs of processing are two important variables for the profitability of MMI.

- Testing of products. The sales and marketing department should inform the sawmill about the demands for products by the market. The sawmill should provide prototype products;
- Kiln drying programmes. Kiln drying strategies and schemes must be further developed and tested. Each species and product has its special requirements.

Market studies

The tropical wood industry faces the need to sell 'lesser-known' species. There is a need to increase knowledge of the markets and knowledge about species, and to develop adequate marketing strategies. This kind of research needs to be done by a group of companies, at a regional and national level, but not by one company alone. What is needed is:

- Information about lesser-known species and comparisons with the properties of already-known species;
- Further processing possibilities of the species in order to reach the markets with a wide palette of products;
- More precise studies about the market possibilities of certified forest products (since MMI is certified by a group accredited by the FSC).

Non-timber forest products (NTFP)

Initially, MMI will produce only timber products. When timber production is consolidated, however, the production of non-timber forest products as a component of the rational utilisation of the forest should be studied. Research on non-timber forest products needs to be done by third parties, not by the company.

Identification of potential non-timber forest products (NTFP)

The potential non-timber forest products (NTFP) should first be identified and evaluated. Possible interesting NTFP could be:

- Bromeliaceae, for use as ornamental plants;
- Vines, especially for the production of baskets and furniture;
- Fruits, for human and animal consumption. Depending on the product, fruits can be interesting for the local or the export market;
- Extractives (exudates and resins). A general study is needed for this type of NTFP. Massaranduba (*Manilkara huberi*) might be a very interesting species because of its high frequency in the forest.

Definition of management strategies for non-timber forest products (NTFP)

The utilisation of NTFP must also be done under a sustainable management regime. The harvest intensity should never exceed the natural production potential.

- Ecological features of NTFP species. If the utilisation of an NTFP has been considered feasible, its phenology, productivity, reproduction strategy, etc., should be studied;
- Experimental trials. Experiments with different harvesting and management systems should be performed to determine the best management strategy for each NTFP.

Modelling and economics
A company needs to have powerful planning tools at its disposal to anticipate the future.

Development of forest simulation models
- The response of the forest to silvicultural interventions in terms of tree growth and forest composition can first be simulated and then improved with the information from the permanent sample plots and other studies.
- The development of simulation models that can project growth and yield under different management strategies. These models are not only useful for MMI, but also for other companies willing to practise sustainable forestry in the Amazon (Alder, unpublished).

Development of financial simulation models
- Based on the simulation models on growth and yield, financial simulation models can be developed to determine the profitability of the general and annual operations of the company;
- Study the potential of transforming the carbon storage and sequestration capability of the forest in an income through joint implementation.

5. FURTHER PLANS

A foundation will be set up that will support social development in the project's area of influence. The intention is not to exercise a kind of paternalistic influence, but to support the communities in determining their own destiny, by trying, initially, to act as mediators with authorities on health, education, and rural development.

A proposal is being prepared to provide technical support to other forest owners, including rural communities. Under this proposal, they will be stimulated to adopt forest management systems similar to those used by MMI, and to run their forest under appropriate low-impact forest management. In this way, they will benefit from the forest indefinitely. We hope to get funding from external sources to set up a team of three to four persons who will be available for technical support for communities and private people. The unit would also be open to give advice to third parties.

Among the plans is the establishment of a training centre for forestry personnel of different levels. At the centre, training would be provided in activities such as planning and conducting forest inventories, forest surveys, elaboration of management plans, low-impact logging and hauling, management of conservation areas, etc. The company already has experience in this field with a school for field forestry technicians in Costa Rica, which has already been running for 8 years. We hope to receive external support for a project that is now being prepared together with the University of Sao Paulo and the Escola de Técnicos Agricolas do Amazonas. They will initially provide a one-year specialisation training to agricultural technicians, who will then become Post-tecnicos in forest management.

It is the intention to establish an experimental station, open to scientists from Brazil and other countries (following previous authorisation of Brazilian authorities), for monitoring the forest management operations and studying the dynamics of intervened and non-intervened ecosystems (preservation areas). We are also seeking support from third parties to establish and operate the research centre.

As is easy to see, we are not now in a position to invest in these initiatives (as a company cannot invest in its early stages of development), because our first target is to demonstrate the feasibility of

sustainable forest management in the Amazonia. What we hope to achieve at present is that our experience (which is not common in tropical forestry) is used for research, training, and extension, so that it can be multiplied to other companies and regions.

6. KEY ISSUES FOR INTERNATIONAL RESEARCH

Section 4, Needs for further research, refers to many issues that should be included in a research plan, if the company wants to benefit optimally from research to improve its operations. Nevertheless, let me mention a few of the issues that are more appropriate for the international forestry research system than for the efforts of a small company:

- Comparative analysis of logging and management impacts. The situations to be compared are primary forest, forest subjected to low-impact logging, and forest subjected to traditional logging. The study should be detailed, taking into account all possible variables: vegetation, fauna, soils, water, and social and economic aspects. We began the formulation of a proposal with EMBRAPA, but we need partners for it.
- To make a better determination of cutting cycle, allowable cut, and composition of the harvest in the years to come, silvicultural research is required on the effect of different harvest intensities and silvicultural practices on species composition, growth, and yield;
- Provisional growth and harvesting modelling, connected with financial models for the monitoring of costs, income, and profitability. The model could be of benefit to any company working in sustainable forestry;
- Market and prices research and information systems. Most of the companies working with management in the Neotropics are facing difficulties with the markets, especially in the area of lesser-known species, market prices, suspicious buyers, the willingness of consumers to pay for certified products, and the possibilities of vertical integration. Existing knowledge and common forestry sense are sufficiently available to practise good forestry; the real difficulties for tropical forestry, however, are in the hands of industry and the markets.

All the subjects mentioned and also the ones in Section 4 would demand a huge amount of resources, which a small company cannot invest without endangering its economic feasibility and its chance to realise sustainable forest management. Research has benefits, not only for one group alone, but for communities, companies, and countries, and should be conducted in partnership with the private sector and the national and international research community.

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RESEARCH NEEDS FOR A LOW IMPACT LOGGING OPERATION IN THE BRAZILIAN AMAZON: THE CASE OF PRECIOUS WOODS/MIL MADEREIRA ITACOATIARA

Achievements

- Forest management system at practical scale was designed on the basis of research.
- Scientific feedback mechanisms integrated in the forest management system.

Challenges and Problems; Information Needs

- Volumes and volume distribution by species; causes and distribution of defects in the volume.
- No information on the response of the forest ecosystem to logging and subsequent silvicultural intervention; changes in species composition; growth rates in response to canopy opening; stand dynamics.
- Lack of compositional data of forests.
- Reluctance of international financing institutions to support commercial projects in primary tropical forests.
- Research is opportunistic and not structured.
- Researchers follow to a certain extent their own interest rather than the one of the company.

Points for Future Research

- Ecology (growth, mortality, phenology) of the main commercial tree species and potential non-timber forest products.
- Development of forest management for carbon sequestration.
- Reforestation and enrichment planting of secondary and intervened forests.
- Improvement of inventory methods: volume estimation; detection of defects.
- Studies on planning and design of harvest, logging cycles, optimum methods of tree elimination; silvicultural treatments.
- The effects of harvesting (logging, winching, skidding) and silvicultural intervention on damage of the remaining stand, on regeneration, on the soil and on water sources and courses.
- Development of an efficient and economic set of criteria and indicators for monitoring the sustainability of system that can be used practically and without high costs.
- Development of an expert system for harvesting including recognition, felling methods, potential diseases etc., per species.
- Development of a Geographic Information System (GIS) for forest management purposes.
- Cost-benefit analysis of forest operations such as harvesting and silvicultural operations, road construction, and processing of management data and information.
- Methodologies for improving the yield during sawmilling; kiln drying programs.
- Improved marketing and internal production optimisation strategies.
- Information about lesser known species and comparisons with the properties of already known species.
- Studies about the possibilities on the markets of certified forest products.
- Development of forest simulation models.
- The development of simulation models that can project growth and yield under different management strategies, extended with financial simulation models.

RESEARCH NEEDS FOR A LOW IMPACT LOGGING OPERATION IN THE BRAZILIAN AMAZON: THE CASE OF PRECIOUS WOODS/MIL MADEREIRA ITACOATIARA (cont'd)

Conclusions

- The company intends to demonstrate the profitability of producing multiple goods from the tropical forest, according to the sustainable development paradigm, for the benefit of the company's shareholders, employees and workers, of the local communities in the area of influence of its projects, the consumer and the environment.
- It has an active policy for stimulating research and applying its results in practice.
- Research has benefits, not just for the interest of one group, but for communities, companies and countries and should be carried out in a partnership among the private sector and the national and international research community.

CHANGING ROLES IN FOREST RESEARCH

Prof. J.A. Sayer
Director General, Center for International Forestry Research

The globalisation of economies and the emergence of a powerful multi-national corporate sector will result in significant shifts in the geographic locations, types, and intensities of forest use. In order to ensure the competitiveness of their countries, governments will increasingly need to apply their resources to creating the optimal policy environment. They will have to focus on ›steering and not rowing‹.

Economic imperatives will inevitably lead to production forestry being more and more dominated by the private sector; market forces will force it to relocate to areas of comparative advantage, and efficiency economics will require that production becomes more intensive. Research to support increases in productivity and in processing efficiency will be profitable and will be increasingly dominated by the private sector.

Figure 1 The general areas of comparative advantage of the public and private sectors in forestry

Figure 1 shows the general areas of comparative advantage of the public and private sectors. Efficiency will mean that more forest products will be produced on less land. Production forestry will gradually cease to be based on extensive harvesting from near-natural systems and will look more like conventional monoculture agriculture. The world's timber needs could, and probably will eventually, be met from the intensive use of a small proportion of the world's forest lands. A large proportion of the world's forests will then be surplus to the requirements of conventional forestry. Figure 2 shows the impact on land requirements of an increase in productivity of timber from 1 m^3/ha/year to 5 m^3/ha/year.

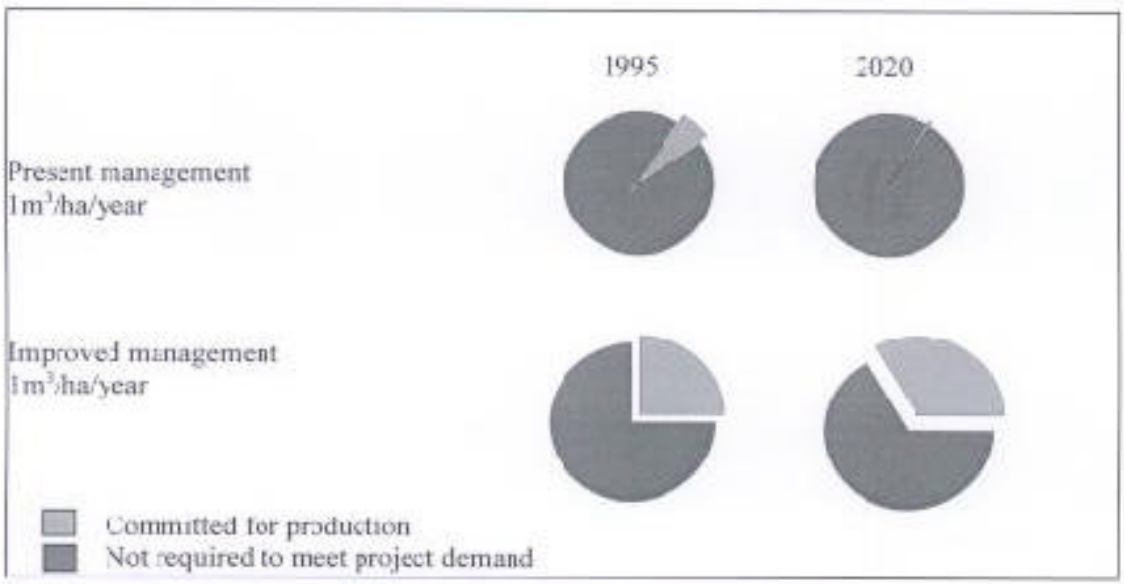

Figure 2 How much forest do we need?

These changes will occur at a time when governments are being forced to become ›leaner‹ and when there will be pressures to minimise regulation in order to attract international investment. Conventional forestry institutions may be perceived as irrelevant to this new environment and may become even more starved of resources than they are now. The increasing areas of forest that are not needed for production forestry may be allocated to preservation agencies or made available for conversion to other uses. There is a danger of an erosion of the institutional capacity to actively manage the ›residual‹ public forest estate.

The maximum utility of the residual forests will not be obtained by allocating them to total protection. Their prime function may be to provide local and global environmental services, but this objective is most likely to be met if the forests also make significant contributions to local economies. Optimal utility will therefore come from an appropriate balance between management for environmental functions and for the variety of products whose harvesting is consistent with the maintenance of these environmental functions. This is classic multiple-use forestry of the type that led to the emergence of public forestry institutions in central Europe in the 18th century. It differs little from the present much-discussed concept of Forest Ecosystem Management (Figure 3). The role of public forest research institutes in the future should be to provide the scientific underpinnings for multiple-use forest management, with a heavy emphasis on environmental public goods and the equitable distribution of costs and benefits.

- Multiple products and services
- All stakeholders involved
- Balancing agricultural and forestry uses
- Adaptive - feedback mechanisms

Figure 3 Forest ecosystem management

These challenges will require new types of forest research institutions and a new culture of forest research. The new paradigm that is required for forestry has been variously described as ›New Forestry‹ or ›Ecosystem Management‹. It requires science that operates at the scale of landscapes and not stands, that allows the optimisation of a number of products and not the maximisation of one, that treats forests in their social context and does not pretend that they exist in a ›people-free‹ environment, and it requires management that can adapt quickly to changing social and economic conditions. There will no longer be a single best option for the management of any category of forest; choices will have to be made on which of a number of options is appropriate, and it will have to be accepted that the options chosen will vary over space and time. Figure 4 attempts to portray the characteristics of the new research culture that is required.

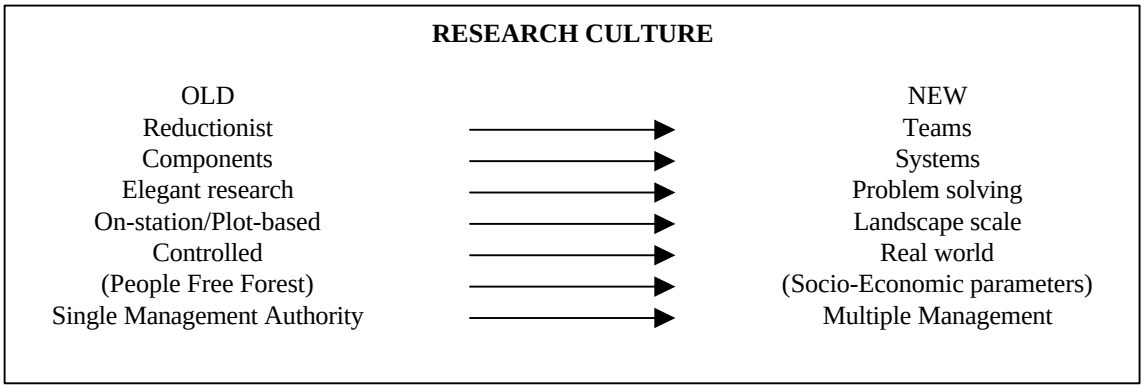

Figure 4 Research culture

The Center for International Forestry Research (CIFOR) and the Tropenbos Foundation are two initiatives that respond to this need for new approaches to forest research. Tropenbos mobilises a major capacity in the biophysical and social sciences to generate understanding of the functioning of forest ecosystems at large spatial scales and in their local social and economic context through long-term in-depth studies at a series of sites in the humid tropics. Its special contribution may be to develop our capacity to predict the response of these systems to a variety of management interventions.

CIFOR's contribution lies in drawing on the information produced by Tropenbos and other upstream science to generate options for institutional and policy interventions to achieve sustainable forestry. The potential exists to exploit the complementarity and potential synergies that exist between the work of Tropenbos, CIFOR, and other international actors to meet some of the challenges posed by the rapid globalisation of forest management. Figures 5 and 6 attempt to portray the areas of maximum potential impact of Tropenbos and CIFOR.

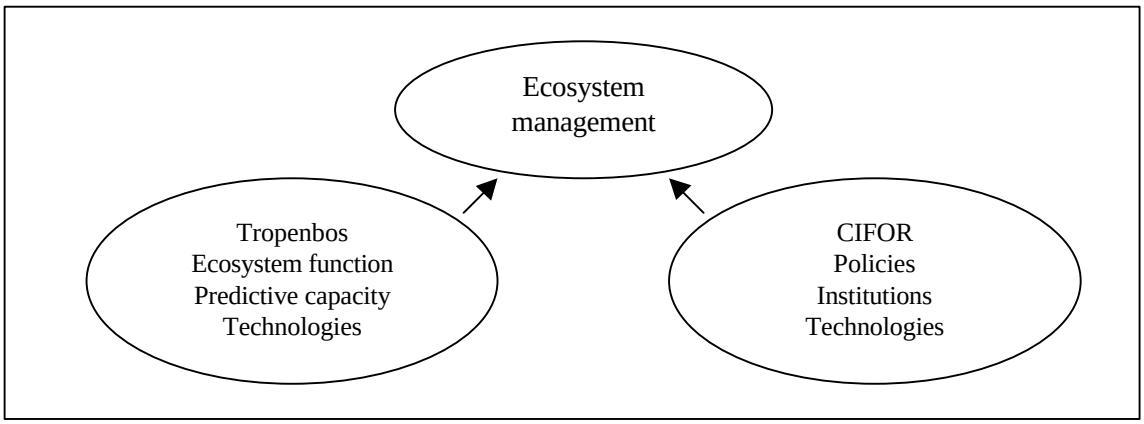

Figure 5 Research capacity of the Tropenbos Foundation and CIFOR

Tropenbos now has a decade of experience in managing a network of multi-disciplinary research programmes at key locations in the tropics. It is the most significant international initiative currently tackling the problems of understanding problems at the ›systems‹ level. The time may now have come to give increased emphasis, and resources, to achieving greater integration to the management of research within each site. The preponderance of research students preparing theses at these sites has reinforced the inevitable tendency towards reductionism and fragmentation.

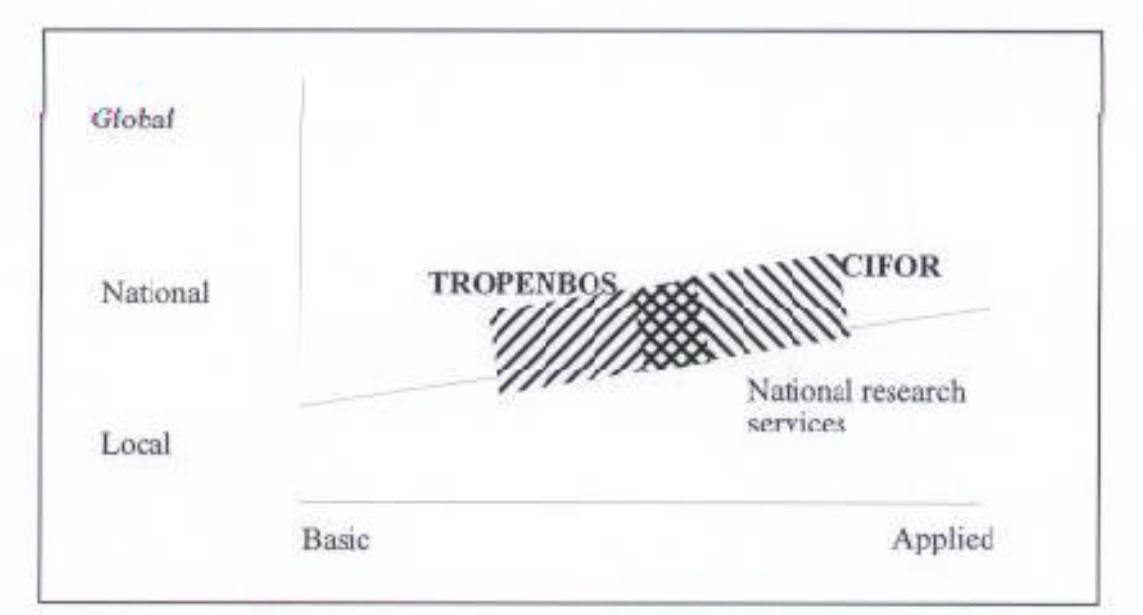

Figure 6 Research domains of CIFOR and the Tropenbos Foundation

Resources need to be allocated to strengthen the cohesion of the research at each site so that the ›whole‹ research impact becomes greater than the ›sum of the parts‹. Similar gains in terms of more broadly generalisable outputs can probably be obtained by exploiting a number of potential synergies and complementarities between sites. The present conference and other similar ones will contribute to inter-site collaboration. There may also be opportunities to take inter-site initiatives on specific themes. Work by Tropenbos on non-timber forest products and biodiversity has already gone some distance

in this direction. The past investments in Tropenbos have enabled the Foundation to get to the stage where it has the potential to have a major impact on the global forest agenda. CIFOR, in particular, sees Tropenbos as a major strategic partner and will continue to strive to work in partnership with the Foundation.

Together, CIFOR and Tropenbos must also align themselves with other initiatives and changes that are taking place in the world of forests and forestry. In particular, we must evaluate our potential contribution to the work of the Intergovernmental Forum on Forests (IFF). Austria and Indonesia will be co-hosting an inter-sessional meeting of the IFF at Ort/Gmunden in Austria in September 1998, to bring together scientists, decision-makers, and other forest stakeholders to produce recommendations for the IFF on global research and information needs for forests and forestry. This paper attempts to set out some of the considerations that will be important in thinking of these issues. It also aims to stimulate a debate which will help to strengthen the combined capacities of CIFOR and Tropenbos to meet these challenges.

CHANGING ROLES IN FOREST RESEARCH

Challenges and Problems; Information Needs

- New types of forest research institutions and a new culture of forest research are required: science that operates at the scale of landscapes and not stands, that allows the optimisation of a number of products and not the maximisation of one, that treats forests in their social context and does not pretend that they exist in a 'people-free' environment and it requires management that can adapt quickly to changing social and economic conditions.

Points for Future Research

- Tropenbos' special contribution may be to develop our capacity to predict the response of these systems to a variety of management interventions.
- CIFOR's contribution lies in drawing on the information produced by Tropenbos and other upstream science to generate options for institutional and policy interventions to achieve sustainable forestry.
- Give increased emphasis, and resources, to achieving greater integration to the management of research within each site.

Conclusions

- Optimal utility of the residual forests will come from an appropriate balance between management for environmental functions and for the variety of products whose harvesting is consistent with the maintenance of these environmental functions.
- The role of public forest research institutes in the future should be to provide the scientific underpinnings for multiple use forest management with a heavy emphasis on environmental public goods and the equitable distribution of costs and benefits.

RESULTS OF DUTCH RESEARCH

DUTCH-FUNDED RESEARCH ON TROPICAL RAIN FORESTS

Prof. Dr. K. Verhoeff
Chairman of the Programme Advisory Committee of the Tropenbos Foundation

THE STATE OF THE ART

Tropical rain forests are among the most species-rich ecosystems in the world, providing a habitat for humans and for wildlife, and a source of subsistence for indigenous people and others. Because of their specific nature, their great importance, and the fact that vast areas of forest are disappearing as a result of demands for agricultural land and for timber, they require special attention. For these reasons, the Dutch Government decided to give special attention to this problem by formulating a tropical forest action plan.

The main objectives were formulated in a policy paper in which nine policy strategies were outlined:
1. Actively protecting the surviving rain forests;
2. Encouraging planned land use and land management along with sustainable agriculture and forestry;
3. Encouraging the tropical timber trade in controlled harvesting and in the formulation and implementation of long-term planned timber production;
4. Giving an increased scope to national and international tropical rain forest policies by strengthening research and institutions;
5. Providing national and international encouragement for afforestation and reforestation projects;
6. Strengthening institutions and legislation; empowering local populations;
7. Strengthening the political and social base in tropical nations;
8. Improving economic relations and relieving debt burdens;
9. In principle, no collaboration with projects or developments that are harmful, or potentially harmful, to the rain forest.

Based on that document, additional funding became available for research in tropical rain forests (i.e. fundamental, strategic, and applied research to support the policy strategies set out in the policy paper).

The funding and steering of research in tropical rain forests is done by five Dutch ministries:
1. The Directorate-General for International Cooperation of the Ministry of Foreign Affairs;
2. The Ministry of Education, Culture, and Science (through the National Science Foundation);
3. The Ministry of Agriculture, Nature Management, and Fisheries;
4. The Ministry of Economic Affairs;
5. The Ministry of Housing, Physical Planning, and the Environment.

The first two ministries listed are the most important.

The research is implemented in four ways:

1. Research coordinated and/or executed by Dutch institutions and largely financed by the Dutch Government (e.g. the Tropenbos Foundation; the National Science Foundation/NWO; the National Remote Sensing Programme/NRSP; and the National Research Programme on Air Pollution and Climate Change/NRP);
2. International research institutions financially supported by the Dutch Government (e.g. CIFOR);
3. Research funded by the Netherlands and executed by national institutions in countries with tropical rain forests;
4. Research (primarily) financed by international or foreign funding agencies (e.g. the International Tropical Timber Organisation/ITTO) and implemented by Dutch institutions.

The main research programmes on tropical rain forest in the Netherlands are:

- The Tropenbos Foundation, which conducts research and development to support conservation of biodiversity and sustainable forest use. Strategic and applied research is being done in Indonesia, Colombia, Guyana, Cameroon, and Côte d'Ivoire.
- The Priority Programme of the National Science Foundation, entitled 'Biodiversity in Disturbed Ecosystems', which is providing tools to conserve biodiversity. Research projects are being implemented in Indonesia, South East Asia, Costa Rica, the Amazon region, and Cameroon.
- The National Remote Sensing Programme, with the working group 'Remote Sensing Research of Forests'. Remote sensing techniques are being used for the systematic observation and monitoring of forests to support sustainable forest management. Work is being done in Indonesia, Brazil, and Guyana.

Table 1 Participation of Dutch institutions in national research programmes

National research programme				
	NRP-II	NRSP-2	NWO-biod	Tropenbos
Universities				
RUG			○	○
RUL	○	○		●
UU				●
UvA			●	●
WAU	○	●	○	●
Research institutes				
DLO		○		●
RIVM	●			
ITC		○		○
NNM			○	○
CBS			○	○
CTO-NIOO			○	

! > 3 fte involvement in TRF research
" < 3 fte involvement in TRF research

How the different Dutch universities and research institutes are participating in these four national programmes is shown in Table 1. Of the programmes and projects being implemented by Dutch universities and funded in part by these universities, and by the National Science Foundation and others, I would like to mention the following:

- PROSEA, an international programme focussed on South East Asia. The purpose of PROSEA is to make the wealth of knowledge on plant resources available for education, extension, research, and industry, through a computerised databank and an illustrated multi-volume handbook. The Wageningen Agricultural University is the focal point in the Netherlands;
- Flora Malesiana, with the Herbarium of the University of Leiden as the focal point;
- Fauna Malesiana Terrestrica, with the National Natural History Museum in Leiden as the focal point;
- Flora of the Guianas, with the Herbarium of the Utrecht University as the focal point;
- Centre for Environmental Sciences in Leiden, with a programme on Environment and Development. Work is being done in the Philippines, Ecuador, and Cameroon;
- PROMAB, sustainable use of forest products in the rain forest of Northern Bolivia, a programme of the Utrecht University;
- The Forestry Department of the Wageningen Agricultural University, with the programme 'Ecology, Silvicultural Systems, and Management of Tropical Rain Forest'. The work is concentrated in Cameroon and French Guyana, with additional projects in other parts of the world;
- The Agricultural Research Department of the Ministry of Agriculture, Nature Management, and Fisheries, which is implementing various projects, mainly in connection with other larger programmes (e.g. Tropenbos and the National Remote Sensing Programme).

Figure 1 shows the participation of Dutch universities, research institutes, non-profit organisations, and private consultancy firms in research on tropical rain forest.

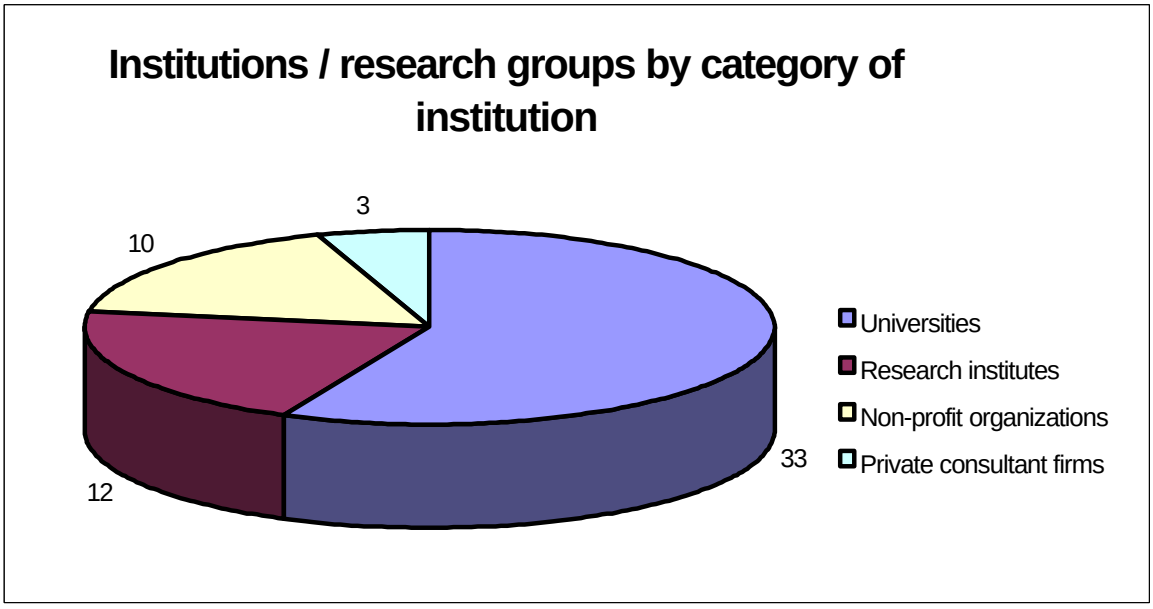

Figure 1 Institutions/research groups by category of institution

Figure 2 shows the volume, in man-years, of the research work being implemented in tropical rain forests by Dutch universities, research institutes, and non-profit organisations. Most of the research work is being done by PhD students, mainly for financial reasons. They are guided by senior staff of the research organisations.

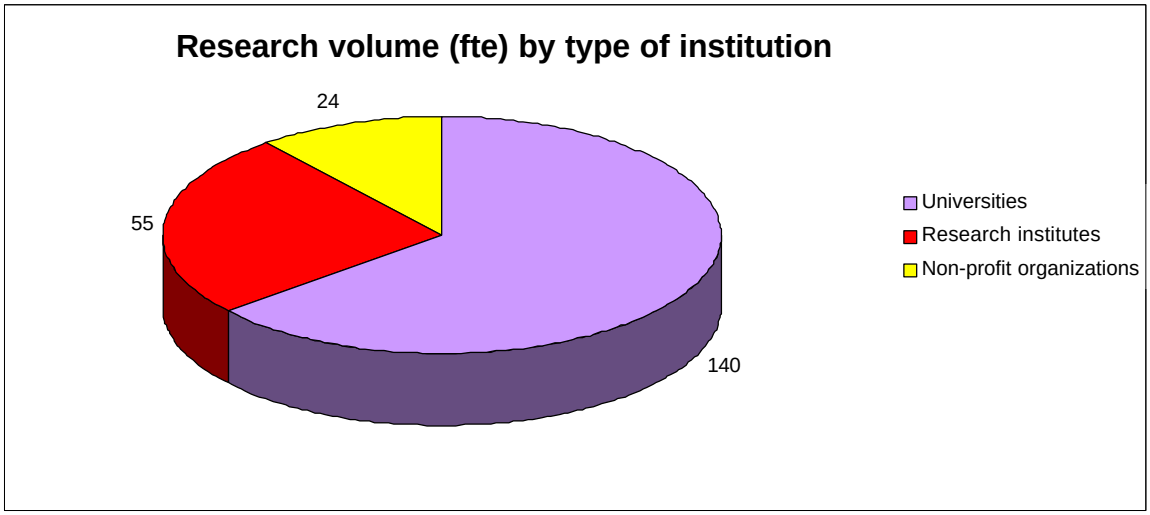

Figure 2 Participation of Dutch institutions in (inter)national research programmes

There are, of course, linkages between programmes and with international programmes, funded by others. Examples are CIFOR (Center for International Forest Research), IGBP (International Geosphere and Biosphere Programme), and LBA (Large-scale Biosphere- Atmosphere Experiment in Amazonia).

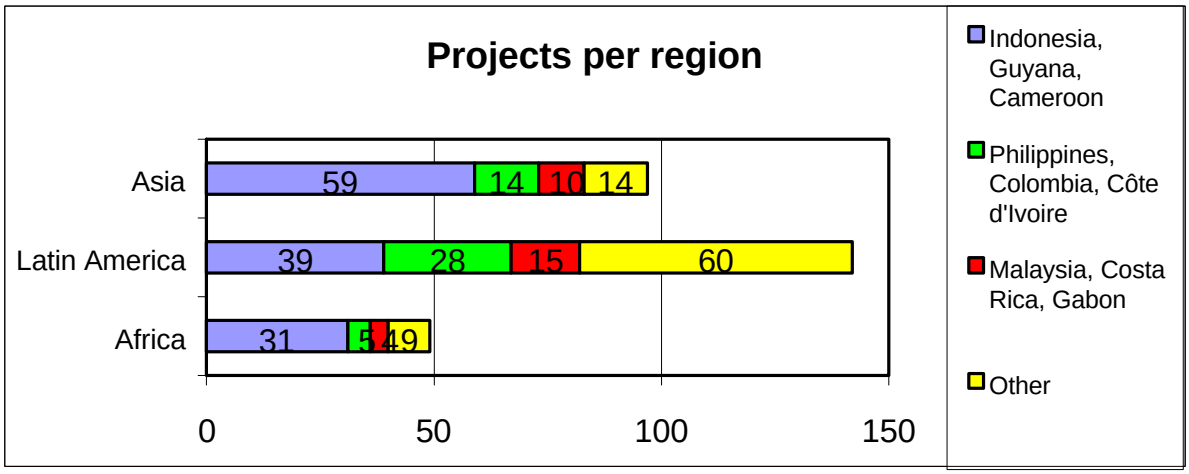

Figure 3 Geographic orientation of Dutch TRF research

A map showing the areas in the world where the research is being, or has been, implemented demonstrates that the work in Asia and Africa is somewhat concentrated in one or two countries: Cameroon in Africa and Indonesia and the Philippines in Asia (Figures 3 and 4). In contrast, the work in Latin America is more evenly distributed over a larger number of countries, with the highest concentration in Colombia and Guyana.

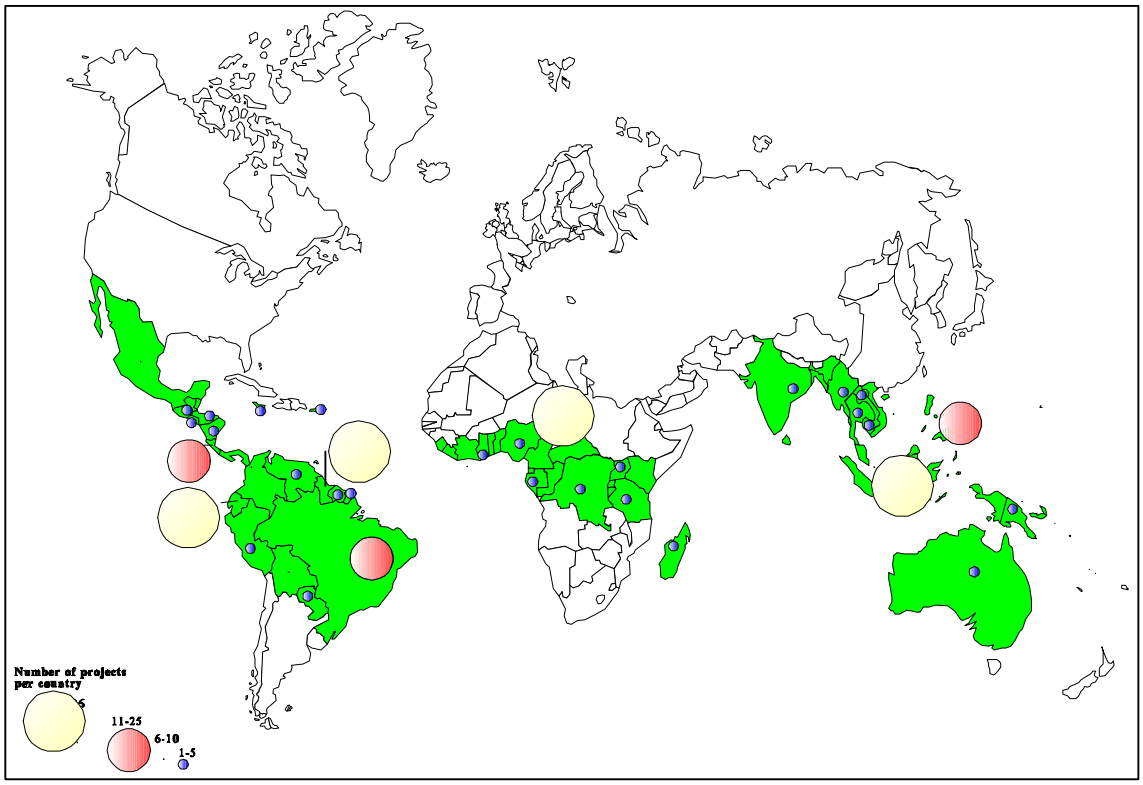

Figure 4 Geographic orientation of Dutch TRF research

The emphasis of much of the research work is in the field of ecology and, within this sub-discipline, in plant ecology. This is shown in Figures 5 and 6. As such, this is quite understandable, because work in forests starts with gaining ecological knowledge of the vegetation and the various processes involved with this. At a more detailed level, it appears that the research work is concentrated on:

- Conservation and biodiversity;
- Sustainable forest management;
- Sustainable land-use planning;
- People-forest interaction.

Less attention has been given to the utilisation, processing, and trade of forest products; policy and the legal and institutional framework; the reforestation and restoration of secondary forests and the use of their products; information, communication, and extension; and climate change.

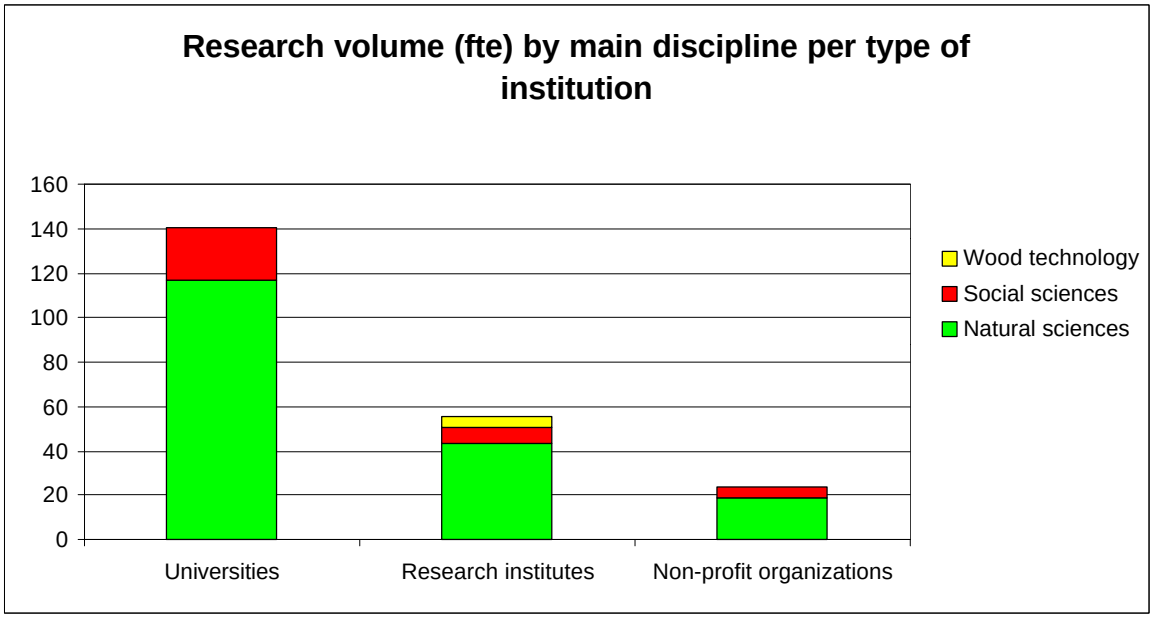

Figure 5 Research volume (fte) by main discipline per type of institution

Although a number of research programmes on tropical rain forest have started only recently, interesting and important results have already been obtained. More information can be found in other papers in this book, but I would like to mention a few, at the same time indicating the impact of that work:

- A number of volumes of the PROSEA handbook have been published and were well received;
- The same holds for volumes of the Flora Malesiana and the Flora of the Guianas;
- The CELOS system for timber harvesting in rain forests is being used in other locations (e.g. in Brazil);
- Work on the Tropenbos site in Indonesia has led to adaptations in the Indonesian forest policy and regulations, to the successful re-planting of Meranti trees, and to the re-introduction of Orang-utans;
- The results of the work on the Tropenbos site in Colombia were used for the elaboration of a Colombian research strategy and land-use planning.

Some preliminary conclusions can be drawn.

Publications, reports, and other means of disseminating results show that the Dutch-funded work in tropical rain forests is successful. Not only is this work cited in other publications, but it has already led to the implementation of the >wise use of tropical rain forest=. In addition, communication and collaboration with timber companies is receiving more and more attention.

A first glance at the database of Dutch research, now available at the Tropenbos office (Simons 1997), shows that the research projects are well-attuned to the priorities defined in the Dutch policy on tropical rain forests. But there are also some points that are lacking or under-represented.

A major shortcoming in most of the research work, as yet, is the lack of integration of its results. This integration is badly needed because, as said before, most of the work is being done by PhD students. This work tends to become somewhat mono-disciplinary, which is fair enough for the students, as they have to finish their work in a fairly short period and with a thesis as their final document. Unfortunately, the integration of the various results of these theses is usually not budgeted for. This needs to be done, however, as such information is necessary for >translation= for policy makers and for implementation by the various governments. It ought to be done by senior scientists, or by the PhD students after finishing their thesis work.

Another shortcoming is the virtual neglect of the socio-economic aspects of ecosystems and biodiversity conservation (e.g. attitudes of local communities and property rights). The involvement of social and societal sciences is still marginal. This hinders a real multidisciplinary approach. In addition, the current contribution of social sciences to the development of alternative land-use options is insufficient.

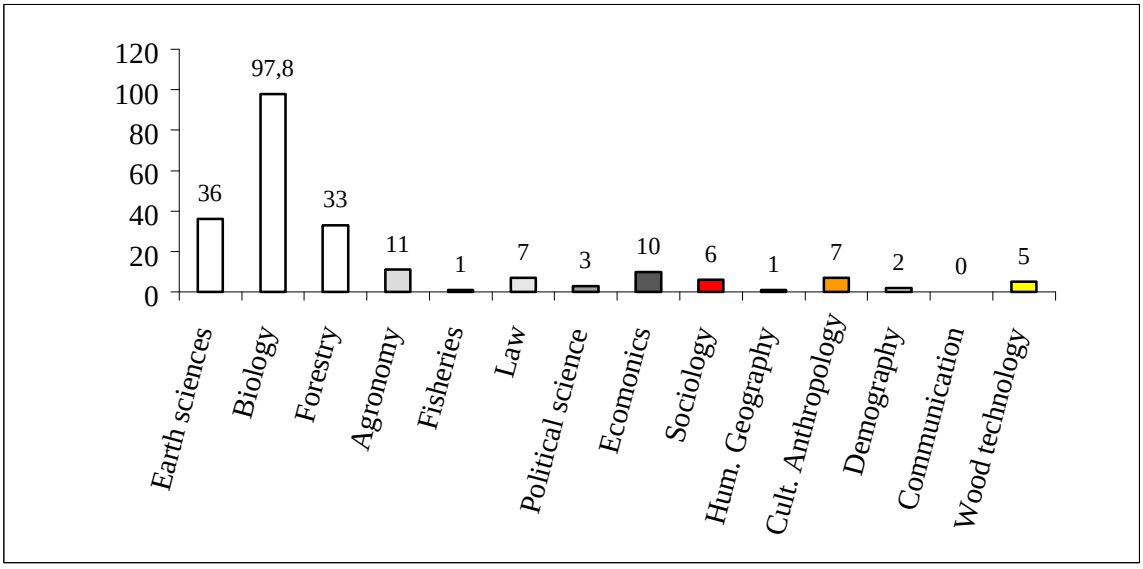

Figure 6 Research volume (fte) by scientific discipline

Whether Dutch research on tropical rain forests is adequately geared to developing strategies related to all the priorities set in the Dutch policy paper is not so easy to say. One should bear in mind that, of all the research world-wide in and on tropical rain forests, the Dutch work is a relatively small part. But considering the results obtained so far, it must be said that the Netherlands is definitely playing a role.

Furthermore, it would be a waste of money if the Dutch expertise in various fields on, and related to, tropical rain forests is not used.

For the coming years, the following points can be raised:

- The number of programmes and projects funded completely or partly by the Dutch Government, directly or indirectly, is quite large, namely 72 different groups. Although all on-going research is now in a databank, this does not guarantee that coherence between the various projects will be improved. I think it would be wise to have not only a central registration of projects, but also a sort

of clearing house, which would advise researchers planning to conduct work in tropical forests on opportunities for the combination with other work, sites where the work could be most successfully implemented, and so on. A clearing house will convince (if still necessary) the funding agencies that their money is being efficiently used. It will make research programmes more coherent and effective.

- Up till now, the scientific community has been playing a dominant role in formulating the research programmes. This means that the process of 'translating' general policy strategies into a research agenda is primarily in the hands of the research community. Is that correct?
- In addition to demand-driven research, there has to be sufficient funding for basic research. Demand-driven research has to be supported by results of basic research. Is there a balance between demand-driven and basic research in tropical rain forests?
- 'Translation', dissemination, and extension of the results of scientific research for policy makers need to be improved. Is this a matter of public relations only?
- The current contribution of social sciences is not sufficiently reflected in land-use planning and biodiversity conservation programmes. Social scientists execute their research separately and their research methodologies often do not match with those of the biological sciences.
- Multidisciplinary work is still scarce; social scientists and biologists do not speak each other's language.
- NTFP research is a focal issue in socio-economic research. Is that correct?
- Should Dutch-funded research focus on certain themes and thus play a more specific role in the international research community on tropical rain forests?

REFERENCE

Simons, H.W. (1997). *Dutch research on tropical rain forests: an overview and analysis*. Tropenbos Documents 13, The Tropenbos Foundation, Wageningen, the Netherlands.

Achievements

- Dutch-funded work is cited in other publications, and has already led to implementation into the 'wise use of tropical rain forest'.
- There is a good attunement and matching of the research projects with the defined priorities of the Dutch policy on tropical rain forest.

Challenges and Problems; Information Needs

- Integration of scientific results is required because of existing tendency to monodisciplinarity.
- There is an under-representation of the study of socio-economic aspects of ecosystems and biodiversity conservation, like attitudes of local communities and property rights.
- Involvement of social and societal sciences to tropical rain forest research is marginal.
- Social scientists and biologists do not speak each others language.

Points for Future Research

- A clearing house should advise on opportunities for scientific cooperation and appropriate localities for carrying out research.
- Improve the involvement of policy makers in setting of research agendas, and translation of results towards them.
- Improve the balance between demand-driven and basic research.

Conclusions

- A large number of Dutch (research) organisations and universities is involved in research in tropical rain forests, distributed over 72 research projects and -programmes.
- The emphasis of much of the research work is in the field of ecology and within this sub-discipline, in plant ecology, with special attention for conservation and biodiversity, sustainable forest management and land use planning, and the people - forest interaction.
- Less attention has been given to utilisation, processing and trade; policy, the legal and institutional framework; reforestation and restoration of secondary forest and the use of their products; information, communication and extension; and climate change.

PRE-CONDITIONS FOR EFFECTIVE RESEARCH

SOME ASPECTS OF THE TROPENBOS-GUYANA PROGRAMME

Dr. G.L. Walcott
The Tropenbos-Guyana programme

I have a sense of both ›challenge‹ and ›opportunity‹ as I approach the task of presenting what is described, ambitiously I feel, as a case study of the Tropenbos-Guyana programme - a case study designed, so I am advised, to illustrate ›pre-conditions for effective research‹; and, more intimidating, to identify ›failing factors‹ and ›success factors‹ in the organising of research programmes directed at sustainable use of tropical rain forests.

What more, I have asked myself, can I add to the very professional study of the Tropenbos-Guyana case which was completed by the Evaluation Mission four months ago?

But I draw some confidence from the fact that I do have a possessive interest in the Tropenbos-Guyana programme, having been associated with it long before ›biodiversity‹ and ›sustainable development‹ became international buzzwords; and also from my abiding hope for what a programme such as this can contribute to the ›sustaining development‹ of Guyana.

This presentation is therefore made, more as a personal testament than a professional case study. I speak, on this occasion, for myself. The opinion I express, like the possessive interest and the abiding hope, are entirely my own!

The July 1997 Evaluation Mission report of the Tropenbos-Guyana programme is, as the Team itself put it, ›very positive‹-- which borders, I suggest, on rank understatement!

The Mission listed among its positive findings that ›Tropenbos (Guyana) is unique‹ since ›with the exception of early work by the Guyana Forestry Commission‹ -- which, in this connection, I suggest, might more appropriately have been given the colonial name of the ›Forest Department‹ -- ›very little, if any, research has been undertaken and published in the country, other than in the Tropenbos programme‹.

This statement in itself opens the way for any assessor to make an international comparison. As an example, I can quote the opinion of a very senior, very experienced, very disinterested, international public servant and Forestry expert: ›This is one of the best programmes I have ever seen, anywhere!‹ As an illustration, I can refer to the fact that every prospective researcher, every forestry consultant who comes to Guyana, comes sooner or later to the Tropenbos-Guyana office, to seek information or to acquire a publication. (This is a paradoxical comment on the view that Tropenbos-Guyana does not publicise its work and is little known. But more of this later.)

The impressive list of Tropenbos-Guyana publications is itself largely the result of the fact that the programme has depended for its execution mainly on the postgraduate programme of Utrecht University, an excellent programme blessed with a continuing stream of talented and dedicated students. But the PhD connection may also be a little bit of a ›fail factor‹. Of which, again, more later! Equally ›unique‹ in Guyana is the Tropenbos-Guyana contribution to training. As noted in the Evaluation Mission Report, eight out of nine students working locally toward University of Guyana (UG) MSc's in Forest Biology, and all the three Guyanese women studying for PhDs of British and Dutch universities in this field, are in the Tropenbos-Guyana programme. I have myself, on more than

one occasion, commented publicly on the fact that opportunities for higher degrees and short courses available to Guyanese students through Tropenbos usually exceed the number of suitable students available for training. Another valid comment is that the UG MSc (Forest Biology) Programme depends almost entirely on Tropenbos student sponsorship.

In the light of what I have described -- accurately, I am sure -- as the outstanding success of the Tropenbos-Guyana programme, and this success in the two broad areas of its mandate, Research and Training, it would seem almost contradictory for me to list ›fail factors=. I prefer to speak of what, to me, are ›areas needing improvement=.

When ideas of protecting the world=s forests first began to gain popular currency in the 70s and 80s, the greatest emphasis seemed to be on concerns such as pollution control, saving wildlife, and even maintaining aesthetic beauty. In so far as Guyana is concerned, two subsequent consequences, among several others, might be mentioned. One was the occasional use of the term ›Rabid Environmentalists= (Josh Ramsammy, a member of the Evaluation Team was a Rabid Environmentalist!) and the other, popular among a small but influential group of producers, was the idea that scientists who preached the developing doctrine of sustainable management of tropical forests were to be looked at with, at least, suspicion.

This lingering suspicion may help to explain the paradox of a programme, so well-favoured by many in Guyana and abroad, receiving the stigma of the statement that Tropenbos appears to be pursuing its own interests (see Evaluation Mission Report); and why the image of Tropenbos among some locals, particularly timber producers, may not be as bright as the scientific success of its programme deserves.

The conservative inclinations (conservative in more than one sense) of the 70s and 80s are evident in the Tropenbos-Guyana Agreement (1989), which recognised ›the danger of continuing deterioration of humid tropical forest lands= and which aimed to prepare plans to conserve and develop the humid tropical forest lands of Guyana. My own simple sermon, repeated *ad nauseam* has been that any programme of tropical rain forest research should aim to conserve the forest and develop the **people** - and that means **all** the people, not just the people who live in the forest. Moreover, if we are talking about a partnership programme between two nations, I mean the people of both nations, recognising that development need not mean the same thing for both nations or even for all groups within each nation.

One of the ideas that I think that I can claim to have nagged the Tropenbos director about, in my own small way and whenever I had the opportunity, was the inclusion of specific reference to economic development in the Tropenbos Aims and Objectives. I note, with some personal satisfaction, that the sub-objectives of the Tropenbos-Guyana programme now refer to the establishment of ecological, economic, social, and operational parameters for sustainability . But my greatest expectations for the future arise from two concepts which were passed on to me during my visit to the Netherlands last September. The first, in a draft paper received from the director of Tropenbos, defines a sustainable forestry system as a coherent set of conditions and activities to produce timber in an ecologically sustainable, and financially profitable, way, while maintaining the ability of the forests to deliver other products and services. In this paper, the sustainable forestry system is seen as comprising three interlinked sub-systems, namely:

- Ecological system;
- Financial system;
- Social system.

Further, one illustration of the interlinkages is the statement that if, technically seen, the ecological system and/or the financial economic system cannot meet the requirements, a sustainable forestry system does not even exist in theory.

The second encouraging concept that I caught during my visit to the Netherlands, is the concept of win-win, which it seems that more and more leaders are openly promulgating.

I make my own point that ›win-win‹ has to be tangibly and impressively evident, even enshrined in a new Agreement - plus - Administrative Arrangement; and the winnings, on both sides of the Agreement, must be available to all who hold a stake - including industry, environmentalists, individual researchers, and their organisations.

The Evaluation Mission has identified as an ›area needing improvement‹ the fact that a significant number of people interviewed felt that ›Tropenbos was little known -‹, and that, by implication, there was need for better-focused dissemination of information, and for the promotion of a public image which more sharply reflects the importance and excellence of Tropenbos research. The very fact that such an opinion could be expressed, and by a set of such influential ›insiders‹, is a matter for attention; but the opinion itself requires analysis and raises questions:

Why, the ›Internet‹ apart, does such a comparatively large proportion of involved persons overseas, producers as well as environmentalists, compared to Guyanese, either know about Tropenbos or are very ready to take the trouble to find out?

Is Tropenbos-Guyana so little known to the more than one hundred local individuals and agencies to whom previous issues of Tropenbos-Guyana newsletters or the provisional manual of the CELOS forest management system were sent? Or to the thousands of newspaper readers who at least see the advertisements inviting, for example, applications for postgraduate research assistantships?

Is it, in some cases, that people **don‹t know** about Tropenbos or that, in idiomatic language, they **›don‹t want to know‹,** which is loosely translated as they ›don‹t care‹?

A don‹t-want-to-know attitude may perhaps be illustrated by the negative opinion received by the Evaluation Mission that ›Tropenbos appears to be pursuing its own interests‹. Or in the boast, made by some members of the (Guyana) Forest Products Association from time to time: That they do not need foreign researchers to teach them sustainable management of the forests! (›Look at our forests! Fly over them! They are just as they were sixty years ago!‹)

Herein, I feel maybe lies a ›fail factor‹ inherent in the policy of executing Tropenbos-Guyana research through PhD students - that the research and the results may be perceived, perhaps prejudged, correctly or incorrectly, as mainly reflecting the academic interests of these students and their supervisors, and not the concern of ›real forest managers‹.

One further point of interest: While I associate myself with the Evaluation Mission=s position on the need for greater emphasis on public relations and outreach by Tropenbos-Guyana, I feel that such an extension programme, if it covers >all forestry research work in Guyana= might more appropriately be coordinated by the Guyana Forestry Commission.

The lesson that all this aspires to teach is that Guyanese stakeholders, and I mean all stakeholders, need continuously to be convinced that the Tropenbos-Guyana programme is for their tangible and sustainable benefit - that the programme is **sustaining** as well as **sustainable.**

In Guyana, one of the most >failing= of >failing factors= has been perceived to be the difficulty involved in obtaining meaningful participation of local research agencies and researchers. However, from its objective perspective, the Evaluation Report rationalised the present position, and >found no noticeable shortcoming in this area=. But the Evaluation Team, and, by implication, the persons the Team interviewed, also found >the level and quality of participation of the various agencies= was >limited=.

Causes of this limitation are more or less identifiable, and solutions seem more or less feasible. The causes include, but are certainly not limited to, low local capacity in the agreed research areas -- which may be taken as an argument for tailoring the programme to fit proven local skills, other things being equivalent -- and competing demands for the services of the few qualified staff. One solution, but certainly not the only one, is a change in strategy which temporarily makes MSc and PhD training of Guyanese students contracted to the participating institutions, the main vehicle for implementation of the Tropenbos-Guyana programme. While it is not intended to go into detail in a short paper, it must be pointed out that, as far as Guyanese participation is concerned, such training would more easily allow for continuous change in the shape of the Tropenbos-Guyana programme, rather than just response to the previously agreed shape.

Other factors which might promote more effective local participation include:

The Institutions must be held responsible for their own performance. Or, in other words, the Guyana Government, as a show of ownership, should demand more of the local institutions. Participation must bring better financial rewards to participants.

A review by Tropenbos of the process of project approval has gone some way to removing the dissatisfaction which existed locally in this matter. However, several points of unease remain, mainly linked to what are commonly described as >breakdowns in communications=. The mechanism recommended by the Evaluation Mission to address such situations seems reasonable; and it could help toward both the quality of other new proposals, and the execution of approved projects.

Also, the influence of counterparts on the evolving shape of the programme and the fixing of priorities remains very low. It is a little ironic that Tropenbos should be concerned, in a major way, about whether its research programme was helping policy formulation in site counties, but should appear to be indifferent to how a site country=s already agreed national policies should be reflected in the shaping of the research programme. But perhaps the root cause of the problem has been that, for Guyana, such agreed national policies, and strategies, are only now beginning to emerge in key areas such as forestry in general, and in land use and biodiversity.

A number of >Structural Issues= have been raised by the Evaluation Mission. Together, they constitute a major >area needing improvements=. They may have arisen from changing circumstances, political and institutional, which make several provisions of the Agreement(s) now invalid or inappropriate. Or they

may have been introduced in *ad hoc*, piecemeal, ways, without the necessary formal acceptance at the highest levels.

They affect:
- The (Bi)-National Committee. (The brackets are themselves a part of the problem!);
- The Administrative Committee (My own solution for a particular problem). The Guyana Executive Authority. (Should the responsibility be delegated?);
- The Implementing Agencies (Their roles? Which should be the ›Main‹ one? Should they each have separate contracts?);
- The Coordinators and the PTL (Conflicts {definitely plural} of interests and loyalties!).

These matters all require to be addressed by the provisions of a new agreement. And the most fundamental aspect of a new agreement could be a synchronisation of purposes, a clear statement on what each of the two sides, working together, will give to and get from the cooperation.

Nowhere does there appear to be a greater need for a synchronisation of purposes than in the area of Biodiversity and Non-Timber Rain Forest Products.

As the nation possessing the resource, Guyana‹s purposes must be guided by the collective view of the Elected Heads of American States, who recognised that ›better choices regarding the use of our natural resources require that we develop the necessary knowledge and information regarding their nature, status, and potential‹. But this must be done in a controlled way, even though with the very minimum of bureaucratic regulation.

Two examples taken from the WWF Environment Handbook illustrate the inter-linkage of ecological, financial and social studies which comprise a sustainable and sustaining forestry system.

The first example, which is now chosen to illustrate the importance of financial studies as a basis for forest management decisions, describes a study carried out near Iquitos in Peru, which showed that while extracting all the marketable timber from 1 hectare of Amazonian rain forest in a single operation would yield a one-off payment of only US$ 1,000, harvesting the NTFPs on a sustainable basis could earn an annual income of an unexpected US$ 6,280, both at local markets.

In acknowledging the value of Social Sciences research, I also cite from the WWF Environment Handbook the case of the Yanomani people, where a finding that they make no clear distinction between physical and mental illness has suggested to bioprospectors that their knowledge and use of plants may point the way to treatments for conditions such as schizophrenia and severe depression.

I am a little embarrassed at the fact that I have been able to identify so many areas needing improvement. But they have a common thread -- they can all, or almost all, be addressed through negotiation of a new agreement -- one which would take us into a new Tropenbos-Guyana phase, in a new century, with new visions, new goals, and new performers.

SOME ASPECTS OF THE TROPENBOS-GUYANA PROGRAMME

Achievements

- Programme is successful in terms of scientific output, training of local academics and as information source about forestry in Guyana.

Challenges and Problems; Information Needs

- Programme has the image of pursuing its own interests, possibly exacerbated by strong dependence on PhD students.
- Programme is insufficiently known with the public in Guyana.
- Problems with obtaining meaningful participation of local research agencies and researchers.
- Limited influence of host country on formulation of research programmes.

Points for Future Research

- Create a win-win concept while setting up research programmes, with clearly identifiable benefits to all parties.
- Improve the mechanisms and transparency of project approval.

Conclusions

- Any programme of tropical rain forest research should aim to conserve the forest and develop the people.

ACTION RESEARCH FOR COMMUNITY-BASED RESOURCE MANAGEMENT AND DEVELOPMENT: THE CASE OF THE NORTHERN SIERRA MADRE NATURAL PARK CONSERVATION PROJECT, NORTHEASTERN PHILIPPINES

Dr. R.R. Araño
Northern Sierra Madre Natural Park Conservation Project, the Philippines
Dr. G.A. Persoon
Centre of Environmental Science, Leiden University, the Netherlands

1. INTRODUCTION

In March 1997, through Presidential Proclamation, the Government of the Philippines established the Northern Sierra Madre Natural Park - one of the last remaining areas of rain forest in the country, with a size of 359,486 hectares - as an official National Park. A few months earlier, as part of its rain forest protection policy, the Dutch Government had approved a proposal (US$5.5 million) to implement a conservation project in the same area, which was to give due attention to the rights and needs of the local people. The regional branch of PLAN International was selected as the implementing NGO of the project - named the Northern Sierra Madre Natural Park Conservation Project (NSMNP-CP).

In this presentation, we shall briefly review the history of this project, giving attention to the factors that determine its constraints and opportunities, and referring in particular to its research components.

2. CAGAYAN VALLEY PROGRAMME ON ENVIRONMENT AND DEVELOPMENT

The history of the Conservation Project and the involvement of the Dutch Government is directly related to the research activities of the Cagayan Valley Programme on Environment and Development, a joint programme of the Centre of Environmental Science of Leiden University (the Netherlands) and the College of Forestry and Environmental Management of Isabela State University (Philippines). In 1989, an official agreement was signed by the two universities to cooperate in the field of environmental science and education, thereby contributing to safeguarding the natural heritage of the Sierra Madre Mountain Range in Northeastern Luzon. This cooperation was designed as a joint undertaking, managed on the basis of equal partnership of the two institutions involved. It was also designed as a research programme with a long-term perspective instead of a short-term project. Up to the present moment, the programme is still running and, as yet, the cooperation is considered to be yielding positive results in terms of research, education, and impact on the environment. Though the programme is primarily a RUL/ISU programme, other universities and institutions in the Netherlands and the Philippines have participated in its activities over the years. In particular, we would like to mention the Institute of Cultural Anthropology in Leiden and the Forestry Department of the Wageningen Agricultural University in the Netherlands, and SEARCA in Los Baños and the regional Department of Environment and Natural Resources in Tuguegarao, Cagayan, in the Philippines.

Over the years, more than 100 Filipino and Dutch graduate students and a number of PhD students and senior researchers of both countries have built up a considerable body of interdisciplinary knowledge on forest exploitation, forest policies, and environmental consequences of various land-use systems. Attention has been given to subjects such as the analysis of the deforestation process, the relationship

between land rights and forest use, the implementation of forest policies such as reforestation and social forestry, and the exploitation and trade in non-timber forest products (de Groot and Kamminga, 1995; Pasicolan, 1996; van den Top, 1997).

Two international conferences were organised in 1991 and 1994 to present and discuss the results of the research with an audience consisting of scientists, local people, non-governmental organisations, and policy-makers (CVPED, 1992; Guzman and de Groot, 1997).

When this programme started in 1989, large-scale logging was still big business, with hundreds of heavily loaded trucks leaving the area daily. The forests of the Sierra Madre were a major supplier of wood for the domestic market as well as for export. The deeply-felt concern for effective measures for protection led both participating institutions to formulate project proposals and to submit them to relevant agencies. After a number of revisions, two of these projects are at present being implemented:

- A project funded by U.S. Aid, for grassland rehabilitation; and The Northern Sierra Madre
- Conservation Project funded by the Dutch Government.

Both projects were initiated and formulated by researchers connected with the cooperating institutions. The project proposals were based on their joint research activities. The cooperation programme has also been instrumental in setting up an environmental information and training centre on the campus of Isabela State University, where both projects are housed.

3. BACKGROUND OF THE CONSERVATION PROJECT

3.1 National situation

Protected areas are generic banks; they contain a country=s biological capital, and serve as the ultimate resource that provides genetic materials for the improvement of agriculture, medicine, and industry. Protected areas provide more immediate benefits by:

- Reducing the intensity of floods and droughts;
- Protecting the soil from erosion;
- Regulating the climate; and
- Maintaining the integrity of life-support systems.

Protected areas are thus essential for national survival.

In the Philippines, wilderness and protected areas are under severe threat from the degrading activities of human occupants. In 1975, the Development Academy of the Philippines estimated that as many as 76,000 people were living inside national parks, and that about 4,000 hectares were being logged yearly (DAP, 1975). Today, these figures have to be adjusted to take into account increasing rural poverty, population growth, and upland migration. The continuous decline of protected areas is borne out by the results of a study conducted by IUCN. This study established that the number of national parks in the Philippines that meet international standards markedly decreased from 23 in 1975 to 12 in 1980, and went further down to 7 in 1982. At present, no national park in the Philippines meets international standards. All of the national parks of biological importance and adequate size (more than 10,000 hectares) have human settlements within their boundaries.

The main problem for the management of protected areas in the Philippines lies in the lack of grassroots participation in biological conservation, particularly among the inhabitants of poor and remote villages adjacent to or within the wilderness and protected areas. The country has recently experienced a rapid growth of environmental non-governmental organisations, and the growth of environmental constituency has been no less than remarkable. In spite of this emerging constituency, however, the local population=s willingness to participate in conservation is overridden by the imperatives of economic survival. To the burgeoning rural population, the desperate search for

livelihood, often at the expense of the environment, is still the order of the day. The Government Department of the Environment and Natural Resources (DENR) is thus having great difficulty in halting the rapid decline of wilderness areas.

3.2 The Northern Sierra Madre Natural Park

The Northern Sierra Madre Natural Park is one of the country's ten priority areas, selected for biodiversity conservation within the framework of the Global-Environment-Facility-funded National Integrated Protected Area System (DENR, 1992). The area was already turned into the Palanan Wilderness Area during the Marcos regime in 1979, but not much had been done about conservation during those years. Large-scale and small-scale logging, as well as shifting cultivation by pioneer settlers originating from various parts of the country, had already reduced the ›wilderness‹ character of the forest land of the proclaimed area. Owing to the rapid loss of forest cover in the Philippines since the 1950s, the area now contains about 25% of the remaining old growth forests of the country. The pristine forest area of more than 220,000 hectares abounds with a multitude of species of flora and fauna, many of which are endemic or still have to be identified. Among the more spectacular elements of the Park are the endangered Philippine eagle and some rare habitat types, such as the still intact coastal forest.

The original inhabitants of the area are the Agta, a Negrito population, traditionally living as hunters and gatherers, but increasingly forced to adapt to changing habitat conditions brought about by logging operations and waves of encroaching farmers. The population density of the Agta has always been relatively low, but waves of migrants have entered the area in the wake of logging operations. The migrants have settled in the logged-over areas, converting forest land to agricultural land through slash-and-burn agriculture. By now, the migrants outnumber the local people. Among these migrants are many people (such as the Ifugao and the Tinggian) who originate from the tribal, upland communities in the Cordellera Mountains.

3.3 Long-term and short-term objectives of the Project

In general, the Project seeks to sustain the natural resource base of the NSMNP through improved community-based protection and conservation activities, while at the same time, enhancing the quality of life of the local population.

Specifically, the long-term objectives of the Project are:

- To preserve the remaining biodiversity of the NSMNP;
- To rehabilitate degraded areas;
- To protect the forested watershed of the NSMNP, which serves as the source of groundwater and surface water for domestic, agricultural, and industrial purposes;
- To address the socio-economic needs and cultural aspirations of the local population on the periphery and within the NSMNP.

On the other hand, the short-term objectives are:
- To establish management zones and the physical boundaries of the NSMNP;
- To generate benchmark socio-economic, ethnographic, and bio-physical information;
- To develop a set of implementing guidelines for the management plan.

Within the framework of preparing the management plan, the following research components have been identified (PLAN International, 1995):
- Flora and fauna surveys;
- Soil surveys and hydrological studies;
- Coastal and marine surveys;
- Mapping activities;
- Ethnographic studies among the people dwelling in the forest, including the mode and intensity of resource use;
- Community-based resource management and alternative livelihood opportunities;
- Preparation of an integrated management plan.

The programme can build on the research work done within the Project and can involve many people with previous experience in the Project.

4. SUCCESS AND FAIL FACTORS OF THE NSMNP-CP

4.1 Success indicators of the NSMNP-CP

By and large, the successful implementation of the various elements of the Project can be attributed to the following factors:
- Cancellation of logging concessions. Though an act imposing a total ban on logging in the country was never passed through Congress, most of the Timber License Agreements (logging concessions) have been cancelled, suspended, or were simply not renewed. Large-scale logging, previously in 35 areas, has almost completely disappeared from the region. Only three concessions remain, with one under suspension. Though small-scale logging still occurs, the rate of deforestation has been greatly reduced. No more logging roads are being constructed, and old ones are deteriorating because of lack of maintenance. This has removed a major threat to the National Park;
- Recognition of the rights of indigenous peoples. For a long time, all forest land and forest resources were claimed to be state property. Even the Agta, the original inhabitants of the area, were regarded as squatters on state land, just as the newly-arrived migrants were. Lack of security prevented many of them from investing in more sustainable forms of land use. Recently, a new Act was passed in Congress recognising the ancestral rights of the indigenous peoples in the country (DENR, 1997). Through this Act, indigenous communities can obtain communal titles to the land they have occupied ›since time immemorial‹. This law will provide a better basis for the joint management of forest resources by the people and the park authorities, unlike the previous situation in which they were considered illegal occupants of state property, but which in fact was being exploited by those with close connections to the ones in power (Ramos, 1997);
- The spirit of the time. Compared with the boom times of large-scale logging in the 70s and 80s, with almost everybody having a stake in the business, things have changed dramatically in the region. Protection of what is left of the country's biodiversity has become the concern of many. Governmental agencies, local people, non-governmental organisations, the church, the media, and the universities have adopted a greater interest in the protection of the environment. As a consequence of this change, research has shifted its prime focus from studying and describing patterns of resource depletion and their environmental consequences, to the more creative dimension

that is the design of systems of sustainable natural resource management and development.

4.2 Recruitment of qualified staff and training

An essential condition for the successful planning and implementation of field activities is the recruitment of qualified and deeply committed staff. The importance of a deeply committed staff is underscored because of the hardships of working in the field due to the ruggedness and inaccessibility of the terrain and adverse weather conditions, among other things.

The recruitment of the initial key staff - with deep commitment, a solid academic background, and field experience for the Project is considered crucial in terms of:

- Translating the Project proposal into action and budget plans;
- Laying the contacts with the key players of the Park.

Given the bureaucratic red tape of the local government units such as the DENR (with its legendary ›turf mentality‹), the appointment of a Project Manager who is very familiar with the study region proved crucial in establishing the necessary linkages and network with key staff in the DENR department - at the national, regional, and local levels. Through him, the necessary cooperation and collaboration in the execution of Project activities became easier.

The selection of the two Project Area Managers (one for the coastal zone and one for the western-side/valley-zone) was equally crucial - especially during the first year of the Project (the inception period). Given the remoteness and isolation of the coastal zone, the Area Manager needed to be familiar with the area and to have solid experience in community-based projects. On the other hand, the Area Manager for the western side needed not only to have good field exposure, but also had to be familiar with the administrative systems of PLAN-International since the Project was to collaborate with the regular programmes of PLAN in this area.

The training of field staff also contributes towards the effective planning and implementation of field activities. While the senior staff have an adequate academic background and field experience, the field staff - the agroforestry technicians, community organisers, botany and wildlife technicians - require continuous training in their relevant disciplines. Thus, periodic training workshops are conducted, not only for the target groups but also for the staff.

4.2.1 Appointment of local and external technical advisers

At this stage of the Project, the appointment of a full-time local technical adviser - who had the required academic credentials and field experience and was also familiar with the region and Project area - helped significantly in the review of various activities, both at the planning and implementation stage. The full-time appointment of the local adviser ensures sustainability of focus in terms of technical backstopping to both field staff and staff at the Project Management Office. It should also be mentioned that, as a former staff member of ISU with residence still on the campus, the local technical adviser also provided the additional advantage of networking with various levels and units of DENR in the region. In contrast, the appointment of part-time technical advisers, with terms of reference based on output, did not provide the necessary continuous support - especially for the field staff.

4.2.2 Authority to implement the Project through a Memorandum of Agreement/MOA with DENR/PAMB

Contributing greatly to the smooth start of the Project was a Memorandum of Agreement with the DENR, through the Regional Executive Director and Protected Area Management Board, which is a necessary condition (as specified in the implementation rules and regulations of the National Integrated Protected Area System Act of June 1992). The Agreement not only gives legal permission to

implement the Project, but also specifies the support that DENR can extend to the Project. This is important because, as mentioned earlier, DENR, just like other government units, has a tendency to be bureaucratic. And equally important, the Agreement comes in handy when other stakeholders ask whether the Project has the authority from DENR to undertake research and conservation and development activities inside the Park and its buffer zones.

4.2.3 Support from academic institutions

As an integrated conservation and development project that is addressing very complex and dynamic socio-bio-physical systems, the need for an interdisciplinary approach cannot be over-emphasised. Setting aside the consulting firms, which are generally based in Metro Manila, the academic institutions in the region - specifically the Isabela State University - is the major provider of the expertise needed for the various work elements of the Project. With its Project Management Office located on the campus of ISU, access to ISU and the Centre of Environmental Science of Leiden University through CVPED, not only becomes easier, but further strengthens their complementary and collaborative work. These relationships may come in the form of:

- The appointment of staff, either on a part-time or a full-time basis;
- Field research by undergraduate and graduate students;
- Sharing of resources (space, equipment, networks, and so on).

Because the area is a ›hot spot‹ for biological as well as cultural diversity, generating research interest from other institutions within the Philippines or abroad is not very difficult.

4.2.4 Effective networking and the establishment of the Inter-Agency Coordinating Group

As the largest protected area in the country and one of the biodiversity ›hot spots‹ in the world, the Park has drawn a lot of attention from various groups, both local and foreign. It thus became essential for these interest groups to form an Inter-Agency Coordinating Group, with the immediate objective of integrating, complementing, and collaborating their efforts, instead of developing feelings of competition and jealousy. It is noteworthy to mention here that the Coordinating Group was established as early as March 1996 - about two months before the Project was formally approved and signed through a Memorandum of Agreement between the Netherlands Government and PLAN-International. The early formation of the Coordinating Group significantly optimised the utilisation of the resources of its members.

4.2.5 Strong organisational backstopping

PLAN‹s experience in community development, and its very sound and time-tested administrative and financial systems, provided the Project with a solid foundation. The regular staff of PLAN have been very useful in providing support, not only during the early stage of the Project, but even more so in its present stage. The implementation of a US-AID-funded project by PLAN, in the buffer zones not covered by this Project, required the strong dovetailing of activities located adjacent to each other. This was immediately attained by reorganising PLAN‹s regional setting to reflect and account for the individual project‹s distinct character and the administrative support it requires. These two large special projects (i.e. those funded by DGIS and US-AID), with their administrative staff, are housed in one office.

4.3Limiting factors and fail indicators of the NSMNP-CP

Needless to say, apart from the generally favourable conditions of the Project, there are also certain limiting factors that need permanent attention.

4.3.1 Conflicting rights and resource competition

At present, there are still large settlements - and even towns - inside the Park. These towns are still growing owing to immigration from resource-poor or overpopulated areas. This situation is enhancing

the claims for the same natural resources as are targeted for conservation. The migrants also compete with the traditional population for arable land and forest resources (see e.g. Masipiqueña *et al*., 1997).

Over the years, a variety of policy instruments have been used to stabilise the ever-moving forest frontier (e.g. stewardship certificates, reforestation, irrigation, upgrading spontaneous settlements to *barangay*[1] level). As a result of these projects, there are various kinds of overlapping claims on the use of forest resources. These claims need to be handled with care in order not to undermine the conservation aims of the National Park. Of primary importance during all phases of the Project is adequate consultation with the local government units and working with the local people. Along this line, the formulation and development of the community-based (*barangay*) resources management and development plans is an example of real participatory planning in the Project.

The overlapping claims originate not only from the local people; within the Government itself, there are still overlapping claims on the area that have not ceased to exist once the National Park was officially proclaimed (e.g. exploration permits issued by the Bureau of Mining).

4.3.2 Establishment of a coastal Isabela industrial and tourism estate and construction of a road

The biggest threat to safeguarding the Sierra Madre Natural Park is the combination of two proposals that have been circulating for a number of years among some groups of provincial and national politicians. These proposals imply the establishment of an industrial complex and a tourism estate on the east coast of Isabela Province and the construction of a road. The Provincial Government of Isabela has proposed the establishment of the industrial state on an 18,000 hectare block of primary forest, located in the Bicobian and Dimasalansan areas of Divilican, Isabela. The proposed area is not only pristine, but is host to the endangered Dugong and Giant sea turtles, among others. As envisioned, the industrial state will consist of an industrial zone, a built-up area (hotels and cottages), a golf course, and an international airport. The magnitude of these proposed undertakings are expected to have adverse impacts on the fragile environment of the area - on both its nature and its people.

Due to the remoteness of the coastal towns vis-à-vis the need for access to health services, education, and markets, the local government units, at both the provincial and the municipal levels (coastal and valley side), are strongly proposing the construction of roads that will cut across the NSMNP (Figure 1)! When this is approved and implemented, the high biodiversity value of the Park will be lost forever. As shown elsewhere - in the Philippines, as in the rest of south-east Asia and the world - when roads are constructed across forest lands, people immediately follow the opening of such roads and convert forest land into agricultural land with slash-and-burn agriculture. This will also encourage the poaching of wildlife and timber.

[1] *barangay* = community-based resources management, smallest political unit.

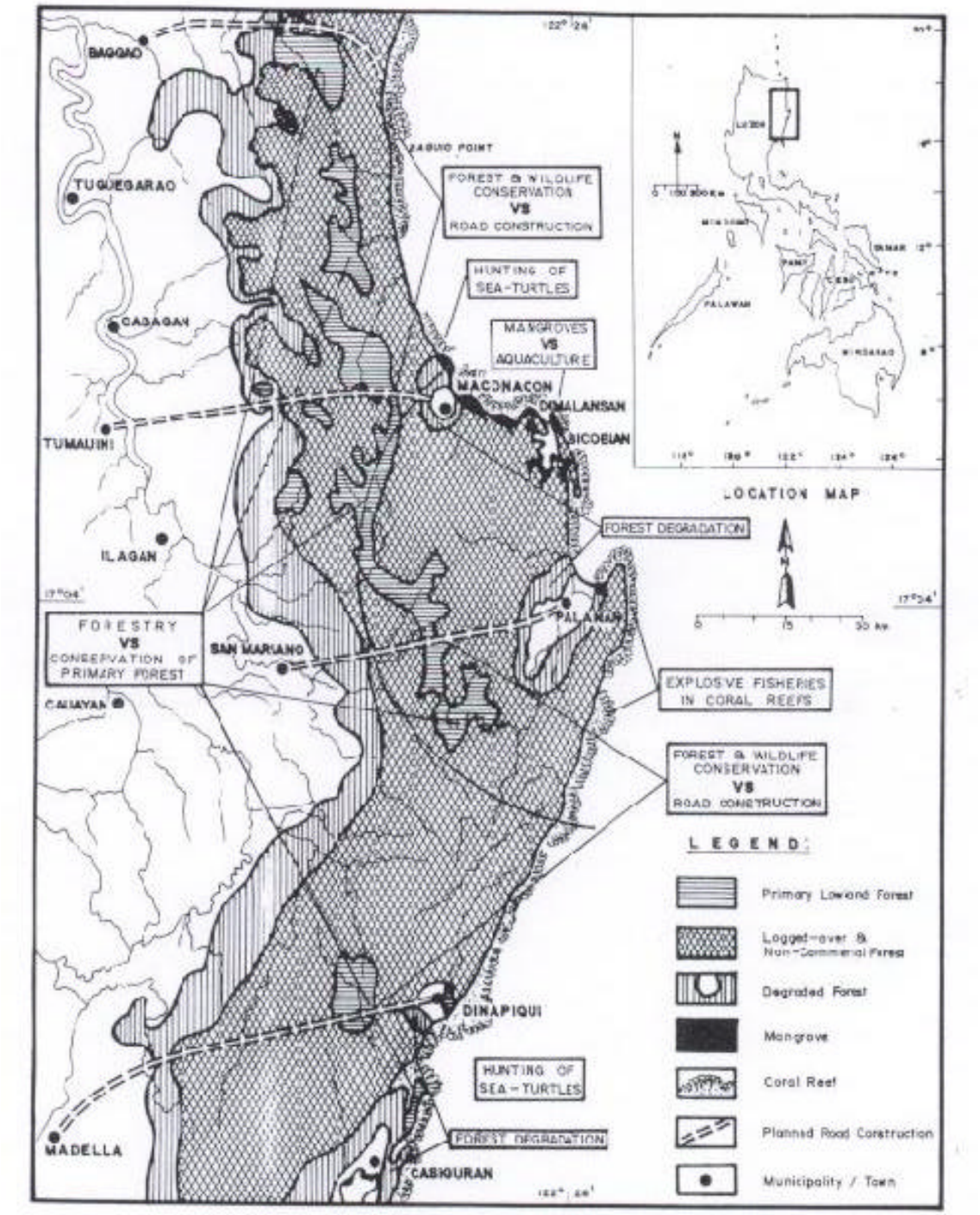

Figure 1 Present and potential environmental conflict areas

As yet, these plans have not reached maturity, but they are a constant threat to all efforts to safeguard the region=s biodiversity. They require permanent attention and lobbying to keep biodiversity conservation in the region high on the agenda of politicians. They also require that the research output should not only be directed towards the research community. To have a lasting impact, research output should also be presented in an idiom that will guide the politicians in their decisions. Otherwise, research activities may not have the desired effects. In the end, the fate of the hot spots of the world=s

biodiversity is in the hands of politicians.

4.3.3 Rigid Government policies in the conduct of biodiversity research in protected areas

The conduct of biodiversity research in protected areas in the country is now governed by Executive Order No. 247 series of 1995. Under this policy, only recognised Philippine academic and research institutions, government agencies, and inter-government institutions are eligible for an Academic Research Agreement - an instrument that normally takes at least a 6-month processing period. And, since PLAN International-Philippines is neither a government organisation nor an academic institution, it is working with Isabela State University (ISU) to apply for a research agreement. It is to be hoped that ISU will get this Agreement early in 1998. Meanwhile, the Project is conducting biodiversity research under the Resource Base Inventory system of DENR to generate the much needed database in support of the preparation of the Community-Based Resource and Management Plan - also called *Barangay* Land Use and Development Plan and the Integrated Environmental Management Plan for the Park. The limitation for the inventory system, however, is that no collection is allowed for both flora and fauna, which makes identification of new, unknown species next to impossible. It may be mentioned here that some Dipterocarp species (e.g. *Dipterocarpus grandiflorus*) are now in the flowering stage. And considering that the Dipterocarps flowers only every 5-7 years, the opportunity to collect fertile specimens is lost because of this rigid policy.

4.3.4 Administrative procedures and equipment acquisition and support

While PLAN-International is a non-government organisation, its administrative and financial systems are as rigid as government procedures. The response to a call for more flexible policies and procedures, inherent to the kind of project and the prevailing circumstances in the region, is rather slow. While ensuring the necessary control, these have significantly affected the processing time of contracting personnel services and the acquisition of equipment and supplies. Many kinds of equipment require long periods of order time (3-4 months) because they are not locally available. Their acquisition is further aggravated by the fluctuation of the Philippine peso.

A contributory factor to delays in the implementation and response to field problems is the lack of reliable communication systems that can connect the Project management office with the field staff and the whereabouts of technical advisers (both appointed and potential). A single side band as well as a very high frequency radio system have just been installed - providing a vital link between the Project office and the field stations. On the other hand, the Project office has yet no direct telephone link (i.e. land line) with its collaborators. To transmit or receive an E-mail or fax message, one has to go to PLAN=s headquarters in Tuguegarao, Cagayan - which is about 40 kilometres from the Project office, or a travel time of some 35-50 minutes by car.

4.3.5 Rugged terrain and adverse weather conditions

The ruggedness of the terrain and the difficulty of access to the coastal area, which can only be reached by small air planes, combined with inclement weather (typhoons) for more than half of the year, significantly affect the generation of the needed database. Given these conditions, what is needed is a combination of advance planning, institutional arrangements with key participants, and the building up of more than adequate logistical support.

4.3.6 Limited institutional counterparting

Manpower and funding resources of the NSMNP managing authority - the Protected Area Superintendent Unit (PASU) - are so limited that even its basic operational activities are hampered; much less is it able to respond to the requirement of NSMNP-CP for counterparting. As provided for by the NIPAS Law (Republic Act No. 7586), the PASU has its own regular funding, but its setting up is being delayed by the non-passage of the congressional bill that would enable it.

5. RECOMMENDATIONS FOR ORGANISING RESEARCH PROGRAMMES

Based on our past and present experiences in the Philippines, we would like to propose the following recommendations for the organisation of research programmes:

1. Research programmes related to the conservation of tropical rain forests should be problem-oriented, which implies an interdisciplinary or multidisciplinary approach, not dominated by a particular discipline or some closely related disciplines. Emphasis within the programme may change with time as the programme develops to reflect the multifaceted character of rain forest conservation. This implies that it should incorporate relevant social, economic, ecological, and political (governance) questions. The nature of this type of research requires a broad-minded and experienced management style, capable of bridging the differences in approach, methodologies, and types of research outputs of the disciplines involved. Finding a balance between the research needs of the project and the quest for more fundamental, basic knowledge of the academics involved, is crucial to the programme. Finding this balance should steer the research agenda from the beginning.
2. If, as in our case, the research programme is implemented by institutions from different countries, the collaboration should be based on an equal partnership, with benefits to all partners in terms of output. This partnership idea should be expressed in the style of (joint) management, in the kind and amount of contributions made by the partners to the programme, in transparency of its mode of operations, and in the distribution of the fruits and opportunities that result from it. Imbalances in these aspects are bound to create tensions in the long run.
3. In the field of rain forest conservation, research programmes that aim at long-lasting effects need, by definition, to have a long-term time commitment. In order to become embedded in the local context, in order to fully understand the complexity of rain forest conservation, including the relevant social-political context, and in order to allow the project to really have an impact on forest policies, a programme should go through a process of ›natural‹ growth and incorporation. Grounded knowledge, encompassing all aspects of effective rain forest conservation and creating a context that is sensitive and susceptible to recommendations originating from the research, are unlikely to be achieved within a short time span.
4. ›Plan as you proceed‹: over the years, the focus within the research programme will change. In most developing countries, forest policies and implementation mechanisms change rapidly, sometimes through the influence of international agencies. Just as protection of the rain forest itself requires continuous attention, research that is aimed at improving the effectiveness of measures taken or at proposing better or more efficient solutions, should not be abandoned quickly. In our research area, forest lands have moved within a limited number of years from state property, through quasi-property by issuing certificates of stewardship for a 25-year period, to areas officially claimed by indigenous communities, while with the new Act they are now open to legal titles held by indigenous peoples. The successive changes in policy instruments need to be studied in their implementation, side effects, and their consequences in order to determine their impact on conservation. Short-term research, or rigidly designed research projects, can never yield similar results. In general, the need for long-term social and policy- related studies is bigger than natural science studies because of

changing circumstances, which may induce various kinds of innovations.
Moreover, in-depth knowledge of one particular research site, obtained over a longer period of time will allow for more relevant comparison with other areas, thereby producing increasingly valid ideas, research methods, and theory regarding natural resource management, and ›people and parks‹-related issues.

5. Research programmes in the context of rain forest conservation and utilisation should outlive donor sponsorship and relatively short-term implementation projects. Usually, projects start with research before moving into implementation. But once the implementation has started, research interests fade out. Evaluations by an external observer on the impact of the project rarely take place. Internal project evaluations do not serve this purpose well. The research programme which incorporates community-based management must recognise that the programme duration cannot be determined in advance, and the donor should be made aware of this. We therefore strongly recommend a close relationship between rain forest conservation projects and academic institutions (local, national, and international) that can support the project with solid information in numerous fields and sustain the interest in relevant issues once implementation projects have come to an end.
6. There is a great need for the exchange of information between projects of this kind because we feel that there is a lot to be learned from experiences elsewhere. We therefore appreciate the initiative taken by Tropenbos to bring together representatives of various countries to openly discuss the work-in-progress. A moment of reflection amidst day-to-day activities is fruitful and provides new ideas and inspiration for the work ahead of us.

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ACTION RESEARCH FOR COMMUNITY-BASED RESOURCE MANAGEMENT AND DEVELOPMENT: *THE CASE OF THE NORTHERN SIERRA MADRE NATURAL PARK CONSERVATION PROJECT, NORTHEASTERN PHILIPPINES*

Achievements

- The project is contributing to conservation of the Northern Sierra Madre Natural Park through improved community-based protection and conservation activities, and at the improvement of the quality of life of the local population.

Challenges and Problems; Information Needs

- Conflicting rights between people and conservation needs; overlapping claims even within the government.
- Threat of infrastructural projects that conflict with conservation needs.
- Rigid government policies in the conduct of biodiversity research in protected areas.
- Difficulties with administrative procedures, equipment acquisition and support within the NGO.
- Rugged terrain conditions.
- Limited institutional counterparting.

Conclusions

- Research programmes related to tropical rain forest conservation should be problem oriented, which implies an interdisciplinary or multidisciplinary approach.
- Collaboration between institutions should be based on a equal partnership with benefits to all partners.
- The recruitment and training of qualified and deeply committed staff is essential for success of the project.
- A long term time commitment is required for research programmes that aim to have lasting effects.
- The focus of research programmes will change over the years, but longer-term research is also needed to determine the impact of changing circumstances.
- Research programmes in the context of rain forest conservation and utilisation should outlive donor sponsorship.
- There is a need for information-exchange between similar projects.

EFFECTIVE RESEARCH FOR THE CONSERVATION AND WISE UTILISATION OF TROPICAL RAIN FORESTS

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INTRODUCTION

This presentation elaborates on the question of when research is effective for the conservation and wise utilisation of tropical rain forests. We present five criteria that should be met for research to be effective. The managerial tasks and challenges to meet the criteria are subsequently highlighted. Finally, some observations are made on interdisciplinary research.

1. THE QUESTION OF EFFECTIVE RESEARCH

The aim of Tropenbos is to contribute to the conservation and wise utilisation of tropical rain forests. The Foundation does this by generating relevant knowledge and insights, and by developing techniques and methods to implement forest policy and management.

The effectiveness of scientific research as being conducted by Tropenbos can be assessed against five criteria. Research must be (1) relevant; (2) scientifically sound; (3) the results must be accepted; (4) the results must be applied; and (5) their application must have a positive impact on tropical forest ecosystems and on socio-economic systems.

The requirements on programme management in meeting these criteria are given special attention and some are further elaborated in Section 2.

1.1 Research must be relevant

Research should be relevant to the social and policy issues that are being addressed. This is particularly of interest to policy makers, forest users, NGOs, and donors.

It must be relevant to training and capacity building, being spearheads to achieve a definite anchorage in the country. The main interested parties are policy makers, forest users, research institutions, and donors.

And, last but not least, research should be relevant to those who are conducting the research. Here, the interest of research institutes is most profound.

The selection of relevant issues requires programme management:

- To conduct participatory procedures to identify forest policy and management issues and to set priorities. Tropenbos has gained experience with two processes: (1) Project Rapid Rural Appraisal and (2) the Objective-Oriented Planning Procedure;
- To match and reconcile the different interests of different partners.

From the fields of interest of the different parties distinguished above, it is clear that matching these interests requires specific efforts. Universities are focussed on the scientific interest of the subject and the scientific quality of the results, whereas forest users and policy makers are much more interested in an outcome that is meaningful for their purposes.

1.2 Research must be scientifically sound

Research results must be fully accountable and verifiable to support the credibility of information and advice.

- Programme management should secure a strong commitment from the scientific community.

1.3 Research must be accepted

Research results must be accepted by the different partners, specifically by those who are directly responsible for planning and managing the forest use.

Some prerequisites for acceptance:

- Research should produce knowledge and insights that cannot be ignored, and hence should determine planning and actions:
- Implications of research findings must be presented to the users of these results in understandable language and digestible portions;
- Recommendations must be realistic (financially, socially) with a potential for immediate application;
- Acceptance will be promoted by the long-term presence of all involved, including interested groups, and by good communication among those involved. Agreements at a high policy level should provide favourable conditions for support to the programme and for the acceptance of the results at that level.

- Programme management should continuously provide conditions to involve policy makers and forest users, to solicit their input, and to keep their interest during the course of the programme.

1.4 Research must be applied

This requirement lies beyond the responsibility of research managers. Whether research results are applied is heavily dependent on political will or political power. Results accepted at a certain decision level may not be applied if they are undesired by a more influential decision level or by a group of users who are beyond the control of the national or sub-national administrations.

- During the course of a programme, *research management* should deliberately work at establishing and extending a network with the aim of promoting favourable conditions for the implementation of the research recommendations.

1.5 Evaluation and monitoring

Indispensable for programmes like those of Tropenbos is the availability of a system to evaluate the effect of a research programme on forest policy and management. Unfortunately, evaluation methods to assess the impact of strategic research programmes still have to be elaborated or tested. Tropenbos, together with a scientific consultant agency, Sci Quest, has made a first attempt to develop a methodology to measure the success of a programme. This methodology, however, still appears to be too rigid a framework to be applied by persons who were not involved in its design.

Finally, in cases where research results and recommendations are applied, they should be monitored as to their real impact on the conservation of forest ecosystems, on the contributions of these resources

to the local and national economy, and on the social conditions of the local population.

- Programme management needs to develop and implement evaluation and monitoring systems.

2. MANAGERIAL TASKS

Some of the managerial tasks, notably those referred to under the criteria of relevance and acceptance, will be more extensively elaborated.

2.1 Securing the societal relevance of research

In the context of this presentation, research is of societal relevance if it provides information, insights, and methods indispensable for sound policy and management for the conservation and wise use of tropical rain forests. Securing the societal relevance is a point of attention throughout the whole project cycle.

Tropenbos distinguishes four stages in the project cycle, during which continuous monitoring and regular evaluation should take place. The first three stages of the cycle (Figure 1) are under the control of the programme management. They are (1) programme formulation, (2) programme execution, and (3) the dissemination and translation of results. Stage (4) is the implementation resulting in a positive impact on ecosystems and social conditions. The realisation of this stage is in the hands of policy makers and forest managers or users.
Specifically, Stage 1 (i.e. programme formulation) needs closer observation. Several steps can be distinguished, each of them requiring specific attention and procedures.

1. Identification of societal problems and/or targets;
2. Identification of policy and management objectives and prioritisation on the scope of the programme;
3. Identification of information needs;
4. Formulation of research questions;
5. Decisions on project objectives and output.

The first two steps can be tackled together. The outcome is information in terms of forest policy and management issues. The third step provides an insight into the information needs and shows the necessity for prioritisation on the scope and subjects of the research programme. Priority setting selects the issues and sub-issues to be addressed by the research programme. These (sub)issues are formulated in forest policy and management terms. This is followed by the formulation of the research questions, and finally institutions/scientists will be assigned to formulate and execute the research projects.

An example of the transformation of a policy question (Step 3) into a research question (Step 4) and into a research project (Step 5) is the following. Policy-makers face the challenge of designing a network of protected areas with the aim of covering close to 100% of the biodiversity occurring in the natural forests. Policy questions are: where to locate the protected areas, and what size should they be? Research questions are: what biodiversity occurs, what are their distribution patterns, and what is the impact of fragmentation on (generic) diversity? Projects that will be formulated to address these questions should be tested on their effectiveness and efficiency against possible alternative projects.

Programme management faces the challenge of selecting and conducting participatory procedures to identify forest policy and management issues and to set priorities. It is strongly recommended to involve professionals to guide such procedures as Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA), Participatory Technology Development (PTD), and Objective-Oriented Project Planning (OOPP).

2.2 Involvement of different partners in the project cycle

The input in the first stages of programme formulation must be dominated by forest policy makers, forest users and managers, and NGOs (Figure 1). Those who are supposed to benefit from the programme should have a strong voice in the focus and prioritisation of the programme elements. The scientific community plays only a modest role in the very first stage of programme formulation, but its involvement becomes much stronger in the course of the process.

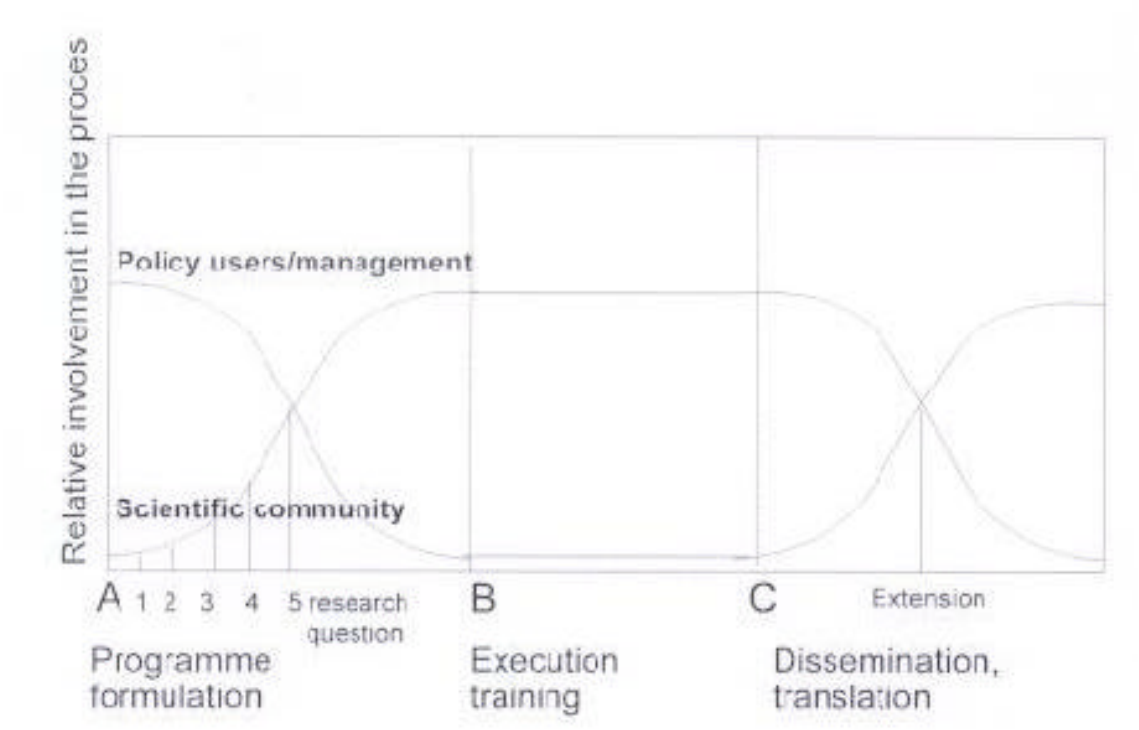

Figure 1

Identifying the need for information, technologies, and techniques is a finely-tuned process requiring a thorough analysis of the forest policy and management decisions and actions that are and will be

taken. The role of scientists becomes more pronounced.
The relevant research questions must be identified in a dialogue between scientists and policy-makers, forest users, and NGOs. The scientific community takes the initiative in project formulation and execution, and in producing the integrated scientific results.

Translation into meaningful information, presented in a digestible way, is again an activity of extension services and programme management, in consultation with the scientists.

In conclusion, emphasis must be put on some crucial conditions for a better chance of success:
- Prioritisation on subjects and scope of the research programme is needed;
- For each subject area, a number of projects must assure sufficient coverage to make meaningful recommendations;
- Formulation of right research questions is an art in itself and should be accomplished in an intensive dialogue between the scientists and the future users of the information or methods.

3. INTERDISCIPLINARITY

By their very nature, research programmes oriented to societal problems are multidisciplinary. The challenge is to make them interdisciplinary. The output of the programme should consist of meaningful recommendations that integrate information from different, closely-linked disciplines (hydrology, soil science, population dynamics), and combining the insights of the a, b, g sciences.

A meaningful integrated outcome starts with an integrated problem approach. A wrong start cannot be compensated for by high-quality disciplinary research. The decomposition of problems into a coherent set of researchable elements is a prerequisite to achieve results that can be integrated into meaningful information for forest policy and forest management.

Some constraints on interdisciplinary research programmes that need the specific attention of programme management are:
- Differences in interest of the scientific community and of forest policy makers and forest users. Matching the interest by careful programme development is the answer, as explained above. Fundamental research questions may be most challenging to the scientific community. It is a misunderstanding that the development of demand-driven social problem-oriented research programmes would prohibit the identification of fundamental research questions;
- Conflict of interests between PhD students and programme management. PhD students have to earn their disciplinary excellence. Time for communication, collaboration, and an exchange of data is often lacking. Management must keep the researchers on track, leading them to the common objective. A solution may be to extend the involvement of PhD students after they have defended their theses;
- Lack of an adequate rewarding system to promote interdisciplinary research. Incentives should reward skills and experiences required for successful team work. In the selection of researchers, programme criteria such as a good team player, disciplinary generalists, should play an important role;
- Project objectives and formulated project output that are too ambitious. This causes delays in project execution and an expansion of project time. Project outputs should be committed through binding contracts;
- Difference in perception and expression between disciplines. Management must recognise these differences and invest time and energy to bring about mutual understanding and respect;

- Difficulties related to planning, presence in the field, and data exchange. Create-use matrix is a tool to identify the production and use of information among researchers. It is a helpful tool to compose packages of projects for submission to funding agencies. Nevertheless, carefully planned time schedules may have to be changed, depending on the availability of funds and thus of the interest of donors, or according to changing circumstances.

Preconditions for the implementation of interdisciplinary research are:
- Allocation of time for communication and collaboration;
- Ample availability of logistic support: the availability of transport, computers, and operational funds creates a supportive environment for interdisciplinary research;
- Funds, capacity, and time for the integration, translation, and dissemination of project results.

4. FINAL COMMENTS

Effective problem-oriented research requires:
- Complex identification procedures, avoiding disciplinary bias and a dispersed research programme;
- Interdisciplinary programmes;
- Communication strategy, especially when the programme is being conducted in a form of cooperation between countries;
- Long-term presence in the host country;
- Agreements (Memoranda of Understanding) at high policy level.

The management of these programmes requires:
- Experience, focus, and abilities that are complementary to disciplinary skills;
- An environment that is conducive to fulfil these criteria.

The overriding management objective, however, is to keep all players motivated and to give them a sense of co-ownership.

EFFECTIVE RESEARCH FOR THE CONSERVATION AND WISE UTILISATION OF TROPICAL RAIN FORESTS

Challenges and Problems
- Research must be relevant, scientifically sound, the results must be accepted, the results must be applied and application must have a positive impact on tropical forest ecosystems and the socio-economic systems.
- There are inherent differences in interest of the scientific community, cq. PhD students and of forest policy makers and forest users.
- There are no incentives that promote true inter-disciplinary research.

Conclusions
- The scientific community plays a modest role in the first stage of programme formulation but its involvement becomes much stronger in the course of the process.
- Effective problem oriented research requires complex identification procedures, avoiding disciplinary bias and a dispersed research programme.
- Interdisciplinary programmes are needed for most societal problems.
- A clear communication strategy facilitates effective research.

CASE STUDIES

Sustainable forest management - social and land-use planning aspects

THE SCIENTIFIC APPROACH TO SUSTAINABLE FOREST MANAGEMENT, WITH PARTICULAR ATTENTION TO LAND-USE PLANNING AND SOCIAL ASPECTS

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1. INTRODUCTION

It is a well-known fact that tropical rain forests are of great significance for the well-being of present and future generations, provided that this threatened resource is wisely and responsibly exploited.

Whereas the early people used the forests mainly for hunting and fruit gathering, human needs vis-à-vis the forests have multiplied as the population has grown and the circumference of technology and education has expanded. Benefits derivable from the forests are becoming limitless.

Unfortunately, the use of tropical forests has been undertaken with little care about their future. Lack of management (Caillez, 1991) or small-scale economically-oriented management (Vantomme, 1991) - combined with an intensification of forest use - have led to the degradation and ultimately to the disappearance of forests at an alarming rate. As a matter of fact, 17 million hectares of forest disappear every year from among a total of 1.8 billion hectares (Birot and Lacaze, 1994). At this rate, a century would be enough for the entire tropical forests to disappear. The phenomenon affects not only the major tropical regions of the world, but also boreal and temperate forests (Baharuddin, 1995).

Because of this ill-considered forest land use, the future of the tropical forests has become a major concern among scientists, and even among the general public. More and more people are realising that there is an urgent need for Sustainable Forest Management (SFM), if are to secure the aptitude of the forests to perform their multiple functions, now and in the future.

Sustainable Forest Management can be referred to as a complex issue, integrating many interrelated components. A good illustration of this complexity are the difficulties in measuring its efficiency (Kao and Yang, 1991), and in developing a common understanding of terms, concepts, and processes of hierarchical standards to capture the concept of Sustainable Forest Management (Lammerts van Bueren and Blom, 1997). The concept needs to be looked into closely with a view to gaining an insight into research expectations for tropical rain forests. This paper addresses the most important issues of its land-use planning and social aspects, which are among the aspects to be taken care of in the process of securing the multiple functions of the forests.

2. THE ›WHAT?‹ OF LAND-USE PLANNING AS A PRE-REQUISITE FOR SFM

The main focus of the topic here refers to the concept of sustainability, of which key aspects are land-use planning and forestry research which are used to emphasise the concept. Land-use planning itself refers to social issues, as human beings must be in the centre of the process. It is not exaggerated to

regard land-use planning as the backbone of sustainable forest management.

It is therefore important to give an overview of the main ideas behind the notion of sustainable forest management, since the issue has been among the top issues in almost all debates related to natural resources these last years.

The quest for sustainability seems to have been one of the most important aspects in forest management since the earliest development of forestry as a science. Nevertheless, it appears to have been mainly oriented towards the conservation of forest for hunting by kings and nobles (FAO, 1993), or to have quickly turned to focus mainly on sustainable timber production (Davis, 1966).

Nowadays, the growing awareness of the threat that tropical rain forests are facing has led to a perception of sustainability that focuses on the forest as a multiple-product and multiple-use ecosystem. The International Tropical Timber Organisation (ITTO, 1992), in its struggle to ensure that all timber from tropical countries is extracted in sustainably-managed forests by the year 2000, defines sustainable management as:

> ›The process of managing permanent forest land to achieve one or more clearly specified objectives of management with regard to the production of continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity, and without undue undesirable effects on the physical and social environment.‹

It is in this respect that Gregersen *et al.* (1993) identified the following four major operational implications that the concept of sustainable development has on forestry projects:

- To avoid damage to critical natural capital, and to be wary of starting processes that are irreversible;
- Where the resource can be maintained, to limit exploitation to a sustainable level; where it is to be run down (land for agriculture), to set aside and invest enough of the proceeds to produce a permanent income stream or alternative sources of forest products for those who depend upon the forest;
- Where possible, to put economic values on social environmental costs and benefits so that they are taken into account in decisions;
- To ensure to the fullest extent possible that impacts normally treated as externalised are internalised within the design of the project (by including compensatory measures where necessary).

This perception of sustainable forest management is in line with the use of the forest according to its actual and potential functions, and to safeguard the benefits derived by humans, now and in the future. Conflicting interests become unavoidable in such conditions and the task is to harmonise contradictory users‹ needs. It has become a point of duty to shift emphasis from the tree to the entire forest, the tree having long eclipsed the forest.

The conflicting interests mentioned above are a consequence of the necessary multiple-use vocation of the forest ecosystem. Provisions should be made to ensure that forest exploitation is ecologically sound, socially acceptable, and economically viable. The forest is a source of land for agriculture, cultural assets and knowledge, and livelihood. Forest use has ecological implications, such as an impact on biodiversity and climatic change (Dickinson, 1989; Idso, 1989; Choisnel, 1991).

Land-use planning can therefore be defined as the systematic assessment of land potential and alternatives for land use, taking into consideration ecological, economic, and social conditions, in order to select and adopt the best land-use options.

3. THE ›WHY?‹ AND ›HOW?‹ OF LAND-USE PLANNING

SFM is needed because of the multiple functions that tropical forest ecosystems can fulfil. Local dwellers rely mainly on forest products and on agriculture. Shifting cultivation and slash-and-burn are not only the most widespread agricultural systems in tropical forests (Jumuar, 1991; Jepma and Blom, 1991; Cleaver, 1992), but also constitute the major cause of their destruction. The case of Indonesia, where the struggle for self-sufficiency is a policy of the government, can be pointed out (Jepma and Blom, 1991). Moreover, agricultural yields have been increased by expanding the area under cultivation, usually at the expense of forest and woodland, rather than by the intensification or stabilisation of farming methods. Unless agricultural productivity rises sufficiently, there will thus be a need for more land. Most governments of developing countries depend on the export of tropical wood to advanced countries for their exchange earnings. As the result of this, those governments with insufficient scientific and technical knowledge have a short planning horizon that affects the conceptualisation of appropriate forest management. Last but not least is that tropical forests are recognised as a real reservoir of biodiversity and other non-consumptive benefits.

SFM implies the categorisation of forest, as distinguished by the ITTO guidelines (1990):

- Permanent forests, consisting of forests set aside for the preservation of animal and plant species and where logging is not allowed;
- Production forest, designated for the sustainable production of timber and other forest products; and
- Non-permanent forest, designated as conversion forest for other uses, provided that they are kept under forest until required, and harvested according to some guidelines as permanent production forest.

These conflicting needs of forest users highlights the importance of land-use planning.

Forest land use should be guided by long-term objectives, based on careful land-use planning. This applies to all forms of land use, including timber production. Technical solutions to sustainable timber production should combine with ecological key processes and social key issues, which include people=s needs and people=s perception and knowledge.

Land inventory and evaluation form important components of forestry research programmes, whose aims are to develop methods and strategies directed to sustainable forest management.

There are two reasons for this:
- They provide a scientific base to be taken into consideration when deciding on the ›how?‹ of the future land use;
- They serve as a framework for all ecologically-oriented research activities.

Land inventory and evaluation include:
- A vegetation survey on a reconnaissance scale, which will lead to the identification of plant communities characterised by phyto-sociological groups. Soil types, drainage features, altitude, slope, exposition, and vegetation history are also taken into consideration;
- A reconnaissance land form and soil survey, leading to a general overview of the diversity in physical and biotic land characteristics, with the aim of assessing the distribution of land potential;
- Land evaluation, in which research findings from the above investigations are to be aggregated, in order to identify gaps in scientific knowledge to be investigated further. Land evaluation includes matching of land qualities with the requirements of relevant land-utilisation types, and provides a basis for land-use planning.

4. THE NEED FOR RESEARCH

Forestry research is the quest for knowledge about forestry. Research is needed when the existing knowledge about a subject matter can no longer fully satisfy the needs of the people (Adegboye, 1994). It is a matter of ›closing the gap‹ that exists between what we speculate and what we know. The second interest of research is to focus on various facets of the planning technologies for forest management. Both types of research are needed to improve the effectiveness of land-use planning.

The issue of ›closing the gap‹ refers mainly to the need of forest management for a better understanding of forest ecosystem processes and outcomes. It also refers to the necessity of intensifying research on the supply and demand of resources. That should include both marketable and non-marketable goods and services. This may lead to a better understanding and a quantification of factors that influence the availability of resources.

It is now clear that, if we want to tackle problems brought about by forest exploitation and to secure the capacity of tropical forest to fulfil their multiple functions, we need SFM, and we need it to include ecological, economic, and social aspects.

Tropical rain forests present the particularity of being diversified and complex. Their complexity is a consequence of their many interacting components. The physical or visible aspect of the forest is the result of these complex interactions, which are not easy to handle. Disturbance of fragile forest ecosystems (Foahom, 1993) may lead to a gradual change, which is not necessarily in the direction that is needed to provide human beings with benefits from the forest. It is quite understood that benefits derived from the forest will be sustained only if human intervention is such that the gradual change keeps the forest in a position to fulfil its functions.

Basic scientific knowledge on the response of the forest to disturbance is therefore needed as a prerequisite for developing methods and strategies directed at forest biodiversity protection,

sustainable timber production, and other forest benefits. This is feasible because forest resources have the advantage of being renewable, provided that their exploitation is conducted in a reasonable and rational way. This is also feasible, provided that - on the basis of a systematic assessment of land potential, alternatives for land use, and economic and social conditions - the best land-use options are adopted.

Sociological studies conducted since the late 1970=s have provided an improved understanding of the importance of the forest to people, and the socio-economic dynamics of forest management. Nevertheless, in spite of the importance of socio-economic factors, proposed research programmes or projects have overwhelmingly focused on biological and technological factors, at least until the beginning of the 1990=s, even if the well-being of local people has often been used as a justification for conducting research. A useful forestry research endeavour should be multidisciplinary (as is highlighted below), one of the parties being social scientists. This applies to rural-oriented forestry research where Participatory Technology Development (PTD) is essential. PTD involves the direct interaction between scientists and research beneficiaries (referred to here as local populations), starting from research conception to the analysis and interpretation of results. In this line, CIFOR recognises socio-economic research as a prerequisite for efficient management of wood resources (Dewees, 1992).

5. THE NEED FOR A MULTIDISCIPLINARY APPROACH

A multidisciplinary programme is referred to as a programme involving more than one discipline, with a common objective. A multidisciplinary approach is required because many problems cannot be appropriately handled through a monodisciplinary approach. This is often, if not always, the case for natural resource management (referred to here as forest management), where most problems have many dimensions.

Land evaluation in its broadest sense includes the process of inventory and mapping of natural resources, the classification and identification of tracts of land, and the interpretation of these data in terms of suitability of all individual tracts of land for a specified use. This is a call for integrated systematic research of natural resources, aiming at a multipurpose land evaluation. To obtain this, field information collected during reconnaissance surveys must not be restricted in its application to a specific single use (e.g. timber production, coffee estate farming, or any other kind of land utilisation). It should provide basic information that enables interpretation for a wide range of utilisation types, from conservation forest to agricultural development. A multidisciplinary research approach is therefore the only one that can result in a >quantitative, multi-purpose management land evaluation, and the design of suitable options for the management of the main forest land units= (Sombroek, 1986).

Land-use planning will not be the solution to all sustainable forest management needs. Other disciplines are required to fill the gaps in a >broader master plan= drawn in the framework of land-use planning. In other respects, the focus of sociological research on rural populations already has a wide range of tasks. This direction must be maintained, provided that social scientists are part of a multidisciplinary research team.

6. SOME KEY ISSUES TO BE ADDRESSED

The need to strengthen cooperation is emphasised by the realisation that a tendency exists to duplicate research completed or in progress elsewhere. Many ecosystems occur across several countries and research findings in one country can easily be adapted and used by other countries.

The sustainability of forest resource utilisation by the local population and local participation in forest management is crucial for sustainable forest use. For this purpose, participatory technology development (PTD) is needed. Research should determine the what and the how of PTD.

There is a need to investigate current farming systems, gathering and hunting methods and their environmental impacts, and people-s perspectives on forest land use, in order to identify possibilities for such participation and for improvements in the people-s forest resource utilisation. These complex issues are important for the land evaluation exercise, and have agronomic, social, legal, and ecological aspects.

Sustainable forest management is mainly in need of direct and applicable research and should be strengthened. It is a point of duty to relate research to development needs.

What are the forest land qualities and forest land-use requirements in view of conservation strategies? These especially concern requirements related to conservation forests, the role of non-timber forest products (NTFPs), and the sustainability of timber production - in view of their compatibility with the land use by local population and the competitive elements of areas under shifting cultivation.

There is a strong tendency in sociological studies to focus on the rights of local populations at the expense of their duties. Taking care of the rights of local populations will be beneficial for the SFM target, but only on the condition that the local populations are aware of their duties as a partner in the process of meeting the target.

Most of these issues are taken care of in the Tropenbos-Cameroon programme (TCP). The programme is made up of fourteen interrelated projects executed by a multidisciplinary team of more than twenty researchers. Its implementation is gradually leading to a better understanding of forest management processes. Land-use planning is an essential part of one of the fourteen projects (Land Inventory and Land Evaluation), which has gone a long way to identifying user-s needs and forest land-use requirements. Social aspects of the programme are about to be concluded. The following issues were found to be of critical importance (von Benda-Beckmann *et al*., 1997):

- The issue of community, difficult to identify in the study area;
- Issues of leadership and negotiation power;
- Issue of indigenous and newly-introduced techniques of exploitation;
- Issue of local perceptions of the activities of logging companies;
- Law and rights-related issues, notably on the difficult articulation of local rights and the claims of the State as expressed in the law.

The Tropenbos-Cameroon programme is on its way to a set of solutions for appropriate forest management in Cameroon. This is clear from the strategy that has been developed - a strategy

based on a necessary research option and a multidisciplinary approach. This strategy stays far from the current tendency of using the forest without any knowledge of the response of the forest after exploitation. It aims to find an intermediate solution between the *status quo* and the unrealistic aims of integral conservation of tropical forest as formally proposed by some international organisations.

As we saw earlier, tropical forest ecosystems are characterised by many interacting components. Obtaining an insight into these complex interactions is the only way to help the forest play its multi-purpose role. Notwithstanding the unavoidable gaps, the strategy developed is likely to go a long way in boosting the rational utilisation of the tropical rain forest.

Shall we acquire all the relevant knowledge to reach the target? What next, and how far to go? These are among the fundamental questions to address. Research in forestry directed to sustainable forest management is a long and exacting task, for nature delivers its secrets parsimoniously and nobody can foresee what will be needed tomorrow to progress in this direction.

In many respects, research findings are nothing if they are not applied. They are nothing if they are not properly applied. Their application may lead to insights into other processes that need to be studied in their turn, as science solves some problems by creating others.

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THE SCIENTIFIC APPROACH TO SUSTAINABLE FOREST MANAGEMENT, WITH PARTICULAR ATTENTION TO LAND-USE PLANNING AND SOCIAL ASPECTS

Achievements

- Implementation of a multi-disciplinary research programme is gradually leading to a better understanding of forest management processes.

Points for Future Research

- Leadership and negotiation power.
- Indigenous and newly introduced techniques of exploitation.
- Local perceptions of the activities of logging companies.
- State law and local rights.

Conclusions

- Forest land use should be guided by long-term objectives, based on careful land-use planning.
- Basic scientific knowledge on how the forest responds to disturbance is a prerequisite for developing methods and strategies directed at forest biodiversity protection, sustainable timber production and other forest benefits.
- Natural resource management nearly always requires a multidisciplinary approach because many problems cannot be appropriately handled through a monodisciplinary approach.

$ Field information should provide basic information that enables interpretation for a wide range of utilisation types.

$ There is a need to strengthen cooperation in order to benefit from each others experience and avoid duplication.

$ Participatory techniques need to be used to involve the local population.

$ Sustainable forest management is mainly in need of direct and applicable research and should be strengthened.

- Sustainable forest management should take care of local population rights but also requires awareness of its duties.

CONTRIBUTIONS OF SOCIAL SCIENCES TO THE TROPENBOS-CAMEROON PROGRAMME

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1. ABSTRACT

Since the launching of the Tropenbos-Cameroon programme (TCP) in 1992, its multi-disciplinary approach called for the active participation of the social sciences. After five critical years of scientific osmosis, social sciences have contributed in their way to the achievements of TCP. As part of its capacity-building goals, four PhD students worked under the supervision of senior professors from Cameroon and the Netherlands. Vital data useful to biological sciences for the achievement of TCP goals have been generated. This paper attempts to situate the role of social sciences in the development of the Rain forest Master Plan or management plans. It discusses the problems and possibilities of enhancing interdisciplinary exchange within TCP and the benefits that can be drawn by each discipline from such an exchange. The paper also addresses the existing gaps that require more research and the ways in which the social science component can contribute significantly to the development of management plans for rain forest projects.

2. INTRODUCTION

The Tropenbos-Cameroon programme (TCP) is a research programme established through an agreement of cooperation between the Governments of the Netherlands and Cameroon. Its main objective is to develop methods and strategies through multidisciplinary research for the sustainable management of the humid tropical rain forest. The thirteen sub-projects of TCP focus on biological sciences (forestry, forest economy, ecology, botany, etc.). The social sciences are also included in achieving the objectives of the programme.

The Tropenbos-Cameroon programme is based in the city of Kribi, a coastal holiday resort. The research area or zone of operation is about 80 km south-east of Kribi, covering about 200,000 hectares extending over two administrative divisions (Ocean and Mvila) of the South Province. The research site has over fifty Bantu villages and an undetermined number of Pygmy camps or villages. The population of the entire research site is over 100,000 people. The search for employment and farm lands has brought into the region many other ethnic groups who are competing for the management of natural resources. With the increasing demand for people's participation in environmental management, the involvement of social sciences has been considered critical for the development of sustainable long-term management plans.

3. MAIN ACHIEVEMENTS BY THE SOCIAL SCIENCES

From the very beginning, the participation of social sciences was designed to achieve two major goals. The primary goal was the generation of social, cultural, economic, and demographic data essential in understanding the human component of environment management. The second goal focused on capacity-building and institutional strengthening. Senior staff and graduate students working on the

TCP come from the Universities of Yaounde I in Cameroon, and of Leiden and Wageningen in the Netherlands. This represents a good case of north-south cooperation in capacity-building and institutional strengthening and the acquisition of scarce skills and resources from the north, which the south often lacks.

Three senior social scientists and four graduate students from Cameroon and the Netherlands have been intimately involved in the TCP, representing the social science contributions to the Project over the years. What social sciences contribute to TCP can be classified in informative and the operational categories.

The first category provides information to researchers (inter-disciplinarity), decision-makers, forest exploiters or logging companies, and NGOs, to serve as a guide for action or concrete initiatives. For example, data gathered on the exploitation and utilisation of forest resources by the local population help decision-makers and others in understanding how critical some of these are for the people's daily survival. At the same time, the data may also indicate to what extent resource exploitation causes conflict between different competing social actors: the local people versus the logging companies; the State versus the local people; the Bantus versus the Bagyeli Pygmies; or different lineages versus one another. The data may also be used to develop strategies for the sustainable and non-conflictual management of such resources. The large amount of informative data generated by social scientists has enhanced sustainable environmental management.

Some of the social science contributions have been used for operational purposes. Far from being just simple guides to action, this category of information contributes to the rational use of forest resources by the local people. Although we are making this distinction here, there is no clear-cut dichotomy between informative and operational contributions. The major contributions of social sciences to the TCP can, indeed, be reviewed under the following headings:

- Indigenous system of knowledge;
- Perception and social representation of the forest;
- Exploitation and utilisation of forest resources;
- Agricultural practices;
- The internal organisation of the different ethnic groups.

3.1 Indigenous system of knowledge

An inventory of the people’s systems of knowledge of the forest has led to the establishment of a taxonomy of the different plants (ethnobotany) and non-timber species of the forest. This inventory shows how local people have mastered the cycle of production and reproduction of plants and animals. The compatibility of these indigenous knowledge systems with the sustainable management strategies of the humid rain forest was also examined. Researchers have discovered an elaborate indigenous system of knowledge, showing how local people use this knowledge for the management of their forest environment. Most often, the system of knowledge shows a utilitarian character (i.e. it enhances the utilisation of forest resources). The indigenous knowledge system deserves to be reinforced in any sustainable management. How can conservationists, agronomists, and land-use experts utilise the local knowledge system in the management of soil fertility and the local techniques of cultivating certain plant species? These questions have answers that can be provided by social sciences.

3.2 Social representations of the forest

In a general way, a review of the functions of the forest in the material and symbolic life of the local people shows a dominance of the utilitarian or material functions. Agriculture is one of the utilitarian functions of the forest. The local people perceive the forest as a major reservoir of cultivable land. Such a perception is common among the Bantu villages, while the Pygmies see the forest first as synergetic space for the collection of plant and non-wood products (hunting and gathering).

The local perceptions in its temporal and perennial dimensions show that the population of the TCP site (Bantu and Pygmies) perceive the forest as an inexhaustible resource base: 'The forest can never disappear'. This perception contrasts, however, with their acknowledgement that the forest is not as rich as it used to be. The local people are also increasingly aware of the endogenous as well as exogenous factors of this depletion. The research into the perceptions and social representations of the forest within the TCP has led to some basic conclusions:

- That the local people perceive the forest as having primarily a utilitarian function;
- That the people also perceive the forest as an inexhaustible resource base;
- That there are no uniform perceptions about the present state of the forest.

These variations persist among the major human groups (Bantu and Pygmies) as well as among members of the same ethnic group. Certain external factors such an industrial exploitation, actions of NGOs and the local elite, policy-makers, and others, play different roles in determining and restructuring local perceptions of the forest environment by enhancing the >bundle of rights= of the local people.

On the whole, the work of social scientists has been to analyse these perceptions within a historical perspective and to identify the different types of interventions that will lead to the emergence of new attitudes conducive to sustainable management. Because of the importance of high social differentiation, more systematic research within the site is still required. This will permit the identification and the analysis of the different local perceptions of ecological and socio-economic conditions. The advantage of such a study is that it will target actions designed to bring about a change in behaviour and perceptions vis-à-vis the forest. Such studies will presuppose that both the social and physical units of analysis are the same and are well known. At the present level of our knowledge, social scientists are unaware of the geographical limitations of the area for which management plans will be developed.

3.3 Exploitation and utilisation of forest resources

Social research has also focused on the exploitation and utilisation of forest resources. What emerges from these studies are a series of observations that need to be highlighted here. A list of plant and non-wood forest products exploited by the local people as well as their different uses have been identified. It is on this basis that it has been possible to identify plants useful to the local people, but which are becoming rare. To this end, a close look at the impact of forestry exploitation on certain resources shows a remarkable depletion and a competitive exploitation between logging companies and the local people. The *Moabi* is a typical tree exploited by logging companies. Some logging practices sometimes destroy certain non-wood forest products used by the local people. The local people are in conflict with the logging companies for destroying in their paths non-wood products vital for the daily life of the local people. This information constitutes a good basis for developing non-conflictual strategies for the exploitation of forestry resources, specially when the interests of other groups of social actors are in jeopardy. In the present context, the identification of commercial benefits as well as increasing the market value of some forest resources certainly enhances local people's commitment to participatory management of such resources.

On the other hand, an evaluation of the impact of local techniques has shown that many endogenous techniques of exploitation of plant and animal resources do not match well with the criteria of regeneration and renewal. The money value of forest products has had a remarkable influence on local techniques of exploitation. The intensification of certain local techniques (wire snares, collection of honey) has had negative effects on the available forest resources. It is important to recognise that certain local techniques do not have a sustainable value. Defining actions designed to promote a rational exploitation of forest products is therefore the logical conclusion, but it is important to distinguish between good and unsustainable local techniques or methods. It is important to note here that interdisciplinary exchanges between ecologists and social scientists have occurred within the research carried out on the exploitation and use of forest resources.

At the operational level, an ecologist was integrated into the social science team, an integration that was beneficial for both disciplines.

3.4 Agricultural practices

Social studies conducted so far show the influence of the market economy on the industrial exploitation of wood (use of the engine saw). The local agricultural practices, however, have remained dominated by shifting cultivation. This has immediate implications on the dynamics of the agriculture-forest continuum. No direct conversion of forest to agricultural land exists because slashing and burning are preferred, principally because of several socio-economic, human, social, and ecological gains.

The development of the local agrarian system has important implications for the development of strategies for land use and forest management. In a more concrete way, the research has provided information permitting the review of existing zonal plans of the Southern Cameroon Forestry Plan within the TCP site. The elaboration of micro-zonal plans of the TCP site will also be possible with information compiled from intensive multi-disciplinary field research.

The optimal use of these data on agrarian systems will be enhanced by more studies on a certain number of representative villages. These studies will enhance the analysis of the present agrarian system, showing the specific socio-economic, ecological, and demographic characteristics of the zones. It will not only give us a proper understanding of the local agrarian system, but also an evaluation of the complex interaction and impact of agriculture on the forest.

Such studies are certainly at the cross-roads of several disciplines concerned with land use, soil, plants, agronomy, and society. The different studies conducted through a combination of different perspectives will determine the demographic pressure on the forest through agricultural practices. The necessity of such studies will be determined by the results of the other sub-projects whose research activities are still in progress. Their capacity to maximise the abundant information and integrate the data will determine the success of the TCP.

This last perspective raises one of the major problems in multi-disciplinarity. In this context, there is always a risk of discovering that results are not integrated or just juxtaposed, therefore requiring another effort to pull them together into an integrative structure. For inter-disciplinarity research to be meaningful, the teams must work together on common objectives and problems. By bringing in their unique insights, each discipline can contribute to seeking solutions and appropriate strategies for the participatory management of rain-forest resources. Apparently, this did not happen in the TCP because they were not integrated *ab initio*.

Beyond these studies, it is imperative that socio-economic and demographic surveys be conducted on the entire TCP site. In order to have useful baseline data, however, clear terms of reference should target actions to be undertaken within the entire site. In any case, these surveys constitute the pre-conditions for actions to be undertaken towards the development of sustainable management plans. Other studies that deserve to be done include land-use patterns that will highlight the distinction between primary (disturbed and undisturbed) and secondary forests. Such studies would enlighten the claims of local people to certain portions of the forest and will also determine and target the criteria of appropriation or those on which these claims are based.

3.5 Internal organisation of different ethnic groups

Several questions may be raised within the framework of sustainable management of forestry resources and the participation of local people. These questions are many and varied. What is a community? What are its rights and duties? What are community forests? How can these be managed? What are production forests? Does the creation of such forests restrict the exploitation of its resources by people who have owned them for generations? What types of activities respect the 'bundle of rights' of local people? These fundamental questions raise critical issues about the nature of participation. The degree and nature of participation will depend on the type of socio-political organisation of the different ethnic groups. To approach these issues in a more constructive way, a clear understanding of such terms as leadership, community, and empowerment are needed.

3.5.1 Definition of the term community or social unit of action

Social research has indicated that, if participation is to be meaningful, one must have a clear notion of the term 'community'. Identifying the appropriate communities can play a role in the sustainable management of the rain forest environment. The new Cameroon Forest Law makes references to communities, but fails to define what these social units are. Recent ODA research conducted by P. Burnham, M. Rowlands, and students in various parts of Cameroon indicate that this concept is difficult to interpret. Before colonial penetration, the Bantu groups were highly mobile societies and had a segmentary political organisation, with villages composed of patrilineal segments. Because of the diffuse nature of political organisation, it was easy for ambitious leaders to split off and move away to establish new villages elsewhere in the forest. The ethnic group was therefore a composition of independent villages with no clearly instituted central authority above the village level. Leadership was largely built on charisma, a sense of organisation, and personal achievements. A person could emerge as a leader by accumulating a large number of followers beyond his kinship groups and affinal relatives (friends or even clients) from other lineages and families. There were no clearly institutionalised positions of power or 'offices'.

Without any unique leader, the colonial state borrowed a leaf from the centralised chiefdoms. It forcefully introduced 'chiefs' to groups that were highly mobile to facilitate the collection of taxes and the recruitment of labour. Most villages, usually located along the roads, were composed of different kin-groups. Such a reorganisation, however, often led to the constitution of heterogeneous villages. Today, many villages are composed of a variable number of patrilineages that are often not related by common descent. Lineages that claim an often mythical common descent have a strong sense of belonging to a larger group, the 'clan'. Clans tend to be dispersed over different villages. In all villages, one finds lineages of different clans. This variation shows that people from three to four clans will live in different villages. In some cases, a clan segment in one village may contain up to twenty 'lineages', constituting approximately independent segments. Claiming often different origins, they assert rights over different parts of the forest. Today, a 'traditional chief' is a misleading idea imposed by the colonial state. Because of the heterogeneity of these villages and the need for identifiable persons to perform functions for the colonial administrative officials, the newly instituted 'chiefs' often found it

difficult to impose their authority on members of their village communities.

The situation is even more elusive among the Bagyeli (Pygmies). Most camps constitute small patrilineal units. For example, two or three brothers with a varying number of relatives, maternal kin, and possibly 'friends' may establish a camp. The composition of these groups, however, changes constantly because of great individual mobility. Individuals may decide to go temporarily or definitively and live with other groups. What characterises the Pygmy group is the constant movement of people between well-defined settlements (*kwaato*) and from time to time make their home in hunting camps (*ngya'a*). The periods that people sojourn outside the *kwaato* seem to get shorter as most Bagyeli tend to settle for longer periods in such *kwaato*. Each group of Bagyeli Pygmies recognises a special relationship with a Bantu villager, expressed in common clanship (*ka'a*), with the Bantu villager providing patronage and protection. In principle, he will play a mediating role in Bantu and Bagyeli commercial exchanges and disputes. Such a 'patron' will claim some authority over 'his' Bagyeli friend or fictive kinsman.

During the first decade after independence, the State encouraged Pygmy groups to settle in permanent camps. A sedentarisation policy was designed to provide social services (education, health, etc.) to these marginalised ethnic groups of Cameroon. The Bagyeli groups were encouraged to settle along the road, often near the village of their 'patrons'. In more recent times, however, the sedentarisation policy suffered a set-back. The conviviality between the Bantus and Bagyeli witnessed many growing problems, obliging Bagyeli groups to take refuge in settlements deeper in the forest. This withdrawal permitted some of the Pygmy groups to re-evaluate the advantages and disadvantages of sedentarisation and their relative mobility. Today, it seems that Bagyeli groups are trying to combine the advantages of both. More permanent settlements provide regular access to markets for the sale of bush-meat, honey, and other forest products. The Bagyeli also have access to medical and educational facilities provided by Catholic nuns in the Bipindi area. Data obtained in the TCP area show that most Bagyeli groups prefer to combine permanent settlements with long-term stays in 'hunting camps', which allow them to exploit additional resources through hunting and gathering. A number of camps along the roads have been established (around a well-known Pygmy healer, whose healing services attracted both Bantu and Pygmy settlers, who regularly live there for long periods of time).

One of the great advantages of sedentarisation has been the increasing independence of Pygmy hunters from the overbearing Bantu 'patrons'. The Bagyeli have a greater direct access to the markets than ever before, and their 'patrons' now complain about their failure to respect their special obligations. These changing relations have led to increasing tensions between Bantu villagers and Bagyeli. On several occasions, physical attacks have been perpetuated on the Bagyeli, even leading to manslaughter.

The above analysis does suggest that it is important and even crucial to clearly define what we mean when we refer to 'communities' and 'villages'. Social studies have shown how misleading some of these concepts can be when it comes to the level of application and the participatory management of natural resources. The new Cameroon Forest Law seem to use these terms interchangeably. Evidence from social science research indicates that different social actors exist within social units of various compositions and levels, inferring that the new Forest Law is highly problematic. It is important that participation be constructed on the evidence from the ground that suggests the development of a more complex model of 'co-management' by different social units and levels. Recent studies in the TCP area have identified the following social units that could play a role in such a more complex model:

- The Bagyeli *camp*, whose claims to parts of the forest are formulated on the basis of its special relationship with its Bantu 'patron';
- The *village*, which claims a general right of control over a more or less clearly delimited part of the forest (user rights are established by lineages and households through clearing and cultivation);
- The *lineage*, in principle, claims rights to specific parts of the village's forest domain but, in practice, such a lineage domain may be dispersed over different parts of the village domain;
- The *household* also enjoys user rights over those parts of the forest that are cleared and brought under cultivation by one of its members (or ancestors); such user rights have become greatly enhanced by the spread of cocoa cultivation, which is leading to the establishment of more permanent farms.

To guarantee and ensure the active participation in sustainable management of natural forest resources by Bantu ethnic groups marked by clan and lineage heterogeneity, the following observations would seem to be appropriate:

- That the new Cameroon Forest Law imply that the terms 'community' and 'village' seem to be one and the same thing;
- The villages are composite units; they are not necessarily mono-ethnic, and, even if they are, they are still clans and lineages, each having its rights and obligations over natural resources;
- The option that regards villages as units of operation is misleading and unoperational within the context of community forest provided for by the law.

The village with its various social actors does not provide a coherent homogeneous structure capable of mobilising consensus on land use or exploitation.

The situation again appears more confused among the Bagyeli Pygmy groups, because they often settle near Bantu villages, but still maintain their specific community identity. It would appear imperative that this specificity of the Pygmies be taken into account in any strategies enhancing the participation of local people in the sustainable management. Their specific ways of life, interests, and forms of forest exploitation are distinct from those of the Bantu groups. All these points suggest that, in any participatory management schemes, the Bantu and Bagyeli social units (villages, camps, clans, lineage, and households) should be taken very seriously. Village consultation exercises designed to empower the people must consider these as important social partners.

Because of the hierarchisation in the exercise of rights by different social groups over different sections of the forest, it will be important that any management model must integrate, at all levels, the different social units and the different levels of decision-making.

3.5.2 Leadership vacuum and the power of negotiation (empowerment)

Faced with a social organisation marked by heterogeneity and a perennial problem of social representation, the emergence of charismatic leaders seems desirable and even urgent. Such leaders could play a role as opinion leaders or representatives of social groups in which they are recognised as

such. Unfortunately, these kinds of persons in these segmentary forest societies are difficult to come by. As we have seen, the so-called 'traditional chiefdoms' are a colonial institution maintained after independence to perform administrative functions. They are not the true representatives of the villages. Among the Pygmies, this state of things is again worse as their social and organisational structures are far more fluid. In these forest societies where leadership is loose and diffused, there are no credible leaders, posing a serious problem to participatory management.

Data obtained from social research offer some alternatives. A closer look at the different social forces in the villages enables different levels of authority to be identified. Firstly, each village or group of hamlets always has a '*conseil du village'*, constituted by the village chief, his notables, lineage heads, and other leaders who play a consultative role in decision-making processes. Secondly, the urban elite, although living and working outside their villages, are agents of change and useful partners. Thirdly, the State's withdrawal from community development in the early 1980s has promoted an effervescence of development or cultural association throughout the country, and this region is no exception. Within the TCP site, an association known as *ARBI* (*Association des Retraites de Bipindi*) could also be brought into the picture. The local NGO such as CODEBABIK (Committee of Development of the Bagyeli of Bipindi-Kribi) could also be associated in any efforts to enhance people's participation in the sustainable management of forest resources. Fourthly, the creation of '*Groupes d'Initiatives Communes'* (*GIC*), which pull interest groups and social actors together for a common cause, may also be an option. In this case, care must be taken to avoid any negative fall-out of such a new structure. In any case, it will be important to give legal support to such an institution, and to define the roles of each social entity in relationship to the activities to be undertaken within the Project.

Each of these suggestions or alternative solutions have some advantages and disadvantages. To use these suggestions for any rational management of the forest, one has to examine the constraints and opportunities offered by each option, removing or mitigating the constraints.

3.6 Normative framework of management and exploitation of forest resources

Studies conducted so far reveal the existence of rules for the exploitation of different natural resources (trees, non-plant forest products, animals, water, and land). The first categories of rules govern behaviour among the Bantu and Pygmy ethnic groups. There is even a differentiation among different ethnic Bantu groups. Nevertheless, the exploitation of forest resources by local people is characterised by the plurality of norms. The situation is more complex when this plurality of norms at the local level is juxtaposed to the land tenure and forest laws of the Cameroon State. What is paradoxical is the dominance of the State laws and regulations over the already plural and complex Bantu and Pygmy regulations.

The contradiction between the different normative levels and the definition of the rights over the management and exploitation of forest resources exist. The differential conception of space and its boundaries shows different contradictory perspectives (Bantu, Bagyeli, State). The different rights are superimposed on the same space and the same resources.

What emerges from this analysis are conflicts between the different rules of management and rights, and conflicts between the social partners (Bantu, Bagyeli, State, logging companies). This situation makes collaboration within the perspective of co-management of forest resources very difficult. The question is how to manage the forest sustainably in the context of legal pluralism?

3.7 Master plan: perspective for people's participation

If sustainable management is to be achieved, all initiatives within the context of people's participation

must acknowledge this normative plurality and the potential conflicts embedded in them. Examining the validity or the non-validity of these norms and the possible compromises that can be made, may be a useful exercise. It will be unfortunate and erroneous to accept the principle that only basic laws of the State have the legal force over the control and exploitation of forest resources. Local people have, from generation to generation, owned and managed the resources over which, today, an artificially- created State claims total right and control.

There is also a need, firstly, to recognise the rights of the people over forest resources, and secondly, also to acknowledge their rights to an equitable share of the benefits of forest exploitation. In doing so, there should also be a clear demarcation between the rights of the Bantu and those of the Pygmies. The recognition of the extensive rights of the local people is fundamental for any meaningful participation. After all, their claims are much older than those of the State. This recognition infers the necessity of proceeding to integrate management planning with due regard to the people's 'bundle of rights' over their resources, instead of proceeding to the management plans that exclude and prohibit people from exercising any rights over what they believe is their ancestral patrimony.

The demarcation of boundaries ought to make use of the local people's 'cartography of rights'. People's claims are usually based on 'traditional well-known' limits or boundaries. It will be a useful exercise to map out the space that villages, clans, lineages, and even households believe is their 'ancestral territory'. Maps obtained on this basis must be superposed on those drawn according to technical, ecological, and economic criteria. Through these methods, zones of potential conflicts can be identified and possible compromises worked out. The emphasis must not be placed on zones for exclusive use but, above all, on the priority functions without which other functions will be excluded. This exercise therefore requires the collaborative effort of other disciplines. Interdisciplinary exchanges between the social issues and other biological issues within TCP become all the more important.

4. SOCIAL SCIENCES AND POLICY

According to the terms of the agreement between the two Governments, TCP was required to initiate and coordinate multi-disciplinary research. The results would be used as tools for policy and for the rational management of the Cameroon forest patrimony. Within this perspective, the results obtained within the entire project would not only be used in policy formulation, but also in the review of State legislation on the management of natural resources.

Indeed, there is an iteration between the results (actual and potential) of research in TCP and policy. The master plan ('*plan d'aménagement'*) for the TCP forest area was, from the very beginning, not one of the explicit objectives of the programme. Its inclusion as a specific objective, and even as a priority objective for TCP, falls within the political domain, and is teleguided by the demands of subsidiary donors. Such a decision leads naturally to the re-focus of social research. At least, it imposes a re-interpretation of research results, if the operationalisation of this objective has to be taken into account. Evidently, research has become donor-driven and highly politically motivated. Because the outcome of social research is still being awaited, it is impossible at the moment to predict the political and operational implications. Even so, one recommendation that needs to be made here is the necessity to conduct baseline surveys whose data will be used to design the said 'Master Plan'.

Nevertheless, despite these iterations identified between politics and research, there is a need to be prudent, especially when it is a question of research in the social sciences. Can the research results be converted into policy instruments for sustainable management? What will be the importance of research

conducted in social sciences and in other sub-projects of TCP?

Prudence is based on the fact that, in Cameroon, the forest domain and that of petrol are considered 'private affairs of the State'. It is a domain of which the State, despite appearances, does not want to lose part of its sovereignty and control. Usually, policy declarations are designed for international consumption but, on the ground, the practice is the contrary. Within such a context, the recommendations that social research can offer for participatory management of natural resources run the risk of being coldly received. For most Government officials, the concept of participation is an empty concept; the State's sovereignty is primordial. Under the present economic recession, enhanced by corruption in high places, the intensification of forest exploitation has become one of the potential environmental hazards. The wanton destruction of the forest by foreign companies seems to go on with little or no control. Participation has come to mean the distribution of rice, oil, and imported wine to local villagers who pretend to represent the people. Instead of providing social services (e.g. health facilities, schools, better road systems, good drinking water, etc.), the logging companies are more concerned with their Structural Adjustment Programmes (SAP) through organised corruption. As the State officials defraud in national elections, so they defraud in the management of the nation's natural resources.

One may rely on the influence of the international community and international ecological lobbies capable of influencing State rigidity. Indeed, the rational management and exploitation of forests in Cameroon are often replaced by occult interests capable of ignoring research design that seeks to determine the conditions for a better participation of local people in the management of forest resources.

5. SOCIAL SCIENCES AND OTHER DISCIPLINES

In this paper, allusion has been made to the working relationship between social sciences and hard sciences. The question is, has there been any real interdisciplinary exchange? On the whole, social research within the TCP has benefited substantially from experiences and findings of other disciplinary work. I believe the reverse is also true. Nevertheless, despite these interactions, the research findings of the social scientists have sometimes been perceived in a negative way by certain forest researchers, either because of the pretension of a superior methodology of their discipline, or because of the failure to understand the qualitative nature of social sciences.

The survival of a reductionist perception of the forest has persisted among a category of foresters, despite the significant break-through of 'social foresters'. They have continued to think that the forest can be planned and preserved exclusively for the intensive production of the demands of the market. This economist's perception of certain foresters does not tally well with disciplinary exchanges.
Despite these misunderstandings, there is hope that public, national, and international lobbies will bring their weight to a change in mentalities. Certainly, there will be no dichotomy between economic, political, and ecological and the social imperatives. It is under such conditions that research will have a real impact on the policies and, above all, on the decision-making process towards a more participatory management of forest resources.

6. SOME REFLECTIONS ON THE GAPS AND PERSPECTIVES

According to some programme managers, the production of a Master Plan ('*plan d'amenagement'*)

is just one of the results of the TCP programme. For others, it a major goal of the TCP. The social science findings should therefore have broader relevance to the newly defined TCP mandate. However, the experiences in the field offer the following suggestions:

- A detailed Master Plan (‘*plan d’aménagement’*) is not possible unless institutional channels have been created that permit representatives of local social units to make appropriate choices. The empowerment of the different social units and actors seems to be an important condition for the negotiation and formulation of such a Master Plan.

- A Master Plan is not possible at this critical level of our knowledge; social research has not collected baseline data on the socio-economic aspects of all local communities within the project site. To fulfill the demands of the State, the gathering of baseline information on demography, social infrastructure, number of villages, the exact surface area of cultivable land, becomes a *conditio sine qua non*. There is a new cost implication not provided earlier.

- Social research has not only demonstrated the high diversity of ethnic composition (Bagyeli, Bulu, Ngomba, Bassa, and ‘*allogenes’* or strangers), but also the representative character of the study will be further enhanced by the baseline survey recommended above.

- There are visible signs that the hard disciplines regard social sciences as second-rate because of the qualitative nature of their data and their lack of quantifiable information. Social sciences have generated tons of qualitative data that are difficult for other scientists to use. The tendency among the hard sciences is to seek quantitative data from the soft sciences. Most hard scientists show a poor understanding of social science methods and techniques. If the hard sciences are to understand and use the data generated by social scientists, it is imperative that they take a closer look at the social science methods and techniques.

- Although, there is a desire to promote inter-disciplinarity, research teams were never inter-disciplinarily working around specific objectives, nor were they focusing on specific problems. Apparently, each discipline went on to do its work in the hope that the reports of others would be useful to them. Instead of social science working in close relationship with other sciences, providing a service and insights on a permanent basis, its sporadic discourse did not match well with the integrative nature of the Project. To enhance future action, a number of steps need to be taken. First, through workshops, researchers in the hard sciences should be educated in the methods and techniques of social sciences. Secondly, by working closely with hard scientists, social scientists must become integral parts of multi-disciplinary teams and not just marginal individuals. Other scientists should share their methods and techniques with the social sciences, and social sciences should not just be an adjunct subject, but an integral part of the process of seeking solutions to human problems.

- Researchers (in both the hard and the soft sciences) usually believe that their work can only be understood by their peers, and that local people cannot contribute to the production and reshaping of knowledge. No village workshops have been conducted to share research findings with the local communities and to get feed-back. This is a very useful method of validating data and collecting complementary or supplementary information.

7. SOURCE

In April 1997, Professors Peter Geschiere, Franz von Benda Beckmann, and myself produced an evaluation report on the social science component of TCP entitled *Project Tropenbos-Cameroon Social Sciences*. The present paper is a recast of that report, built entirely on the work conducted by the four graduate students, Francis Nkoumbele, Francoise Tiayon, Karen Biesbrouck, and Jolanda van den Berg.

CONTRIBUTIONS OF SOCIAL SCIENCES TO THE TROPENBOS-CAMEROON PROGRAMME

Achievements

- Clear overview obtained on the variation in perception on the forest among and within ethnic groups.
- Plants that are useful but are threatened by commercial logging are identified.
- Evaluation on the sustainability of indigenous exploitation methods is conducted.

Challenges and Problems; Information Needs

- Current forest laws (in Cameroon) do not recognise the complex patterns of social organisation and its implication for forest management, which reduces the possibilities and success of participatory management of natural resources.
- Different rights are superimposed on identical space and on the same resources, leading to conflicts between the different rules of management and rights, and conflicts between the social partners.
- The is a discordance between the quantitative nature of 'hard sciences' and the qualitative nature of 'soft sciences'.

Points for Future Research

- Studies highlighting the distinction in land use of primary and secondary forests.
- Map out the various spatial claims of villages, clans, lineages, households and determine zones of overlap with spatial claims based on technical, ecological and economic criteria.
- Empowerment of the different social units and actors in order to stimulate their meaningful input in resource use planning.
- Gather social baseline information.
- Educate researchers in hard sciences on methods and techniques of social sciences through workshops.
- Organise village workshops in order to obtain feedback from population.

Conclusions

- Meaningful interdiciplinarity implies that teams work together on common objectives and problems from the beginning.
- Any management model should integrate at all levels the different social units and levels of decision-making.
- Social science research in the programme has benefited substantially from other disciplinary work and reverse, but significant problems of integration remain.

EMERGING LOCAL AND GLOBAL DISCOURSES ON NTFP USE AND STUDY: A VIEW FROM GUYANA

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1. INTRODUCTION

On 22 November 1998 I sat in on a Village Meeting in Sebai, a Mixed Amerindian community of about 230 persons (Warau/Carib/Arawak), located about 12 miles up a creek of the same name and some 22 miles distant from the sub-regional centre of Port Kaituma. The Captain was accused of poor administration of village resources, including marketable logs and palm hearts. One villager announced that people from the Aruka River were increasingly coming over to cut palm hearts (*Euterpe oleracea*) in the Yakirikat Creek, which formed one boundary of Sebai's titled land, and asked what the Captain was doing about that.

The Captain's response was succinct: for all his pains on behalf of the village, he received a monthly stipend of G$ 2,800 (equiv. US$ 16) from the Government. For that pittance, would he also have to be a watchman in the distant Yakirikat Creek area? He also pointed out that the Aruka 'cabbage cutters' would invariably claim that they were cutting down palm trees located on the State-owned bank of the Yakirikat River, not over on the village side. Since no Sebai households were sited in the area, who was there to dispute the Aruka claim?

A major part of Sebai folk came over originally from the Aruka River and the communities continue to be closely linked by ties of consanguinity and affinity. No doubt, a large number of palm hearts are harvested illegally from Sebai's titled area, but the bad guys in this instance are family and friends, all as poor as the Sebai villagers. Village administration in Sebai can be said to be non-existent and the same is probably true of the Aruka River settlements.

Stories such as this illustrate the complex world in which discussions of NTFPs take place. In a thoughtful introductory piece entitled 'Whose Knowledge, Whose Genes, Whose Rights?' Stephen B. Brush concluded:

> 'Effective conservation cannot be planned or accomplished without addressing the issues of poverty, domination and exploitation. Nevertheless, these problems are centuries old in most places. Understanding them strains the modest theoretical and methodological tools of social science. Solving them is beyond the grasp of the available political tools. Yet the value of human life, cultural diversity, and biological resources is so great that we cannot shirk from the challenge of finding viable conservation methods. The press of poverty and

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> population growth and the urgency of protecting human dignity make this challenge as difficult as any intellectual or political challenge in the modern world' (1996: 18).

It is precisely such a challenge that a seminar such as this one takes up, focussing on the indigenous management of forest resources in the interests of both equity and conservation.

This paper examines some of the emerging discourses, local and global, on NTFP use and study. The context includes such factors as advances in biotechnology, the establishment and consolidation of supranational institutions, particularly since the 1990s, designed to regulate international flows of 'natural capital'; an increasing acceptance of indigenous rights and wider recognition of the link between cultural and natural diversity.

2. THE CARIB STUDY AREA

Sebai village is located in the upper Kaituma/Barima/Barama watershed area, in which the Carib Studies Programme is being carried out by three Tropenbos-sponsored researchers, including myself. My own research focus is not primarily directed at the knowledge or use of NTFPs by the indigenous inhabitants of this area, but rather at the geopolitical and socio-economic processes that have shaped indigenous life in the Carib heartland.

One of the surprises of my research so far has been the realisation that this population has not been, either in this or the last century, strictly peripheral to the dominant colonial (later independent) society. Exposure to gold (and, later, manganese) mining has left its stamp on all facets of indigenous life, so that here, as elsewhere, the global dimensions of modern life are all-pervasive - in patterns of consumption and recreation, in the willingness of a significant number to seek out industrial labour, in some cases even bonded labour[3], in preference to subsistence life, and the widespread interest in the fluctuations of the gold price on the London Stock Exchange (see the discussion of 'modernity' in, for example, Miller (1995).

The principal subsistence and commercial NTFP in the Port Kaituma/Sebai area is wildlife, including fish, a finding in line with van Andel's comprehensive study in the wider North West District (1998). At the same time, I met very few Amerindians in the Port Kaituma/Sebai area who would admit that they used 'bush medicines,' in answering one of the questions I posed to over 150 heads of household during my last period of fieldwork. In an area of endemic malaria, where most people had suffered recurring bouts of malaria annually since the upsurge in the early 1980s, still the majority insisted that they used only modern pharmaceutical preparations. 'We don't know anything about bush,' as if knowledge of herbal remedies was a yardstick to measure savagery.

There is often, of course, a chasm separating what people do from what they profess to do, and this is where the lived experience of the field worker has its justification. In the case of the

[3] Bonded labour is a form of debt-peonage which exists in the North West District, in which the worker is seldom or never paid in cash for his work. Instead he is advanced goods by his employer, so that many labourers find themselves unable to free themselves from contractual obligations to the employer (*cf* the system of *aviamento* in the article of Assies (this volume) or *endeude* in the paper by Rodríguez and Van der Hammen (this volume).

Kaituma/Sebai area, the attitudes stated by Amerindians to the use of bush medicines can be understood in relation to:
- the considerable population of non-Amerindian Guyanese (and now non-Guyanese Asians) in the townships of Port Kaituma and Matthews Ridge, forming a social and ideological hegemony;
- the traditional antipathies to Amerindians expressed by the other ethnic groups;
- the establishment of well-equipped hospitals, accessible to all, in Matthews Ridge and Port Kaituma by the manganese company in the early 1950s; and
- the fact that malaria is not an indigenous disease.

It is in scenarios like this one that outsider-led research projects into NTFPs, for example, can play and have played key roles in coalescing cultural revitalisation, a revaluation of indigenous knowledge and an awareness of the potential marketability of such knowledge to outsiders.

3. NTFP RESEARCH AND EXPLOITATION IN GUYANA

Reinders' ethno-medicinal investigation in the Barabina area of the North West (1993) was probably the first of the post-1990 NTFP projects in Guyana. It was followed by the study of palm heart harvesting in the North West District made by Dennis Johnson for the Amerindian Research Unit of the University of Guyana (in Forte, 1995) and a study carried out in the Mixed Arawak village of Kurupukari (now Fair View) by Johnston and Colquhoun (1996). Then, almost simultaneously, projects were executed by van Andel and collaborators in the North West (from 1996), the Foundation for Ethno-biology in Surama (from 1995)[4], GEF-UNDP[5]-Iwokrama, also in the North Savannahs (see Forte, 1996), and Hoffman (1997), who worked with the liana *nibi*.

Also ongoing in this period has been the Conservation International (CI) work on developing a balata (*Mimusops globosa*) handicraft industry, aimed at the tourist trade and the 'fair trade' export niche, the setting up of an NGO called the Amerindian Handicraft Association and, more recently, of the Handicraft Industrial Development Agency (HIDA) and the establishment of a number of medium and small-scale factories making *nibi* and *cufa* furniture. During 1997 and 1998, CI teamed up with Hoffman to explore the possibilities of working with a regional Amerindian grouping named the Region Two Coordinating Committee on the sustainable utilisation of lianas used in the furniture and handicraft trade (see Verheij and Reinders 1997). A number of exploratory meetings were held and a two-day workshop brought together harvesters from several different areas with resource persons from CI and the Amerindian Research Unit.

The largest commercial NTFP exploited is the palm heart, on which at least three studies have been made, and an excellent monograph has been produced (van Andel *et al.*, 1998). Although it is not exhaustive, the brevity of this list underlines the point that the study and use of NTFPs in Guyana is still in its nascent stage. Nonetheless, a number of issues have already emerged, including the following:

3.1 The Darwin Initiative-funded project of the Foundation for Ethno-biology in Surama

[4] Funded by the Darwin Initiative and associated with Dr Conrad Gorinsky.

[5] Global Environmental Facility / United Nations Development Programme.

This project began in 1995 as a partnership between the U.K.-based Foundation for Ethnobiology (FEB) and the Surama community. The 'Surama Resource Centre', called 'FEB' locally, was built in the centre of the village and stocked with some pieces of equipment, including a small generator, portable computer and printer and, for a while, a satellite telephone. The project also owned a motor cycle. The three full-time staff of the FEB were salaried, as were at least two other local principals, one in Annai and the other in Surama. Two of the full-time staff were data processors, but other persons were hired to collect and dry samples of various plants, which were shipped out of Guyana at various times.

This project was started before the Environmental Protection Agency (EPA) was set up, which might account for the dearth of knowledge at the regional and national levels of what exactly was happening in Surama. The only counterparts seemed to be a few individuals within Surama, but since they were key local leaders, the project was never subject to any scrutiny either within or outside the village.

The patenting of active ingredients of the greenheart seed, one of which he named 'rupununine,' and of the fish poison called 'kunami' by the London-based principal, Dr. Conrad Gorinsky, eventually came to light in Guyana and was publicly condemned, at least in the capital city. Gorinsky also set up a biotechnology company named Biolink, which has at least one Surama principal. The case was also publicised internationally, which perhaps contributed to the withdrawal of funding for the project by the Darwin Foundation (see the home page of RAFI (Rural Advancement Foundation International) based in Canada: http://www.rafi.ca).

Even though some awareness of the controversy which had developed around the project internationally filtered down to the village level, the absence of public censure of the principal was more in keeping with Amerindian mores. The local opinions I was aware of ranged from total ignorance of the project's aims and *modus operandi*, to gratitude for some jobs and training, to the feeling that Gorinsky was being demonised by larger, ill-understood forces, perhaps because he was part Amerindian. Some people outside Surama and within the larger region were more readily critical of the Surama operation, but few seemed to know what it had entailed anyway. Locally, people did not have strong feelings at first, but over time, with increasing interest aroused on the issue, particularly as a result of the Iwokrama programme, the words 'intellectual property rights' invariably came up at every public discussion (over 20 of them, in eight communities) that I attended.

3.2 The Iwokrama-sponsored project on biodiversity use and ethnobotany

During this same time period, I was coordinating a biodiversity project in this same region on behalf of Iwokrama, which involved researchers and others of the same village. At that time, the view held by key Surama leaders was that the Iwokrama-sponsored project would steal their knowledge, while the Gorinsky-led one was grounded in Surama and would benefit them. Over time, however, Gorinsky stopped visiting, some of the equipment broke down, and the FEB project lost momentum. Village interest, here as elsewhere in the North Savannahs, shifted to the collaborative management of natural resources in partnership with the Iwokrama programme (see North Rupununi District Development Board (NRDDB) and Iwokrama, 1998). Earlier local views on either project became irrelevant as against the immediate benefits derived, and as the whole issue of valuing local knowledge was more deeply explored.

Some time after the end of my own work with the Makushi Women's Project, Iwokrama arranged a formal consultation with the NRDDB to discuss the issue of copyright of the information contained in the two Reports it had commissioned. Copyright belonged to the UNDP and the

Ministry of Foreign Affairs, which had jointly financed the project, but was formally transferred to the NRDDB. The reports are to be published soon in one volume with a formal copyright claim by the NRDDB as publisher. Iwokrama has also been extending its links and outreach beyond the NRDDB to encompass the entire Rupununi. A two-day 'Outreach Workshop' for some 200 persons was held in Lethem, the regional centre, on January 20–21, 1999, to discuss issues of development and conservation and networking with the Iwokrama programme.

3.3 The COICA meeting in Georgetown

In mid-1996, the Fifth Congress of the Coordinating Secretariat of Organisations of Indigenous People from the Amazon (COICA), held in Georgetown, Guyana, passed a resolution about the patent registered by a U.S. citizen, Loren Miller, for the processing and commercialisation of *ayahuasca*, a sacred plant from the Amazon. Miller is the owner of the International Plant Medicine Corporation, a pharmaceutical laboratory with headquarters in the United States. COICA's vigorous reaction to Mr. Miller's action led to a correspondence, strong and polemical on COICA's part, between them and the funding agency, which was widely publicised internationally. The issue received more international and local publicity in early 1998 than it did at the time, and it was and still is most certainly being publicised locally by indigenous organisations, particularly the Association for the Amerindian Peoples Association (APA), the local affiliate of COICA.

In part, both the Gorinsky-led project and the fall-out from the COICA resolution have accelerated local ventilation of the issues of biodiversity and the privatisation and commoditisation of nature and social knowledge. There certainly increasing recognition, if not understanding, of buzzwords like IPR (Intellectual Property Rights), CBD (Convention on Biological Diversity), bioprospecting and biopiracy, even in remote indigenous communities. It would not be overstating the case to say that any future project concerned with NTFPs or more general biodiversity research will be much more closely examined at the local level, whatever might be the view taken by the players in the capital city, including the Environmental Protection Agency (EPA).

Some of these future projects may well choose to ignore local responses once the necessary state permissions have been secured, but even if their primary objectives have more to do with employment opportunities for foreign-based researchers, their conduct should still take into account how they are viewed by the host community.

4. THE INTERNATIONAL SITUATION

The Convention on Biological Diversity was launched at the 1992 UNCED 'Earth Summit' in Rio de Janeiro, focussing attention, both worldwide and in Guyana, on the precarious situation of the planet's remaining biodiversity. A number of authors has analysed the diverging interests of North/South, developed/developing, in what was from the start a contested arena, 'nature', and in which there is still no consensus on definitions, goals, the reasons behind the dwindling of biodiversity or how best to manage what biodiversity is left.

On this battle front, writers such as Nijar (1996), McAfee (1999), Purdue (1995), and Zerner (1996) argue that 'Northern' interests have focussed on carbon emissions that contribute to global warming, the need to preserve some tropical forests as carbon sinks (by selling carbon credits), the need to slow the rate of species extinction, and the reconceptualisation of nature as a world currency, and of biodiversity as tradable genetic resources, (see Articles 1, 15(7) and 19(2)

of the Convention on Biological Diversity). This without any reference to environmental limits to growth, the historical and spatial inequalities within and between nation states, or to any 'Southern' agenda. In McAfee's words:

> 'The 1990s have seen the establishment of supranational institutions designed to regulate international 'environmental investments' and the transboundary flows of natural resources, including genetic information and knowledge about nature. These structures of eco-economic governance include environmental treaties, especially the Framework Convention on Climate Change, the Convention on Biological Diversity and the Global Environment Facility, among others. These new multilateral institutions work closely with the World Bank, with United Nations agencies that have taken up green agendas and with mainstream conservationist organisations, many of which now embrace international mandates… [They] recast the popular environmentalist account of the spoiling of Eden by industrialism run amok into a parable of policy failures correctable by market solutions. The key to those market solutions, according to the theory, is the privatisation and commoditisation of nearly every aspect of nature, from molecules to mountainscapes, from human tissues to the earth's atmosphere' (1999, in press).

4.1 World Trade Organisation/Trade-Related Intellectual Property Rights (TRIPS)

Even before the CBD was opened for signing in Rio, the commoditisation of nature was underway in the TRIPS negotiations. Although the 'South' argued that intellectual property rights were not a trade issue at all and was already covered by an existing UN organisation, the World Intellectual Property Organisation (WIPO), key Northern interests were able to shift Intellectual Property Rights negotiations to the General Agreement on Tariffs and Trade (GATT), which led to the establishment of the World Trade Organisation in 1995. Article 27 of the WTO/TRIPS (GATT: 379–80) obliges member states to enact IPR legislation within a prescribed time.

> 'In summary, countries are obliged to enact legislation which (1) reproduces the IPR regime of industrialised countries, in particular the USA; (2) extends patenting to micro-organisms and 'modified' life forms; and (3) obliges nations to provide patents or other forms of protection to plant varieties' (Nijar, Paper 2: 8).

These clauses in Article 27 allow biotechnology to patent any genetically modified organism, since DNA is not considered to be an essentially biological process. At this point, enter the bio-pirates, recently featured on the cover of TIME magazine (November 30, 1998). In TIME's words [Gene Piracy]:

> 'The confrontation between industrialised countries and resource-rich emerging nations is heating up. Drug companies have been methodically testing animals and medicinal plants for decades. But now, innovations in genetic research are enabling scientists to cast a far wider net - covering entire rain forests… in their search for cures. 'We see a tremendous battle shaping up', says Andrew Kimbrell, director of the International Center for Technology Assessment in Washington. The fight, he says, will be fought in part over how to revise world trade laws. Some Western countries want to exempt plants and animals from being covered by international property rights. 'Third World countries', says Kimbrell, 'are certain to object.' The Convention on Biodiversity, drafted in 1992, is the closest the world community has come to tackling the dispute. But there is no consensus. The U.S., which has the greatest number of biological research labs, refuses to ratify the convention. 'Congress blocked it', Kimbrell says, 'because there's a certain

> element opposed to all international environmental efforts. They feel it limits U.S. options.' (McGirk, 1998).

Few knowledgeable writers foresee any benefits for indigenous peoples from global trends in IPR legislation (Daly, 1996; Patel, 1996). The economist Herman Daly, at a public lecture at the Institute for Social Studies in The Netherlands in September 1996, argued against free trade and capital mobility (this went unheeded, since Brazil is even now in free fall), and the myth (also stated in the CBD) that natural resources can simultaneously be 'conserved' and 'sustainably used'. According to Daly:

1. Many nations have grown to the point that the limiting factor in their further growth or development is no longer man-made capital but remaining natural capital… [and] therefore seek to appropriate whatever natural capital remains in the international commons, and to trade for natural capital with those less-developed countries still willing and able to supply it… But of course all countries cannot be net importers of natural capital… For the aggregate of all countries net imports of anything, including natural capital, are zero (p. 4).
2. Free trade tends to push the world economy to grow beyond its optimal scale relative to the containing ecosystem… creates the illusion that by making natural capital more available to some nations, trade is capable of making it more available to the aggregate of nations (p. 4).
3. To avoid wars, nations must consume less and become more self-sufficient. Yet free traders say we should become less self-sufficient and more globally integrated as part of the overriding quest to consume ever more. It is the worst advice I can think of (p. 13).

5. THE NATIONAL SITUATION

In the post-CBD period, the Guyanese State, with financial and other support from the Global Environmental Facility and other multilateral agencies, passed the Environmental Protection Act (6 May 1996), and subsequently established the Environmental Protection Agency (EPA), charged among other things with regulating research in NTFPs. All of the NTFP projects mentioned above were carried out before the formation of the EPA, although the majority had to be approved by various Government agencies, including the Office of the President.

Legal summaries of the status of IPR in Guyana (Scotland, 1996; Khan, 1998) concur that IPR-related legislation in Guyana is hopelessly outdated and that the current situation affecting trade mark and patent applications is in crisis. According to Khan:

> 'To illustrate the extent of this crisis, my firm has quite a large amount of trade mark and patent applications which have been filed since 1992 (some even earlier) which have not been processed. In terms of numbers, we have - as at the end of 1996 - approximately 1,140 outstanding applications to register Trade Marks in Part A of the Register; approximately 112 Part C Trade Mark applications; and approximately 1,068 miscellaneous applications, such as assignments, mergers, changes of names and addresses, searches and renewals. We also have approximately 45 Patent applications pending… In the face of this disastrous situation… we sign treaties, we become members of international intellectual property organisations, we hold various internationally attended workshops, symposia and conferences pontificating on the virtues of and respect for intellectual property rights, while those of us who do daily battle in the proverbial trenches of the Trade Marks and Patents Registry cannot even get a single trade mark or patent registered (43–44).' (Khan, 1998:43-44).

If top legal firms based in the capital are frustrated with the non-functioning of the Deeds Registry, poor and powerless indigenous groups located in the distant hinterlands areas of Guyana who might be thinking of approaching the national bodies charged with regulating IPR-related issues, would probably fare worse. The crisis in the Deeds Registry of Guyana, however, is irrelevant to Gorinsky-type bioprospectors who move directly to the Patent Offices of developed countries to register their finds.

Few of the knowledgeable people working in this area, however, are sanguine about the chances of secure IPR reversing the poverty of indigenous and other people who still possess valuable local knowledge. McAfee points out that no nation has become developed from the sale of primary commodities, that such groups/nations start out from a weak base anyway, and that 'meanwhile, the international 'market price' of genetic resources is falling from its already low level, and biotech firms are patenting far more molecules than they have any idea of whether or how they'll ever 'develop' ('drift net patenting'). So IPR claims and market deals won't do a whole lot for most local/indigenous groups' (pers. comm.).

6. CONCLUSION

The link between NTFP development and biodiversity conservation/equity in the pre-CBD era rose to prominence with the extractive reserves associated with the anthropologist Mary Allegretti and local leader Chico Mendes in the late 1980s. Throughout these years, activists and others have argued bitterly over the wisdom of this course, those against arguing that drawing poor people even closer into market relations would only lead to their further long-term impoverishment, while diverting scarce resources from the struggle for land and other fundamental rights. This debate was perhaps most sharply drawn in the exchange between Survival International's Stephen Corry versus Cultural Survival's Jason Clay, the former arguing that a focus on marketing products like Rainforest Crunch, or extracting products for 'The Body Shop' furthered the underdevelopment of traditional peoples (Corry, 1993).

Prominent organisations in this field, like the Malaysian-based Third World Network, incline more to Corry's view, but take the realistic position that since they probably cannot change the terms of the exchange in the short run, they might as well draw up draft contracts which can be used by governments and/or indigenous peoples *vis à vis* collectors of biological resources (Nijar, Paper 1). Certainly the people themselves - in Sebai, the Rupununi, and elsewhere - want information on tradable items, including NTFPs, now (see statement of the Chairman of the NRDDB in Iwokrama 1998: 4). Increasingly, however, they will insist on partnership arrangements, and on the drawing up of contracts for sharing profits generated as a result of their knowledge. From their position of relative powerlessness, they probably will have to rely more on goodwill than the acuity of their lawyers. However, Tropenbos researchers can be guided by the growing consensus that the best way to save what remains of biological diversity is to work alongside the remaining pockets of cultural diversity, the world's traditional peoples.

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TEMPORAL AND SPATIAL DYNAMICS IN THE EXTRACTION OF NON-TIMBER FOREST PRODUCTS IN THE NORTHERN BOLIVIAN AMAZON

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Programa Manejo de Bosques de la Amazonia Boliviana PROMAB

ABSTRACT

For more than a century, northern Bolivia has had a tradition of commercial forest exploitation. For several decades into the twentieth century, the extraction of rubber and Brazil nuts was combined with subsistence agriculture, resulting in an agro-extractive cycle that fostered a sedentary lifestyle of forest dwellers. The extraction of rubber and Brazil nuts used to be organized in a debt-peonage system, often leaving extractivists in debt to the patron. The decline of the Bolivian rubber market during the 1980s induced the breakdown of the agro-extractive cycle. Most people left the patron-controlled extraction areas (*barracas*), and either established themselves as farmers in independent communities close to urban areas or migrated to the cities where the processing of forest products had increased job opportunities. About half the Brazil nut collectors are now seasonal migrants, mainly from the cities. Depending on access to land, forest resources, and markets, extraction-based income can contribute to more than 50% of the overall household income, especially in the more remote forest settlements. Some processing plants gain direct access to the Brazil nut resource base through vertical integration, thereby increasing their control of the production process. These large enterprises partly take over the role of the former patrons (e.g. in making advance payments to the Brazil nut collectors). The increasing demand for Brazil nuts and the increased in-country processing in Bolivia has benefited all participants in the production process, including the collectors. Especially the collectors from independent communities manage to get a higher price for the nuts they collect. Even so, an unequal exchange continues to be characteristic of many non-timber-forest-products-based (NTFP-based) production systems. In addition, more recent extractive activities (e.g. logging and palm-heart extraction) are threatened by depletion of the resource base. None of the extractive activities thus fulfills all the criteria of sustainable development.

1. INTRODUCTION

The extraction of non-timber forest products (NTFPs) has been advocated as a land-use practice that

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integrates the conservation of the rain forest and the economic development of the forest-dependent people (see, e.g., Nepstad and Schwartzman, 1992; Allegretti, 1990; Plotkin and Famolare, 1992). Based on the concept of sustainable development as defined by Barbier (1987), NTFP extraction is said to be economically viable, ecologically sound, and socially acceptable.
The potential economic value of NTFPs has been demonstrated by the bench- mark study of Peters *et al.* (1989). An income comparison for one hectare of forest near Iquitos (Peru) between three land-use types (i.e. logging, cattle ranching, and NTFP extraction) revealed that the net present value of NTFP extraction is highest. At that time, through the IUCN-Nl study of de Beer and Dermott (updated in 1997), the Netherlands participated in the international debate on the economic value of NTFPs in South-East Asia. These and other studies emphasized not only the subsistence value of these products but also their monetary value (see, e.g., Anderson, 1990; Balick and Mendelsohn, 1992). A second study, initiated in the early nineties by IUCN-NL and executed by the Prince Bernhard Centre for International Nature Conservation of the Utrecht University, showed the dynamics in the export value of some NTFPs for several Amazonian economies (Broekhoven, 1996). The study revealed that, although in several cases the economic value of these products is substantial, the assumed sustainability of these exploitation systems is often based on wishful thinking, rather than a thorough analysis of all components of sustainability.

The second IUCN study launched several new initiatives in the Netherlands:

- In 1992, Utrecht University, in collaboration with the Universidad Tecnica del Beni and the Instituto para el Hombre Agricultura y Ecologia, started a multi-disciplinary research, training, and extension programme on the sustainable exploitation of (non-timber) forest products in northern Bolivia: PROMAB.
- In 1996, the CIFOR-BMZ Project on "Contributions of non-timber products to socio-economic development" commended its collaboration with the socio-economic component of PROMAB. The CIFOR-BMZ Project comprises the Universities of Freiburg and Hamburg, Germany, and partner institutions in Bolivia and Zimbabwe;
- The Tropenbos Foundation published a research strategy on this topic (Ros-Tonen *et al.*, 1995), incorporating NTFP research in their ongoing research (see, e.g., van Valkenburg, 1997).

In this paper, we shall summarize some results of the socio-economic research derived from the collaboration between PROMAB and CIFOR. The content of this paper is based mainly on the following publications by Assies (1997), Stoian (1998), and Stoian and Henkemans (1998).

2. NORTHERN BOLIVIA

Northern Bolivia is still blessed with large tracts of relatively undisturbed rain forest. The study area encompasses the Department of Pando, the Province of Vaca Diez (Beni Department), and the northernmost part of the Province of Iturralde (La Paz Department). On an area of about 100,000 km^2, the population in 1997 was estimated at 140,000 people, 70% of whom reside in urban areas while the remainder inhabit the rural areas (Stoian and Henkemans, 1998). More than 95% of the original forest cover is still intact. Between 1986 and 1990, the mean annual deforestation rate was 0.15 % (DHV, 1993a). This contrasts sharply with deforestation in adjacent areas in Brasilia: Acre (0.58%) and Rondonia (2.09%). The low population density in the rural areas is a result of a low level of social services (education, health), poor infrastructure, and the lack of employment opportunities. In the light of low soil fertility and poor agricultural tradition, slash-and-burn agriculture suffers from low productivity. Agrarian underdevelopment has its roots in the prohibition of subsistence agriculture during the boom years of rubber production. Nowadays, agricultural development is impeded by

insecure land rights and the lack of access to credits and technical assistance.

3. DETERMINANTS FOR SUSTAINED EXTRACTION OF NON-TIMBER FOREST PRODUCTS

From a socio-economic perspective, the sustainable exploitation of NTFPs is determined by a complex set of interacting and interrelated factors (Ros-Tonen *et al*., 1995). Chief among them is probably the economic incentive for those involved in the extraction, processing, and marketing of NTFPs and in forest management. For the collectors of NTFPs, the incomes generated from this activity and its competitiveness with other economic activities are the key factors determining their participation. For the entities involved in processing and marketing, the determinants of their continued involvement in the exploitation of NTFPs are the availability and costs of labour, credits, technology, access to resources and markets, and, above all, the internal rate of return as the main determinant. Some of these factors are spatially dependent, or, in other words, they vary from place to place.

These considerations have led to the following aim of the socio-economic research conducted jointly by PROMAB and CIFOR:

To determine the underlying factors of spatial and temporal dynamics in forest resources in northern Bolivia.

Research is divided into three interrelated studies operating at various levels:

- The *analysis of livelihood strategies of the people living in the forest* reveals the scope of their economic activities and their motivitation to participate in them. Their situation is highly dynamic as new job opportunities are perceived outside the forest and as others enter the forest (i.e. the increasing timber logging, and agriculture and agroforestry activities that are generating more prosperity because of the improving infrastructure and a change in the tenure systems);
- The *variation and dynamics in NTFP-based economies at the rural-urban interface*. This study will determine the dependence of various types of rural and peri-urban households on NTFP-based income, the underlying modes of NTFP commercialization, as well as the distribution of benefits along the marketing chain of Brazil nuts and palm hearts;
- The *spatial and temporal importance of forest products in the regional economy*. This will result in an economic and socio-political perspective for the forest industry and consequences for the use of natural resources. It is revealing the partly contrasting valuation of forest resources at the local, national, and global levels, and the political mechanisms that are steering land-use planning.

4. TEMPORAL DYNAMICS IN FOREST PRODUCT EXTRACTION IN NORTHERN BOLIVIA

In northern Bolivia, the commercial extraction of NTFPs commenced in the first half of the nineteenth century, with the exploitation of Peruvian bark (*quina* in Spanish). During the 1860s, extractivism shifted towards rubber, but it was not until 1880 that its export began on a large scale (Ormachea and Fernández, 1989). Between 1900 and 1913, Bolivian rubber production reached its boom years. The exploitation of rubber was organized in estates, locally known as *barracas*. The rubber tappers worked and lived in a debt-peonage system: they were advanced subsistence goods and basic necessities in return for the future delivery of rubber. Family-based agriculture was discouraged in the *barracas* so as not to divert the work force from the main activity and to enforce the dependency relationship between the estate owners and their workers (Assies, 1997). In some *barracas*, a common agricultural plot was worked by some of the dependants under the control of the patron. For their labour, however, they were reimbursed with only a small share of the harvest. From 1913 onwards, the production slowly

decreased because of competition from rubber plantations established in South-East Asia and the introduction of synthetic substitutes. When the boom had turned into a bust, the *barraca* economy had to be modified considerably. Many patrons permitted subsistence agriculture on their estates, while they turned towards the utilization of Brazil nuts to compensate for the income losses. Other patrons, especially the most indebted ones, had to abandon their *barraca*. The first independent communities founded by previously dependent rubber tappers thus came into existence.

Commencing in the late 1920s and continuing up to the present, the commercial extraction of Brazil nuts is still playing an important role, both in the *barracas* and in independent communities. During the 1990s, Brazil nuts became the chief forest product in northern Bolivia (see Figures 1 and 2). This increase in value is due to (López, 1996):

- Increased in-country processing:
- An increase in unit price;
- Increased production.

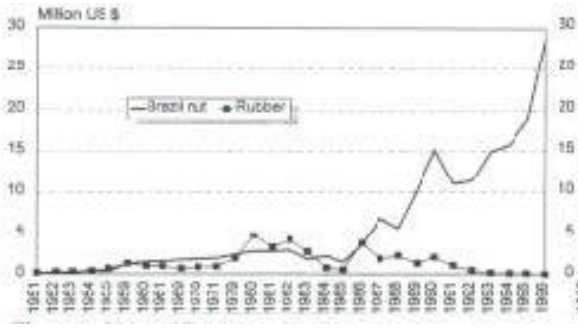

Figure 1 Value of Brazil nut and rubber exports from Bolivia between 1951-1996 (Stoian and Henkemans, 1998)

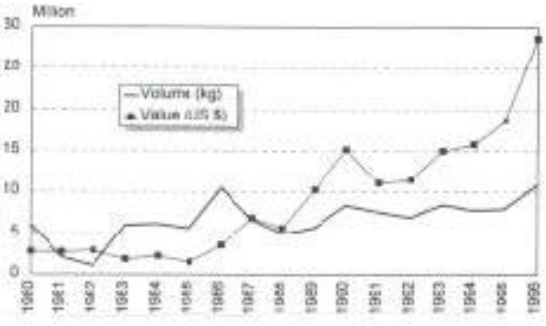

Figure 2 Volume and value of Brazil nut exports from Bolivia between 1979-1996 (Stoian and Henkemans, 1998)

Bolivia partly took over the export share of Brazil, where the introduction of minimum wages had rendered in-country processing less competitive, given that wages in the Brazilian processing plants are 30% higher than those paid in Bolivia (Assies, 1997). Similarly, prices per unit rose because of an impressive increase in the export of shelled nuts. It increased from 12% in 1985, via 58%, to 99% in 1996 (Broekhoven, 1996; Stoian, 1998). In the same period, the number of processing plants (*beneficiadoras*) in Riberalta increased from one to seventeen, which provide employment to some 5,500 (mainly female) workers (Coesmans and Medina, 1997).

For a few decades, the extraction of rubber and Brazil nuts, in combination with small-scale agriculture, had provided a set of complementary economic activities that enabled people to make a living in the forest throughout the year. In this agro-extractive cycle (Assies, 1997), forest-dwelling people allocated more than 50% of their working hours to the extraction of forest products (see Figure 3).

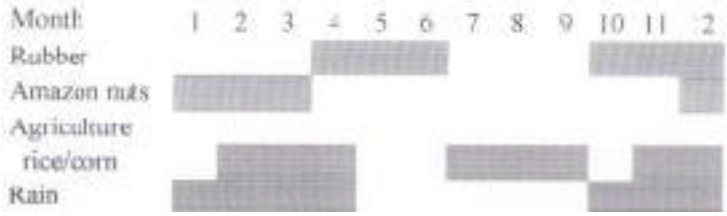

Figure 3 Agro-extractive cycle northern Bolivia

During the late 1980s, rubber production in northern Bolivia declined and finally reached a standstill in the early 1990s (Stoian, 1998). This had severe repercussions for the rural people, who had to replace their rubber-based income with income derived from other forest products. Mainly for this reason, the exploitation of palm hearts and timber has increased substantially in the last few years. For example, the value of palm hearts exported from northern Bolivia rose from US$ 2 million in 1993 to US$ 5.7 in 1996 (Stoian, 1998).

5. SPATIAL VARIATION IN FOREST-PRODUCT EXTRACTION

5.1 Settlement differentiation and related migration patterns

With the collapse of the Bolivian rubber market and consequently the breakdown of the agro-extractive cycle, many former rubber-tapper families emigrated from the *barracas*, especially from the more remote ones. Most of them migrated to one of the three urban centres in search of better school and health facilities and employment in one of the processing plants or in the tertiary sector. Others opted for an independent community to make their living from (commercial) agriculture and extractive activities on their own plots, often supplemented by income derived from wage labour. Varying trade-offs between these three main economic activities in rural areas are taken as a base for a settlement typology suggested by Stoain and Henkemans (1998). Their typology distinguishes four types of *barracas* and six types of independent communities, some features of which are laid down in Table 1.

Table 1 illustrates the pattern of movements that occurred between *barracas* and independent communities in the wake of the economic transformation induced by Bolivia's rubber crisis. During the late 1980s and early 1990s, the *barracas* suffered from a marked-out emigration, while independent communities on the average experienced substantial immigration.

An important aspect of the above-mentioned transformation process is the decline of the patrons' central position as the main providers of Brazil nuts. The owners of the processing plants gained in status by buying up patron-owned *barracas* in an effort to gain vertical integration (Assies, 1997). Because of the massive emigration from the *barracas*, both patron-owned and enterprise-run *barracas* nowadays depend heavily on a labour force that seasonally migrates to the production areas. Out of a total of about 10,000 Brazil nut collectors, some 5,000 are recruited from urban areas; the other 5,000 stem from rural areas, 1,000 of whom leave for the *barracas* after having secured the Brazil nuts from their own forest lands (Stoian, 1998; Stoian and Henkemans, 1998).

The boom in the Brazil nut industry generated new job opportunities in the cities, especially in Riberalta. During the collection season, most processing plants close down, and many worker families take part in the Brazil nut collection.

Table 1 A few characteristics of rural settlements in northern Bolivia. Data are a result of a sample of 173 settlements out of the approximately 700 settlements in the study area. The sample is regarded as representative for *barracas* and independent communities in northern Bolivia. Settlements poorly accessible by road or river, however, may be slightly underrepresented in the sample. Source: Village-level Survey 1997 (Stoian and Henkemans, 1998)

		Demographic		**Spatial arrangements**		**Brazil nut economy**			**Agricul.**
	(N)	# families in 1997 (avg.)	# former rubber tapping families (avg.)	distance to next urban center (hours)	settlements accessible by road (%)	# Brazil nut crates per settlement (avg.)	# Brazil nut crates per collector family (avg.)	Avg. price per crate (96/97) in Bs = 0.2 US$	hectares cultivated land per family (avg.)
Barracas									
- Enterprise/owned	14	6.2	65.2	15.6	14.3	9807	110.9	19.4	1.04
- Large private	22	3.9	30.2	11.9	36.4	5950	177.2	19.8	1.34
- Small private	22	3	8.8	9.4	31.8	878	105.7	20.8	1.69
- In transition	15	10.9	40.6	6.8	73.3	4660	169.7	22.9	1.31
Independent communities									
- Peri-urban	7	27.9	4.7	0.3	100	1171	42.1	35.6	1.63
- Agrarian	19	19.9	4.9	0.6	94.7	98	4.7	33.3	2.27
- Agro-extractive	22	29.6	13.1	0.7	100	1174	36.1	33.8	2.11
- Extractive	26	28.2	21.5	2.8	80.8	5074	139	36	1.97
- Indigenous	8	27.9	7.5	11.2	37.5	2669	87.5	35.6	1.44
- Rural sub-centers[2]	8	145.9	90.8	2.7	100	22250	150.9	32.1	2.19

5.2 Spatially-dependent production and income

Fueled by an ongoing conversion of *barracas* into independent communities, the latter's share in the Brazil nut production of northern Bolivia has increased in recent years. It was estimated at 20% to 32% in 1992 (DHV, 1993b), but the highly productive extractive communities along the main road Puerto Rico-Cobija were not taken into account. Data based on a more comprehensive village-level survey conducted in 1997 suggest that today's shares of *barracas* and independent communities are 60% and 40%, respectively (Stoian, 1998).

2 The rural sub-centres emerged from the first large *barracas* established by rubber barons in areas with abundant rubber trees and located at intersections of important roads or rivers. Nowadays, they are the base of a municipality enabling them to tap from funds of the *Participación Polular*, the decentralization process that is going on in Bolivia. These centers have access to infrastructure like secondary schools, health centers, communication facilities, drinking water and electricity. A large number of families immigrated into these centers facilitated by the availability of lots of a considerable size for a lower price than those in the urban centers.

Remarkable is the higher price paid for Brazil nuts to independent communities; it is an average of 1.7 times higher than that paid to the *barracas* (see Table 1). This is mainly due to the fact that the urban-based processing plants pay the same price for the raw material to independent collectors, patrons, or intermediaries. As a result, an independent collector receives not only the minimum price, which, according to the labour inspectorate, has to be paid to a *barraca*, but also the surplus of a patron. Differences in transport distance play only a marginal role in the stipulation of raw material prices. Among the different *barraca* types, however, there is a price differentiation: in enterprise-run *barracas* and large private *barracas*, prices paid to the collectors usually do not exceed the minimum price. In contrast, patrons of small private *barracas* and *barracas* in transition have to top up this price by one to three *bolivianos* per box, as their production areas are situated closer to independent communities, which means that they face more competition. The Brazil-nut-based income earned by an average collector in *barracas* and independent communities varies only slightly, as the latter collect fewer nuts at a higher price than the former. In the season 1996/97, for instance, an average collector in a *barraca* earned about US$ 540 from the collection of 139 boxes, whereas his counterpart in an independent community earned US$ 520 with the collection of only 79 boxes (Stoian, 1998). The increasingly stronger position of independent collectors reflects a process called the ›democratization of the Brazil nut trade‹ (DHV, 1993a).

5.3 Exploitation moving through the forest

In contrast to the Brazil nut harvest, palm heart extraction takes place during the dry season, that is to say the period when rubber used to be tapped. Thus, exploitation of the Asai palm (*Euterpe precatoria*) could potentially fill the gap left in the agro-extractive cycle by the abandonment of rubber tapping. The single-stemmed nature of the palm, however, implies the plant's death upon removal of the palm heart. As it takes the palm several decades (if not more than a century) to mature (cf. Peña, 1996; PROMAB, 1998), and thus to produce a palm heart of exploitable size, raw material stocks are depleted within three to four years in a given place (Stoian, 1998). After the harvest, the raw material has to be transported to and processed in a palm heart factory within 72 hours to avoid perishing. This fact and the over-exploitation of palm hearts in the surroundings of the urban centres force the factories to move further upstream to be within reach of unexploited stocks (Stoian, 1998). The palm heart industry of northern Bolivia has about 620 permanent employees (Hofmann, 1997) and provides temporary employment to an estimated 2,300 collectors (Stoian and Hofmann, in prep.).

In addition to the exploitation of palm hearts, many *barraca*-owners have permitted the extraction of timber from their forest lands. As they lack the necessary machinery, they allow sawmills to conduct the logging operations. The provision of the raw material, however, is reimbursed only marginally. Unlike the palm heart factories, most of the sawmills are urban-based because of the better infrastructure available in towns. Spatial variations in the procurement of the raw material, however, resemble those of palm heart extraction, in that each year more remote settlements are affected by logging because of the depletion of commercially valuable species in the vicinity of urban centres (Stoian, 1998).

6. CONCLUSIONS

The extraction of non-timber forest products is an essential part of livelihood systems in the northern Bolivian Amazon. The commercial exploitation of rubber and Brazil nuts used to be an integral part of an agro-extractive cycle within which their extraction was combined with (subsistence) agriculture. The recent collapse of the Bolivian rubber market thus called for substantial modifications in livelihood strategies. In rural areas, rubber exploitation as a dry-season activity has mainly been replaced by the

extraction of palm hearts and timber, while the importance of agriculture has increased. In urban areas, to which a large number of former rubber tappers migrated with their families, the thriving Brazil nut industry and an increasing tertiary sector provide new employment opportunities. The boom of the Brazil nut trade further benefits the collectors, an increasing number of whom receive higher prices as independent collectors. Nevertheless, more than half of the Brazil nuts continue to be collected in the *barracas*, which are controlled by patrons or enterprises. The distribution of benefits is thus skewed towards those who have larger production units at their disposal. Nevertheless, all actors along the Bolivian marketing chain benefit from increased in-country processing and, consequently, bringing economic value close to the sites of production. The processing plants play a vital role in a vivid Brazil nut market, whose benefits finally trickle down to both independent and dependent collectors.

Despite all doubts that remain about social-equity issues in the Bolivian NTFP trade, more attention needs to be given to the ecological soundness and, hence, to the economic viability of palm heart and timber extraction. In contrast to rubber tapping, these extractive activities are hardly practised in a sustainable fashion. Although the loss of rubber-based incomes could be partly compensated for by the exploitation of palm hearts and timber, the continuance of this endeavor is severely threatened by the rapid depletion of the resource bases. For this reason, new paths have to be explored that reconcile the economic needs of the rural and peri-urban population with the ecological requirements of sound forest management.

Institutional support to rural households is mostly needed for land rights, formal and non-formal education, improvement of local infrastructure, and diversification of agricultural practices. In urban and peri-urban areas, upgrading of skills of the previously mainly rural population has to be accompanied by a diversification of the urban economy, which depends both on initiatives of political institutions at various levels and on investments by the private sector. The utilization and marketing of non-timber forest products will continue to play a vital role in the development of the regional economy, but has to be seen and promoted in the wider context of rural and urban development.

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TEMPORAL AND SPATIAL DYNAMICS IN THE EXTRACTION OF NON-TIMBER PRODUCTS IN THE NORTHERN BOLIVIAN AMAZON

Achievements

- Study on export values of NTFP.
- Inventory of (spatial) mechanisms of resource extraction on Northern Bolivia.

Challenges and Problems; Information Needs

- High dynamism of population movements and utilisation of NTFP prevents sustainable management of NTFP.
- Isolation and poor level of services.
- Unequal access to natural resources.

Points for Future Research

- Mechanisms for participation of forest-dependent people in NTFP extraction and management.
- Population ecology and management of NTFP.

Conclusions

- Sustainability of NTFP extraction is an assumption rather than an established fact.
- The forest is an open economic system.
- External factors push forest and NTFP exploitation.

CASE STUDIES

Sustainable forest management - technical and production aspects

SUSTAINABLE FOREST MANAGEMENT: IS IT POSSIBLE?

Dr. H. ter Steege
The Tropenbos-Guyana programme

Sustainability of forest management usually implies the maintenance of three main services of the forest:

- The ecological services (e.g. hydrology, nutrients, biodiversity);
- The timber production services (annual allowable cut); and
- The social services (employment).

It has been shown and it will be shown at this seminar (van der Hout and van Leersum, 1997; Yasman, 1997) that, in all three major tropical rain forest blocks, considerable progress has been made in terms of the technical aspects of sustainable forest management, or more precisely, the harvesting aspect of it. Arguably, suitable harvesting systems have been developed for most tropical rain forest regions.

As tree falls are not uncommon in the rain forest, felling at moderate intensities appears not to be a too unnatural event in the forest. There are two problems:

- Felling increases the natural dynamics of the forest; and
- Felling gaps are usually larger than natural gaps, because prime trees, in the full bloom of their life, are preferred for felling.

Furthermore, mechanical assistance is necessary to extract the logs from the forest, and usually skidders or small bulldozers are being used for this purpose. There is no natural equivalent for this sort of impact (except possibly elephants in Africa and Asia). Particularly in unplanned operations, these machines account for the major part of the damage to the remaining stand, including the small regeneration (Hendrison, 1990; ter Steege *et al*., 1996).

Damage can be reduced considerably by using directional felling (Hendrison, 1990; van der Hout, 1996; van der Hout and van Leersum, 1997; Blate, 1997). Directional felling can be used to avoid damage to the future crop trees and small regeneration, to facilitate skidding, or a combination of both.

If systems that use low-impact logging have been developed in several areas and their technical feasibility has been shown, a question we have to ask ourselves is: why are they not used more often? One logical answer could be that there is no guarantee that subsequent harvests will be as good as predicted, nor that land tenure will be secured. Nevertheless, if it can be shown that low-impact logging is already profitable at the first harvest (Hendrison, 1990; Blate, 1997), then the question is not satisfactorily answered by the above, but rather by a lack of convincing demonstration and/or extension in those areas where it is needed most.

When these problems can be overcome, half of the race may be won. What is not yet known is what will happen with the forest after the extraction of timber - the uncertainty of the second and later harvests.

It has been shown that felling results in increased gap sizes (Hammond and Brown, 1991) and that, in large gaps, small-seeded, fast-growing pioneers are at an advantage, compared with small gaps, where large- seeded climax species may regenerate more prolifically (Boot, 1994; 1996; see also ter Steege

et al., 1996; ter Steege and Hammond, 1996). Furthermore, logging can be viewed as increased dynamics, to which dense slow-growing species are less adapted. Consequently, medium and light wood species will prevail in the future in forests with a history of logging (ter Steege *et al*., 1996; ter Steege and Hammond, 1996).

As an example, the secondary tree species *Cecropia* and *Pourouma* are very common in several CELOS experimental plots in Suriname, and their input into the soil-seed bank should be enormous. Thus, if heavy liberation or second harvest will occur before their life cycle has ended and before their seeds have disappeared from the seed bank (several years after the pioneers have died out; Dalling *et al*., 1997), their abundance will be enhanced.

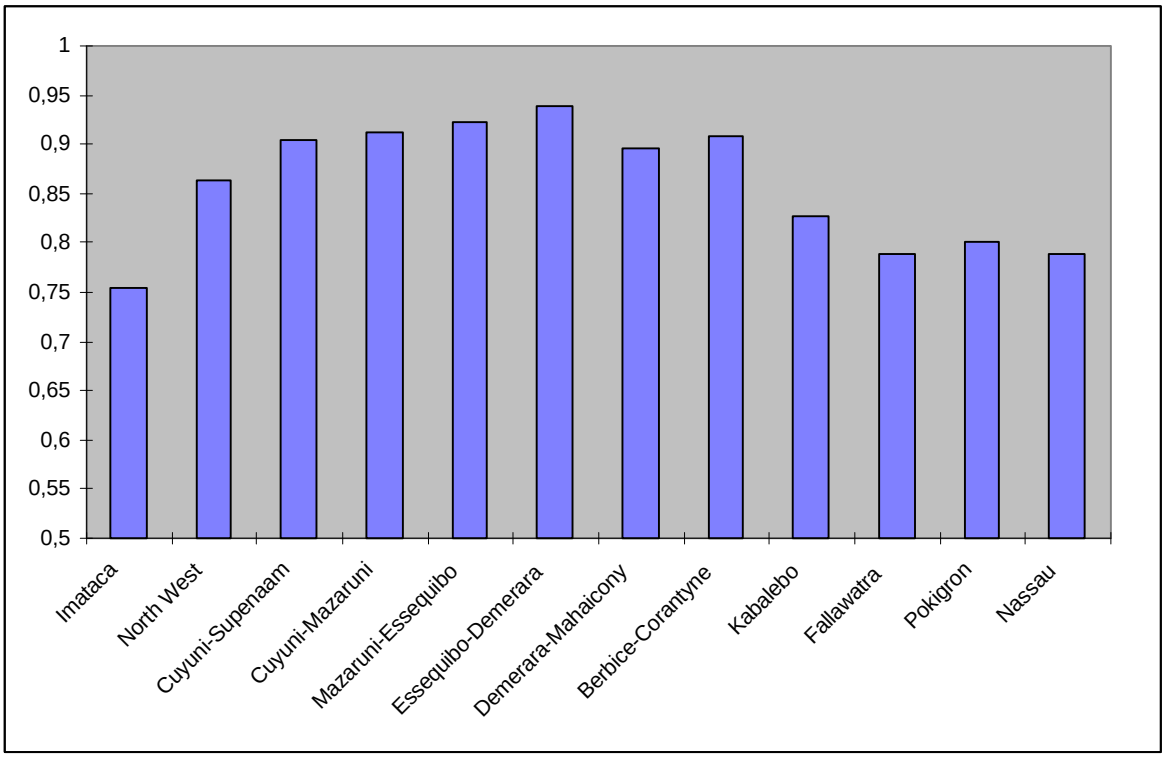

Figure 1 Average wood density meausred in large forest areas in a geographical transect running east Venezuela to east Suriname. The high average wood density of Guyana:s forest is thought to be the product of long term stability in this area (ter Steege and Hammond, *unpublished data*).

If seed-size characteristics and wood density of a forest are a product of the past disturbance regime of the forest (ter Steege and Hammond, *unpublished data*), logging should have an effect on forests that differs in these characteristics. Because forests may differ substantially in terms of median seed size (Figure 1) and wood density (Figure 2), even over relatively small areas, the forest management will have to be fine-tuned to each situation.

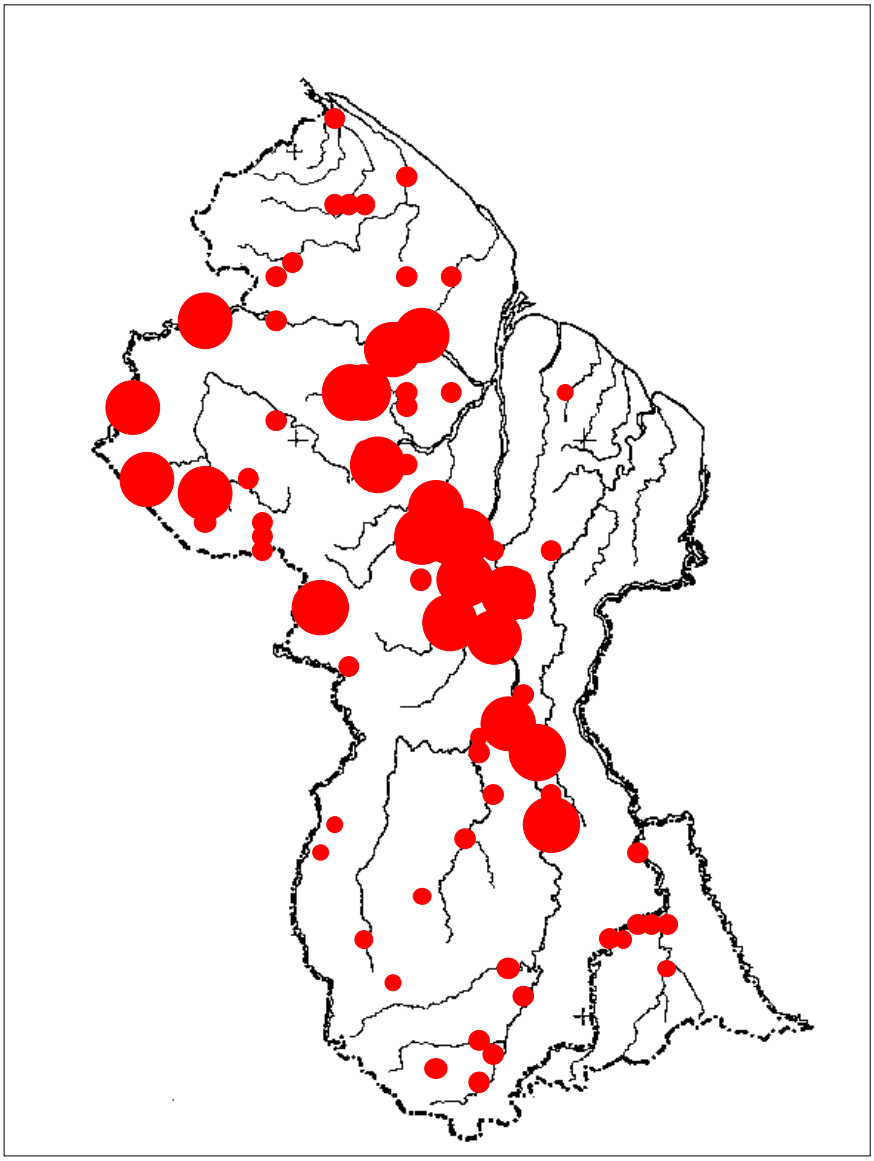

Figure 2 Median seed mass of trees expressed as median per forest community in Guyana. The seed mass in south Guyana differs by two orders of magnitude from central Guyana, probably as a result of higher disturbance in the south.

Relationships between seed dispersers and trees are important for ensuring long-term sustainability (Hammond *et al*., 1996). At present, harvesting does not take this into consideration and may disproportionately target tree species of a specific disperser type (e.g. mammal-dispersed species in Guyana and wind-dispersed species in French Guiana; Hammond *et al*., 1996). There are substantial geographic differences in the dispersal spectrum between forests (Figure 3), and such differences should be taken into consideration for sustainable forest management.

Silvicultural treatments are thought to be important for sustainable forest management. Only with such treatments can the balance of commercial versus non-commercial trees be restored and can sufficient production be attained (de Graaf, 1986). However, there are some doubts about the effect of such treatments (ter Steege *et al*., 1996; ter Steege and Hammond, 1996, see above). Also, as the timber

market changes over the years, trees that were eliminated may become commercial. For instance, the *Couratari* individuals poison-girdled in the CELOS experimental plots in Suriname several years ago would fetch a good price now (G. Zondervan, *pers. comm.*). Furthermore, treatments are a long-term investment, only to be made by a concessionaire if long-term tenure without land-use conflicts is guaranteed. So, who will carry them out?

We cannot accurately predict how forest composition will change under heavy or light forest management, but we can predict that it will change, and that the forest will likely be less valuable in terms of marketable timber. It may need careful monitoring over a period of three harvests to obtain a better appreciation of future forest composition.

One has to agree with ITTO (Prebble, 1997) that there should be much emphasis on the establishment of demonstration forests where low- impact logging is practised, and on the extension of these practices. Also important are the monitoring and modelling of forest composition changes and the marketing efforts that take foreseeable changes in log availability into account.

Sustainable forest management may be possible if we accept that changes in forest composition occur. Part of global sustainability of forest diversity should include good land-use planning to ensure that a comprehensive set of forest communities - preserving not only species, but also processes that have led to current forest communities (ter Steege and Hammond, *unpublished data*) - will be achieved.

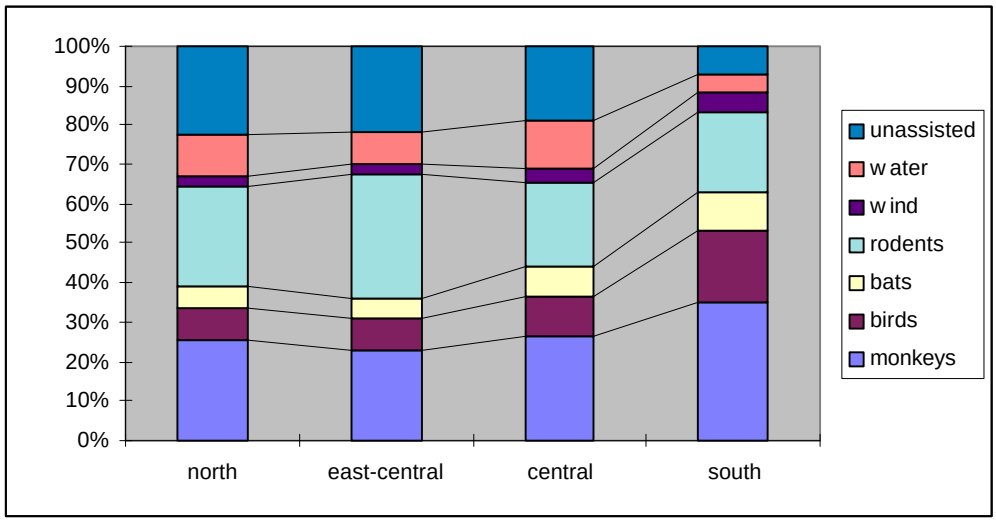

Figure 3 Proportional dispersal mechanisms of forest trees in Guyana. Many species in central Guyana are dispersed by rodents. In the south bird and primate dispersal prevail.

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SUSTAINABLE FOREST MANAGEMENT. IS IT POSSIBLE?

Achievements
- Suitable harvesting systems have been developed for most tropical rain forest regions.

Challenges and Problems; Information Needs
- Even though feasible harvesting systems have been developed, they are not applied.

Points for Future Research
- Efficiency of silvicultural treatments for regenerating timber species.
- Response of forest system and timber resources to second felling cycle and beyond.

Conclusions
- Intervened forests will be dominated by light-wooded species.
- Regional differences in forest composition and dispersers should be taken into consideration for sustainable forest management.
- Sustainable forest management may be possible if we accept that changes in forest composition occur.

MANIPULATION OF LIGHT IN TROPICAL RAIN FOREST

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1. ABSTRACT

The manipulation of tropical forest is directed towards transforming the forest, or its components, in such a way that the forest delivers more products. In tropical silvicultural systems, manipulating the structure of the forest is what is important, and in nearly all cases this is aimed at influencing the competition among individuals - competition mainly for light. To be able to manipulate rationally and functionally, we need to know whether species react to changes in light, and how they react to these changes.

The ecological research of our group is dedicated mainly to the biological aspects of the relationship between light and (1) the structure of the forest, (2) the dynamics of the populations of selected species, and (3) the growth and development of trees.

Light in the forest is mainly determined by the openness of the forest canopy. Gaps in the canopy that result from falling trees and branches are crucial in this respect. Their dynamics in space and time determine the dynamics of light in the forest. The survival probability of a tree increases with tree size, and light has a positive influence on tree size. At high light, trees grow better, seedlings as well as large trees, but the trees' reactions are related to the ontogenetic tree phase. Pioneer trees grow faster than shade-tolerants do, and profit more from higher light levels.

A manipulative increase in light level is only worth the effort when desired species and individuals profit more from it than do undesired species and individuals. Manipulations aimed at small individuals also pay off, as a small increase in survival directly leads to a higher density of desired individuals. Manipulations directed at large individuals only lead to higher production on the individuals already present. Research on reactions of individuals and species to light and changes in light can lead to predictions of the effects of manipulations, which we need for sound manipulation. New analyses of old data using modern knowledge and techniques could be rewarding. Experiments directed to answering specific questions could also increase our understanding. This could improve the predictions as well as the results of manipulations.

Diversification, small-scale use, and spatial stratification of manipulations, focused on species and individuals, deserve more attention. For that, we should also look more at systems that local people use. Studies need to be positioned into a general frame of manipulations aimed at specific products from, and functions of, tropical forest.

2. INTRODUCTION

Tropical rain forests have many uses. One group of uses is the extraction of forest products (e.g. fruit, latex, bush meat, medicines, and wood). Most tropical rain forests are very rich in species. On the one hand, this leads to a high probability that at least some of the species provide products wanted by humans, but on the other hand it implies that typically the number of individuals of one species is low.

This also means that the natural production per species may be badly reduced, when expressed per unit of area. The extraction of forest products, thus, is nearly always hampered by the low availability of the individuals that provide the products. For some species, however, individuals tend to grow together, and thus, on a local scale, the availability of products can be high.

Ever since people have used products from the forest, they have, in one way or another, been influencing the production of the goods (Wiersum, 1997). Nowadays, it is beyond dispute that nearly all tropical forests are influenced by man. Such influence may range from picking fruits, via cutting down scattered trees for honey collection, tending individual trees in forest gardens near a village, to operating large-scale logging concessions.

Silvicultural systems in the tropics are focused on transforming the natural forest into a forest with a higher abundance and production capacity of one or more species that are wanted for their products (cf. Lamprecht, 1989). These transformations vary in intensity:

- A low-intensity transformation does not change the system or its constituent parts very much and thus has a low impact. In most cases, the result is only a slight change in the production capacity of the system;
- Low-to-medium intensity transformation. The near-to-nature or nature-analogous systems generally cause only mild transformations. The yield of products in such systems is typically low, at least the short-term yield is;
- Medium-to-high intensity transformation. Most sustained-yield silvicultural systems have a medium-to-heavy impact on the forest ecosystem. In many cases, the forest is opened up drastically (basal area reductions up to 75%), leading to a completely different forest;
- A high-intensity transformation is a transformation that drastically changes the system (e.g. into a plantation designed for one special product only). The original system then ceases to exist.

Most silvicultural systems have in common that they are designed to stimulate the growth and production of desired species by changing the environment of individuals of these species. In most cases, this boils down to killing individuals of undesired species. The central idea is that the desired individuals grow or produce better when competition from others, mainly for abiotic environmental resources, is reduced. In many forests, light is the most important limiting abiotic resource for plant growth, constituting a bottleneck for growth and development of individuals, especially in the young phases. Water and nutrients come in the second place, but this, of course, depends on local conditions (e.g. in forests on poor white sand soils, the importance of resources may be reversed).

In this paper, I will discuss the role of light in forests, and the way in which knowledge of the light environment and the light requirements of trees can be applied in silviculture. First, I will treat in detail the manipulation of light in silviculture. Second, I will summarise some major results of research work on the role of light in the tropical rain forest in French Guiana. Third, I will discuss the importance of these findings for silvicultural manipulation of the forest. I will conclude with promising new directions for research in the near future in the field of light and the manipulation of tropical rain forest.

3. SILVICULTURE AND MANIPULATION OF THE LIGHT ENVIRONMENT

In silvicultural systems, manipulation of the forest is mostly aimed at one desired species, or a group of such species: species that provide desired products. Three general types of intervention are possible in forest manipulation:

- A change in abiotic resource availability (e.g. light, water, nutrients), aiming at a reduction of competition (for light, water, nutrients, physical space);
- A change in the intensity of interactions: plant-plant, plant-animal, animal-animal (e.g. hunting seed-dispersing animals);
- A reduction or elimination of 'bad' individuals (e.g. bad stem, little fruit, high disease susceptibility), or a specific stimulation of 'good' individuals (e.g. leading to genetic selection).

Most types of interventions used in silvicultural systems lead to a change in the light conditions in the forest (Lamprecht, 1989; 1993). The most commonly used intervention is refinement thinning, which is a general stimulation of all individuals of desired species by an overall, systematic reduction of competition by individuals of undesired species. In those cases, all or most undesired trees are cut or poison-girdled in order to promote the growth of desired trees. The second intervention is liberation thinning, which is the stimulation of selected individuals by a strong reduction in competition from nearby individuals. Both are mainly focused on the desired individuals already present. An example is the CELOS Silvicultural System, which uses both general refinement thinning and specific liberation thinning (de Graaf, 1986; Jonkers, 1987). A third intervention is the creation of gaps in the canopy (e.g. the Kintap System; Sagala, 1994), or the cutting of small strips (e.g. the Palcazu System: Hartshorn, 1989; Stocks and Hartshorn, 1993). On the one hand, this is a way of logging; on the other, it is a manipulation aimed at an increased recruitment of a specific group of species.

Table 1 Forest manipulation: some of the questions to be asked

Forest manipulation: questions to be asked
• Which species and which individuals to focus on? Which criteria?
• Where should individuals be eliminated? Which criteria?
• How to eliminate individuals?
• How do species react? What do species need?
• Biological and physiological background: how does it work?

Ideally, these interventions are based on ecological knowledge of the targeted species. Only in a very few cases, however, and only for a very few species is this ecological knowledge sufficiently available. In fact, what do we need to know for each of these manipulation types (Table 1)?

1. Refinement: stimulation of all individuals of desired species by an overall systematic reduction of competition by individuals of undesired species (all or most undesired trees are cut or poison-girdled to promote the growth of desired trees).
   - On which (group of) species should the measures be focused, and which species should be eliminated? What criteria should be used for selecting desired species? Especially the undesired species deserve attention. Which individuals should be eliminated? Lower- diameter limits of cutting are very important in this respect (e.g. in relation to tree size at maturity);

- Where should undesired individuals be eliminated? Is this everywhere, or on specific locations (e.g. depending on the competitive influence on desired individuals)?
- By what method should individuals be eliminated? Cutting, for instance, leads to high damage levels, while poisoning and poison-girdling is slower, but less damaging;
- Is it possible to use the same elimination techniques for all these species? Do all desired species respond in the same way to treatment?

2. Creating gaps or cutting strips in the canopy, aimed at an increased recruitment of a specific species or group of species.
   - Which species should be targeted? Which criteria are to be used?
   - What kind and sizes of gaps or strips are needed for these species?
   - Do light levels in the gap and light requirements of the species change in the same direction with increasing gap age and tree development?
3. Liberation: stimulation of selected individuals by a severe reduction in competition from nearby individuals;
   - Which species (and which individuals of these species) should be targeted? Which criteria are to be used?
   - What is the hierarchy in desirability of the species, and of the individuals? (Is Species A favoured over Species B, both being desired species?);

   C Is this hierarchy location-specific? (Species A is favoured here; Species B is favoured there.);
   - How does a species respond to liberation? How much liberation is needed? When is liberation needed? When is liberation most effective? What are the effects on, for instance, wood quality?
   - What is the biological and physiological background of liberation? How does it work? What biological mechanisms are important? How can we understand these mechanisms? What is the variation that exists among and within species?

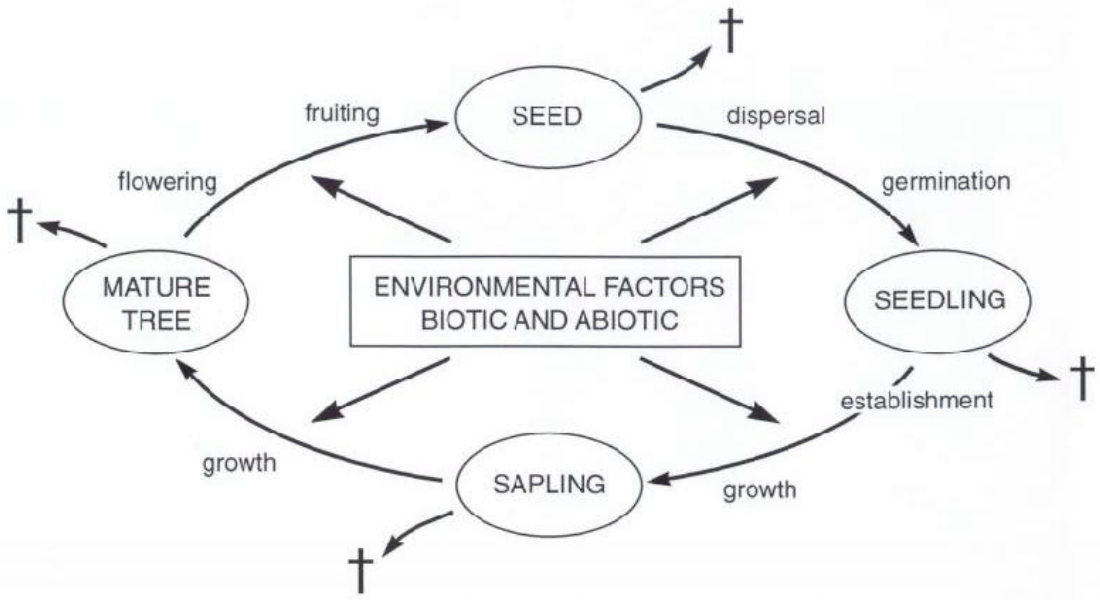

Figure 1 Life cycle diagram of a tree. Light is an important abiotic factor influencing all processes involved.

From the ecological point of view, it is central that we know as much as possible about the effect of

light on the life history of species. Figure 1 schematises the life history of a tree, and the role of the environment. Mature trees produce seeds that are dispersed and germinate to produce seedlings. These grow into saplings and further to mature trees. Individuals may die in all stages. The processes involved in the transition from one phase to another (e.g. pollination, germination, growth) are influenced by environmental factors, biotic as well as abiotic. Here I will concentrate on the role of light.

4. CANOPY DYNAMICS, LIGHT, AND TREE-LIFE HISTORY RESEARCH IN FRENCH GUIANA

In the rain forest of French Guiana, we are studying some of the processes mentioned (Figure 1), and how light shapes the outcome of these processes. Our main research area is the forest of the Biological Station, Les Nouragues, approximately 100 km south of Cayenne. The forest is tropical lowland rain forest and is typical of a large part of the area. Recent human influence (over the last 200 years) is virtually nil. We are concentrating our efforts on 12 ha of forest, where we started our research in 1990. The concentration in that area gives us the opportunity to integrate data from several sub-studies. Figure 2 indicates the main research lines.

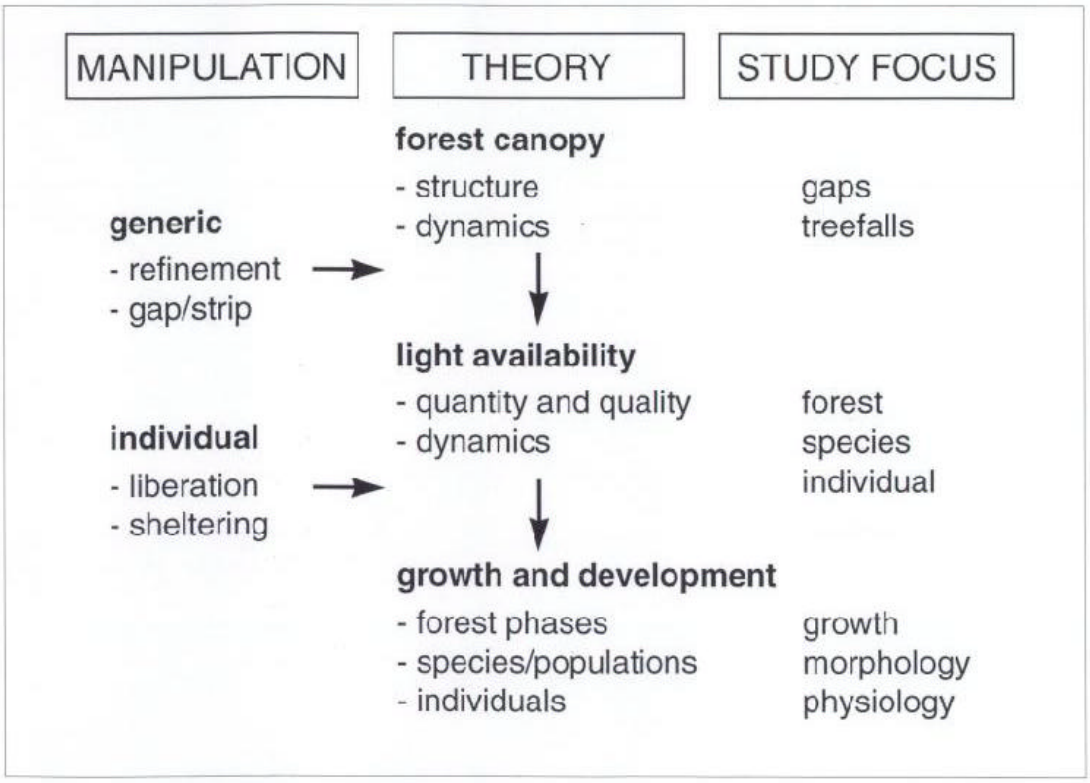

Figure 2 Conceptual scheme of our studies in French Guiana

In forests, light and variations in light are mainly determined by the above-ground structure of the forest and by changes in it. Openings in the canopy of the forest, mostly caused by falling trees or large branches, are of primary importance for the light climate. We analyse the effect of canopy dynamics on the light environment, using a forest patch perspective as well as an individual tree perspective. We focus on both the temporal and the spatial dynamics of light, mainly the quantity of light but also its quality. As the next step in the chain, we study the effects of light on some selected species. We look at the responses of the trees to variations in the availability of light, in terms of recruitment, mortality,

growth, and development. Crown development is studied at various scales: the whole crown, branches, shoots, internodes, and individual leaves. We try to understand the processes and resulting patterns, using detailed studies of morphology and ecophysiology.

The results of these studies can be directly related to intervention and manipulation techniques. Generic treatments such as general refinements affect the general light climate at the level of tree canopies. Refinement will lead to an overall increase in light availability. Gap and strip-cutting techniques will do the same, but on a relatively small scale. In contrast, liberation thinning directly influences the light availability at the scale of individuals. Our studies address most of these aspects.

4.1 Canopy dynamics and light availability

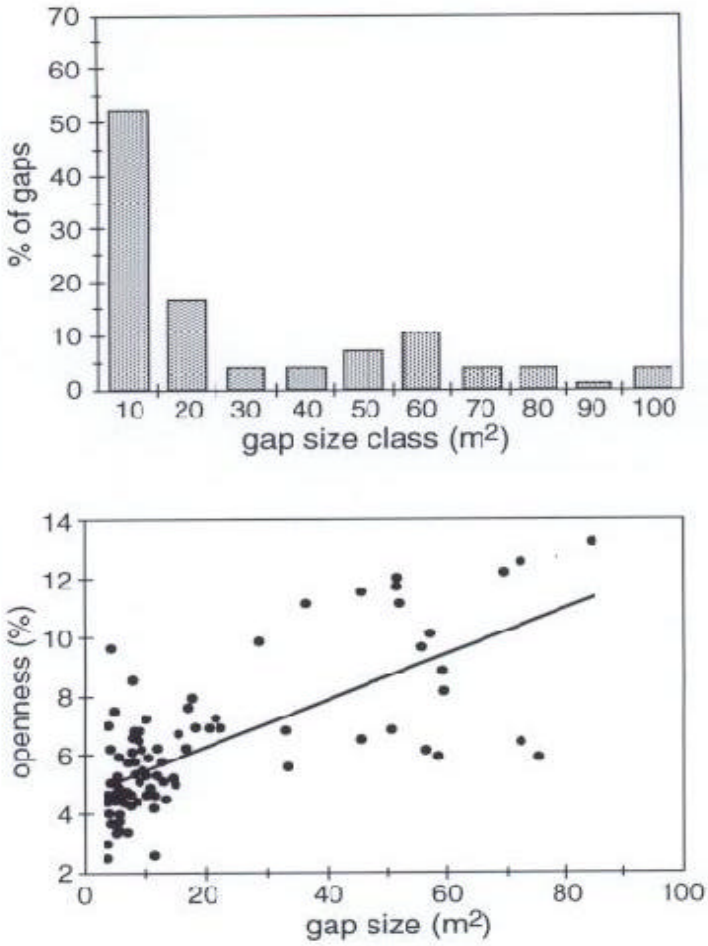

Figure 3 (A) Frequency distribution of sizes of canopy gaps that occurred between 1990 and 1993 in 12 ha of forest (n=42, sizes according to the Brokaw method)
(B) Gap size and canopy openness, Les Nouragues forest. Openness = 4.70 + 0.077 * gap size. R^2 = 0.47 (after van der Meer and Bongers, 1996b)

The results of our studies on canopy dynamics show that in the natural forest of Nouragues (van der Meer, 1995; van der Meer and Bongers, 1996a and b):

- The number of gaps per year is highly variable, both in time and in space;
- Most gaps are very small, and the number of large gaps is very low;

- The total forest area in gap phase at any moment is small (1-2%);
- It takes 10-15 years for a gap to close, depending on the original gap size;
- About 1-2% of the trees >10 cm DBH fall each year;
- Most falling trees do not result in canopy gaps;
- Most trees die because other trees knock them over.

These canopy dynamics result in great changes in the availability of light in the forest. Because of the different sizes of canopy openings and the changes therein, light availability is highly variable, on all scales, in space as well as in time. Figure 3 shows some of this variability in frequencies of gap size and light levels in the centre of gaps of different sizes. Because most gaps are small, the light levels are generally low, compared with the light levels in the open. As large gaps are scarce, high light levels are also scarce. A direct result of the scarcity of large gaps is that, in this forest, the proportion of light-demanding species (the species that require high light levels throughout their life history) and individuals is low.

We are currently analysing the dynamics of changes in gaps: closure in terms of vegetation, and changes in terms of light. These studies include the transition zones towards the closed forest, and the closed forest itself.

4.2Light and performance of species and individuals

Our studies on the effect of light and changes therein on individual trees of four selected species (Sterck, 1997; Bongers and Sterck, 1998) show that:

- Individuals of all size classes may be found under all light conditions, except for the largest individuals;
- The proportion of individuals in high light increases with height;
- Pioneer trees grow under higher light levels than shade-tolerants, but
- Pioneer trees are also found in the shade, and shade-tolerants are also found in high light;
- For many trees, light levels changed during the 5 years of study: some received more light, others received less;
- Small individuals experience greater changes in light than large individuals.

These light levels, and the changes therein, have great effects on population dynamics and on the growth and development of individual trees. To be able to quantify these influences, we are studying these aspects for some selected species. The leading questions here are:

- What is the relationship between light and the probability of survival? What is the relationship between light and the growth and development of individuals?
- What are the differences between species in this respect?

We monitor individuals in the field in a range of light conditions, and we also analyse experimental liberation of individual trees, taking into account possible differences between size classes. We do not merely confine ourselves to growth in size (diameter, height), but look more closely at an individual's response in terms of shoot development, leaf and branch turnover, leaf area development, branching patterns, and leaf characteristics.

Figure 4 gives an example of the development over three years of two individuals of *Dicorynia guianensis*, one in a gap, and the other in the understorey. These individuals were equal in size and development phase at the start of the study. After three years, the individual in the gap had more leaves, a higher LAI, more branches, was higher, and had a thicker stem. The crown was larger and more elongated because the top shoots grew relatively faster than the lateral crown shoots (Sterck, 1997).

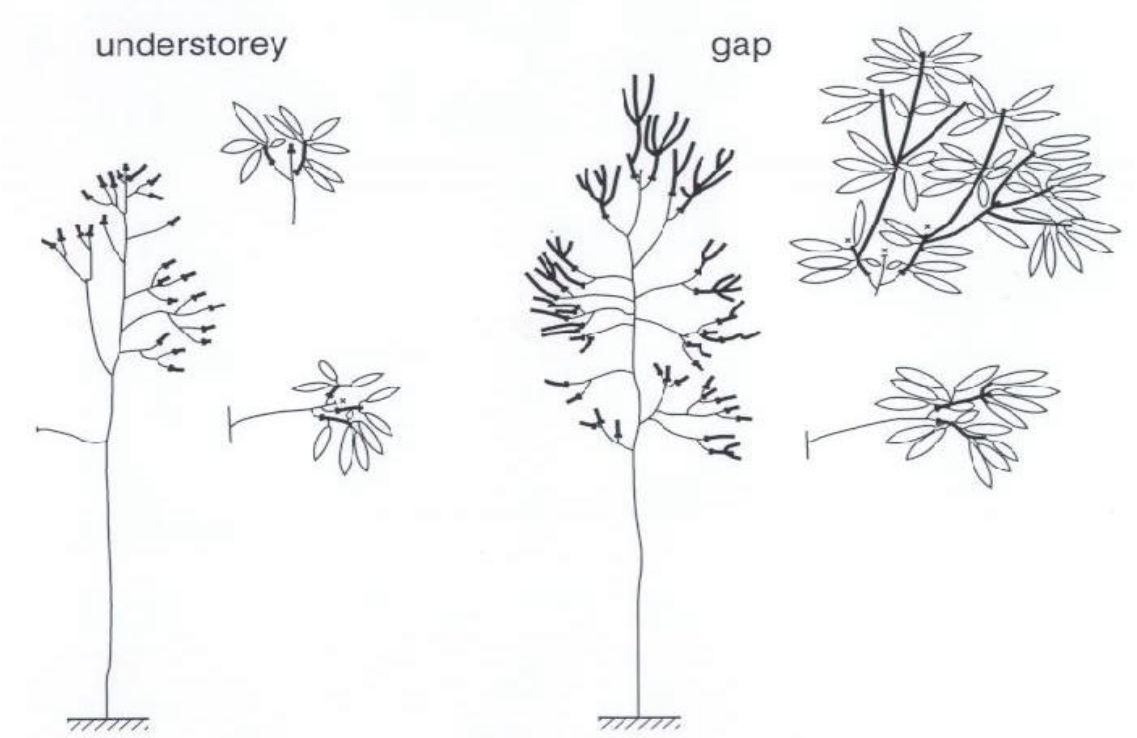

Figure 4 Tree development of *Dicorynia guianensis* (1991-1994) in two contrasting environments, Les Nouragues forest, French Guiana. Trees were 9 m high at the start of the measurements. For each tree the development at the top and halfway into the crown is depicted in detail. (from Bongers and Sterck, 1998).

4.3 What did we learn about the influence of light on individual and species performance?

The results on the population dynamics of several species (van der Meer, 1995; van der Meer, Sterck and Bongers, 1998; Bongers *et al*., unpublished data) show that:

- All species studied perform better in high light than in low light. Pioneer species do very badly in very low light, but benefit more from high light than shade-tolerant species;
- Germination and seedling survival are higher in high light than in low light, leading to more established individuals;
- Growth in high light (in terms of biomass, height, diameter) is faster, but may be at the cost of flexibility and efficiency of light interception (needed when overshaded);
- Seedlings and small saplings contribute more to population size than pre-mature individuals.

The results of research on the tree architecture of *Dicorynia guianensis* and *Vouacapoua americana* (Sterck, 1997; Bongers and Sterck, 1998; Sterck and Bongers, 1998) show that:

- Light limitation plays a crucial role in trees up to a height of at least 20 m;
- Trees of both species respond to increased light levels with accelerated crown expansion;
- Trees respond to decreased light levels with more efficient light interception (reduced self-shading, reduced crown elongation, lower costs of producing leaf area, lower investment in stability);
- Responses to light occur at all levels within the crown hierarchy (i.e. the leaf, metamer, extension unit, sympodial unit, and whole crown level), when comparing trees from contrasting light environments;
- In natural populations, responses to light occur at some, but not all, crown light levels. Probably, this reflects the rarity of extremely high light levels in the forest, rather than the inability to respond;
- Trees shorter than 20 m show similar responses to light, irrespective of their height;
- Trees taller than 20 m may show different responses to light than shorter trees, because of

ontogenetic constraints or the high light levels in the upper canopy;
- The mechanical stability of trees decreases with size in early life phases, but increases in later life phases;
- Tall stature species are more slender than shorter stature species because they support narrower crowns;
- Tropical trees are more slender than temperate trees. This may be due to lower light levels and/or wind speeds in the tropics;
- The architecture of trees is of great importance for the interception of light, and for competition for light with neighbours.

Currently, we are studying the ecophysiological background of these light adaptations in trees of these and other species in the Les Nouragues forest (Rijkers *et al*. *unpublished data*). In current and future studies, the results of the single studies mentioned here will be integrated, and the processes and results (e.g. those on leaf, shoot, branch, crown, and trees of different sizes) will be up-scaled and down-scaled, which will lead to predictions of the influence of light on the development of the species.

Also, to find the influence of light on the seed-to-seedling transition, studies are being performed on the interactions between light and animals (as seed dispersers and seed destroyers, and seed and seedling herbivores). Especially the interaction between light, canopy gaps, and the scatter-hoarding of large seeds of selected species (e.g. *Carapa guianensis, Vouacapoua americana, Licania albida*) by the ground-dwelling rodents Agouti (*Dasyprocta agouti*) and Acouchi (*Myoprocta acouchi*) is receiving detailed study (Jansen *et al*. unpublished data). By following the fate of the seeds of these species, we quantify the effects of this interaction on the regeneration of these species. One important preliminary result is that some of the large seeds are dispersed preferentially into treefall gaps. This, however, is not for the light conditions, but mainly for the shelter that the treefall debris supplies. Another example of an interaction between treefall gaps and animals is the dispersal, by Manakin birds, of Melastome plants away from treefall gaps. The birds disperse the seeds of these gap pioneer plants preferentially out of the gaps towards the lek, the display ground of these birds (Krijger *et al.*, 1997).

5. IMPLICATIONS FOR SILVICULTURE

What can we learn from our studies, and other comparable studies, for application in silviculture? Figure 5 shows applied aspects for the components of the life history of trees and for the processes involved therein. It shows three applications dealing with the influence of light on the main processes occurring in each component of the life history. I will briefly expand on a few of them.

Many seeds need safe sites (*sensu* Harper, 1977) to be able to germinate. The high light environment of a large canopy gap and its importance for some pioneer trees (e.g. *Cecropia* species; see e.g. Alvarez-Buylla and Martinez-Ramos, 1992) is just one example. To reach a safe site, directional dispersal is an advantage and animals play a crucial role therein. The interaction between light environment and animal dispersal has a direct influence on seed survival and seed germination. The results of the studies we are performing on Agoutis and their role in seed dispersal and seedling establishment of *Carapa guianensis* and *Vouacapoua americana* clearly indicate the extreme importance of such animals (see also Forget *et al.*, 1998). The direct effect of man on such animals (e.g. by hunting, which increases after the forest is opened up in logging concessions) may have a cascade of effects on various tree species that depend on these animals for their regeneration.

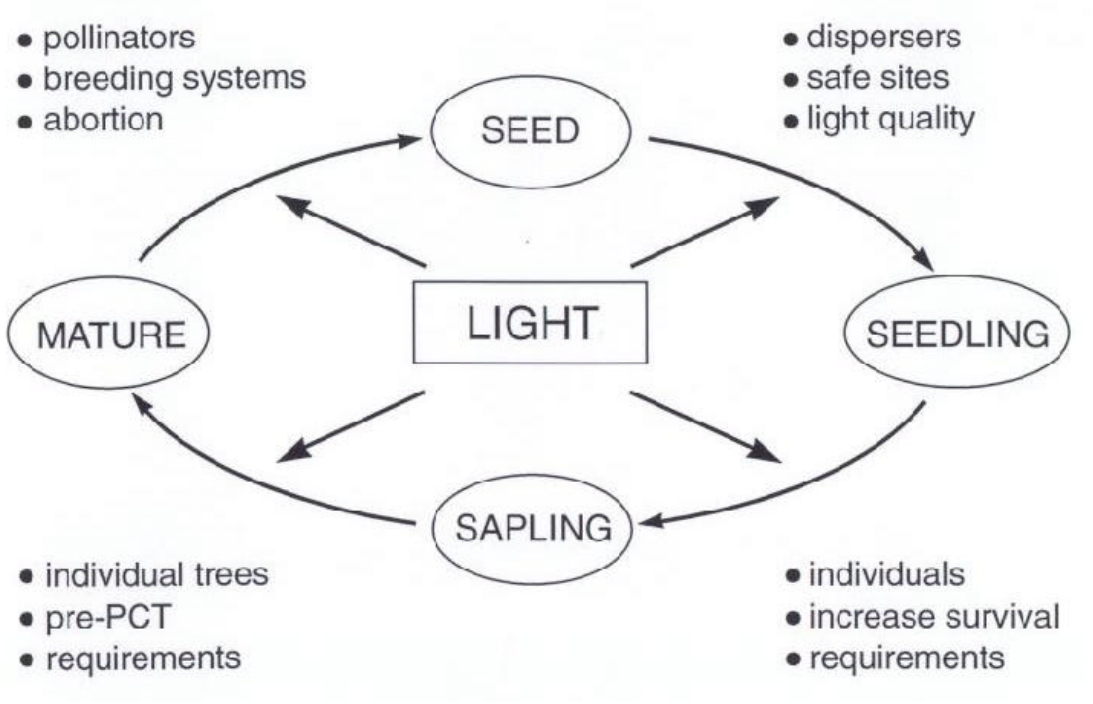

Figure 5 Application in silviculture of research on the effects of light on tree life history aspects (see text)

Light clearly improves the establishment probabilities of seedlings, and also the growth of seedlings, saplings, and large individuals (Swaine, 1996). The fact that secondary species benefit most from high light indicates that light manipulation should not be general, but should be specifically directed towards desired species and individuals. Too much light will have a negative effect, both in terms of a shift in species composition and in tree allometry (heavy branching early in life).

The relatively high importance of small individuals for the overall population size (see also Zagt, 1997) asks for manipulations directed towards individuals with high reproductive output and towards seedlings and saplings. As light increases the survival of small plants that grow in the dark understorey (see e.g. Zagt, 1997), a specific manipulation will directly lead to a higher stock of desired individuals. Especially in the cases where highly valued species hardly regenerate (like some of the African mahogany species; see e.g. Poorter *et al.*, 1996), specific treatment of the few individuals is worth the effort. Manipulations directed only at larger individuals, like all manipulations directed at potential crop trees (which in most cases have a diameter of between 30 and 50 cm), will increase growth only on presently available larger trees. Manipulation of potential crop trees will thus give results in the

silviculturally short term only, while manipulation of smaller individuals will give results in the long term. This clearly calls for a broadening of the scope and purpose of light manipulations.

For most species, including many commercially interesting ones, we know little about the specific requirements for germination, establishment, growth, and development. In the scientific literature, information is available about specific components of the life cycle of several species (see e.g. Swaine, 1996, for seedlings), but in many cases these are not commercially interesting species. Also, the translation of scientific information on species requirements towards the community of users of the information (e.g. foresters working for large forestry enterprises) should be improved. The production of monographs in which the current knowledge on specific tree species or specific genera is presented should be stimulated. Such monographs could be valuable for the scientific community as well as for user groups (but in the latter case the information should be transformed and translated).

Studies on actual light levels to which individuals are subjected and how these change with time are important. They give us information about the natural conditions under which species live. Manipulation enables us to benefit from that natural variation. Manipulation of forest structure can be translated directly into manipulation of light levels. It is clear that manipulations should at least extend the period of high light over a longer time than under natural conditions.

What has clearly emerged from our studies is that light influences various parts of the plant in different ways. High or low light levels cause trees to change their growth and investment patterns in such a way that it is profitable for the tree - now, or in the near or distant future. Growth responses depend much on the tree species, and any manipulation directed towards an increase in growth should be attuned to the natural response pattern of the species. To be able to do this, we need to have detailed knowledge of the ecological requirements of a species. What is also important is the individual=s developmental phase: ontogenetic effects need to be separated from light effects (Coleman *et al.*, 1994). It should be noted that light requirements are not constant during the lifetime of a tree, and that relative light requirements among species also change (Oldeman and van Dijk, 1991; Grubb, 1996).

Table 2 Effects of forest intervention on mortality rate, gap area, and individuals of heliophilous species, Paracou, French Guiana. All values are percentages. Data from Durrieu de Madron (1993, 1994).

	Control	**Logging**	**Logging + refinement**	**Logging + refinement + extraction**
Mortality	11	20	29	26
Gap area	13	50	64	83
Heliophilous	11	34	41	47

Most manipulations in tropical forestry systems are not species-specific, but are directed towards a whole group of species. Species, however, are not usually grouped on the basis of ecological requirements, but on their usefulness and value. There is, however, no *a priori* reason why species from such value groups should respond similarly to manipulations. In most cases, manipulations are aimed at the group of commercial species, species that have a relatively high value and can be sold on the market. The non-commercial species are then classified into a secondary species group. Examples from the Guianas region are the studies underlying the CELOS Silvicultural System in Suriname (de Graaf, 1986; Jonkers, 1987; Jonkers and Schmidt, 1984; Poels, 1987) and the studies done at Paracou, French

Guiana (Durrieu de Madron, 1993; 1994; Favrichon, 1997). In these studies, various logging intensities and refinement thinning regimes are being tested. Table 2 shows some of the results of the Paracou experiments.

Three levels of manipulations were compared with a control. In the first treatment, individuals of first-class timber species with a diameter above 50 or 60 cm were cut. In the second treatment, this logging intensity was combined with a refinement in which all individuals of secondary species above 40 cm diameter were poison-girdled. In the third treatment, all individuals of secondary species between 40 and 50 cm were exploited, and individuals over 50 cm were poison-girdled. In the heavier treatments, the mortality of the remaining trees was considerably higher than in the control. Also the total area classified as gap was drastically increased, from 1.3% in the control to over 80% in the heaviest treatment. This high percentage indicates that, in fact, the remaining area no longer consists of a matrix of high forest with gaps in it, but of a matrix of open area with scattered patches of high forest. The gap concept (the area opened up by the fall of one or more canopy trees) can no longer describe the situation after such heavy treatments. The damage to remaining trees was high (ranging from 8-9% in Treatment 1 to 15-17% in Treatment 3; Durrieu de Madron, 1993, p. 127). It is striking that the percentage of individuals of secondary species (undesired species) was very high three to four years after the treatment. The secondary species almost dominates the vegetation. This means that the increase in the undesired species is much higher than the increase in desired species.

This result is comparable with results obtained in the CELOS experiments: the desired species do increase, but the undesired species profit much more from the manipulation (de Graaf, unpublished data; Poels *et al.*, 1997). The same accounts for the SODEFOR experiments in Côte d=Ivoire (Dupuy *et al.*, 1997). This leads to the question of the effectiveness of the interventions. Only a regularly repeated intervention in which the secondary species are killed will lead to a higher density of individuals of desired species. But, what will be the effect when the number of secondary individuals is drastically reduced? This will depend greatly on the interactions and dependence of the desired species on animals which, in their turn, may depend heavily on secondary species for their survival. In the end, this may lead to a severe impoverishment of the system and a decrease in the number of desired species as well. Also important is the loss of nutrients after several heavy interventions.

6. CONCLUSIONS

Manipulation of the structure of the forest aimed at increasing the light levels on species and individuals leads to an increase in growth and production of the trees involved. Generic treatments aimed at the general group of commercially interesting species may stimulate the growth and development of undesired species at the cost of the desired ones. This calls for regular treatments favouring the desired species.

Many studies on species distribution and species composition of tropical forest show that the tropical rain forest is spatially strongly stratified. Some species are abundant here; others are abundant there. Our studies also show that the requirements for light depend strongly on the species and on the developmental phase of the individuals, and that the same accounts for the responses of species to light and changes therein. Manipulations should thus be directed towards species and what these species need, instead of directing it to large, ecologically very vaguely defined groups of species. Give species and individuals what they need (e.g. to assist them to deliver what we need from them). This calls for highly stratified manipulations: treatments that are different from place to place, from species to species, and to some extent, from individual to individual.

Scientifically sound data are needed to enable us to use specific treatments. Relatively little is known about the requirements of species with respect to light, other than very general notions of shade tolerance. As studies on manipulations at the species level and at the individual level are scarce, we can do two things: First, reanalyse already collected data but with an individual focus, using new techniques and new insights. Second, design new experiments directed at specific questions. The experiments performed by the German Technical Development Agency, GTZ, in Côte d=Ivoire, where the effects of individual treatments were studied, are a nice example of this approach (Waitkuwait, pers. comm.; Parren and de Graaf, 1995).
Deserving more attention are the inventory and monitoring of the present situation in the forest, and the effects of logging and silvicultural treatments on the forest, not only in research, but especially in forest enterprises. For long-term forest enterprises, such investments will soon pay off. The methods and the details should depend on the local variability in the area in question. Hierarchically stratified approaches are needed.

Because we know that species respond in different ways, we ourselves should refrain from general manipulations to increase light availability. In many cases, the wrong species have the highest benefit. Modern information technology, together with information on species-specific requirements, make highly stratified manipulations possible. In this respect, we could look at recent developments in forestry and agriculture. What could tropical forestry learn from recent developments in ecology-based forestry and agriculture? And also, what could tropical forestry learn from the sheer endless ways in which local people influence and manipulate their forests (Wiersum, 1997)?

An often heard argument against specific manipulations is that they are too expensive. But, activities in the forest generally make up a relatively small part of the total costs (de Graaf, pers. comm.), and by far the highest cost is the use of heavy machinery (van Leersum, pers. comm.). I predict that, at least for the higher-valued species, specific manipulations will pay off very soon. The question is not: can we afford specific manipulations? The question should be: under what conditions are such manipulations worth the effort? Scenario studies are needed: scenario studies in which many aspects of the manipulation of light in the forest are taken into account.

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MANIPULATION OF LIGHT IN TROPICAL RAIN FOREST

Achievements

- Insight has been achieved in the significance of gap and light dynamics in tropical rain forest.
- Understanding of variation in response to light between species belonging to different regeneration strategies.

Challenges and Problems; Information Needs

- Still limited knowledge concerning the biological mechanisms that govern tree growth and variation therein between species and life cycle stage.
- Manipulations in tropical forestry are not species-specific, but directed towards biologically ill-defined groups of species.
- Application of silvicultural intervention may lead to an increase of undesired species that is much higher than the increase of desired species.

Points for Future Research

- Design of refinement treatments: species choice; lower cutting limits; spatial aspects of tree elimination; method of elimination.
- Design of gap and strip cutting treatments: species choice; gap sizes to be created.
- Design of liberation treatments: species choice; timing and efficiency of liberation; effects on wood quality; biological mechanism of liberation.
- Relation between light and growth, survival of species; and species-specific differences therein.
- Re-analysis of existing datasets, focusing on tree individuals
- Development of forest models in order to carry out scenario studies.

Conclusions

- Silvicultural manipulation of forests should be attuned to the natural response pattern of the species, rather than to commercially defined groups of species.

REDUCED IMPACT LOGGING: A GLOBAL PANACEA? COMPARISON OF TWO LOGGING STUDIES

P. van der Hout and G.J.R. van Leersum
The Tropenbos-Guyana and Tropenbos-Cameroon programme

INTRODUCTION

In recent years, several major events have drawn the attention of the public to the importance of forestry and the global environment. Perhaps the most important of these was the United Nations Conference on Environment and Development, which was held in Rio de Janeiro in June 1992. One of the main outcomes of this Conference was the explicit recognition by policy-makers that forests are essential for sustainable economic development and also for the cultural and physical well-being of current and future generations. To ensure that forests are sustained for future generations and to improve the economic and social contributions of forestry, environmentally-sound harvesting techniques that will improve standards of utilisation and reduce environmental impacts should be developed and promoted. Given the current state of knowledge, however, it is not clear whether specific practices will actually achieve the desired outcome: i.e. that the standards of sustainable forest management be met.

Publications on reduced-impact logging or the improvement of codes of practice for sustainable management are on the increase. After Mattson Mårn and Jonkers (1981) in Sabah, Ward and Kanowksi (1985) in Australia, and Hendrison (1990) in Suriname, a whole new generation of researchers have taken up the topic, and all describe its advantages: Crome *et al.* (1992) in Australia; Blate (1997) and Johns *et al.* (1996) in Brazil; Webb (1997) in Costa Rica; van der Hout (1996) in Guyana; Bertault and Sist (1995) in Kalimantan; Pinard and Putz (1996) and Cedergren *et al.* (1994) in Sabah. Some describe the methods and the results obtained more precisely than others (i.e. quantitatively), but the general message is: reduced-impact logging is less destructive than conventional practices and increases utilisation standards. These conclusions suggest that there should be no hesitation among logging companies to start employing this practice or for governments to enforce its implementation. On the contrary, the adoption of the techniques remains an elusive goal. In the Brazilian Amazon, for example, only a few forestry operations have implemented low-impact-logging techniques, despite the legal requirements to do so (Uhl *et al.*, 1996). The question arises: what withholds the implementation of these techniques (see also ter Steege, this seminar).

Two projects concerning the impact of selective logging have more or less been completed at the same time in two different Tropenbos programmes: one in Guyana, the other in Cameroon. While writing their reports, the authors discussed their respective results, explained what they had learned from complementary experiences, and sought support for their impressions and conclusions. For the purpose of this seminar, they have placed their tentative results in the framework of reduced-impact logging for sustainable management. The difference in set-up, and in the scientific and natural environment between the two projects became clear. In this paper, we will focus on the impact of selective logging on the vegetation and how this was attenuated by introducing reduced-impact-logging systems. The impact of these systems on the cost/benefit aspects will not be considered here.

DEFINITIONS

What are ›conventional practice‹ and ›reduced-impact logging‹? Some expressions may need further

clarification before we continue. Both logging practices refer to selective logging of commercially viable stems, meaning a limited number of individuals (of a minimum size and stem quality) out of a restricted number of tree species.

Reduced-impact logging (RIL), in our view, comprises new techniques and new concepts of organising and planning timber harvesting, with the primordial objective of damage reduction, and with a proximate goal of improving the efficiency of the operation. ›New‹ in this context means new to the environment and to the society in which these concepts are to be introduced. They are consequently experimental, and hence a topic of research and validation. The adjective ›reduced‹ hints at a comparison with another logging method, obviously the current, conventional practice. So RIL is about new, not yet commercially validated logging techniques that lead to less damage than the conventional methods of logging.

Now, *conventional practice* covers a broad range of methods, varying from ›*savage*‹ forest exploitation (timber mining with hardly any degree of planning at all) to ›*close-to-best practice*[1]‹. Which extreme to chose? Comparing the RIL concept with savage-logging practices does not really put new technological and conceptual developments in their right perspective. The commonly presented RIL package includes many concepts and techniques already present in the close-to-best practices. This means that many of these concepts and techniques have already been validated on a practical scale and have been incorporated in a company‹s production strategy.

We consider this clarification and demystification of RIL important when looking at the aspects of disseminating research results. Taking enterprises practising savage logging to the level of close-to-best practice can best be done by demonstrating or imposing techniques that have already been commercially validated by the forestry sector itself. Taking the *avant-garde* enterprises a step further to RIL level can best be done through a comparison between their current standard of practice and the experimental one. To really demonstrate the added value of new concepts and techniques, a comparison of the RIL concept with close-to-best practices would therefore seem a far more useful exercise.

BACKGROUND OF THE TWO PROJECTS

The two Tropenbos programmes differ considerably in set-up. The Guyana programme hooked on to an existing programme of the University of Utrecht. It formally commenced in 1989 and initially involved the Departments of Plant Ecology and Evolutionary Biology, and Physical Geography, the former being represented by the sections Vegetation Ecology, Ecophysiology, and Herbarium. Its focus has been on trees and their environment, with special attention to individual tree species, population dynamics, environmental stress, plant-animal interactions, and biodiversity offset by human-induced disturbances, specially artificial canopy gaps. In its current second phase, this scope has been broadened, notably with ethnobotany and non-timber forest products. The forestry

component was inserted in 1992, with a study to assess the impact of logging intensity on logging damage and subsequent growth and yield rates. Reduced-impact logging, following the system developed by Hendrison (1990) in the neighbouring country of Suriname, was treated as an extrinsic variable in the research (i.e. it was included in the experiment as a complete package approach to be compared with conventional practice). The core of the programme was basically ecological in nature, and forestry was dealt with within one project only.

In Cameroon, the Department of Forestry of the Agricultural University of Wageningen started a multi-disciplinary research programme from scratch in 1994. Best represented from the onset were Land-Use Planning, Economy, Social Science, and Logging research. Logging research was rather a separate project in a range of complementary forestry studies. The study focussed largely on the logging itself and aimed at the modification of current logging practices towards reduced- impact logging. No ecological or silvicultural studies had been undertaken at the start of the research. Social science and land-use studies did make tentative results available and could thus be taken into account.

In Guyana, the above factors led to an intrinsic link between logging, silviculture, and ecology, whereas in Cameroon the study tended towards a scrutiny of logging operations and their relationship with the rest of the production chain and the local forest population.

The environmental setting of the two programmes also differed, specially concerning the forest composition and the presence of forest dwellers (Table 1). Forests in Guyana are relatively poor in terms of species (*cf*. Ek, 1997) and log dimensions. Traditionally, logging has targeted mono-dominant patches of exploitable species in the forest, the most important being Greenheart (*Chlorocardium rodiei*, Lauraceae), a timber species. Recently, the set of targeted species has been broadened by an increased demand for peeler species, which is related to an increased interest of mainly South-East Asian timber companies. Logging activities in the study area, although also influenced by an increased marketability of lesser-used species, still aim at Greenheart. Because of the clumping of this species, selective logging in Guyana is disturbing the landscape in a very patchy fashion, and exploitation can reach a level of 20 stems per hectare or 60m^3/ha (Clarke, 1956; Zagt, 1997). Tree diameters are relatively small, most logs being smaller than 70 cm. The canopy height of Greenheart reaches 30-40 m. Some sought-after species are emergents and attain large diameters, but these usually comprise only a small proportion of the harvest.

In Cameroon, the forests are richer in species; no similar-sized clusters occur, and large individuals are broadly dispersed. Logs are considerably bigger on the average. The concessionaire focuses mainly on Azobé (*Lophira alata*, Ochnaceae) for its sawn timber. Adult individuals of Azobé and most other marketable species are emergent, and therefore cause considerably more damage upon felling than trees belonging to the canopy.

Another important difference in setting is the fact that the concession area in Guyana is virtually uninhabited, whereas sedentary as well as shifting-cultivation dwellers are present in Cameroon. Cameroon is also a prominent tropical timber exporting country while this is not the case for Guyana. The reasons for this difference can be found in the extremely low population density in Guyana, its relatively poor forests, and its geographical position. Because of the latter, Guyana is not located along a major trade route, which increases the transportation cost and results in smaller export profit margins.

The two projects coincide in the choice of their partners: both conduct their research in ›close-to-best practice‹ concessions, owned by foreign companies. The terrain of the two projects also correspond, both being flat to gently rolling.

Table 1 Characterisation of the environmental setting of the two Tropenbos research sites

	Guyana	**Cameroon**
Species diversity	moderate	rich
Exploitable species	in patches	dispersed
Topography (slopes)	<20%	<20%
Diameter range	under 120 cm	sometimes > 200 cm
Average diameter	60 cm	120 cm
Exploitation level (100 ha)	2 trees = 6 m^3/ha	0.5 tree = 6 m^3/ha
Concessionaire	Close-to-best practice	close-to-best practice
Forest dwellers	uninhabited	6 per km^2

HARVESTING PHASES

Four components can be identified in environmentally-sound harvesting practices (Dykstra, 1996):
1) Harvest planning;
2) Implementation and control of harvesting operations;
3) Assessment and communication of results between planners and operators;
4) A competent and properly motivated workforce.

Harvest planning should be a part of overall forest-management planning. The strategic harvest plan describes non-harvest areas, annual operating areas (coupes), the working methods, the main transportation and extraction system, and annual labour requirements. The tactical harvest plan provides the details of operations within the annual coupe. The following aspects are usually recommended for tactical harvest plans:
- Preparation of topographic maps;
- Identification of individual cutting units (blocks);
- Inventory of the trees per cutting block;
- Layout of a detailed transportation and extraction system;
- Scheduling of operations to accommodate the timing of, for example, the rainy season (Dykstra, 1996).

The comparison of the two logging studies focuses on these aspects and on the logging method. We will tackle these aspects not from a tactical viewpoint but from a strategic viewpoint. We will focus on the four harvesting phases most cited in literature: a) inventory, b) pre-felling logging activities, c) felling, and d) skidding.

INVENTORY

In temperate forests, forest inventory for harvesting through sampling is usually sufficient (see e.g. de Vries, 1986), as the volume to be harvested from each hectare is high and it is not necessary to know the location of each individual tree. In mixed tropical forests, the volume harvested per hectare is

usually low, and it is now generally considered essential to make a complete inventory of all trees that might be harvestable (100% enumeration) to reduce harvesting and infrastructure cost.

The traditional way of making an inventory in both countries (close-to-best practice situation) is that a cutting block is delimited by cut lines, usually 1 km apart. Between these cut lines, the forest is divided into strips, which are systematically browsed to locate harvestable stems. The position, size, and species are marked on a map, together with topographic details such as slope direction, gullies, and streams (see e.g. Hendrison, 1990). It is also common practice to project this information on a blown-up version of a standard topographic map, scale 1:50,000 (Guyana) or 1: 200,000 (Cameroon). The map that is used for felling and skidding has a scale of 1:2,500 in Guyana and 1: 5,000 in Cameroon.

The tree-stock map assembled in this way may look neat, but contains a high degree of false accuracy. Firstly, the blown-up grid of contour lines is too coarse and does not take into account very local steep slopes and ridges. Secondly, the combination of primitive field equipment (compass and surveyor-s rope), dense vegetation, and the strip system lead to considerable deviations from the reality in the forest. A compass misreading of only one degree will lead to an error of more than 17 m on a strip length of 1 km. Larger deviations are not uncommon when working under dense forest conditions. Moreover, the tree-s position is represented by a circle, in which species code, tree size, and tag number are pictured, which easily takes up 1 cm on the map = 50 m. Consequently, mapped tree locations and distances between trees show great aberrations.

Surprisingly, the low accuracy of the map generally appeared to pose no problem with the low density of the trees to be felled and skidded in Cameroon. The prospector still had time to locate trees while the feller was busy bucking the previously felled tree, and the logging clerk could lead the way to the next tree when the skidder was on its way to and from the landing. In Guyana, the density of the trees to be felled is often high. In this case, a low accuracy can influence the efficiency of the operation, because trees are being omitted or felled in the wrong sequence.

But what demands does Reduced Impact Logging (RIL) impose on the quality of the current inventory work? One of the major credits ascribed to RIL is the reduction of damage to the residual forest - especially to sub-adult trees of commercial species - by designating skid trails and by directional felling. For this purpose, it is important to know the number and condition of these potential crop trees (PCT), as well as seed trees, and to know where they are. Hence it is often suggested that they should be included in the pre-felling inventory. But it should be realised that the number of trees to be mapped doubles when trees only 10 cm below the cutting limit are taken, and triples when trees 20 cm below the cutting limit are taken. In the case of Guyana, where tree densities can already reach 20 trees per ha, there would be physically no space left on a map with a scale of 1:2,500. In Cameroon, larger map scales were experimented with, but did not improve accuracy. There are also practical reproaches; the daily coupe should be on one manageable map.

It is also suggested that the direction of fall of each tree to be harvested should be marked on the map. Indicating the expected and proposed direction of fall of a tree would require space to such an extent that the map would be fully filled and hence not workable.

CONCLUSION

To accommodate the demands that RIL imposes on forest inventory for harvesting (e.g. inclusion of potential crop trees, mapping of proper alignment of the designated extraction system, and indicating the direction of fall) requires more accurate topographic and tree position information and a better presentation of the inventory data. Within the current inventory technology, the current inaccuracies can only be partially tackled by increasing the scale of the maps and working with smaller inventory blocks. A switch to a completely new technology, GPS/GIS, for instance, may be inevitable.

Table 2 Pre-felling logging activities in two countries

Frequently mentioned activities	**Location**	**Cameroon**	**Guyana**
Planning	in camp	some	some
Climber cutting	in forest	no	no
Marking PCT	in forest	no	no
Marking Seed trees	in forest	no	no
Skid trail alignment	in forest	some	no

PRE-FELLING LOGGING ACTIVITIES

In the current discussions on Reduced Impact Logging, there is a lot of attention for activities that should take place before one proceeds with the actual felling of the trees that were enumerated during the inventory. A whole array of activities is mentioned in literature. It is usually advised to perform them during the inventory, or to base them upon the results of the inventory. The actual state of affairs in Cameroon and Guyana is that none of these activities are employed (Table 2). Their applicability was studied explicitly in Cameroon. In Guyana, three activities were incorporated in the RIL experiment: 1) planning; 2) climber cutting, and 3) pre-felling skid-trail alignment.

Table 3 Constituting elements of harvest plan preparation

Activity	**›Current practice‹**	**Reduced Impact Logging**
Manpower-machine input	present	frequently mentioned
Designation cutting blocks	present	frequently mentioned
Roads and landings	present	frequently mentioned
Designation buffer zones	absent/present	frequently mentioned
Skid rail alignment	absent	frequently mentioned
Tree selection system	absent	rarely mentioned
Seed trees	absent	rarely mentioned
Social trees*	absent/present	rarely mentioned
Exploitation level*	absent	rarely mentioned
Felling patterns*	absent	not mentioned

* = added by the authors

Planning

The preparation of the harvest plan requires a confrontation of the working-method outline - as described in the strategic plan - with the actual results of the inventory. Planning commonly comprises the planning of the monthly production, the machine and personnel input, and the planning of cutting blocks, truck roads, and landings. Some of the above elements are included in a ›close-to-best practice‹ situation, although usually in a crude form. The planning is mostly executed at forest-camp level and is pretty much a straightforward calculation of the machines and personnel needed, based on the commercial composition of the forest (number and volume of tree to be cut per species). Table 3 shows what is expected to take place under the RIL scenario, according to various publications and completed with impressions obtained at the two sites.

Most of the frequently-mentioned features of the RIL method are already in place at a considerable level at the two research sites. Under the present circumstances, however, the designation of ›buffer zones‹ is based on the abundance of commercial stems. Poorly stocked or hilly areas are left untouched because the cost/benefit ratio of exploiting those areas is too high. No consideration is given to uniqueness or richness of flora or fauna.

Silvicultural aspects, grouped in the ›tree-selection system‹, are rarely, or not at all, mentioned in current publications on RIL. For forests in Fiji, de Vletter (1993) mentions aspects like maximum attainable diameter per species, (10%) reduction for over-maturity, grouping of species, and diameter limits per group. Burgess (1989) also sums up silvicultural considerations: 70% of the trees in the 15-65 cm class are to be retained as growing stock for future harvests, and 40% of the trees in the 65-75 cm class. But hardly touched upon are the number of seed trees to be left standing during harvesting in relation to the distribution of mature individuals per hectare, or the regeneration strategy per species. Yet, when harvesting for sustainable forest management, these aspects must be taken into account.

Figure 1 Logging intensity: number of trees felled per hectare

A striking feature is that, under RIL, the setting of limits to the (absolute) logging intensity is hardly mentioned. It would seem that one might harvest as much as one likes, as long as one does so correctly. This is of course erroneous, as one may still end up with no forest at all. The study in Guyana revealed that by far the most important damage factor was not the logging method, but the exploitation level (Figure 1). Data from Cameroon confirm that, when one is talking about felling damage, intensity is a more decisive factor than the logging method.

Felling patterns (i.e. the distribution of felling gaps over the area) receive very little attention. Should clustered felling, creating multiple tree gaps, be promoted or rather discouraged? Data from the experiment in Guyana show that, if the felling intensity exceeds 8 trees/ha, the accumulated gap area is less in a conventional Greenheart operation (clustered felling) than in the experimental operation (trees to be felled evenly distributed). RIL compensates for this negative effect, however, by a smaller mean gap size. Apparently, we are being confronted with a trade-off. Is there a maximum or minimum gap size before we start talking about damage? Does it depend on the sort of forest we want to end up with? Again, not much has been published in this regard.

Loss of canopy cover as a percentage of total area (black and hatched parts of bars) and ground area affected by skidding (white and hatched parts of bars) as a percentage of total area in a conventional and an RIL operation in Pibiri, Central Guyana. With an intensity of 8 trees/ha, canopy loss is the same with either method, but, with an intensity of 16 trees/ha, it is higher with RIL. On the other hand, skidding damage is markedly more extensive with conventional logging. Also, skidding damage in canopy gaps (hatched parts of bars) is negligible with RIL and extensive with conventional logging. Ground disturbance in gaps will undoubtedly lead to the development of undesirable vegetation.

The interaction with the local population also remains largely beyond the scope of the publications on RIL. Accommodating the usufruct rights of local gatherers by the concessionaires (e.g. by sparing ›social trees‹ or crop fields) seldom receives attention, and yet the impact of harvesting on the life of the forest dwellers may be considerable. Small adaptations after consultation may well improve the situation at virtually no expense to the concessionaire. In Cameroon, the logging company decides not to cut certain trees, only upon request of the local population and only if the logger thinks the reasons are valid, with a strong inclination towards materialistic reasons rather than customary beliefs.

Climber cutting

Climber cutting is one of the most frequently mentioned tools to reduce felling damage. By cutting climbers some time prior to exploitation, it may be expected that they will have died and that the physical connections binding one crown with another will have weakened considerably. Falling trees may then be less liable to carry down with them their smaller neighbours. Similarly, while felling, fewer trees will be hung up when severed at the base. Studies on the effect of climber cutting on felling damage by Appanah and Putz (1984) and by Fox (1968) showed a substantial reduction of felling damage after climber cutting. Putz (1984) found that climber-infested trees carried down more trees in natural tree falls than did climber-free trees. To ensure that the vine stems have weakened sufficiently, it is recommended that they be cut about one year prior to logging (Pinard,1994), or even two years (Sarre *et al.*, 1996). Cedergren *et al.* (1994) report that pre-felling climber cutting has been found useful when opening skid trails with tractors. They also warn that climber cutting is ecologically questionable, climbers being an important source of food for the fauna. More user- friendly and efficient tools for climber cutting are needed; promising equipment is already available on the market.

In the Pibiri experiment in Guyana, lianas were cut about six months before felling. A comparison of

canopy opening due to felling between conventional and experimental logging did not show any clear difference in canopy opening due to liana cutting. Single tree-fall gaps did not differ in area; gaps containing two trees were slightly smaller with experimental felling, whereas multiple tree gaps were larger. The latter two differences were related rather to the felling pattern than to a climber-removal effect. One may argue that the period of six months was too short. Indeed, field observations during felling confirmed that in some cases the climber stems had not weakened sufficiently. Otherwise, there may have been differences in the density of lianas (unconfirmed). Besides climber cutting, there were other differences between the conventional and experimental logging method, specially the felling pattern, which may have concealed an effect of climber cutting. A definite answer to this question would thus require a specific study into the effect of climber cutting.

In Cameroon, a large-scale climber-cutting experiment was set up to test its effects on felling and skidding damage. In the experiment, with 3 treatments and 7-11 repetitions on 1 hectare plots, climbers were cut 9 and 4.5 months before tree felling. Tentative results show that gap size does not decrease with pre-felling climber cutting. Nor was it demonstrated that the level of damage to individual trees had decreased (Parren, 1998). Canopy openness after skid-trail construction with and without climber cutting did not show any great differences either. Again, one may argue that the time that had elapsed after cutting had been too short, but field observations did not confirm this in Cameroon.

Marking of potential crop trees (PCTs) and seed trees

The marking of potential crop trees (PCTs), in combination with directional felling, is frequently cited as an important tool in reducing damage to the (commercially interesting part of the) residual stand. This aspect was only studied in Cameroon and results are not yet available. Questions in this study are: the phase in which tree marking should take place (during or after inventory, during felling) and the visibility of marked PCTs during felling.

In the Guyana experiment, marking of PCTs was deliberately omitted. In this respect, we have to distinguish between preserving PCTs during felling and during skid-trail construction. During felling, attention was given to the retention of PCTs, but this was secondary to achieving the desired felling pattern. The motive behind this was that a trade-off was expected between choosing for a particular felling pattern (herringbone system) and the retention of PCTs. It was argued that any deviation from the felling pattern would increase the extent of ground disturbance, and also that, during log extraction, it would increase the probability of killing trees that were spared during felling. It was found, however, that strict adherence to the felling directions was not absolutely necessary to achieve the desired pattern (van der Hout, 1996; van Leersum, 1984). With regard to safeguarding trees during skid trail construction, this would require important changes in the procedure for skid-trail alignment. The alignment of the skid trails was marked on the ground prior to felling, on the basis of topography and on a fixed distance between trails. Clearly, it is hardly an option to adjust the alignment in order to safeguard a single PCT, for this would result in undesirable winding of the planned trails, while small diversions would probably not even guarantee that marked trees would be spared.

In summary, felling directions can be adjusted to accommodate the safeguarding of PCTs because of the flexibility when extracting logs. Under Guyanese forest conditions, these adjustments can easily take place at the moment of felling (but probably not under Cameroon:s forest conditions). To avoid unnecessary killing of PCTs during skid-trail construction, it would be necessary to map PCTs and adjust alignments on a map, because *ad hoc* adjustments would lead to sudden diversions. The pros and cons of including PCTs during the inventory have been discussed above. Whether such an activity is necessary will depend strongly on the abundance of PCTs.

Conclusion

Newly-proposed activities in selective logging in mixed tropical forest are extended planning and subsequent pre-felling forest operations. These, by far, require the most labourious adaptations. If they are to be executed in their most extended form, as suggested now in the various publications on RIL, the implications for current practices will be strong - stronger than in the other harvesting stages. They would require:

- Staff capable of obtaining silvicultural, ecological, and sociological data and including these data in harvesting planning;
- Adequate instruments to elaborate the inventory results and communicate harvest prescriptions;
- Intensive communication between office and forest camp;
- Intensive communication between forest operations.

These implications should be seen against an environment which, at present, possesses far from a proper administration and communication structure.

FELLING

As for felling, many publications deal with what could be called the improvement of conventional felling practices. Making proper felling notches, avoiding undermining of the notch, improved cross-cutting, and so on, are all directives to improve safety and to benefit cut-wood utilisation, which came with the introduction of the chainsaw in tropical forestry in the thirties. Nevertheless, only rudimentary elements of what was once controlled felling are being practised nowadays, because of the poor education system of on-the-job apprenticeship in the forest. The necessity to renew the controlled felling concepts amongst fellers in the tropics is becoming more and more apparent.

The really new concept in the discussion on felling may be directional felling. To master this technique, a more extensive knowledge of mechanics and of the tree's properties would be required. Directional felling is quoted by many authors (Mattsson-Mårn and Jonkers, 1981; Hendrison, 1990; Malmer and Grip, 1990; Gullison and Hardner, 1993; Pinard *et al.*, 1995; Pinard and Putz, 1996; Johns *et al.*, 1996; Cedergren *et al.*, 1994; Whitman *et al.*, 1997) as a new concept for the purposes listed in Table 4.

Table 4 Justification for directional felling under RIL and its validity at two research sites

Purpose	**Cameroon**	**Guyana**
Reduction of damage to potential crop trees	Questionable	Questionable
Facilitation of skidding	No	Yes
Reduction of damage to the felled trunk	No	Yes
Creation of multiple tree gaps	Questionable	Yes

By steering the tree to be felled in a certain direction, the destruction of the surrounding young potential crop trees can supposedly be avoided. Instead of tearing off valuable tree crowns, cut trees may hit commercially less-interesting species instead, or may be directed towards natural gaps in the vegetation.

In both countries, it was proved that directional felling is technically possible. In Cameroon, the large diameters and large buttresses do not hinder a successful execution. Wedges are not needed to make the emergent trees gain momentum for the fall. In the experiment in Guyana, a direction of the lie favourable to skidding was the primary objective. Where possible, trees were felled at obtuse angles (30-45°) to the skid trails for ease of skidding. In the field, the felling direction could be adjusted for

the sake of safety to the feller, for the avoidance of damage to the harvested tree and potential crop trees, and for the avoidance of hang-ups. It appeared to be hard to predict how far the impact of a falling tree will reach from the epicentre of its fall, especially when domino effects take place. To be safe, it would probably have been necessary to divert more than 45 degrees from the designated felling direction. Diversions to such an extent would have fouled up the felling pattern and were generally not allowed, but felling in the opposite direction was practised frequently. Despite these efforts, PCTs suffered in the same proportions as non-commercial trees, which means there must have been other reasons for this equality, one of which may be the abundance and dispersion of the PCTs. In Cameroon, simulation with inventory results did not indicate any need to deviate from the natural direction of fall in order to avoid potential destruction of potential crop trees: in whichever direction a tree would be felled, a potential crop tree would be destroyed. In summary, the results from both Guyana and Cameroon indicate that employing directional felling to avoid damage to PCTs is quite equivocal.

Skidding may be facilitated by felling the tree under an angle that makes it easier for a machine to skid or winch the log immediately into the desired direction, instead of having to change the position of the log. The low harvesting levels in Cameroon (Table 1) and the scattered dispersal of the felled trees led to long skidding distances between consecutive logs. These conditions, combined with the impracticability of log winching (see *Skidding* below), are not calling for any scrupulous planning of the direction of fall of a tree. Whatever the angle of the log, the machine could nearly always get to it without deviating too much from the most logical trail pattern.

In Guyana, the extent of skidding damage was reduced tremendously by applying RIL, regardless of logging intensity (Figure 1). This can be mainly contributed to an almost complete reduction of movements around the stump (data not shown). This was achieved by winching the bole to the machine, which in turn was made possible by the favourable position of the logs. As mentioned under *Marking of potential crop trees*, a trade-off between directional felling to safeguard PCTs and directional felling for the ease of skidding is inevitable (although the usefulness of directional felling in retaining PCTs could not be demonstrated by us). This was also pointed out by Cedergren *et al.* (1994), who suggested narrowing down the number of PCTs to be protected through a distinction between PCTs and Next Crop Trees (NCTs). The latter would receive a higher priority for protection. According to their prescriptions, tree crowns should be directed to fall onto skid trails to minimise canopy openings. Such prescriptions would amplify the trade-off, because felling debris on skid trails would have to be chopped up before skid-trail construction.

A reduction in felling damage to the trunk may consist of reducing the loss of wood through breakage when the trunk hits rocky outcrops, felling downhill, suspension of the tree in other crowns, or trees sliding into the bottom of a valley. Under the terrain conditions in the study areas in Guyana and Cameroon, this occurred in less than 1% of the cases.
The creation of multiple tree gaps versus single tree gaps is a question that was highlighted earlier under felling patterns. Directional felling can assist in either of these strategies. Unfortunately, it is not clear which of these strategies should be applied at the two sites.

Results from Guyana showed that the proportion of gaps formed by a single tree, or by two or multiple trees, was influenced both by the logging method and the logging intensity. At an intensity of 8 trees/ha, fewer than most gaps contained less than 3 felled trees with RIL whereas, with conventional logging, 15% of the gaps fell into this class. At an intensity of 16 trees/ha, a quarter of the gaps fell into this class with RIL whereas, with conventional logging, more than half fell in this class. The size of the canopy openings was mainly determined by the number of trees contained in the gap. As mentioned earlier, the total gap area was increased by employing RIL at the highest logging intensity,

and apparently we are being confronted with a trade-off. Applying RIL, with its regular felling pattern, is leading to smaller gaps, but also to a higher total gap area when a certain logging intensity is exceeded. Knowing that, in terms of sustainable forestry, large gaps are far less desirable than small gaps (see e.g. ter Steege *et al.*, 1996), one might still opt to employ the experimental logging method. Nonetheless, also from this point of view, it is of paramount importance that an upper limit to the absolute logging intensity is a prerequisite for sustainable forestry,.

Conclusion
Felling standards surely need improvement, but most of them deal with reinforcing the concepts of controlled felling. Directional felling may only be rarely applicable in Cameroon, whereas in Guyana its usefulness is clear, but so, too, is the increased complexity of decisions to be made because of the trade-off between the various purposes of directional felling. Also, it has become crystal-clear that a high logging intensity neutralises the beneficial effects of directional felling.

SKIDDING

Concerning skidding, it may again be useful to distinguish between practices that have been common for the last decades, but have somehow eroded, and totally new concepts. When bulldozers and skidders were first introduced into the scene of tropical forestry, the extraction of wood was based on inventory maps and was closely supervised. These costly machines have never entered the forest without even the slightest planning. Over the last decade, however, supervision of skidding activities in the forest has steadily declined, and also many new, less-well-organised entrepreneurs, copying everything but the planning aspects, have entered the scene.

The new concepts of RIL comprise:
- Detailed planning of the skid trails on the map;
- Detailed alignment of the skid trails in the forest;
- Log winching to the skid trails.

Planning the skid trails
Planning the skid trails as proposed by RIL goes further than the conventional planning of skidding, in principle, intends to go. Where a primary skid trail should pass and where secondary tracks should branch off is no longer a mere indication on the map. Under RIL in its most extreme forms, we may want to plan nearly every movement of the machine and plan the order in which logs are to be extracted. This should all translate into a map with self-explanatory information for the alignment crew.

Skidding in the ›close-to-best practice‹ situation in Cameroon is still portraying some degree of planning, basing itself on maps and some elementary skid trail alignment in the forest by the crew chief just before the machine enters the forest. Post-logging damage patterns also indicate a reasonable amount of planning in the skidding activities. This impression is reinforced through method studies and interviews with crew members. Skidding damage can be reduced (by as much as 30%), not so much through a better planning on the map or in the forest, but through closer supervision during the execution of the skidding and a better transmission of felling results to the skidding crew beforehand.

The results obtained at both sites will be discussed in the sections below.

Alignment of skid trails
Many authors advise signposting or flagging skid trails before actual skidding takes place. Some

combine this with marking the trees to be felled or trees to be preserved (de Vletter, 1993). Pinard (1994) proposes that, after the appropriateness of the planned locations has been confirmed in the field, the proposed routes for skid trails and their end-points be marked with paint. In addition, all harvestable trees are painted with a paint slash that indicates the preferred felling direction. Putz (1994) adds the necessity of specifying the construction and use practices. Cedergren *et al.* (1994) aligned their trails at a distance of 60 m, as parallel to one another as nature allowed, following natural borders such as streams and ravines. Sharp curves were avoided and culverts in the trails consisted of hollow logs. The PCTs along the trail were marked. Restricting tractors to ridge tops only would not allow logging at full intensity. There is no reason to believe that skidding would be less efficient on pre-aligned trails - rather the opposite.

While planning primary and secondary skid trails along the contours is already an existing activity in Cameroon (and Suriname), detailed alignment of the skid trail represents an additional harvesting activity. Skid-trail alignment (and construction of the trail) can be done before or after felling. In Cameroon, post-felling alignment of the skid trail was done before the extraction of 165 trees by a Caterpillar (CAT) 528 skidder. The alignment was based on an improved inventory map (scale 1:5000). The marking in the forest was then done in the presence of the skidder operator in order to let him indicate whether or not he could pass certain obstacles or between certain trees. Apparently, the scale of the map (1:5000) was not detailed enough, because this inspection led to important deviations from the planned route. Later, when actually opening up the skid trail, further deviations from the aligned track had to be made because, once the operator was on his machine, the situation proved to be more difficult (i.e. more hilly) than he had originally foreseen. Also, parallel routes had to be created because the carrying capacity of the soil did not permit more than a few passes. Finally, the order in which the logs were extracted changed dramatically because of the inaccessibility of large parts of the terrain after heavy rains. Bulldozers had to be deployed to evacuate most of the wood.

In the Pibiri experiment in Guyana, skid trails were aligned with a 80 m spacing, where topography allowed this. Skid trails were planned on a very detailed map (1:1000), marked in the forest before felling, and constructed after felling by a CAT 528 skidder. The system worked well, but it should be noted that it was intensively supervised. It should also be noted that the scale of the experiment was rather small (cutting blocks of 6 ha only) and that the terrain was rather easy, with sandy soils and few slopes. It is questionable whether such detailed planning and intense supervision is (economically) feasible on a large scale. Surprisingly, the total area of the actual trails was only slightly reduced, compared with a conventional operation. As mentioned under *Felling*, the main beneficial effect of the RIL system was the elimination of movements in the bole zone. Winching is playing a major role in this respect.

Log winching

Log winching (in combination with skid trail planning and alignment) is commonly advocated for its damage-reducing features. It consists of restricting the movements of the extraction machinery to the greatest extent possible. The skid-trail grid is designed in such a way that the machines do not need to deviate from the secondary trails to fetch the logs; these are being winched over distances of up to 30-50 m from the stump to the skid trail. It is strictly prohibited to manoeuvre around the stump to position the log in such a way that the skidding crew can easily attach the cable and proceed; this has been replaced by two crew members pulling the winch cable over a considerable distance. The advantages are twofold: logging damage (around the stump and tertiary trails) is reduced, and machine productivity is considerably increased.

In Guyana, skidding in accordance with the RIL principles proved to be highly effective. Hooking did

not present many problems because the majority of the log diameters were below 70 centimetres. Winching distances of up to 30 m were subsequently attained, resulting in a strong decrease in affected ground area (Figure 1). Since winching is playing a decisive role in reducing skidding damage, one might argue that directional felling and skid-trail planning are subordinate and, therefore, could be de-emphasised. Nevertheless, it should be clear that the feasibility of winching depends greatly upon the felling pattern and the skid trail alignment, both being determined by the planned extraction route.

In Cameroon, an experiment with the skidding of 165 trees revealed severe limitations to the applicability of RIL concepts. Hooking, even when a specially designed skidding stick was used to pull the cable underneath the log, proved to be impossible for most of the logs with diameters of over 100 cm and weights of more than 6 tonnes. Winching the log from the stump site frequently yielded the opposite effect, with the machine being pulled to the log instead of the other way round. Most of the supposed beneficial effects in terms of damage reduction therefore proved not to hold true. Table 5 summarises the results obtained at the two sites.

Table 5 Log winching to the skid trail. Tentative results of studies of the two Tropenbos sites

Country	**Activities**		**Effects**	
	Hooking	Winching	Reduction tertiary trails	Reduction manoeuvring
Cameroon	negative	negative	negative	positive
Guyana	positive	positive	positive	positive

Conclusion
Especially when the number of trees harvested per hectare is high and log dimensions are small, as in Guyana, the RIL concept is applicable. In Cameroon, where the opposite prevails, the need and possibilities for a switch is less evident. But, a better organisation and closer supervision of the current skidding phase could already reduce damage considerably.

DISCUSSION

Reduced Impact Logging (RIL) has been hailed as an important step towards sustainable forest management. Given the current state of knowledge, however, it is not clear whether specific practices will actually achieve the desired outcome. One of the reasons for this is that criteria with which to assess the environmental acceptability of various harvesting practices are neither yet fully available nor globally applicable (*cf*. Dykstra, 1996). Most recent publications on this subject seem to agree on an array of activities that will reduce the environmental impact of selective logging in mixed tropical forest. The authors of the present paper have screened these activities against their experiences in Cameroon and Guyana, which has resulted in the following comments on the applicability of RIL.

1. Studies on Reduced Impact Logging (RIL) conducted by Tropenbos in two continents reveal that this concept is not always fully applicable and does (or will) not always lead to less damage than conventional logging practices.
2. Although Reduced Impact Logging is a great step forward, silvicultural, ecological, and sociological considerations need to be added to this technical concept in order to better meet the demands of sustainable forest management, whatever they may be.
3. The set-up and scale of published experiments in which the added value of RIL is being tested are mostly biased and small and not sufficient to convince potential users or legislators.
4. Reduced Impact Logging is an example of developing one of the aspects of ›precision forestry‹ in

the tropics. We can still push for more precision, but improving current conventional practices, taking them to the level of ›the best practice‹, has a far greater impact on forest conservation. The conditions for this improvement lie in better planning, organisation, and supervision in the forest during operations and more adequate training and remuneration of personnel.

5. A careful study of current harvesting practices reveals strong ties between the forest activities on the one hand and, on the other, the demands within the rest of the production chain of the logging enterprise. Even when the economic and financial feasibility of a complete shift towards RIL is clearly demonstrated to a logging enterprise, pressures from outside the forest (and even outside the company) will continue to dictate the forest protocol.
6. The (partial) applicability of RIL guidelines should be taken into account when timber certification schemes are being devised. Non- compliance with what may be globally proclaimed as the solution may have its good reasons locally and may be totally justifiable.
7. On inventory: because of the necessity of integrating silvicultural, ecological, and sociological considerations in logging practices - in Guyana as well as in Cameroon - current inventory practices may need considerable upgrading. Drastic changes in the scale of maps and level of detail during field work, as well as other maps and map-information management, have become inevitable.
8. On pre-felling logging activities: in Guyana as well as in Cameroon, harvest planning following forest inventory will have to shift from a mere ›rule of thumb‹ exercise at the landing site to a more silviculturally-oriented office-level planning process. In this process, attention must be given to the exploitation level, the felling pattern, and the density of potential crop trees and seed trees to be left standing. At forest level, this extended planning will see itself translated into an additional harvest phase before felling, consisting of marking trees to be cut and their direction of fall, marking potential crop trees, and skid-trail alignment. Climber cutting may not necessarily be included in this exercise.

9. On felling: in Guyana, directional felling is an inextricable component of an RIL approach, being a pre-requisite to reducing skidding damage. In Cameroon, although technically feasible, the importance of a shift to directional felling is less evident.
10. On skidding: skid-trail planning and winching are the most promising techniques for Guyana. In Cameroon, winching seems technically impossible in most cases because of the large wood diameters. It may be possible to substantially reduce damage and to increase efficiency by introducing radio communication, skidding sticks, and choker bells, and by reducing blade utilisation.

In summary, the scope for RIL appears to be greater in Guyana than in Cameroon. This is mainly attributable to the higher logging intensity and the smaller log sizes. Nevertheless, it was recognised that the beneficial effects of RIL are strongly tempered if the logging intensity is raised above a certain level. It was also recognised that there is a series of trade-offs that have to be dealt with:

- Directional felling in order to preserve PCTs can adversely affect the ease of skidding and the inherent skidding damage;
- The felling pattern formed by ›herring-bone‹ felling, being a prerequisite to reducing skidding damage, can, with high logging intensities, lead to a larger total gap area;
- Averting multiple tree-fall gaps, in order to form smaller canopy openings, can lead to a higher total gap area (less overlap of tree-falls).

To deal with these matters, ecological and silvicultural thresholds need to be set. Hence, research questions in the fields of forestry, silviculture, and ecology need to be attuned to one another to investigate these thresholds.

Criteria by which to assess the environmental acceptability of various harvesting practices are thus not yet fully available. Combined with the multiplicity and complexity of the trade-offs that are involved, this means that it is impossible to provide standard RIL recipes. Different approaches may be needed in different places and at different times, even within a single country. Moreover, RIL would require extended planning and pre-felling forest operations, flexible scenarios, and dealing with a series of trade-offs. Even though good harvesting practices may be a prerequisite for sustainable forestry, their introduction will definitely not be easy. Quoting Dykstra (1996) in this respect: ›*If it were easy, the majority of forest harvesting crews around the world would already be doing it, and they are not*‹.

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REDUCED IMPACT LOGGING: A GLOBAL PANACEA? COMPARISON OF TWO LOGGING STUDIES

Achievements
- Techniques of Reduced Impact Logging have been developed.
- There is a good insight into the relative contribution of the various field operations to reduce damage and increase efficiency.

Challenges and Problems; Information Needs
- The limited integration of future silvicultural objectives in current logging practices.

Points for Future Research
- Improvement of best current practices of logging.
- Technical and organisational aspects of logging.
- Integration and comparison of logging studies conducted in different localities.
- Research questions in the fields of forestry, silviculture, and ecology must be attuned to one another to investigate the thresholds involved in Reduced Impact Logging.

Conclusions
- Reduced Impact Logging comprises many elements, which are neither always, nor everywhere, nor completely applicable in all situations.
- Silvicultural objectives should, more than is the case at present, be incorporated in the logging strategy. This puts higher requirements on quality and interpretation of the pre-logging inventory.
- While directional felling and winching are important tools in Reduced Impact Logging in Guyana, their application in Cameroon is prevented by technical constraints (the trees are too large).
- Detailed comparisons and combinations of results from logging studies from different research projects greatly enhance our views.
- Although research on forest operations can contribute greatly to the reduction of damage, technological and managerial improvements and political and legal measures are of far greater importance.
- Ecological and forestry research should be matched (e.g. by using create-use matrices).

[1] Best practice means that inputs are used with the highest technical efficiency according to available knowledge and techniques (de Koning *et al*., 1995). Since this is a rather theoretical concept the next best would be >close to best= (or next best) practice.

IMPROVING SILVICULTURAL TECHNIQUES FOR SUSTAINABLE FOREST MANAGEMENT IN INDONESIA

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1. INTRODUCTION

Indonesia has the largest remaining natural Dipterocarp forest in the South-East Asian region. The forest has been playing an important role in Indonesia since the early 1970s, after the Government had enacted the Foreign and Domestic Investment Law in 1967 and 1968. The forests are the main natural resource for the economic growth of the country. After natural gas and oil, forest product exports (mainly plywood, sawn timber, and rattan) are the second highest foreign exchange earners for Indonesia. The natural forest is now receiving more attention from the Government since environmental issues have appeared on the agenda in the last decade.

Nowadays, the forest area of Indonesia is 141.2 million hectares, of which 92.4 million hectares are planned to be retained as forested area. These forests are managed in the form of concessions given out to private and State-owned companies. There are 483 concessions (HPH) in Indonesia, covering an area of 55.6 million hectares (Ardjojoewono, 1995).

During the last 25 years of forest exploitation in concessions, an area of about 40 million hectares throughout Indonesia has been logged-over. The condition of the logged-over areas varies from *belukar* (scrub) to high potential logged-over forest, depending on the way the logging operations were carried out. Most of the logged-over areas from the early 1970-s possess a very good residual stand, at least that is, if no re-logging has been done. These logged-over areas should be regarded as the future timber resource for the Indonesian forestry industry. It is therefore very important to focus attention on the management of logged-over areas for the sustainable production of logs as well as for the future of the forest ecosystem. This is a crucial point for the future of Indonesian forestry.

2. SIVICULTURAL SYSTEMS APPLIED IN INDONESIAN FORESTRY

2.1 The Indonesian selective felling and replanting system (*Tebang Pilih dan Tanam Indonesia, TPTI*)

At the beginning of forest exploitation in Indonesia, no silvicultural systems were applied. There was no felling limit, nor any other requirements for harvesting in natural forest. The only limitation at the time was the limited market for commercial tree species. Only a few species belonging to the red and white Meranti groups were highly commercial on the market. Most of the other tree species belonging to the family of Dipterocarpaceae were known as lesser-known species. The very limited number of commercial trees that were harvested from the natural forest might have created the high potential residual stands in the logged-over areas that were mentioned above.

In 1972, the first silvicultural system, called the Indonesian Selective Felling System (*Tebang Pilih Indonesia*) was introduced. The *TPI* System was a modification of the Malayan Uniform System of Malaysia and The Philippine Selective Felling System. The System was meant for the management of natural forest outside of Java. It consists of selective felling, clear felling with replanting, clear felling

with natural regeneration, and subsequent maintenance. This System was applied until 1989, when a new system for natural forest management in Indonesia was introduced as a revised version of the previous one. The new system was called the Indonesian Selective Felling and Replanting System (*Tebang Pilih dan Tanam Indonesia, TPTI*). Its objectives were to regulate the production in natural forest and to increase the value of the residual stands for the next cycle (rotation), both in quality and in quantity. It was also meant to create the mixed stands that can be expected to function as sources of sustainable timber (Soerianegara, 1995).

Apart from a diameter limit, the main aspect of the *TPTI* System was considered to be the regeneration and maintenance of the residual stand. The *TPTI* System consists of a set of rules for the entire sequence of silvicultural techniques applied before and after harvesting (Table 1).

Table 1 Scheduling of the activities required for the TPTI system

	Activity	**Planning** (years before or after harvesting)
1	Design of the working area	- 3
2	Pre-logging inventory	- 2
3	Road engineering	- 1
4	Harvesting	0
5	Refinement I	+ 1
6	Inventory of residual stand	+ 1
7	Production of planting stock	+ 2
8	Enrichment planting	+ 2
9	First tending	+ 3
10	Refinement II	+ 4
11	Thinning	+ 9
		+ 14
		+ 19
12.	Protection and Research	Continuous

The purpose of the *TPTI* System is to regulate the logging and regeneration of natural forest, especially lowland production forest, which is stocked with at least 25 trees per hectare. The lower diameter felling limit for trees to be cut is 50 cm for lowland forest and 60 cm for hill forest and limited production forest. There are several basic principles to the *TPTI* System:

- Stand inventory, including the structure of the regeneration, species composition, and site characteristics;
- Limits to the diameter and the number of trees to be cut in order to create a highly productive residual stand for the next rotation;
- Maintenance of the residual stand, protecting the forest as a whole, and maintaining the highly necessary biodiversity of the forest.

The fact that a single silvicultural system was applied universally and indiscriminately in all the different types of natural forest in Indonesia might be the reason why *TPTI* did not work effectively in certain areas. Some disadvantages were encountered during its implementation in Indonesia. Sutisna (1990) has criticised the fact that some of the treatments required by *TPTI* lack a scientific basis, especially the refining and liberation treatments. He observed that refinement of the understorey vegetation might be inadequate to improve diameter increment, because the main factor determining

growth is light intensity, rather than root competition. Similarly, the killing of non-desired species during liberation treatment may not be an effective measure to improve the growth of the potential tree crop (Sutisna, 1997). Liberation thinning, however, has proven to be the most effective silvicultural treatment to induce the growth of the residual stand in Sarawak (Hutchinson, 1981), even though this was with different timing sequences as are required in the *TPTI*.

Another criticism that has often been addressed to policy-makers is that the usual concession right of only 20 years might not stimulate the companies to implement the *TPTI* completely , especially not where the System requires the replanting of those areas in which insufficient regeneration occurs. In reality, *TPTI* is a poly-cyclic silvicultural system with an expected rotation of about 70 years. The annual allowable cut under *TPTI* is based on a 35-year cutting cycle, with the assumption of an average annual tree diameter increment of 1 cm. The uncertainty of the future concession rights stimulates the fast deforestation of a forest area. Most concessionaires try to harvest as much as possible during the 20-year period of concession right given to them, with a minimum of investment returning to the forest.

Many of the concessionaires therefore have less than the expected area of virgin forest left at the end of their first concession period of 20 years. An evaluation of concession-holder performance by the Ministry of Forestry revealed that 11% of the concession holders have a good performance classification, with 73% this is fair, and 16% have a bad performance (Simon, 1997). The Government then recalled the concession rights of the bad performance concessionaires and gave the State-owned companies the responsibility of continuing the management of these concessions. The assessment in 1996 showed that afterwards the performance improved to 21% good, 77.7% fair, with 1.3% remaining bad (Tantra and Hutabarat, 1996).

It is very expensive to implement the entire cycle of activities required by the *TPTI*. It costs about US$10-15 for every cubic metre of log retrieved from the forest. To obtain permission to carry out his annual cut, however, every concession holder has to fulfil all the requirements of the *TPTI*. This situation leads to the manipulation of data and reports from the concessionaire to the authorities, while at the same time the authorities have a very limited capacity to check all activities in the field, because of the lack of proper technology and human resources.

Enrichment planting after logging - one of the requirements of the *TPTI* - is no guarantee that rights will be obtained to harvest these trees in the future. No reliable guidelines are available that show the most efficient way to grow and maintain such plantations. There are very few examples of successful line planting producing future harvests, just because of the lack of management of the plantation in the field. The most important factor in managing line plantations is the optimal light conditions for the seedling after being planted. In the history of *TPTI*, no intensive management has been applied for line plantations.

During the 25 years of implementing the *TPI* and *TPTI* Systems in Indonesia, both have proven difficult to execute correctly in the field. Many of the activities required by the Systems are omitted by concessionaires, and the condition of the logged-over forest is not as good as could be expected. An evaluation of the implementation of the Systems has clearly indicated that production forests were managed inadequately and improperly (Anon., 1990). This situation has forced the Ministry of Forestry to find an alternative reliable system to guarantee the sustainable production forest products as well as the sustainable functioning of the ecosystem, especially in logged-over areas and in the remaining natural forest. *TPTI*, however, is still an official system applied for the management of natural forest in Indonesia.

2.2 Strip-cutting and replanting system (*Tebang Jalur dan Tanam Indonesia, TJTI*)

The Indonesian strip-cutting and replanting system (*TJTI*) is an alternative silvicultural system applied for logged-over areas in Indonesia, following guidelines decreed by the Director General of Forest Utilisation in 1995. The system is based on the strip clear-cutting system developed by the Tropical Science Centre in Costa Rica. The system prescribes that strips that are harvested and replanted alternate with strips that are not harvested (conservation strips). All trees with a diameter of 20 cm and up are removed in the harvested strip. No cutting is allowed in the conservation strip. Replanting of the harvested strip has to be done one year after exploitation (Table 2).

Table 2 Scheduling of the activities required for the TJTI system

	Activity	**Planning** (years before or after harvesting)
1.	Design of the working area	- 1
2.	Pre-logging inventory	- 1
3.	Road engineering	- 1
4.	Harvesting	0
5.	Refinement	+ 1
6.	Residual stand inventory	+ 1
7.	Production of planting stock	+ 1
8.	Planting	+ 1
9.	Planting maintenance	+ 2 to + 5

The *TJTI* System is now being tested in several concession areas. Several alternative combinations of harvesting and conservation strips are being tested, whereby the width of strips is 50 m, 100 m, or 200 m. The system is based on a rotation time of about 70 years, with a cutting cycle of 35 years. It has not yet been determined whether the conservation strip could be harvested in the next cutting cycle. If that is not so, this would imply that the area of production forest would be reduced to 30 or 50% of the present area. This aspect is still being discussed by forest management scientists.

The preliminary results from the trial have led to two different recommendations, concerning in particular the width of the strip. One recommendation was to use a combination of 100 m cutting strip with 100 m of conservation strip. In contrast, the alternative recommendation was to use a combination of 200 m of cutting strip with 100 m of conservation strip. The argument for the latter recommendation was that a 200 m harvesting strip minimises the damage to the forest, especially the compaction of soil, because tractor movement can be more flexible during skidding. This recommendation was based on technical considerations only, and it was not mentioned whether ecological aspects were considered.

During the implementation of this system, there are some technical as well as economic problems to be considered. Because strip cutting is in a straight line, many conservation areas (e.g. buffer-zones around rivers and steep slopes within the strip) would be damaged during the harvesting. An economic problem is that, on the one hand, many of the smaller logs will remain unsold if all trees of more than 20 cm in diameter are harvested, even though the cost of harvesting small-diameter trees is about the same as harvesting large-diameter trees. Most of the concessionaires are not interested in harvesting these small-diameter trees. On the other hand, there is no guarantee that high potential commercial trees in the conservation strips will not attract the logger and be harvested. This will in fact lead to selective logging in the conservation strip. One should bear in mind that the *TJTI* System legally allows concessionaires to harvest in logged-over areas, something that is not possible under the *TPTI* System.

As an alternative system that was introduced four years ago, it is still open to discussion whether *TJTI* will be effective enough to manage the logged-over area in Indonesia. Before a decision can be taken to adopt *TJTI* as a national policy, we have to await the results of further comprehensive studies that are still being conducted by several research institutions and universities.

2.3 Felling and line-planting system (*Tebang dan Tanam Jalur, TTJ*)

TTJ, the felling and line-planting system, is a new system put forward by the Ministry of Forestry as an alternative silvicultural system for logged-over areas that are not suitable for timber plantation after clear cutting. *TTJ* consists of two main aspects: harvesting and line planting with intensive maintenance. The System was issued in two separate decrees in 1997. Its objectives are:

- To optimise the utilisation of natural production forest;
- To improve the quality of logged-over areas by replanting with high-value commercial trees, especially the species belonging to the family of Dipterocarpaceae;
- To facilitate the supervision and control of forest regeneration activities in the field.

The general principles of *TTJ* are:

- The system is applied in lowland production forest that is not suitable for clear cutting;
- The limit diameter for cutting is 40 cm and above;
- The period of concession right is 70 years (35 years + 35 years of rotation);
- The planting distance is 5 metres in line, and 25 metres between the lines (5 by 25 metres). To counter the effects of mortality after seedlings have been planted, it is recommended that three seedlings be planted per planting site. The total number of seedlings to be planted per ha is 243;
- By having a concession right for a timber plantation, the plantation belongs to the concessionaire and can be regarded as an asset for him. With any legal change in the land-use status of the concession area, he can claim compensation for any investments made in the concession area (e.g. planting, road construction, building, etc.). Here, *TTJ* differs greatly from the concession right given under the *TPTI* System. In *TPTI*, the concession is still legally in the hands of the Government, while the company has the right to manage the existing forest. Under the *TTJ* System, however, the concessionaires also have the right to manage the forest as a plantation, which means that compensation can be claimed whenever the legal status of the land use is changed. This system would also assure the certainty of long-term management of the area - for at least a 70 year period.

An intensive plantation management will prevent land encroachment and illegal logging after harvesting. These processes are very difficult to control under the *TPTI* System, because the maintenance of the logged-over area after logging is usually omitted by the concessionaires.

Table 3 gives an overview of the activities that form the *TTJ* System.

Table 3 Scheduling of the activities required for the TTJ system

	Activity	**Planning** (years before or after harvesting)
1.	Design of the working area	- 2
2.	Road engineering	- 1
3.	Production of planting stock	- 1
4.	Harvesting of trees above 40 cm	0
5.	Land preparation	0

6.	Preparation of lines for plantation	0
7.	Plantation	0
8.	Maintenance of plantation	+ 1 till harvesting
9.	Plantation protection	continuous

It is too early to judge how effective *TTJ* will be. On the basis of previous experiences of managing plantations, there are several questions to be addressed in this System:

- What is the economic feasibility of the plantation, considering the relatively small number (3 times 83 seedlings per hectare) of seedlings to be planted in the concession area?
- Is it interesting for concessionaires to harvest all trees over 40 cm diameter, as required by the system, knowing that some of the trees belong to lesser-known species?
- What further silvicultural treatments are required for the management of the plantations, including maintenance, thinning, and harvesting? The existing documents supporting this system do not cover these aspects.

3. RESEARCH NEEDED

Cooperative research efforts and programmes are badly needed to support the sustainable management of the expanded logged-over areas in Indonesia. Some specific research needs are:

- To find the proper plantation techniques for local tree species such as Dipterocarps and other high-value tree species;
- To provide a cheap and easy method for post-harvest evaluation for the effective monitoring of concessionaires;
- To develop a management system for logged-over areas by providing reliable guidelines with a scientific basis for improving the residual stand for the next rotation. This can be done by testing existing silvicultural systems and making recommendations for improvement;
- To study the possibilities for, and the effects of, reduced impact logging;
- To establish the criteria and indicators for sustainable forest management that can easily be understood by multi-level management (from field supervisor to top management).

As a leading cooperative research project in Indonesia, the Tropenbos project should review its programme in order to keep in touch with the current issues and forestry problems as outlined above. In this way, it will be able to increase its contribution to sustainable forest management in Indonesia. It should be mentioned that some of the above-mentioned research topics have been addressed in the framework of the International MOF-Tropenbos-Kalimantan Project and should be extended to the concessionaires.

4. CONCLUSION

During the implementation of several silvicultural systems in Indonesia, some disadvantages have surfaced that need to be addressed scientifically. The logged-over areas that result from past harvesting under the *TPTI* system have to be managed with improved silvicultural techniques that are now being developed in Indonesia. Alternative systems that have been introduced still need to be tested comprehensively, in both their technical and ecological aspects. Nevertheless, several research findings have yielded sufficient information on the principal management aspects, but we still need more information in order to optimise the techniques before they become applicable in the field.

Research priorities should be set in order to support the sustainable management of logged-over areas.

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IMPROVING SILVICULTURAL TECHNIQUES FOR SUSTAINABLE FOREST MANAGEMENT IN INDONESIA

Achievements

- Development of several silvicultural systems for sustained timber production.

Challenges and Problems; Information Needs

- Universal application of a single silvicultural system leads to unsatisfactory efficiency in certain areas.
- Problems with the scientific underpinning of certain required management measures.
- Short duration of concession rights incompatible with requirements of sustainable forest management.
- Bad compliance of concession holders with silvicultural prescriptions.

Points for Future Research

- Development of appropriate management techniques for logged-over forests.
- Develop planting techniques for high valued local species.
- Develop techniques for monitoring concession holders.
- Optimisation of strip-cutting systems.
- Development of criteria and indicators for sustainable forest management.

Conclusions

- Present application of silvicultural systems in Indonesia meets with several undesired effects which need to be rectified by developing more sophisticated and scientifically sound techniques.

CASE STUDIES

Biodiversity

THE ROLE OF BIODIVERSITY RESEARCH - SOME INTRODUCTORY COMMENTS

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'Biodiversity is vital to healthy forests, while proper forest management is vital to the maintenance of biodiversity' (Wilson, 1993).

1. INTRODUCTION

On all three main levels of the hierarchy of life - that of genotypes, species, and ecosystems - biodiversity encompasses most of the fundamental issues in modern biology, especially the central theme that is evolution. On all these levels, the diversity - almost by definition - presents a broad spectrum of variation and numerous gaps in knowledge and unresolved questions. If we are to meet the expectations of our national and international funding agencies, who are prepared to spend a limited amount of money on biodiversity research, we need to prioritise our research topics to comply with our duties enshrined in the Convention on Biological Diversity.

The evolutionary dimension of biodiversity also implies that curiosity-driven, rather than policy-driven, research questions are often foremost - and perhaps justifiably so - in the minds of the academic community. At the same time, there is fierce competition within that academic community for the limited contract funds, and specialists of various levels of biodiversity research sometimes alas see fit to claim their own branch of science to be the single holy grail to solve all the problems associated with the biodiversity crisis. In this minefield of conflicting interests and opinions, the Tropenbos Foundation attempts to carry out applied research on biodiversity as an integral part of its aims to work towards the sustainable management and conservation of tropical forest ecosystems. Not an easy task! No wonder that the Tropenbos organisation spent much energy and time in developing a policy document on prioritising biodiversity research (Lammerts van Bueren and van Duivenvoorden, 1996). By its general nature, the document can serve as a model to test the applicability of biodiversity research in general. Thankfully, the document does not discriminate between any of the specialisations that claim to contribute crucially to our understanding of biodiversity. It simply offers a model to identify research needs, depending on the goals set and the existing knowledge gaps for a certain area, group of organisms, or ecosystem.

It is difficult to address the concrete impact of biodiversity research on nature conservation and forestry policy. Nevertheless, the fact that all recent policy documents on sustainable forestry and land use - at the local, national, regional, and global level - are imbibed with biodiversity issues, gives credit to the effectiveness of disseminating the research results on biodiversity. As a concrete and shining example, Costa Rica comes to mind (Heywood and Watson, 1995). Here the Government is stimulating its biodiversity to become the best documented and researched of any tropical country in the world, while at the same time reaping huge benefits from this policy. Ecotourism has become the number-one capital earner for the country, and at the same time local communities are thriving through the development of their traditional knowledge systems of useful plants and animals into more widely marketable products, and through bioprospecting for new

medicinal compounds. I have never been to Costa Rica, and cannot judge whether this summary

statement paints too rosy a picture of reality or not. I am afraid it does.

Many are aware that conserving biodiversity at all levels is a long-term, global, and human self-interest. Intact rain forests would not have burnt to the extent that logged-over and otherwise disturbed forests burnt this year in South-East Asia. Nobody would like to miss the medicinal compounds that are still being discovered in tropical rain forest species. Non-timber forest products from the tropical forest of endless diversity depend, for their sustainable production, on a more or less intact forest. We are talking about a very high percentage of (locally) economic plants in tropical floras: 7,000 PROSEA plant species out of a flora of c. 35,000 species, or 20%, have an economic use (Jansen *et al.*, 1991). The ecotouristic value of intact, species-rich forests, giving shelter to endangered species such as the Sumatran Tiger, Orang Utan, and Rhinoceros, or the majestic parasitic flowers of the genus *Rafflesia*, is also considerable.

In our policy-driven approach, we need to come up with solutions that are a compromise between maximum societal return for the local or international communities, and conserving as much biodiversity as is compatible with that primarily economic objective. Nevertheless, at the end of the day, the conservation of the millions of species of animals, microbes, and plants is, in my opinion, also an ethical problem, based on the conviction that, as the most powerful species on this planet, Man must accept the responsibilities of good stewardship over his fellow creatures. This motivation, also echoed by the late Marius Jacobs in his award-winning book on the Tropical Rain Forest (Jacobs, 1988), but as old as Genesis and enshrined in all other religions, may be as effective in directing conservation policy of governments and peoples as any study of the potential commercial value of medicinal plants and other non-timber forest products in a primary or secondary forest. With this statement, I definitely do not wish to discourage research, but simply to indicate that the question 'Why should we conserve this or that species or ecosystem?' does not always require a scientific or commercial answer.

So what type of research should be prioritised? I give some personal priorities in a number of simple questions:

1.1 What and where?

Tree species composition and distribution comes first to mind. Trees are, after all, the defining elements in forest ecosystems, and they present the greatest biomass. Despite the fact that Tropenbos is supporting projects to prepare user-friendly manuals to help identify the most important forest species, our knowledge of tree species composition at all Tropenbos sites is still fairly fragmentary. The need for such mundane knowledge is indeed urgent: in the harbour of Yokohama, shiploads of mixed tropical timbers arrive with totally wrong species assignments and consequently erroneous end-use categories, at the cost of millions of dollars to the producers. In other words, waste through ignorance remains a major obstacle to the wise use and sustainability of tropical forests (Sudo, 1994). A proper taxonomy and tree and timber knowledge would help. Research and capacity-building in these areas must remain a high priority for Tropenbos. The species diversity of other groups of organisms like pollinators, mycorrhizal fungi, and so-called umbrella species that are sensitive monitors of ecosystem integrity (e.g. apes and other mammals) equally deserves our attention.

A sound taxonomy is also needed to underpin any short-cut methodology to assess biodiversity by classifying forest species into so-called 'functional groups'.

The hot topic of ecolabelling in tropical forestry would remain hot air, if we would fail to put in proper biodiversity criteria. That again can only be implemented with proper biodiversity expertise at the species level.

1.2 Ecosystem dynamics - impact assessments

How does the forest react? What are the impacts of various human pressures (from gathering rattans and fruits, via low to heavy logging)? A Tropenbos study on the botanical diversity in the tropical rain forest in Guyana (Ek, 1997) addresses the impact of logging on the plant diversity in Greenheart forest of Guyana. The on-going study by the botanical team of the Wanariset Site on the tree composition of secondary forests of East Kalimantan (Kessler *et al.*, 1994) can also be seen as a study on the effects of logging and other activities (e.g. slash-and-burn practices) on botanical diversity.

The entire research programme >Biodiversity of Disturbed Ecosystems= of NWO/WOTRO in the Netherlands is geared to these problems. A number of selected organismal groups (pioneer trees, but also flatworms, butterflies, ants, snails, mycorrhizal fungi) of putative key-stone or indicator nature are being studied in variously disturbed forests to increase our understanding of the response and dynamics of tropical forests.

All environmental impact assessments that are now legally required by most governments should in principle also answer some of the above questions. Nevertheless, whether such assessments have much real effect on conservation and sustainable use should be monitored as well.

1.3 How to remedy and restore?

How effective is enrichment planting in disturbed forests? (And is it diverse enough?) What to do to make a deranged Orang Utan part of a semi-natural population again? These themes are, for example, very prominent in the MOF-Tropenbos Kalimantan programme, with profound effects on government policy for sustainable forestry. Research into the propagation of indigenous *Dipterocarpaceae* has led the way to these successes (Smits, 1994).

1.4 Lessons from sustainable traditional use

What can we learn from sustainable traditional use by local populations? Tropenbos has solidly incorporated non-timber forest products (NTFP) in its research programmes in South America, Africa, and South-East Asia, with various emphasis on traditional use and potential economic yield, including regional, national and international marketing (Ros-Tonen *et al.*, 1995). Further studies, fully incorporating ethnobotanical and socio-economic aspects, are needed.

1.5 How to involve the local population?

The involvement of the local population is crucial to support a sustainable policy of wise use and conservation (Heywood and Watson, 1995). This formula has, reputedly, worked well in Costa Rica. Is Tropenbos doing enough in this field at all its sites?

1.6 How to monitor?

Forest management and conservation measures need to be monitored for their effectiveness. All too often, well-intended measures have adverse effects in the real world. For the proper monitoring of species biodiversity, sufficient base-line data for tropical forests are often lacking. This could be remedied by making the wealth of information associated with biological collections accessible to policy-makers (see below).

2. SYNERGISTIC PROGRAMMES

In the Netherlands and the international arena, there are many programmes and projects that address

some of the above issues. Below, I will briefly review those that are associated with Themes 1, 2, 3, and 6. For a full review of Dutch programmes, see also Simons (1997).

2.1 Dutch programmes

The core research programmes of the Research Schools Biodiversity, Functional Ecology, ICG (Geo-Ecological Science), and Sense, and of research institutes such as IBN/DLO institutes, include the biodiversity of tropical forests. For instance, the long-term Flora and Fauna Malesiana Projects, coordinated by the Rijksherbarium/Hortus Botanicus and NNM/Naturalis in Leiden, respectively, the Flora of the Guianas, coordinated by the Utrecht Herbarium, and the ECOSYN Project on the Flora of Tropical West Africa by the Herbarium in Wageningen, underpin much of the biodiversity studies in Tropenbos sites.

The NWO/WOTRO Priority Programme on Biodiversity of Disturbed Ecosystems has several projects that are being conducted on Tropenbos sites, and focuses largely on tropical forest ecosystems (see above).

The Netherlands Government envisages a Biodiversity Stimulation Research Programme in the period 1998-2003 for biodiversity in the Netherlands, jointly with a separate programme in the Philippines. The themes of that programme are still to be decided, but probably a multidisciplinary project in Mindanao will result.

2.2 International initiatives

There are numerous international initiatives on biodiversity. Some of the most important ones are mentioned here.

Diversitas - an International Programme of Biodiversity Science, incorporating Systematics Agenda 2000/International and Species 2000 (an electronic catalogue of life on earth) - has an ambitious programme that sets priorities for global stock-taking of the world's species, their interactions, ecosystem functioning, etc. (Diversitas, 1996). Several groups of people in the Netherlands are involved in the programme. Science ministers of the OECD countries have taken the initiative to develop a programme for Biodiversity Informatics as a MegaScience. The European Science Foundation Network on Systematic Biology is currently developing an ESF research programme, with due emphasis on tropical species. Acknowledging the urgent shortage of taxonomists, especially in tropical countries, to provide the necessary expertise to carry out these programmes, the Conference of Parties to the Convention on Biological Diversity has called for a 'Global Taxonomic Initiative' for capacity building, including taxonomy, to enable developing countries to develop and carry out an initial assessment for designing, implementing, and monitoring biodiversity programmes. This initiative will be taken forward during a first international workshop in Darwin, Australia, in February 1998.

3. CONCLUSION

The number of on-going national and international programmes and initiatives (including the Tropenbos programme itself) may seem impressive, but should not fool us into complacency that enough research is being conducted. The funding of the international initiatives I mentioned is minimal, nil, or still 'forthcoming' in the most optimistic scenarios. The core-funding of the Research Schools and other research institutions, and the way in which their academic performance is evaluated, also restricts the possibilities for policy-driven research on tropical rain forests.

It disturbs me that new research initiatives so often and easily ignore existing programmes and expertise. In the realm of biodiversity information, the zoological, botanical, and mycological collections in the Netherlands and their counterparts in the Tropenbos countries harbour a tremendous wealth of information that cries out to be made accessible as base-line information for future monitoring. Why not capitalise on 200 years of botanical, mycological, and zoological - or rather floristic and faunistic - research, and database the collection information for selected taxa and regions, making full use of GIS with the often detailed geographical information on the specimens labels? Such baseline data would make all inventories of small plots in primary, secondary, or plantation forests so much more meaningful, and would open possibilities of long-term monitoring. The 'Global Taxonomic Initiative' also emphasises the under-utilisation of existing collections.

In conclusion, all six themes mentioned above still present so many gaps in our knowledge that intensified research efforts are required to inform sustainable forestry and conservation in the tropics with the sorely needed basic facts.

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THE ROLE OF BIODIVERSITY RESEARCH – SOME INTRODUCTORY COMMENTS

Achievements

- The biodiversity issue has entered all policy fora.

Challenges and Problems; Information Needs

- Shortage of taxonomists world-wide.
- Poor integration of research programmes.
- Under-utilisation of existing information in collections.
- Limited involvement of local communities in research.

Points for Future Research

- Investigation of tree species composition and distribution.
- Development of the functional diversity concept as a short-cut to biodiversity.
- Response of species and communities to all forms of forest use; environmental impact assessments.
- Restoration of degraded forests.
- Mobilisation and application of sustainable indigenous use of the forest.
- Development of monitoring techniques of forest management.

Conclusions

- Justification of biodiversity conservation must be driven not only by economic and social but also by ethical arguments.

BIODIVERSITY RESEARCH IN COLOMBIA: WHAT WE KNOW AND WHAT WE NEED TO KNOW

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1. INTRODUCTION

Colombia is one of the countries with the highest biological diversity in the world. With a land surface of 1,1400,000 km^2 (approximately 0.7% of the continental surface area of the globe), it is home to more than 40,000 plant species, over 1800 bird species, and over 580 amphibian species, close to 15% of the world's species for these groups.

This enormous richness can be attributed to the geological history and geographical location of the country. Colombia's location near the Equator, as a land bridge between North and South America, has allowed the migration of species between the continents. Many northern species have distributions that reach as far south as Colombia. Oaks of the genus *Quercus,* widespread in North America, are found in higher elevation forests throughout Central America, and in some forests in the Andes of Colombia as far south as the border with Ecuador. The geological history of Colombia has also played a significant role in speciation and diversification. The oldest rock formations in Colombia are parts of the Guyana shield, and are found as giants standing over the plains of the Orinoco and parts of the Amazonian region of Colombia. The Andes is more recent, and is split into three separate ranges, with the Eastern range stretching as far north as Venezuela. The Pacific coast of Colombia, known as the *Chocó,* is one of the places with the highest rainfall world-wide, with some locations getting more than 12,000 mm of rain annually.

Biodiversity research in Colombia dates back to the late 18^{th} century, when the journeys of Alexander von Humboldt through the Orinoco and the Andes and the Botanical Expedition of the Kingdom of Nueva Granada led by the Spanish scientist, José Celestino Mutis, took place. These early explorations revealed many new species and recorded the traditional uses of plants. Some of these groups were extensively used for treating ailments, as in the case of quinine. Since that time, scientists have continued to work on documenting the biodiversity of the Neotropics. Nevertheless, we are still far from understanding what there is, how it functions, and how to use it in a sustainable way.

One of the points that I have been asked to address during this talk is how to translate the results of research into policy and contribute to the decision-making process. In order to answer this, I would like to provide you with a brief description of the institutional structure of the environmental sector in Colombia, and will later continue to describe research priorities.

2. THE ENVIRONMENTAL SECTOR IN COLOMBIA

The environmental sector in Colombia was restructured as a response to the commitments of the Convention on Biological Diversity, signed in Rio de Janeiro and ratified by Colombia in 1994. The result is a series of institutions and organisations that are collectively known as the National Environmental System. The highest ranking body is the National Environmental Council, with representatives from different ministries and government agencies, as well as representatives from the

private sector, universities, and the civil society. This body is in charge of establishing general policy guidelines and facilitating cross-sectoral coordination. The restructuring also led to the creation of the Ministry of the Environment, as a small ministry in charge of supervising environmental policy and representing Colombian positions in international conventions and treaties relating to the environment. Environmental control and management are completely decentralised in the new system, and are in charge of regional autonomous corporations for sustainable development, with a board that includes the state and municipalities, and other representatives.

Last but not least, and most important for the purpose of this meeting, are the research institutes that are in charge of providing the scientific and technical support to the environmental system. This includes five research institutes with specific mandates, such as meteorology, biodiversity, marine research, and two with a regional focus on the Amazon and the Chocó. The Institute in charge of biodiversity research is named after Alexander von Humboldt, and was established in 1995 as a joint venture between 24 partners, including the Colombian Ministry of the Environment, the Colombian Science Foundation, universities, institutes, and non-government organisations. The Institute's mission is to promote, coordinate, and conduct research that contributes to the conservation and sustainable use of biological diversity in Colombia. In order to carry out this mandate, three strategic research programs have been identified: biological inventories, conservation biology, and use and valuation of biodiversity, as well as three cross-cutting programmes on policy and legislation, training, and communications and information.

3. CONCEPTUAL FRAMEWORK

The development of a biodiversity research strategy for Colombia requires a conceptual framework. We have adapted the scheme developed by Noss (1990) to examine the trends in biodiversity research in Colombia. The framework recognises the levels of organisation of biodiversity (genetic, species, and ecosystem diversity), and three attributes that can be discerned (composition, structure, and function). The result is a two-dimensional matrix, allowing for any combination of attributes at any level of organisation. A third dimension can be added to include the impacts of human intervention, from 'intact' ecosystems, through managed ecosystems, to degraded ones where restoration programs need to be implemented.

Composition refers to the identification of the components of biological diversity, as reflected by, for example, species lists. Structure refers to the characterisation of these components, including their relative abundance (e.g. the types of ecosystems in a given area). By function, we mean the study of the dynamic nature of biodiversity in space and time (e.g. the monitoring of allele frequency in a population over time, or the effects of management practices on demography).

Not surprisingly, the analysis of biodiversity research in Colombia over the past two decades shows that most work has been done on the composition at the species level, and very little work has been done on the function at the genetic and ecosystem levels. Therefore the strategic plan for research in biodiversity is designed to address this conceptual framework as a whole, to identify gaps and weaknesses, and to design actions to overcome them. These focus on six main areas: biological inventories, conservation biology, use and valuation of biodiversity, policy and legislation research, training, and information.

4. BIODIVERSITY INVENTORIES

Despite the fact that biological inventories have been carried out over the past two centuries, we still have little data on what is found where. Most of the collections have focused on vascular plants and vertebrates, especially birds and mammals. Groups like invertebrates, fungi, and bacteria have received little attention. Overall, we estimate that we probably know less than 10% of the species found in Colombia, and over half of the information on geographical distribution is housed in collections outside Colombia and is unavailable to researchers. Research relating to characterisation at the genetic level is scarce, except for certain species of importance to agriculture and health. However, the decreasing cost and increasing speed of molecular techniques are making these increasingly available to researchers world-wide.

The Institute has completed an exercise to determine the priority geographical areas for biodiversity inventories nation-wide, through a series of workshops involving leading scientists. The criteria to evaluate geographical priorities include species inventories, endemism, current state of knowledge, and degree of threat, including variables such as extent of original habitat left, degree of fragmentation, rate of change, and existence of protected areas. This has led to the identification of areas which are of top priority and which are, in general terms, areas of high diversity and endemism, poor knowledge, and high degree of threat. The resulting maps are used to establish a map that is used by institutions nation-wide for biodiversity inventories.

What we know:
- Species inventories for over 80% of the vascular plants and vertebrates;
- Characterisation of most ecosystem types;
- Variation in plant species occurrence in recent historical times;
- Geographical distributions of most ecosystems and some species;
- Genetic characterisation of a number of species of importance for agriculture and forestry;
- Taxonomic and geographical priorities for species inventories.

What we need to know:
- Species inventories for most invertebrates, fungi, and micro-organisms;
- Spatial and temporal dynamics of biodiversity;
- Phylogenetic relationships of selected taxa;
- Genetic characterisation of selected taxa.

What we can do in the short term:
- Computerise biological collections and repatriating information to the country of origin for biogeographic analysis;
- Complete collections in geographical areas that have high species richness and levels of endemism, are poorly known, and are threatened;
- Complete biodiversity inventories in some areas as a basis for other research;
- Strengthen inventories on taxa that are of economic potential, are threatened, or can be used as indicators;
- Establish DNA banks to facilitate genetic studies.

5. CONSERVATION BIOLOGY

A second major line of work relates to research that directly contributes to the conservation of biological diversity at all levels. Whereas *ex situ* conservation techniques are useful to conserve genetic diversity, ecosystem level diversity can only be preserved under *in situ* conditions. Furthermore, *in situ* conservation is generally favoured in the absence of a complete understanding of diversity and interactions.

Research relating to conservation should focus on a better understanding of the current status, on monitoring, and on trends of biological diversity, with special emphasis on endangered or threatened taxa or habitats. Preliminary results of this work have provided a complete list of threatened plants of Colombia, including some 600 species to date, following the criteria used by IUCN. We find that a major group of threatened plants are species with restricted geographical distributions and those that are commonly used. By far the largest percentage of these species are orchids (29%), as a result of over-exploitation for ornamental purposes and the transformation of habitats. Some plant families that are used for timber are also threatened or endangered.

One aspect that has received little attention in tropical forests is the impact of alien species and living modified organisms on biodiversity. Research in other countries has shown that introduced species can make up an important fraction of the local biodiversity, and in extreme cases, such as the islands of Hawaii, the total number of plants has doubled over the past two centuries. Some of these species can be aggressive and be more tolerant to environmental change, and can therefore out-compete native species. The effect of these is especially severe on islands and in freshwater ecosystems. Research should address the direct causes of extinction, namely habitat transformation, over-exploitation, competition with alien species, pollution, and climate change.

What we know:
- Ecosystems represented in protected areas;
- Lists of potentially vulnerable and threatened taxa of plants and vertebrates;
- Alien species present in Colombia;
- Underlying causes of habitat transformation.

What we need to know:
- Long-term viability of biodiversity in protected areas;
- Trends in populations of endangered and vulnerable taxa;
- Ecological impact of alien species on native biodiversity;
- Impacts of global climate change on species and ecosystems;
- Resilience of ecosystems to natural and man-made disturbances;
- Ways to accelerate natural regeneration as a tool for restoration.

What we can do in the short term:
- Define priorities for new protected areas using biodiversity criteria;
- Evaluate and monitor populations of endangered taxa;
- Strengthen the role of *ex situ* facilities such as botanical and zoological gardens for conservation of endangered taxa;
- Establish long-term plots for long-term monitoring of biodiversity;
- Begin research programs for the restoration of critically degraded ecosystems.

6. USE AND VALUATION OF BIODIVERSITY

Biodiversity has played, and continues to play, a major role in the structuring of past, present, and future human populations. This can be clearly seen through the impact of crop and livestock exchange between continents in recent history and their effect on modern cultures. Our livelihood ultimately depends on the direct benefits we derive from biological diversity (e.g. food) and ecosystem services (e.g. watershed regulation, air quality control).

The Convention on Biological Diversity is to some extent addressing one of greatest paradoxes of all: the countries with the highest diversity are the ones with the least economic development. These countries have legitimate interests in using the biological diversity for their development in the 21st century, although the expectation of economic benefits in the short term is often over-estimated. It is therefore important to provide a research basis for this, recognising the roles of traditional and scientific knowledge. Preliminary results of our work indicate that the total value of goods and services derived from biodiversity in Colombia can be in the order of 300 billion dollars annually, five times the GNP.

What we know:
- Traditional and modern uses of some species in local and global markets;
- The importance of biodiversity for human history;
- Ways to cultivate and manage some of these species (agriculture, forestry);
- Ecological role of some species (pollinators, fungi, and biological control agents) in production systems;
- Markets for a number of species of local or global importance.

What we need to know:
- The role of traditional communities in biodiversity conservation;
- The role of biodiversity in the lives and well-being of traditional communities;
- The relationship between ecosystem services and biodiversity;
- The impact of human activities on ecosystem services and ways to mitigate them (e.g. sustainable forestry);
- The economic value of goods and services provided by biodiversity;
- New uses for biodiversity and their markets.

What we can do in the short term:
- Document the uses of biodiversity by traditional communities;
- Evaluate the ecological, economic, and social sustainability of production systems;
- Develop mechanisms to measure the value of goods and services derived from biodiversity;
- Design ways to add value to biodiversity at the local level and ways and means to promote an equitable sharing of benefits;
- Identify new markets for biodiversity products and services;
- Identify new uses for biodiversity, including bioprospection.

In addition to the three research programs outlined above, additional actions have to be implemented to strengthen research and allow a better impact on policy, leading ultimately to the conservation and sustainable use of biodiversity.

7. POLICY AND LEGISLATION

One of the major weaknesses of biodiversity research is that it seldom translates into policy decisions. Often the work carried out by researchers does not contribute in any significant way to the decision-making process, because the research priorities are not relevant or we have problems communicating them to stakeholders in a timely and understandable way. On the other hand, policies can have a significant impact (positive and negative) on research. Positive incentives need to be strengthened and negative incentives (or disincentives) need to be identified and removed.

The conservation and sustainable use of biodiversity depends on cross-sectoral policies, since often policies can lead to rapid degradation. A specific case in Colombia were the policies related to agrarian reform during the 1960s, in which a land owner had to prove the use of forests through deforestation in order to claim and maintain property. This led to massive deforestation in many areas of the country. Another example is related to infrastructure development such as roads and highways, which can facilitate access to remote areas that would otherwise be inaccessible.

Some potential areas of work include:
- Evaluating economic incentives and their impact on biodiversity;
- Identifying gaps in legislation and proposing clear priorities for action;
- Designing instruments to incorporate biodiversity into other sectors of the economy;
- Evaluating the impact on international treaties and conventions (including trade) on biodiversity.

8. COMMUNICATION AND INFORMATION

One element that is often not considered in designing research programmes is related to information and communication. This requires the clear identification of stakeholders/users, their information needs, and the best ways and means to deliver it to them. Potential users include decision-makers, other scientists, communications media, and the general public. Each one of these audiences differs in its interests, background, and the ways and means to best deliver information to them.

What we can do in the short term:
- Strengthening scientific publications (journals, field guides, monographs, textbooks)
- Consolidating databases and developing information transfer protocols;
- Supporting scientific congresses and exchange programmes;
- Preparing news bulletins and documentaries;
- Facilitating access to communication technologies such as the Internet.

9. TRAINING

Finally, I would like to address the issue of the human resources available for biodiversity research. It is no secret that the distribution of research capacities is hugely imbalanced geographically, and that many developing countries need to train scientists in many of the topics and areas described above.

What we can do in the short term:
- Strengthening graduate-level training programmes, preferably at the national and regional levels;
- Offering short specialised training courses;
- Establishing scholarship and exchange programmes.

10. THE WORK OF TROPENBOS IN COLOMBIA

The ideas described above are just some of the priorities for biodiversity research, although the status, needs, and opportunities will undoubtedly vary from one country to another. It is clear that scientific and technical cooperation at the international level will play a major role in the development of this research strategy, and should be clearly aimed at strengthening national capacities.

The work that the Tropenbos Foundation has been carrying out in Colombia over the past decade has been a good example of this kind of collaboration, working closely with Colombian institutions and scientists, primarily the SINCHI Institute for Research in the Amazon. Many Colombian students have received graduate-level training in the Netherlands and are now the leading scientists at several Colombian universities. The continuous support for research programmes in a focused geographical area in the Colombian Amazon (Araracuara) has resulted in a good understanding of the composition, structure, and functioning of these ecosystems. The results of these studies have been published as dissertations, scientific articles, and books, and are widely regarded as important scientific contributions internationally.

We are grateful for the continued support to these programmes by the Dutch Government and the partnership we have established with the Tropenbos Foundation, and look forward to continuing this for many years to come. We are also confident that it will lead to a stronger national capacity and to a better scientific understanding of the sustainable management of our tropical forest ecosystems.

11. REFERENCE

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BIODIVERSITY RESEARCH IN COLOMBIA: WHAT WE KNOW AND WHAT WE NEED TO KNOW

Achievements

- A well developed and broadly rooted national environmental authority is developed for Colombia, which is in charge of policy, research strategy and application of research results in policy.
- A conceptual framework for biodiversity research in Colombia was developed.

Challenges and Problems; Information Needs

- Knowledge of biodiversity disproportionally distributed over taxa and space within Colombia; and less than 10% of species is known.
- Biodiversity research seldom translates into policy decisions.
- Poor communication with stakeholders and users during development of research programmes.
- Lack of well-trained scientists in developing countries.

Points for Future Research

- Computerise biological collections and repatriate information to the country of origin.
- Complete collections in selected high priority geographical areas.
- Strengthen inventories on taxa that are of economic potential, are threatened or can be used as indicators; define priorities for protected areas based on these criteria.
- Establish DNA banks to facilitate genetic studies.
- Monitor permanent plots and populations of endangered taxa.
- Begin research programs for the restoration of critical degraded ecosystems.
- Document the uses of biodiversity by traditional communities.
- Evaluate the ecological, economic and social sustainability of production systems.
- Develop mechanisms to measure the value of goods and services derived from biodiversity.
- Design ways to add value to biodiversity at the local level and ways and means to promote equitable sharing of benefits.

BIODIVERSITY CONSERVATION AS A SUSTAINABLE FOREST MANAGEMENT TOOL

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1. INTRODUCTION

Tropical forests continue to be used at an ever-increasing rate for the timber, wildlife, and other saleable products they house. Recent estimates suggest that nearly 1.9 x 10^6 km^2 of forest was utilised during the 1980=s, and current rates are running at 1.69 x 10^5 km^2 per annum (FAO, 1991; WRI, 1994). Whilst clearance for slash-and-burn cultivation once accounted for the majority of forest lands utilised each year, growth in the total area under timber production has now become the main form of use as vast tracts of previously inaccessible forest are opened up in the face of dwindling global timber supplies, increasing demand, and an ever-increasing availability of time-saving technologies.

Non-timber plant products are also playing an increasing role in the international economy, as the demand for alternative materials used in high-value goods, such as home furnishings, and the prospects of biochemical discovery accelerate (Table 1).

International, regional, and local trade in wildlife continue to provide income to rural residents, local businesses, and international export/import companies (Table 2). The pressures on a dwindling forest resource are enormous as increasing numbers of stake-holders, with a multitude of often conflicting objectives, seek to subsist or profit from the large biomass locked in the remaining unexploited stands.

2. BIODIVERSITY CONSERVATION AND FOREST UTILISATION: CONTRASTING ISSUES?

Everyone talks about biodiversity. In most cases, biodiversity conservation is discussed as an issue separate from forest production, often in conflict with large-scale extractive industries (McNeely, 1994). Preservationists traditionally believe that biodiversity is a quantity that must be maintained; all species are important and have value. Conservationists, while more pragmatic, often view large-scale, extractive industries as a threat to biodiversity. Most frequently, their view of the relationship between extractive industry and biodiversity is focused on whether or not the intensity of industrial extraction will negatively impact upon populations and communities of indicator, flagship, or commercial species (Johns, 1985; Sayer *et al*., 1995; Laurance and Laurance, 1996). The issue has become polarised as conservationists and industrial users stand firmly for antithetical solutions, and then try to reconcile these divergent views through arbitration. The outcome is rarely agreeable to all parties because the solutions tendered are often poorly integrated (e.g. see Alpert, 1996).

Table 1 Why tropical forest plants are harvested by non-indigenous[1] forest users

[1] Three factor groups are considered important in conserving biodiversity as part of sustainable management, viz. 1) ecological, 2) economic and 3) cultural groups. Social factors are considered here to be composed of economic and cultural components. Traditional indigenous methods of harvesting and valuation are not covered in this paper because the cultural values and motivations for harvesting of many forest species and habitats is complex and not entirely open to accurate interpretation based on standard Western economic theory. As such, they are not the focus of this paper, though this in no way suggests that indigenous views are less important than those of industry, but simply require

Plant Part	**Use**		**Scale of extraction**
	General	Specific	
Whole plant	Ornamental	Trade	Industrial/Cottage
Stems	Timber	Sawn lumber	Industrial/Cottage
		Plywood	Industrial
		Veneer	Industrial
		Poles/Piles	Industrial/Cottage
		Charcoal/Firewood	Cottage/Household
		Paper	Industrial
	Food	Palm heart	Industrial/Cottage
	Flexi-craft	Furniture	Cottage
		Scaffolding	Industrial/Cottage
	Extracts	Rubber/Balata	Industrial/Cottage
		Resins	Cottage
		Biocides	Household
Leaves	Biochemical activity	Medical	Cottage/Household
Fruit	Food		Household/Cottage/Industrial
	Oil	Edible	Industrial/Cottage
		Lubricants	Industrial
	Flavouring	Drinks/Food	Industrial/Cottage
Seeds	Food		Household/Cottage
	Fats & Oils	Edible	Cottage/Industrial
		Fuel	Cottage
	Provenance/ Genetic improvement		Industrial
Roots	Food		Household/Cottage
	Flexi-craft (aerial)		Cottage

We know that biodiversity is important for our own well-being. Important food, medicine, and building materials - harvested or domesticated in the past from wild stocks - are the building blocks of modern civilisation. Yet, we know next to nothing about what constitutes biodiversity, and whether certain parts are more important than others. We know that certain countries contain a disproportionately large part of global biodiversity, but we do not know whether this means that these areas are in all cases more valuable than others because we do not yet understand the relative significance of each individual species to ecological and economic sustainability. It is unlikely that we will ever know the value of all species, though attempts at inventorying all organisms in a limited area (All-Taxa Biological Inventory, or ATBI) have been proposed as a conduit to understanding their value (D. Janzen, pers.comm.). While ATBI=s may provide unprecedented scientific insight, they are not a practical approach to valuing organisms and finding solutions to problems of biodiversity conservation in the face of increasing human appropriation of global resources (Vitousek *et al*., 1986). Time is short and resources are strained. On the other hand, selective inventory methods such as Rapid Biodiversity Assessments (RBA=s) tend to provide useful information for only the most common species, though some taxa (understorey plants, birds) are clearly more amenable than others to such an approach. RBA=s are

alternative analysis.

likely to overvalue those taxa which are most abundant at the time of assessment and which are most intensively studied.

Table 2 Why tropical forest animals are harvested by non-indigenous forest users

Animal group	**Use**		**Scale of extraction**
	General	Specific	
Mammals	Rodents	Meat	Household/Cottage
	Ungulates	Meat	Household/Cottage
		Skins	Cottage/Industrial
		Traditional Medicine	Industrial/Cottage
	Primates	Meat	Household/Cottage
		Trade	Cottage
Birds	Ground-dwelling	Meat	Household/Cottage
		Eggs	Household
	Arboreal	Trade	Cottage/Industrial
		Meat	Household/Cottage
		Feathers	Household/Cottage
Reptiles	Crocodilians	Skins	Household/Cottage
		Trade	Household/Cottage
	Snakes	Skins	Household/Cottage
		Trade	Household/Cottage
	Turtles/Tortoises	Meat	Household
		Eggs	Household
	Lizards	Meat	Household
		Trade	Cottage
Amphibians	Frogs	Trade	Cottage
	Salamanders	Trade	Cottage
Fish	Large	Meat	Household/Cottage/ Industrial
		Trade	Cottage/Industrial
	Small	Trade	Cottage/Industrial
Insects	Butterflies	Trade	Cottage
	Parasitic wasps	Trade (IPM)	Cottage
	Beetle grubs	Food	Household
	Ants	Food	Household/Cottage
	Bees	Honey	Household

How can we integrate biodiversity conservation issues into forest management practices? Biodiversity conservation is typically integrated into forest land-use planning by spatially partitioning and then earmarking areas for utilisation (often the most productive) and for conservation (often the least productive or most inaccessible). It is now reasonably well-established, however, that small patches of intact forest surrounded by much larger areas of intensive exploitation rarely retain their conservation value (Laurance and Bierregaard ,1997), even when these reserves are representative of regional forest habitat diversity, if the interstitial habitat is unsuited to forest species. This is not to say that all species are unable to persist in isolated fragments; some plant, invertebrate, and small vertebrate species can remain for long periods (e.g. Gascon, 1993). Most of the largest-bodied species,

however, are unable to maintain viable local populations under such conditions, though some vertebrate herbivores may go through transitory periods of hyperabundance when released from their natural predator community (Terborgh *et al*.,. 1997). In such cases, many species are unable to maintain their local populations because of edge effects, dwindling resource availability, and - perhaps most importantly - the fragmentation of their larger, metapopulation structure. Metapopulations buffer against local population extinction or decline through a source to sink immigration process (e.g. Harrison, 1989). In order to effectively buffer against local losses, the metapopulation structure must show a good degree of connectivity between local populations, and this requires large tracts of favourable habitat in most cases where a species is sensitive to rapid habitat transition (e.g. Levins, 1969).

Partitioning forest lands solely on the basis of mutually exclusive forest land-use practices would lead to more intensive exploitation of areas outside reserves. Earmarking certain areas for conservation may increase the pressure on remaining lands in order to achieve short-term profitability while at the same time suggesting that biodiversity has been conserved and thus the process of extraction can proceed unabated. While the need for forest reserves as regenerating foci for species whose populations decline as a result of harvesting practices is clear (Johns, 1992), this should not supplant sound harvesting practices which maximise the value of the regenerating forest to biodiversity conservation (Johns, 1997). Often, regenerating forest stands will support species which cannot persist in isolated forest reserves (e.g. Kavanagh and Bamkin, 1995).

3. A CONTEMPORARY VIEW OF TROPICAL FOREST BIODIVERSITY

While deep integration of biodiversity conservation and utilisation is necessary, few workable frameworks on which to do so have been posited by tropical forest scientists, who rarely see themselves as decision-makers. Which species should be conserved and how?

Firstly, conservation of biodiversity should be seen solely in the context of the present and future needs of humans at local, regional, national and international levels. The preservation of present-day biodiversity on ethical grounds (e.g. Regan, 1981), while noble, is counter-intuitive when viewed in the context of the magnitude of palaeoextinctions and their putative role as catalysts to several of the greatest diversification periods on our planet, including the one which eventually led to the emergence of modern humans (Jablonski, 1986). Biodiversity has evolved in habitat which is under a constant state of flux and thus should be robust to moderate levels of modification (Whitmore and Sayer, 1992). Though current rates of extinction may appear unprecedented (Wilson, 1988), we should not exclude the possibility that this may be an artefact of our inability to maintain the same level of resolution when analysing past trends (10^2 to 10^4 yrs; e.g. Angel, 1994) as applied to contemporary (10^{-5} yrs and upwards) events; our power to detect details diminishes with antiquity (Hammond et al. in prep.). Ironically, at the same time as we discuss conserving the set of present-day species inhabiting tropical forests, we maintain a vast expenditure on efforts to debilitate or eradicate other species that impinge on our existence. What part of biodiversity exactly are we trying to conserve? Clearly, it is those species that we deem beneficial to human society through the material (e.g. timber) or service (e.g. water, tourism) economies they underpin.

Recent studies of temperate ecosystems under experimental manipulation suggest, in fact, that the number of Latin binomials present are less important than the diversity of functional characteristics exhibited by these species in maintaining the productivity of the system (Tilman *et al*., 1997, but see Hooper and Vitousek, 1997). Clinal character convergence of tropical canopy trees across Guyana

suggest more complex, long-term attenuation of species assemblages to both contemporary and historical disturbance events (ter Steege and Hammond, in press.; Hammond *et al*. in prep.).

Thus, while retaining all species may be the ideal way to secure our current resource base, maintaining functional integrity of tropical forests would appear to be a more expeditious approach if we wish to reap material benefit from forests far into the future. While many processes contribute substantially to forest functioning, those which somehow directly affect plant reproduction are most likely to influence, in the short-term, the cycle of regeneration on which nearly all wet tropical forest species are dependent (i.e. disturbance events, *sensu* Whitmore, 1975). Moreover, processes that directly impinge on reproduction and reproductive success often are the source of intense character selection over longer, evolutionary time (e.g. floral morphology). The relationships between plants and animals figures prominently among these processes through pollination, seed dispersal, seed predation, herbivory, and decomposition.

Animals account for nearly three-quarters of all species expected to occur on Earth. Most species are found in the tropics, particularly in neotropical forests, which house the largest number of forest rodent, bird, primate, butterfly, and bat species, among others (e.g. Fleming *et al*., 1987). Many of these species directly promote or impinge on the reproductive success of forest trees, lianas, shrubs, and epiphytes through their selective consumption of pollen, nectar, fruit, seeds, leaves, and stems. At the same time, these resources sustain animal populations, often in an otherwise resource-limited environment. The outcome of these processes is for the most part determined by the factors that influence vertebrate and invertebrate foraging patterns and population dynamics. The way in which a forest stand is utilised by humans will inevitably change the way in which these factors influence foraging patterns and population dynamics of forest animals, and through these, plant reproductive success (e.g. Dirzo and Miranda, 1990).

4. TOWARDS INTEGRATION: THE FOREST MANAGEMENT FRAMEWORK

Available information suggests that management based on natural regeneration holds the greatest prospect for long-term timber production under current market structures, because costs of immediate intervention are difficult to reconcile with the prospect of higher future yields and an uncertain price economy. Other non-timber forest products, by default, rely on natural regeneration to maintain viable populations and buffer harvesting effects. Natural regeneration of plants depends to a certain degree on those processes, such as seed dispersal and predation and herbivory, which influence colonisation and recruitment of juveniles in recently harvested areas. At the same time, natural rejuvenation of animal populations can depend to some extent on resource availability and the ability of population size to buffer against losses brought on by periods of resource scarcity or disease.
Thus, an important part of managing natural regeneration is managing the interactions between plants and animals. Management on this basis assumes, however, that intervention is kept to a minimum (Johns, 1997) and many forests are now so depleted that natural regeneration of target species is no longer possible; management of natural regeneration has become synonymous with forest restoration. In such degraded states, the degree to which inhabiting plants and animals rely on one another has deviated significantly from the tightly-bound community that characterises most unexploited forests stands. The degree of intervention, and thus the cost, of catalysing the re-establishment of relationships between plants and animals in these areas is likely to be high. However, sound ecological knowledge can provide a basis on which to identify plant-animal relationships which may have a disproportionate influence on the rate and trajectory of regeneration. Optimising rates and trajectories will increase cost-effectiveness of a forest amelioration programme by minimising intervention. The identification of

plant-animal relationships which might catalyse the restoration of a community will depend to some extent on the predominance and evolutionary success of certain taxonomic groups and the degree to which they critically depend on the ecology of other species.

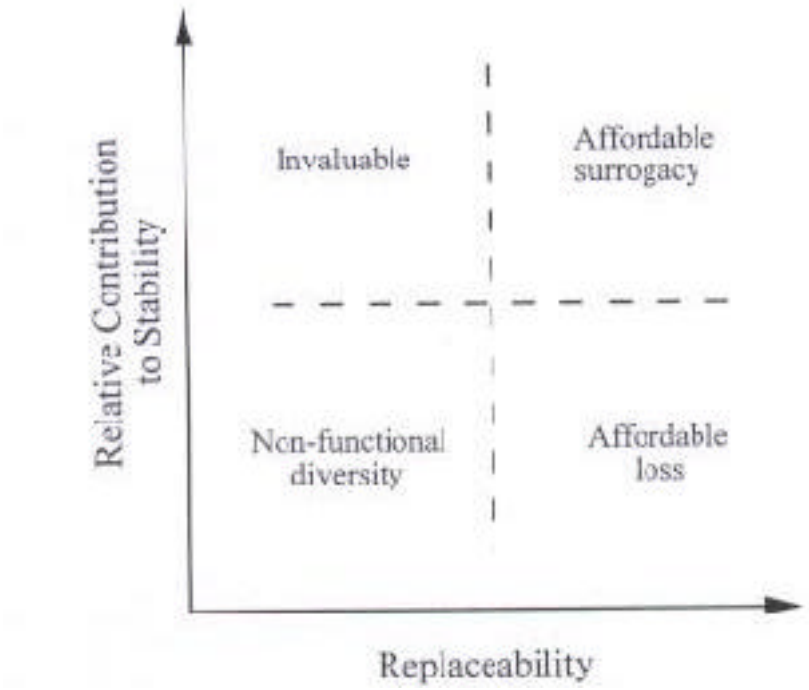

Figure 1 The relationship between a species contribution to community stability, its replaceability, and the emphasis placed on its retention as part of forest management

The predominance of certain taxa would suggest that they are more likely to play an important role in the contemporary forest regeneration process. In contrast, species which are a relict of past forest environments or cultural deprivation, the >living dead=, should be characterised by their declining abundance and poor regeneration (Janzen, 1985). The functional significance of a given taxonomic group, however, hinges not only on the success of their lineage, but on the nature of the contemporary role they play, viz. 1) how important is the role to community stability and 2) the degree to which other taxa, or abiotic processes, can fulfil their role - their replaceability. If their contribution to community stability is marginal, then their loss is more affordable. If few substitutes prove to exist and their contribution to community stability is great, then these taxa are of paramount importance, and their retention must be made a priority (Figure 1). The application of functional significance to sustainable forest management is manifest in the way that taxa pollinate, disperse, consume, and decompose plants of commercial value.

Pollination. Most woody tropical species are obligate outcrossers, either bearing self-incompatible bisexual flowers or separate male and female plants (dioecy) which require some form of pollen transfer between individual flowers for fertilisation (Bawa, 1974). Animal-assisted pollination, mainly by bees, butterflies, moths, beetles, birds, and bats, is characteristic of most tropical forests plants (Bawa *et al*., 1985), though wind-pollination does occur. However, the prevalence - and thus the importance - of different pollen transport mechanisms varies considerably by region because the relative abundance of different host plants weights the impact of the various pollination strategies. For example, many of the main dipterocarp trees in the drier regions of South-East Asian forests are wind-pollinated, and the pollination of many confamilial species of wetter forests has been attributed to

thrips (Thysanoptera) and other small, fast-breeding insects (Cicadellidae, Miridae) (Appanah and Chan, 1981; Appanah, 1987), though the small size of these fragile animals makes a combination of floral feeding and wind the more likely pollination route (Roubik, 1993). In some dipterocarp forests, facultative apomixis is common, making pollination in general unnecessary for reproduction (Ashton, 1969), though a prolonged reliance on apomictic reproduction will most likely lead to reduced genetic variation within a population. Fig wasps are important pollinators in Papua New Guinea, given the abundance and species richness of *Ficus* in these forests. Small beetles and flies dominate the pollinator community in lowland rainforests of North Queensland, Australia (Irvine and Armstrong, 1989). In contrast, long-tongue bats (Glossophaginae), large bees (Apidae, Euglosinni, etc.), flies, and moths appear to be particularly important pollinators of trees in eastern Amazonia and Central America (e.g. Bawa *et al*., 1985; Renner and Feil, 1993) and smaller, stingless bees (Meliponinae) are important agents throughout the tropics.

Seed Dispersal. The seeds of tropical woody angiosperms are for the most part dispersed by vertebrates, ants, wind, water, gravity, or explosive dehiscence. The majority of timber tree species have seeds which are dispersed by vertebrates or wind. Again, however, the functional significance of animals as dispersal agents varies by region. South-East Asian forest dipterocarps have seeds which are dispersed over relatively short-distances by wind-driven processes, such as complex gyration (Burgess, 1970). Dipterocarps can account for 35-50% of basal area, 10-15% of tree species richness, and 20-25% of all individuals (>10 cm dbh) in a stand (Smits, 1994; Schulte and Schöne, 1996). This suggests that animals as dispersal agents do not play a pivotal role in shaping community structure in these forests, though the seeds of other well-represented families, such as the Sapotaceae, Lauraceae, Euphorbiaceae, and Myrtaceae have fruit characteristics typical of vertebrate dispersal. In contrast, over 70% of timber trees are vertebrate dispersed in Guianan forests (Hammond *et al*., 1996), with rodents playing a particularly important role in some locations (ter Steege and Hammond, in prep.). In mixed forest stands, these species can account for more than 90% of the basal area, tree species richness, and number of individuals. Rodents consume and disperse the seeds of a large number of tree and liana species in eastern Amazonia. Caviomorph rodents, such as the agouti (*Dasyprocta* spp.) and paca (*Agouti paca*) are specialised seed consumers found commonly throughout neotropics but do not occur in the Old World tropics. Rodents in general appear to have a more limited role in the dispersal of seeds in tropical forests of West Africa and South-East Asia.

Herbivory and Seed Predation. Many animals feed on the leaves, stems, bark, and roots of plants. If the object of the herbivore's feeding is a small juvenile, the loss of biomass may kill it, reduce its tolerance of stress, such as drought, or impair its ability to compete with siblings and the offspring of other sympatric species (Whitmore and Brown, 1996). As an adult, a plant=s longevity may be reduced by severe attack, often as a consequence of the pathogen infection that follows such events. Sub-lethal attack on adults may lessen their reproductive capacity, reducing seed crop size and/or the size of their offspring.

Again, certain groups of dedicated herbivores tend to be more speciose and/or abundant in one region than another. For example, sap-feeding treehoppers (Membracoidea, Membracidae) are particularly diverse in Neotropical forests (Wood, 1993) and are renowned for spreading disease along with other phloem-feeders (Nault and Ammar, 1989). Leaf-cutting ants (the Attini) are restricted to the neotropics, consuming an estimated 600 kg (dry wt) of vegetation per hectare per year, or 0.5% of total non-woody primary production, on Barro Colorado Island, Panama, alone (Leigh and Windsor, 1982).

Vertebrate herbivores can consume up to 10 times as much non-woody plant parts as invertebrates (Leigh and Windsor, 1982). Forest-dwelling browsers tend to be much larger in South-East Asian and

African forests than in the neotropics. The largest browser in the neotropics, the tapir (*Tapirus* spp.), has only one twentieth the body weight of the largest Old World forest browser, the elephant, and is not restricted to South and Central America.

Decomposers. Decomposer organisms interact with plants by catalysing the breakdown of dead material and, ultimately, increasing the rate at which this material is incorporated into new biomass. The actions of macrodecomposers, such as termites, collembola, and certain groups of beetles, is of particular significance to forest trees, because their relatively large body size allows them to process quickly large amounts of solid, lignified materials over a relatively large area. Foremost among macrodecomposers are the termites. While found throughout the tropics, many taxa are best represented in the paleaotropics, and several others, such as the fungus-feeding termites (Macrotermitidae), are restricted to South-East Asia and Africa.

5. VALUATION OF FOREST RESOURCES, RESOURCE USE, AND PROFITABILITY

The way in which tropical forest resources are integrated into modern human economies is typically swift and narrowly focused; there is a singular purpose which defines harvesting practices by a forest user. Thus, it is not surprising that the value of most forest resources are also singularly defined; a market has been found and the achievable revenue calculated. In reality, the tangible value of most forest plants and animals is composed of a combination of different real and potential commodities and services (Tables 1 and 2). Often these values conflict, such that the capture of one component value invariably leads to a devaluation of another component. The best solution to this conflict is to optimise for current and future values for both commodities and services (Figure 2a and b). Though short-run profitability from any single market is not maximised in this instance, the overall profitability from repeated marketisation would outstrip that achieved under a singular valuation model as long as the total profit margin achieved from this process does not fall below that achieved by a single valuation approach (e.g. timber harvesting alone). Inefficiencies in capital investment and discounting can lead to pessimistic profit forecasts under repeated marketisation, just as is the case with single valuation, though discounting future income based on re-investment of present income from forest resources into higher- yielding alternatives may systematically underrate the profitability of managed natural regeneration (Leslie, 1987) and are not connected to growth rates of forest resources through any established economic relationship (Fearnside, 1989). Despite these caveats, well-coordinated harvesting of the same resources for different markets may enhance the profitability of forest operations that are guided by sustainable management plans. To date, few harvesting operations are profitable and sustainably managed at the same time. Pre-planning market strategies so that harvesting intensities take into account current and expected commodity and service values is likely to be more profitable in the medium to long-run because adjustments in profitability are not necessary after profit stabilisation (Figure 2c and d).

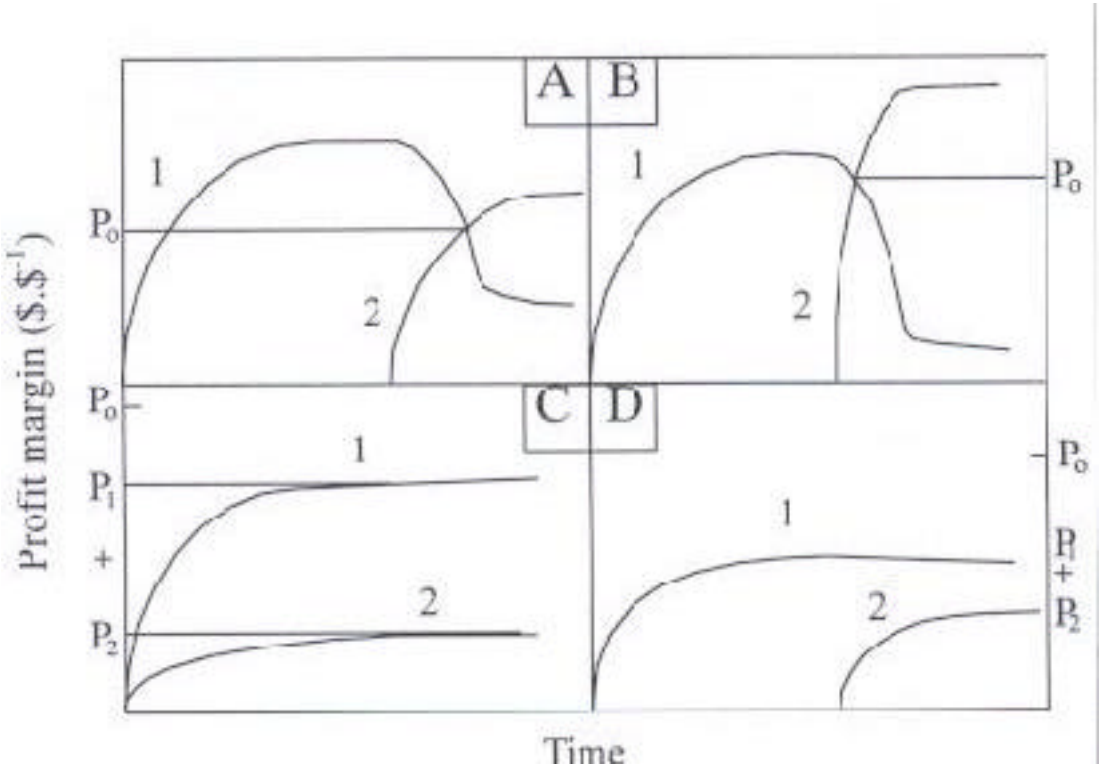

Figure 2 Dual marketisation of tropical forest products based on primary (1) and secondary (2) production goals. A) Optimisation of profit margin (P_O) given future secondary market with stable $P_2 < P_1$. B) Optimisation when stable $P_2 > P_1$. Optimal profit margins are the sum of P_2 and P_1 when dual marketisation is pre-planned under simultaneous (C) and staggered (D) entrance scenarios.

It is clear that the relationships between certain plants and animals are essential in maintaining the functional integrity of forest ecosystems and play an important role in the reproduction and recruitment of commercially valuable biota. The loss of these species through poor design and implementation of management practices will invariably lead to a devaluation of the residual forest stand because many species are locally extirpated without accounting for their contribution to the future market value of other commercial species. The relationships between wildlife use, silvicultural intervention, and timber harvesting provide good examples of how management practices that do not fully integrate biodiversity conservation value at the present may lead to substantial income loss in the future.

Table 3 The value of wildlife when considering more than one valuation axis

	Present value	**Future value**
	Meat	Revalued meat
Commodity	Live trade	Revalued live trade
	Skins/feathers	Sport hunting
	Edological process	Increased/sustained timber volumes
Service	Ecosystem process	Increased abundance of useful NTFP trees
	Tourism	More efficient regeneration after over-harvesting

Wildlife use and timber harvesting. For example, species such as seed and seedling-eating mammals which regulate competitive effects between individuals through seed dispersal, predation, and seedling herbivory often selectively promote regeneration of commercial species. Viewed in this way, they are a component of that species future market value since they contribute to the regeneration success and thus influence future supply. However, many forest animals also have a considerable value as food or as highly sought-after specimens in the wildlife trade.

Hunting and the intensive collection of live animals can have a devastating impact on the local animal communities because these practices typically select out those healthy, adult individuals that contribute most to reproduction, much like the selective harvesting of the most fecund, best-formed trees can promote dysgenic effects (Jonkers, 1987). Often when harvesting is intense, the population crashes after it becomes too small to sustain growth, and local extinction ensues (Redford, 1992). While rapid depletion of wildlife to extinction can be, in theory, the economically optimal strategy if a discount rate is applied to harvesting of fluctuating populations (Lande *et al*., 1994), the income earned from local extirpation of forest game species is unlikely to provide lucrative re-investment opportunities, which are more strongly influenced by other sectors of the national and global economy.

The role of wildlife in timber tree regeneration is rarely addressed when attempting to value biodiversity. Often the value is based only on the direct income achieved from harvesting, rather than the support services that wildlife may provide by sustaining growth of desirable timber species under a low-input management system based on natural regeneration (e.g. Redford, 1993). As supplies of the commercial species diminish worldwide, the unit price achieved for remaining stocks will increase, assuming that demand is relatively inelastic or at least not declining because of product substitution. If the future return on this supply is greater once harvested than the current gain made by harvesting wildlife that supports timber tree regeneration, then it is most economic, in the long run, to conserve these support species. While increasing silvicultural intervention might reduce the need for services provided by wildlife, it is unlikely that the income generated through wildlife harvesting would outstrip the cost of silvicultural intervention. However, since the role of wildlife in timber tree regeneration varies from region to region and taxon to taxon, the value of seed predators, dispersers, and pollinators as support species will also vary.

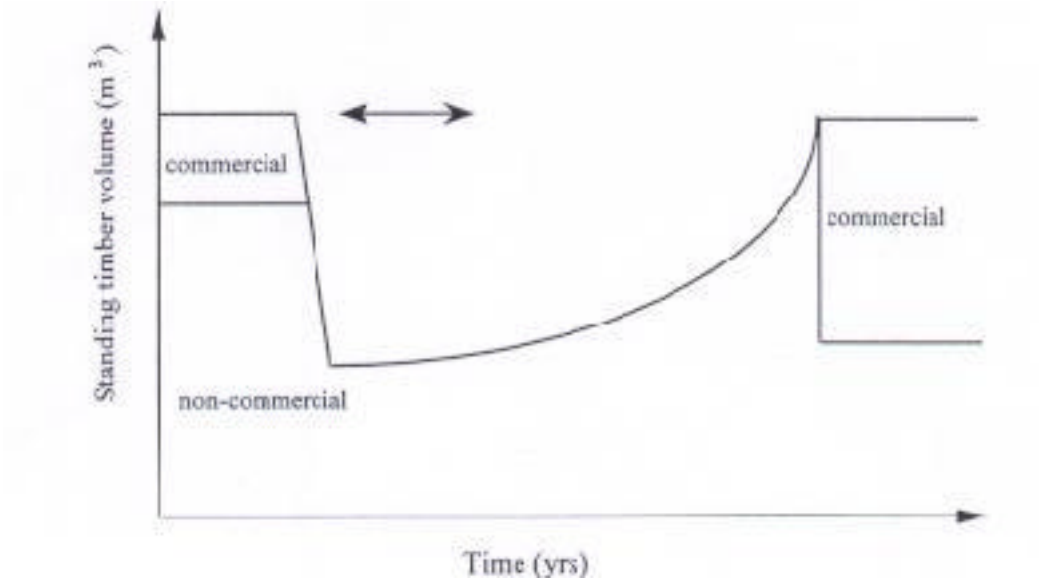

Figure 3 A heuristic representation of the increase in commercial stock as a proportion of total forest volume resulting from extensive silvicultural treatment. The horizontal arrow indicates the forest productivity limit. Adapted from de Graaf (1986).

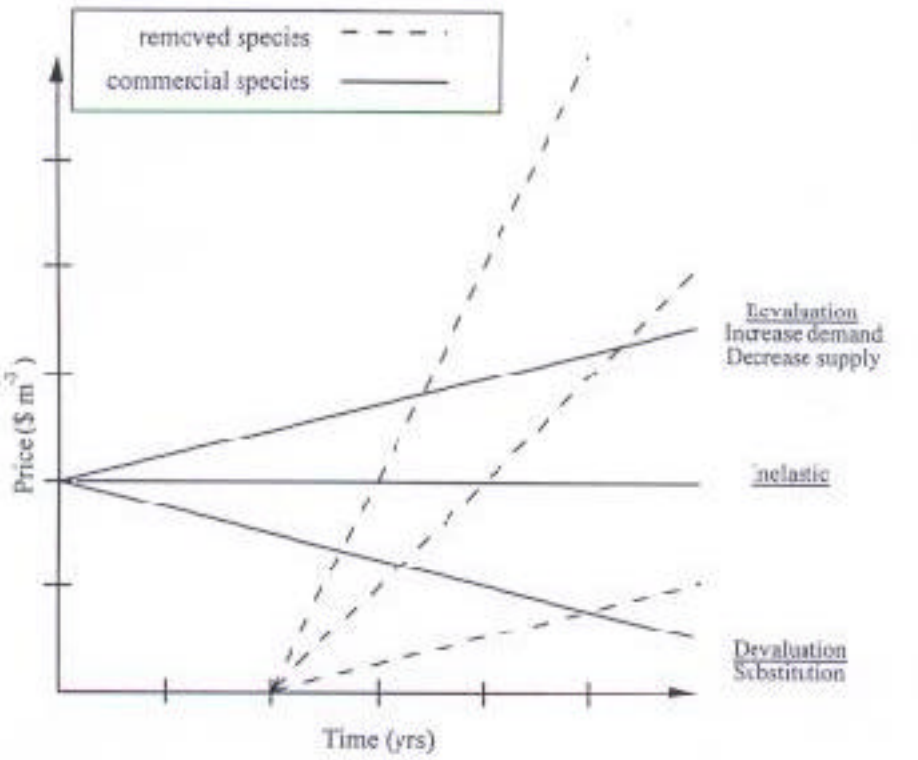

Figure 4 Trade-off between price structures for established (at t = 0) commercial species and future commercial species when the rate of price change varies linearly for both groups under one case scenario. Multiple revaluation of species previously considered non-commercials would in reality lead to more complex trade-off scenarios.

Silvicultural treatments and lesser-known timber species. Most refinements, such as enrichment planting or liberation, are unlikely to be cost-effective (e.g. Chai and Urbade, 1977; Rankin, 1979; Jonkers, 1987) and conversion to plantation is not sustainable from a nutrient standpoint in most instances (e.g. Jari Project, Brazil, Johns, 1996). However, most traditional tropical timber management systems call for some form of post-harvest silvicultural intervention (e.g. Dawkins, 1958; Taylor, 1962; Wyatt-Smith, 1963) and the growth of commercial species can more than double after liberation in some trials, leading many to prescribe such treatments as part of modern sustainable forest management systems (e.g. de Graaf, 1986; Jonkers and Schmidt, 1984).

Increasing the incremental growth of commercial species can increase the future value of the stand as the volume of marketable wood in the stand represents a larger proportion of the biomass than prior to the first harvest (Figure 3). Alternatively, species which do not have a commercial value at time of harvesting, may be saleable in the future. Under most silvicultural prescriptions involving liberation treatments, such as poison and girdling, trees are categorised by their present saleability alone. Often markets are later found for those lesser-known species which had been removed (Freezaillah, 1984; Buschbacher, 1990). If the new market achieves a higher rate of price increase, or the volume of timber from species killed exceeds the additional income received from the enhanced growth of the traditional timber species which were preferentially conserved under the silvicultural prescription, then it is best to leave the forest untreated (Figure 4).

6. WHERE TO GO?

If investment in research and development is going to be of any significant value, forest management models and the guidelines they generate must be implemented. The degree to which results of applied and pure research are used by governmental regulatory bodies, private industry, and local inhabitants is wholly a matter of acceptance. Participation by all stakeholders in the formulation of management models - such as experienced public service staff or trainees, local guides and respected members of local communities, industrial forest workers and managers, governmental policy-makers, and foreign donor representatives, if required - maximises the likelihood that management models will be implemented.

In nearly all instances, a compromise between biodiversity conservation and development must be made (McNeely, 1994; Peres, 1994). The nature of this trade-off, however, is crucial. When forest management models or guidelines are drawn up with the heedless assumption that trade-offs will take place, but without explicitly characterising and quantifying these compromises, they languish as the applicability surrounding oversimplified assumptions (constants) declines with each step in the implementation process. Ultimately, those responsible for implementation will begin to view guidelines as peripheral, rather than pivotal, to the process of conservation and development.

Thus, a model is only as good as its assumptions. If assumptions are too broad and too numerous, the guidelines will be ineffective. If assumptions are poorly characterised, then they may lead to detailed, but erroneous, guidelines. If assumptions are too few, guidelines may prove too detailed and unimplementable (Figure 5). While models that embrace the conservation/development trade-off are rare, several programmes of field research have addressed the issue in a tangible way (Integrated Conservation and Development Projects/ICDP=s; Wells and Brandon, 1993), but are focused, at this stage, on a narrowly delimited set of objectives (Alpert, 1996).

If biodiversity conservation is to be integrated as a tool in forest management, we need to construct flexible management models that are implementable in most scenarios, profitable to most forest-users, and acceptable to most stakeholders within specified limits (geographical, temporal, and social). A plural problem-solving approach to a plural solution cannot be overemphasised, but divergence in stakeholder views should not be initially arbitrated, which is traditionally done, but used as a means of calibrating the degree of flexibility required in the model. Once established, the proto-framework can then be revised on the basis of the information required to refine assumptions and define component variables.

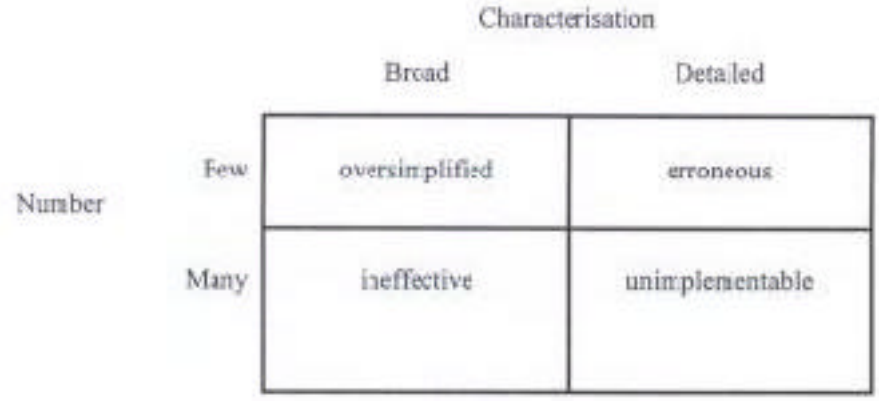

Figure 5 The potential adverse affects of model assumptions on guidelines generated from a forest management model as a function of the number of assumptions and the degree to which they are characterised.

While the need to integrate biodiversity conservation into forest management models is the focus of this paper, the regulatory effects of other abiotic processes, such as water and nutrient cycling, are of obvious - and well-established - significance and largely underpin most current dynamic models of forest ecosystems. Integrating these modules, with like modules addressing biotic processes and socio-economic aspects, into a more comprehensive model should be the mainstay of future forest management research. While developing a computerised management model with a user-friendly interface is technically possible, characterising the component variables, assumptions, and trade-offs is a much larger task, requiring a system of coordinated, small-scale field research programmes. No doubt field researchers need to retain independence in dissemination of their findings, but these findings need to be fed concomitantly to a core team given the task of translating the views, experience, and findings of many participants into acceptable management models. A good deal of information that could be used in characterising model variables and assumptions is already available. Field research in tropical forests is laborious, time-consuming, and, in many cases, expensive. The most parsimonious route would attempt to identify which variables and assumptions are 1) most sensitive to variation in other variables or assumptions, and 2) least supported by hard data. Given the long history of tropical forest data collection in many regions and the explosion of research carried out in the last two decades, it is increasingly possible for a researcher to inadvertently >re-invent= prior knowledge, which is not very cost-effective.

The shape of future biodiversity is largely bound by the decisions which human society, mainly citizens of tropical forest countries, make today. There are several genre of options available. If the entire species assemblage in existence should be maintained, then ATBI=s and RBA=s,

combined with a strong preservation ethic and a substantive system of large forest reserves, should be adopted. Alternatively - though perhaps the least desirable but most well-founded - society can exhaustively harvest what is presently available from tropical forests and hope that reinvestment will yield a higher return than less intensive approaches to harvesting over the long-term. No doubt intensively exploited forest remnants would achieve some degree of revaluation, but the opportunities for optimising revenue over longer periods are likely to be lost in the face of growing human pressure on forest resources. The opportunities for prolonged forest recovery, like that which occurred after the cessation of activities of early Amerindian civilisation (e.g. Piperno, 1994), appear unlikely when viewed in the context of modern globalisation. However, if the task set out is to maintain the functional integrity and sustainable economic well-being of tropical forests and forest users, respectively, then an integrated problem-solving approach needs to be considered, mainly through the development of comprehensive, user-friendly forest management models and continued collection of hard data in the field.

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BIODIVERSITY CONSERVATION AS A SUSTAINABLE FOREST MANAGEMENT TOOL

Challenges and Problems; Information Needs

- Small patches of intact forest surrounded by much larger areas of intensive exploitation rarely retain their conservation value, if the interstitial habitat is unsuited to forest species.
- There is no established framework for setting priorities in spcies conservation.
- Importance of plant-animal relations for maintenance of functional integrity of rain forests is little recognised.
- Biodiversity conservation is not truly integrated in forest manegement models.

Points for Future Research

- Research on trade-offs and assumptions underlying forest management models.

Conclusions

- The preservation of present-day biodiversity on ethical grounds, while noble, is counter-intuitive.
- Diversity of functional characteristics appears to be more important than diversity per se, which suggests that management should be aimed at maintenance of functional integrity of forests.
- Forest management should simultaneously optimise current and future values for commodities and services.
- Wildlife represents a future value in terms of regenerated timber species rather than a direct value in terms of meat.
- Dissemination and integration of research results should be jointly done by field researchers and a team with the specific task to translate information into management models.

BIODIVERSITY, CONFUSION AND WASTAGE OF FUNDS

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The concept of biodiversity was first applied in the early 1980s by U.S. ecologists who tried to alter a political atmosphere that had come to focus on the sustainable utilisation of renewable or natural resources and ignored the protection of species which were not acknowledged as ›resources‹. The new concept was readily adopted in international circles, but it soon appeared to be a Jack-o'-lantern. It was misinterpreted and misunderstood when it soon served to release considerable financial resources. It led to ›world-wide inventories of genetic resources‹ for the commercial market. And it led to infantile questions like ›How many species can be lost from the ecosystem before the economy - or mankind - is affected?‹, ›How small can a nature reserve be?‹, and ›How many heads of game or timber-logs can be harvested?‹

Perhaps the concept of biodiversity may be useful in intellectual circles of ecologists, but in the political arena it is an instrument of confusion. It belongs to the category of catchwords which somehow serve *laissez-faire* development, like participation, integration, and sustainability, more often preventing rather than serving conservation. Since the 1980s, protection is taboo and all marketable biodiversity is sacrificed in *laissez faire* exploitation by ›participating‹ local expert scavengers, under the euphemism of ›sustainability‹. For clarity, I would rather see the old-fashioned concept of ecology restored where it concerns questions of a fundamental scientific nature, and nature protection where it concerns the application of ecological knowledge in the conservation of wildlands. Why would one need to confuse or cheat a potential sponsor for the acquisition of public funds to conduct applied ecological research or nature conservation?

In the early 1990s, the growing public concern for the rapid demolition of tropical rain forest and the imminent extinction of many exotic organisms spurred the Dutch Government to adopt a formal *Government Policy on Tropical Rain Forests*, deploying an annual allocation of 150 million guilders. In spite of the clear public concerns, however, the Policy's objective was opaque, highlighting ›the importance of forests and forestry for the alleviation of poverty‹. Dutch pragmatism was further reflected in the skewed differentiation of the allocation: for the largest part, it was to support ›Policy Development‹ in forestry, and even the 30% intended for conservation had to be shared with the ›sustainable utilisation of the rain forests‹.

Hence, one should not expect too much of the Dutch Government Policy on Tropical Rain Forests in terms of conservation. The main responsibility for implementing the Policy is delegated to the Directorate General for International Cooperation (*DGIS*). It has an overriding humanitarian mission and appears to regard the conservation of biodiversity as being additional to a forestry policy. Why is there no constituency with sufficient ecological insight in the Netherlands to challenge this sort of humbug?

The report of the Ministry of Foreign Affairs, entitled *Bossen en Bosbouw: Projecten in Ontwikkelingssamenwerking* (1997), reveals that in 1996 a total of 1,200 million guilders had been allocated for 119 field projects for forests and forestry in developing countries and an additional 21 institutional support projects world-wide. And although two-thirds of the projects have no bearing on conservation (or even sustainable utilisation), yet, for the general public, the glossy, lavishly illustrated

publications of the Department may well suggest that the whole allocation somehow contributes to the conservation of rain forests and biodiversity.

Be that as it may, it is not easy for Dutch institutions and people who devote their careers to the conservation of species and rain forest ecosystems, to be deployed, or to conduct projects, from the meagre 30% share of the forest and forestry resources. Established Dutch field expertise in international conservation is starved of support, and is dying out; there is hardly any support for the transfer of knowledge in this field, and developing expertise is obliged to corrupt their commitment and adjust to the commercial consultancy market. Where government should support independence of expertise in this field, the Dutch Government rather denies its major institutions for nature conservation to seriously and structurally partake of the allocation, while enforcing their demise in privatisation. All project opportunities are usurped, either by the rural development sector, or by non-Dutch organisations, although 1.6% can be deployed for research in the Tropenbos programme. In the entire list of more than 20 organisations implementing the forest and forestry projects, the Dutch daughter organisation of the Department for International Cooperation, SNV, ranks 6th place with 37.2 million as the first and major Dutch technical input. It is followed by the Netherlands Committee for IUCN with 29.4 million. One may perhaps imagine that the latter concerns active conservation, but it does not. The allocation is meant to be distributed to a scatter of local NGOs in a few selected developing countries through a limited desk-top transfer function of the Dutch IUCN bureau, which is fully throttled by the regular *DGIS* policy-line and without opportunities for opposition or feedback. Finally, the Tropenbos Foundation ranks 11th with a total of 21 million for 6 years of research - to be shared by at least nine institutions (i.e. anything between some 100,000 and 600,000 Nlg/institute/year).

However, 87% of the allocation (1047 million) is channelled through international organisations. The highest ranking is the Global Environment Facility with 121 million, followed closely by FAO with 91.3 million. It is perhaps needless to say that there is no way to control or even supervise the objectives, direction, and cryptic strategic progress of such multi-national molochs; if any support is provided for nature conservation through these channels, it is conditional to a traditional development project. A project called ›Technical Support and Policy Research‹ was given to the World Resources Institute (7.7 million), while the Dutch Government has established a renowned institute for policy research, namely the Institute for Forest and Nature Research (*IBN*), with up-to-date expertise in tropical forestry and international nature conservation. Yet the major point is that the implementation of the Dutch Rain Forest Policy is mainly delegated to foreign organisations, with overruling missions in rural development, resource use, and production.

Some ignorant people may be inclined to challenge this conclusion by pointing at a third place for the World Wide Fund for Nature (WWF) (60.7 million) and a fifth place for the World Conservation Union (IUCN - 46.6 million). According to the statutes, WWF is supposed to be a fund-raising organisation and IUCN the alleged ›ecologic conscience of the world‹, but neither was designed for project implementation, and both have a poor record in the field. Yet, for both organisations, the same basic objections apply; they are corporate molochs with their own socio-political agendas, but without any effective bearing on nature conservation at the field level, and few opportunities for conceptual adjustment - and Dutch deployment. Through their World Conservation Strategy, both organisations have adapted their missions since the early 1980s, and have joined other international development corporations so as to focus primarily on the supposedly sustainable development of rural people, rather than on nature conservation. Could it be that the lure of such vast potential financial resources for what is euphemistically called ›integrated conservation of biodiversity‹, even if it could be expected only from the peculiar Dutch xenomaniac policy, has played a role in adapting their missions? Anyway, how can one expect to achieve the conservation of rain forests and organisms through a disproportionate

emphasis on alternative measures such as sustainable development and forestry? The point is that there is neither leadership nor solid commitment to nature conservation in a world dominated by false compassion for poor people and a real interest in money.

As a scientist devoted to the conservation of nature, it is well beyond my comprehension how a Government policy can cheat with the public concern for the demolition of the rain forest and the extinction of species. Has the Government installed any monitoring and feedback mechanism for its policy implementation? Is the Directorate General susceptible for empirical evidence from the field that is revealing an increasing level of destruction? What kind of democracy would allow such a muddled treatment of its public resources? Maybe one has to accept that international political promises must be kept, and can mean that two-thirds of an allocation must be discarded for diplomacy. However, it drives me mad to find that the meagre 30% which is supposedly meant to support field projects ›for the conservation and sustainable use of the rain forests‹, is so constrained by irrelevant conditions that they cannot possibly achieve the stated objective - i.e. conserving the rain forest. Is it not odd that the responsible Directorate General for International Cooperation is unable to deal with many of the countries that have the last vestiges of pristine rain forest and the greatest stock of remaining richness of biological diversity, such as Indonesia, because of its humanitarian standpoint? Is not the global importance of the rain forest and its biodiversity of a higher order than temporary local politics? Would there be any reason for the Department to have an obsessive lack of confidence in Dutch organisations for implementation? And why must any deployment of the allocation be focused on the development of local rural people, and primarily serve the alleviation of poverty? Why must protection of unique, sensitive areas be thwarted with euphemistic concepts such as ›participatory management‹ of biodiversity in conservation areas?

For a simple ecologist with very extensive anthropological experience, it is incomprehensible to me how these constraints can be related to the conservation of biodiversity and the rain forest - in an inverse relation. After all, scientific evidence shatters the illusion that the alleviation of poverty and raising the standard of welfare would somehow diminish the destruction of rain forests and the depletion of biodiversity! Why has there been no special policy-allocation to collect such ›sensitive‹ evidence as a major task for a Tropenbos programme?

More serious, however, is that it must be expected that once the public discovers the utter ineffectiveness of the considerable public allocation, the political arena will retract all support for rain forests and biodiversity. Perhaps the fact that a politically virtuous project like the Tropenbos programme is gradually but inevitably being starved of support, rather than being guided, was a first sign. Another sign is a new project called ›Accelerated Implementation of the Government Policy on Tropical Rain Forest‹, to be implemented through the Netherlands Committee for IUCN, in order to spend 19 million in three years on small-scale local NGO projects in developing countries. It has the eerie aura of a sell-out, and may well be the omen of a dying political will to support what the public might have believed to be international nature conservation. All the scientific results of the Tropenbos programme will not be able to alter that fate. One day, politicians will ask: ›Can someone show us where our national allocation of 1.2 billion guilders for forests and forestry has contributed significantly to the conservation of biodiversity and rain forest?‹ In spite of beautiful glossy propaganda of the Ministry of Foreign Affairs, I have great difficulty finding even a diplomatic answer. Indeed, when the Minister presented a similar question with reference to the Tropenbos programme to the general assembly, it struck me that nobody in the hall had convincing replies close at hand. The answer, of course, would have been: ›Hardly any cent of the allocation was put into the effective conservation of the rain forest.‹ Your simple humanitarian policies focusing on poverty alleviation have prevented that; they have no bearing on conservation because they are ambiguous and based on false ideology

rather than on scientific knowledge.

It would not be difficult to deploy a mighty annual allocation of some 100 million US$ in a much better way, so that, after some six years, one can show where rain forest is being saved from demolition, and biodiversity is being conserved. However, that would in the first place require the issue of international nature conservation being lifted above the petty concerns of politicians with an overriding humanitarian mission. It would require guidance by scientific knowledge and realistic opportunism, directing significant attention to a few selected places where biodiversity can be saved from further depletion, irrespective of our western evaluation of the structure and beliefs of a local society. In the second place, it requires a policy free of all irrelevant or secondary constraints, such as poverty alleviation, the role of women, and other ideological issues. Finally, it would require a straightforward objective - e.g. conserving this or that rain forest or umbrella species.

Most important, however, in consideration of the recent history of skewed, ineffective allocation, one should ask: ›Should it not be prescribed that the design and implementation of a clear, accountable policy is to be delegated to a non-governmental professional organisation?‹ It has been done for many other sectors of international cooperation (e.g. SNV, Ecooperation, and the co-financing organisations NOVIB, ICCO, and HIVOS), and there is ample reason to apply it in the field of international conservation.

If the concept of biodiversity is meant to serve the conservation of nature, either in the form of reliable scientific information and propaganda, or as an empirical basis for protection management, then the issues of research interest can be differentiated in the following way - from fine to coarse-grained, or from a fundamental to an applied level:

- An inventory and analysis of the legal basis of conservation, and the establishment of appropriate monitoring hardware (including GIS) and skills;
- An inventory of spectacular (keystone or umbrella) species to create a simplified image of the main structural components of a natural ecosystem - to be applied in monitoring the integrity of the system;
- An analysis, on all socio-political levels, of the local threats to the structural integrity of the ecosystem (and, where necessary, determining thresholds of steady-state in structural terms for controlled harvesting in some selected sectors or buffer-zones);
- Experimental approaches towards undoing the analysed threats and the effectiveness of protection; to be continuously monitored for feedback;
- Attempts at restoration and guidance on regeneration;

And on a general level, the most important issue:

- A regular comparative evaluation of nature conservation projects for strategic feedback.

The audience will note that, in this strategic approach, there is no place for deep inventories or sophisticated ecological studies. There are professional conservation experts who are familiar with all the causes of destruction and are able to produce tailor-made strategies for conservation, if only conservation could be sponsored unfettered by irrelevant objectives. Saving rain forests is politics and power-play, but has little to do with ordinary biology, and producing articles. It has even less to do with compassion for poor people, or any other aspect of proper government by other governmental and public sectors. Yet, strategies need up-to-date information on the status and conditions of what must be conserved, and on the threats and opportunities to defuse those threats. As a consequence, any research subject must be part and parcel of the strategy, and it must be integrated so that an active protection programme can be composed. In this respect, Tropenbos can play an important role.

The Tropenbos project in Indonesia has so far been concerned mainly with research on the techniques of establishing timber plantations, and on the selective, minimum impact extraction of timber. Especially the latter research has real significance for the conservation of rain forest and its structure of biological diversity, although it approaches the problem from a pragmatic, if not essentially destructive, angle. It is also important, however, because it has yielded tremendous credit for the Programme in circles of modern Indonesian forestry, and has demonstrated opportunities for a professional exploitation sector to contribute somehow to the conservation of biodiversity. In addition, some research has been concerned with taxonomy, and skims the surface of restoration, for which the knowledge gained in the plantation research may be useful. The Programme is even involved in a minor aspect of species protection, with powerful media attraction potential, namely the rehabilitation of Orang-Utans. However, the Programme has so far not been tuned to seek the design of a strategy; the research subjects are an opportunistic scatter with a diffuse effect on conservation. The primary objective of the Tropenbos programme must be the conservation of rain forest. Considering the upcoming political scrutiny of the effectiveness for conservation, while responding also to the gradual re-orientation of Indonesian society towards conservation, it is imperative that the Tropenbos project in Indonesia directs its main interests towards the issues enumerated above in order to compose a conservation strategy. Only then can it significantly contribute to the conservation of the last remnants of natural rain forest ecosystems in Indonesia, and get so much credit in political circles that a public allocation can be sustained.

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BIODIVERSITY, CONFUSION AND WASTAGE OF FUNDS

Challenges and Problems; Information Needs

- The funding and attention by politicians for protection do not reflect the public concern for disappearance of species and ecosystems.
- Little of the funds earmarked for forests and conservation is used for species protection, in favour of humanitarian and people-oriented projects.

Points for Future Research

- Part of financing and responsibility of forestry policy should be delegated to NGOs.

Conclusions

- Spectacular species (keystone species, umbrella species) are a useful tool to create a simplified picture of the state of the ecosystem.
- Protection of species and habitats should be accomplished through a analysis of threats and systematic removal of these.

FROM THE LOCAL TO THE GLOBAL PERSPECTIVE

Interaction of research at different scale levels

AN INTEGRATED APPROACH TO FOREST RESEARCH IN INDONESIA

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1. INTRODUCTION

The Wanariset Forest Research Station falls under the jurisdiction of the Indonesian Ministry of Forestry through its Forest Research Institute Samarinda. Wanariset is located near the village of Samboja, between the cities of Balikpapan and Samarinda in the province of East-Kalimantan. It was officially established in 1978 as a field station for the Centre of Forestry Research in Bogor, but developed few activities until 1985. That year marked the start of the project >Mycorrhizae in the Tropical Rain Forest=, a joint project between the Wageningen Agricultural University of the Netherlands and the Forest Research and Development Agency of the Indonesian Ministry of Forestry.

In November 1987, a new project started at Wanariset: 'The Tropenbos-Kalimantan Project' (now called 'The International Ministry of Forestry-Tropenbos-Kalimantan Project'). This project was to continue the work of the previous project and was to extend the programme with 'Growth and Yield Studies' and 'Soil and Site Research'. The focus of the programme was on efforts to rehabilitate the forest. Its basis was a Memorandum of Understanding between the Indonesian Ministry of Forestry and the Dutch Ministry of Education. Later, Tropenbos became an independent foundation, and the state forestry enterprises, *PT. INHUTANI I and II*, were incorporated into the cooperation. Still later, the Association of Indonesian Forest Concession Holders (*APHI*) became more actively involved.

Since then, the project has run for 10 years and has undergone many changes and developments. The cooperation has been evaluated by the Ministry of Forestry (*FORDA*) as one of the best foreign cooperative endeavours. Also in terms of the Tropenbos philosophy, the Indonesian site has probably come furthest in achieving Tropenbos's goals of bringing research results into operational practice and of influencing forest policy. The project has been used as an example for many other projects, leading, for instance, to regional interest from neighbouring countries and from organisations such as the FAO Forspa Programme.

This paper will present a brief historical overview of the factors and approaches that have contributed to reaching the present situation. It will also sketch some ideas for the possible future direction of the project. The recurring theme in this overview and analysis will be integration: the integration of (i) practical aspects; (ii) developmental stages of the project; and (iii) research subjects. It is hoped that the relatively long and multi-faceted experience obtained in the project can provide other projects with valuable inputs as well.

2. DEVELOPMENT OF THE PROJECT

2.1 Infrastructure and basic facilities

In 1985, the Wanariset Forestry Research Station consisted of a few wooden buildings and a non-functioning greenhouse. There was no electricity, no water supply, virtually no staff, no communication facilities, and no means of transport. Still, because of the following considerations, this location was chosen to become the central location of the project:

- The presence of forests of various types and conditions in the research forest (within walking distance) and in nearby forest concessions and protected forests;
- A wide variety of social factors such as local people of various cultural backgrounds and with different methods of land cultivation;
- A strategic location between the city of Balikpapan - the gateway to East-Kalimantan, with its harbour and international airport - and the provincial capital of Samarinda, which guaranteed easy access for potentially interested persons and attention to the project;
- Easy logistics for supplies from the nearby city of Balikpapan.

To start a project under such conditions is not easy, and, with the very limited annual budget, careful choices had to be made in developing facilities and infrastructure, and in allocating funds to research and operation. All aspects were equally important in that no research could be done if no operational budget was available and that it was very hard to keep people motivated to do research without any facilities or operational budget. It should be mentioned that, as a positive effect of the severely limiting starting conditions, all initial research was very simple and practical, which soon started generating interest from the forestry sector in East-Kalimantan.

The growing confidence in the project made it possible to solicit the participation of the state forestry enterprise *PT. INHUTANI I*, which provided staff (Dr. Irsyal Yasman), some facilities for transporting materials, and some additional houses for personnel. Starting with old second-hand cars and motorbikes (all of which are still the basis for operating the station, and all with an average of more than half a million kilometres of usage and an average age of 15 years), and the appointment of a mechanic to the project, the facilities for living and working at Wanariset improved. It still took another four years before some form of reliable supplies of electricity and water became available.

Then, through extra funding from Tropenbos and *APHI*, it became possible to build a herbarium - a building that included a multi-purpose room for lectures and meetings and an experimental and educational nursery, where demonstration-scale research could be performed. Through cooperation with the local police, a radio link was established with the police and Balikpapan, which greatly improved security. Other developments were made possible through increased support from the Ministry of Forestry and other parties (e.g. the Balikpapan Orang-Utan Society).

In the meantime, the Wanariset Research Station has developed into a 3-ha compound with reasonable housing and dormitory facilities, a good electricity supply, several (radio) telephone lines with access to Internet, a soon-to-be-reliable water supply, a laboratory, operational greenhouses and nurseries, a canteen, an information centre, an excellent accredited herbarium, and well-trained support staff. It has also become the centre for many new local job opportunities. One feels that it is this gradual physical development that has led to the present set-up, which is greatly enhancing the possibilities for doing research. Over the years, the number of students working at Wanariset has increased, as has the number of researchers. Also the number of outside parties asking for support from the Wanariset Station is constantly growing.

In combination with local experience and knowledge about the forest environment, the Wanariset Station has now become a prime location for doing research that is efficient both in time and in costs. This is attracting many other parties, such as researchers from abroad and from CIFOR, who come to work at Wanariset and in this way enhance the total research output. By being selective as to the type of research that receives priority for execution at Wanariset, the Ministry of Forestry of Indonesia and Tropenbos can create a multiplier effect. By operating a Programme Management Unit, the project has now set the scene for a wide range of research projects financed by various parties.

2.2 The organisational set-up of research

Problems associated with operating a station with a very mixed group of researchers and persons from different institutions consist of the standards of payment for support personnel, the various formats required for work plans, progress reports, budgeting, and so on. It is also difficult to deal with the different schedules for budgeting, reporting, etc., between the various partners in the project. Of course, there are also slightly different priorities for activities to be undertaken with the different partners, but these have proven to be minor obstacles. The yearly Work Plan meetings and the National Steering Committee meetings, where the Annual Work Plan is approved, have always been able to accommodate the different wishes in a satisfactory way.

Over the years, the Ministry of Forestry and Tropenbos have developed a very open and flexible organisation. One standard set of working conditions and rules was created according to Indonesian rules and regulations. These have become an example for many other projects. Some of the procedures have now been made the national standard in Indonesia. Through a 1995 Ministerial Decree, for instance, the financial standards for participating researchers are to be followed by all other foreign projects cooperating with the Ministry of Forestry.

Quite special is the accounting system used at the Wanariset Station. All expenditures of all partners are administered by the same Accounts Department, while allowing for the use of individual budgeting techniques and financial codes. The administration is checked by all partners in the project and twice a year by an accountant. This includes the expenditures financed by the local NGO, the Balikpapan Orang-Utan Society. This approach is extremely useful in overcoming temporary cash-flow problems, as, for instance, when Indonesian budgets are not available at the start of the financial year (delays can sometimes be up to half a year). The transparent accounting system may also help in attracting other research projects to the same location. Of course, the complexity of the system implies that the Programme Management Unit should be well-staffed and capable.

As with the infrastructure and the basic research facilities, good general organisational backing is vital in promoting research, including those activities not directly financed by the Ministry of Forestry and Tropenbos. The approach that Tropenbos has chosen to support its various sites through Programme Management Units would therefore seem to be a sound one.

3. FROM RESEARCH TO APPLICATION

All over Indonesia, the research findings of the project have been translated into large-scale application of the techniques, and into many policy decisions as laid down in Ministerial Decrees of the Indonesian Ministry of Forestry. Some of these concern the planting of Dipterocarps, inventory methodology, and Orang-Utan rehabilitation. Several components utilised in the project have contributed to this successful translation of research into application. These components are:

- Choice of partners in the project;
- Type of research subjects tackled;
- Integration of research results;
- Publication policy;
- Education and training;
- Information and feed-back from the field;
- Long-term involvement.

3.1 Choice of partners

Involved in the project are basic scientists (many of whom have written or are in the process of writing their PhD dissertations and are producing other scientific publications), applied researchers (for nursery trials, large field trials), end-users (*APHI* and the *INHUTANIs*), and policy makers (Ministry of Forestry).

This unique combination of partners meant that sometimes the scientific findings had already been tested on a practical scale before the scientific publication had come out. The opportunity to do large-scale trials at, for instance, the field sites of *PT. INHUTANI I* (Longnah and Batu Ampar) has the added advantage that it can convince policy makers that the research findings are feasible for large-scale application, not only by demonstrating this in the field but also by being able to provide some insight into costs and cost/benefit analyses of the techniques used.

Through cooperation with the people of the operational forestry sector (*INHUTANI I and II, APHI*), the team at the Wanariset Station has a good insight into the practical problems and the needs of users of forestry research. The feedback provided by these partners from field trials elsewhere is also valuable for further research planning.

3.2 Type of research subjects, publication policy, and the integration of research results

The type of research conducted has been crucial. The research started with very specific subjects (e.g. physiology and mycorrhizal surveys), but, from the start, it was always clear where the research would fit into the bigger picture. There was a publication policy in which, starting from scientific papers, the step was taken towards more practical overview papers, which eventually led to manuals for the application of the findings in operational field methods. Later, the policy papers and input in policy formulation also became important. In all project activities, the chain approach is clearly discernible.

The research first concentrated on the specific problem of the supply of good-quality planting stock for Dipterocarpaceae, but quickly combined this with studying the performance of many different tree species in a range of ecosystems and under various treatments. This especially developed under the 'Growth and Yield Studies', which, in their analysis, combined the 'Soil and Site' component. At the same time, initial efforts were made (as early as 1989) to translate the research findings into economic terms. The first example of this was the Nursery Model, a software package that enabled nursery managers to calculate the costs of producing Dipterocarp planting stock by various means of propagation. The model could also predict the practical inputs, both in terms of capital and means, that were needed to use these techniques.

The next step was to integrate the Nursery software into a new software package called the Cost Comparison Model. This Model calculates the costs of forest rehabilitation, including planting, maintenance, and harvesting. The Model has a modest possibility to adjust predictions of cost effectiveness, based upon growth and yield figures. Some of those figures can be derived from the database of long-term growth and yield plots initiated by the project, together with the English ODA:

the Clearing House for Growth and Yield Data in Samarinda.

In the Cost Comparison Model, different silvicultural systems can be designed and tested for their profitability. A different package with species-site-matching possibilities can be used to select the best species for the silvicultural system to be used. The latter programme utilises data from the Biodiversity Research Group as well as performance data from the Research Groups on the Propagation and Stand Establishment and on Growth and Yield.

The Cost Comparison Model is based upon blocks of terrain to which certain silvicultural 'options' are assigned. At present, work is under way to assign those blocks to map units in a GIS that will enable the use of remote-sensing techniques to monitor the predicted performance of the forest rehabilitation work.

The Cost Comparison Model approach is particularly suitable for forest rehabilitation and plantation establishment. Parallel to the above-mentioned work, activities were started on a better tree-position mapping methodology for natural forest, which also included detailed topographical maps. These maps are useful for detailed growth and yield plots, but the maps were originally designed to improve skid road design, which helps to reduce the impact of the logging operation on the post-logging condition of the forest. The new inventory technique (the software package named FIEPLP) provides the user with highly accurate tree-position maps that can be used to validate remote-sensing imagery, especially radar, and to determine whether harvesting has been done according to plan. FIEPLP is now widely used in Indonesia and training courses are regularly being given.

By having tree-by-tree data in the system, it also becomes possible to optimise the forest management according to the latest research findings. If, for instance, a species that was previously considered non-commercial becomes valuable, the harvesting and management of the forest can be instantly adjusted on the basis of the new values assigned to this tree species. This was the case with Ramin, which was once considered a weed species in the silvicultural manuals, but, after becoming popular in Japan, now ironically finds itself listed in CITES. It is critical, however, to have correct tree-species identifications and good species-based performance data. The Wanariset herbarium and botanists are working to produce a system for the quick and accurate identification of the most important tree species (e.g. through the production of a flora that stresses vegetative characteristics). Performance data (species-site matching, growth and yield data, etc.) can continuously be updated while research progresses. As mentioned earlier, this technology is especially suitable for natural forest management where a large number of species are found on small areas.

As can be seen from the sketchy overview above, the different types of activities in the Tropenbos-Indonesia project all come together in one forest management information system.

By focusing on the information needs for good forest management, priorities can be set for the research work. It is important that all the results can be used in an integrated way. This means that compatibility issues are very important. The present publication does not allow a discussion of all the research projects taking place at Wanariset and how they are integrated. For these, the reader is referred to the work plans and the Multi-Annual Plan.

Concerning the integration of research subjects, it is important to keep in mind the need to focus not only on ecological and economic aspects, but also on social aspects. The project has done a lot of work on understanding the interaction of people with their environment, both in traditional systems like those in the upper stream area of the Mahakam River and in areas recently encroached upon by non-

traditional shifting cultivators. As previously mentioned, this publication is not the place to enter into an exhaustive discussion of all the subjects treated in the Tropenbos-Indonesia project.

3.3 Education and training and feedback from the field

Another important factor for the success of the project has been its training and education programme. In 1996, as many as 425 people from various concession-holders and other forestry institutions followed training courses at Wanariset: on tree recognition, nursery management, forest inventory, fire-control management, and Orang-Utan handling. Many of the participants in these courses stay in touch with the staff at Wanariset after returning to their respective companies or institutions. They often provide valuable feedback from the field, which can be used to improve the research or to adjust software to specific conditions.

The Wanariset Station is also visited by many thousands of other people each year. Sometimes these visitors inform us about other problem areas as well. For instance, there are many requests from oil and mining companies in Indonesia to help them in rehabilitating their drilling and mining areas. Fertiliser companies are also interested in the Wanariset experience and want to have their products tested in East-Kalimantan. These contacts increase the potential for doing research and widening the horizon of research needs.

For the national researchers at Wanariset, one can offer some facilities to induce them to stay, but, for permanent researchers, the location of the Wanariset Station is not optimal when seen from a family point of view. Samboja is a small community, with perhaps sub-optimal opportunities for schooling in the direct vicinity of the Station, and it is far from shops and recreation facilities in town. The topping-up of salary that is provided to the Indonesian researchers is but a part of what motivates them to participate in the project. The opportunity to obtain fellowships for MSc or PhD programmes is the best motivation for the active, long-term, and dedicated participation by the researchers in the project.

The language skills of the participating researchers have also been an asset for the project, both at the project site as well as during studies in the Netherlands. Being able to solve problems in other languages is a definite advantage.

3.4Long-term involvement

Another important factor for the success of the Tropenbos-Indonesia project is the long-term involvement of the partners. Indeed, it would be extremely difficult to build up infrastructure, qualified staff, databases, and so on, in a period of just three years, and then expect the project to be self-sufficient. Besides, it would be impossible to set up a herbarium in a matter of a few years. The development of a project of this kind must be gradual, with, over the years, a shift in the programme towards the better integration of research activities and field needs. There is a constant learning cycle, for instance with the farmers who have been involved with the project for many years and who provide valuable additional insights into field problems.

Many more concrete examples could be mentioned, but it is equally important to show that there is a joint commitment to the cause of sustainable forest management. To be able to work from a basis of mutual trust with its partners, a project has to prove its commitment to, and its understanding of, the situation. The long-term approach followed in the Tropenbos philosophy is therefore a very sound one, and not only because results in forestry tend to emerge less rapidly than in other fields.

4. PRESENT TRENDS AND FUTURE DIRECTIONS

There are a number of important trends discernible in the Tropenbos-Indonesia project. One of these is the increasing geographical area being covered by the project. Initially, the project started out just at the Wanariset Station and the nearby research forest. Later, research began in the nearby ITCI concession, the Batu Ampar concession, and still later in many other places in East- Kalimantan. Examples are the Longnah Dipterocarp Planting Project, the coal mine rehabilitation in Sangata, the study on non-timber forest products in the interior of East-Kalimantan, and botanical surveys in many more areas of East-Kalimantan.

More recently, the botanical work has been extended to cover all of Kalimantan and, through the feedback from many trainees, much more information could be collected from various other production forests as well. The Orang-Utan work is now also important for application in Sumatra. Recently, at the request of the Minister of Forestry, work started in Sulawesi to propagate some tree species specific to Sulawesi (belonging to the Magnoliaceae), where the techniques developed for the Dipterocarpaceae of Kalimantan proved to be useful for the Magnoliaceae of Sulawesi.

Many people from the South-East Asian region have visited the Wanariset Station, where training in various aspects of forest management has been given to people from Malaysia, The Philippines, Brunei, Thailand, Vietnam, Bangladesh, Pakistan, India, and Nepal. The recent request for support from Vietnam, under the Forspa Programme, also indicates that the present trend towards a much wider impact of the project is likely to continue.

It is expected that the strong basis of practical knowledge within the joint project will continue to be an important asset. Undoubtedly, there are many more tree species that could be propagated better with the techniques already tested for the Dipterocarpaceae. Also, the use of nutrient-efficient ectomycorrhizae will be just as important in other soils that have experienced erosion. Many other examples could be mentioned.

Another trend that is likely to continue in the future is the focus on integrating the research results into a forest management information system to make the results ideally accessible to forest policy makers. Especially the combination of ground inventories and remote-sensing techniques using GIS systems (with the main focus on radar technologies) and economic models for evaluation is the most promising direction to follow.

A year ago, a workshop was held to discuss whether a local foundation might be set up to enhance the work of the project. The large number of trainees, for instance, takes away time and facilities from researchers. A foundation could deal with consultancies, for which many requests are received; it could organise the training, and could operate facilities such as the canteen or a nursery that could provide plants to local people and other parties wanting to use local tree species. At the same time, it could earn income to enable more research to be done by the project. Researchers involved would gain a better insight into the field problems and therefore be better able to formulate research needs. They would also benefit financially in some way, so that working with the project would be easier for them. Through the foundation, the project would be better able to cope with the many requests for support without interfering with the on-going research programme.

Some seven years ago, an Indonesian Ministerial Decree laid the legal groundwork for such a set-up. Contract research is also a worldwide trend. It will be very interesting to see if an open approach to contract research can enhance the research potential in Indonesia. A name for the foundation has already been proposed (Bornean Meranti Foundation) and a first project with a gold-mining company

offers the opportunity to do additional research that had been planned before but had to be postponed for lack of funding.

5. CONCLUSION

Valuable experience in research project management has been gained under the joint Ministry of Forestry and Tropenbos Foundation project in Indonesia. The results indicate that the Tropenbos principles of influencing policy through practical research and an integrated approach to problems of sustainable forest management are correct and hold great potential for the years to come.

AN INTEGRATED APPROACH TO FOREST RESEARCH IN INDONESIA

Achievements

- Results of a multi-faceted research programme have become extensively integrated in Indonesian policy and forest management practices.

Challenges and Problems; Information Needs

- Extra managerial expertise is required for integrated programmes involving different institutes and budget lines involved.

Points for Future Research

- Development of a forest management information system.

Conclusions

- The research programme was built up from solving specific problems, eventually developing into an integrated approach to provide solutions for forest management.
- Adequate attention for translation of research into economic terms, and training and education programmes has been an important success factor.
- A long-term funding commitment is a pre-requisite for developing integrated programmes.

TOP-DOWN VERSUS BOTTOM-UP RESEARCH FOR SUSTAINABLE TROPICAL FOREST USE

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SOME STATEMENTS FOR DISCUSSION

- Research priorities should be based on a top-down overview.
- This applies equally to policy design.
- Overly detailed research is less relevant, given the scope of the tropical deforestation problem.
- The lack of a multidisciplinary approach in tropical forest research may easily lead to biased and wrong conclusions.
- The fundamental cause of tropical deforestation is human behaviour; without a proper understanding of such behaviour, there is no serious clue to a solution.
- Since ecosystems as well as economic systems are linked internationally, one must, in serious macro-research, pay attention to such interlinkages.
- Various well-intended instruments aiming at sustainable tropical land use are counter-effective, because the important interlinkages are overlooked.
- The population-pressure/mobility/land-use/deforestation nexus is somewhat under-researched, when compared with research investment in other issues related to tropical forests.
- Bottom-up tropical forest research needs to fit into top-down tropical forest research, not the other way around.
- Bottom-up tropical forest research can well be monodisciplinary; top-down tropical forest research should not be.
- As far as rules for tropical forest land use are concerned, a clear distinction should be made between the rules themselves, and the compliance with these rules.
- For tropical rain forest research to be effective, strong lines of communication between the on-site research teams and the regional and national authorities are imperative, so that all parties can realistically assess what can be gained from one another, and what can be achieved; concessionaires can play an important liaison role in this respect, but also local NGOs, experts, etc.
- Researchers who show more respect for the local forest than for the local people may easily suffer from counteractive local behaviour.

DISCUSSION AND INTEGRATION

Dr. R.J. Zagt
The Tropenbos-Guyana programme

In this chapter the editors have assembled and integrated the conclusions of the speakers and the experts gathered in the two expert meetings on 26 November (›Linking policy and research‹ and ›Translating preconditions into policy recommendations‹). The chapter is organised along the lines set out by the Chairman, Prof. Dr. R. Rabbinge, in his Introduction of the objectives of the seminar (Page 21):

1. To present an overview of the role of Dutch research on tropical rain forests in an international context.
2. To identify crucial gaps in research on sustainable forest management and conservation.
3. To develop policy recommendations for improving the link between research and policy.
4. To develop recommendations for improving pre-conditions for effective research.

1. PRESENT RESEARCH CAPACITY AND OVERVIEW OF ONGOING RESEARCH

The report of Simons (1997), presented by Verhoeff, showed that there is considerable Dutch research activity in tropical rain forests. The total amount of funds involved could not be calculated precisely but may be around Nlg 50,000,000 per year; the manpower involved in this research amounted to some 220 full-time equivalents. Particularly strongly represented are research on conservation and biodiversity, sustainable forest management, sustainable land use planning and the people - forest interaction. Comparably less attention is being paid to utilisation, processing and trade; policy, the legal and institutional framework; reforestation and restoration of secondary forest and the use of their products; information, communication and extension; and climate change. In general, the natural sciences have a dominant position in Dutch research on tropical rain forests, while the social sciences are marginally represented.

According to Sayer, the comparative advantage of Dutch (*in casu* Tropenbos) research is its capacity to generate understanding of the functioning of forest ecosystems at large spatial scales and in their local social and economic context. Long-term, in-depth studies at a series of sites in the humid tropics contribute much to this advantage. He particularly emphasised the knowledge that is available about the response of forest ecosystems to human intervention. Sayer was supported by Smits, who also specifically pointed out that the long-term funding commitment to the MOF-Tropenbos-Kalimantan project of Tropenbos was instrumental in reaching the status and achievements that the project has acquired now.

Although much research is organised in large research programmes such as Tropenbos, it was noted that Dutch research efforts were scattered over 72 different institutions, raising concerns that the efforts may not be so well coordinated. Verhoeff recommended improving coherence by setting up a clearing house as a tool for improving the synergy and effectiveness of research projects.

2. PAST ACHIEVEMENTS OF DUTCH RESEARCH

One of the objectives of the seminar, reiterated by the Minister for Development Cooperation in his opening address, was to give an overview of the achievements of Dutch and Dutch-funded research efforts. What is known now that was previously not known, and to what extent did this contribute to better protection of the rain forest and improved living conditions for those people that depend on it?

The seminar provided several approaches to this question from the Minister: first, Verhoeff gave a summary of the recent report on Dutch research in tropical rain forests (Simons 1997), a study that was partly designed to answer this question. Second, some answers could be extracted from the presentations of the speakers.

Verhoeff concluded that it was very difficult to give an answer to this question, simply because even in successful research projects there is often a considerable time-lag between the conclusion of a project and the application of the results in the field. Also, research is only one of the components of applying new insights into practice. Verhoeff concluded that ›the Dutch-funded work in tropical rain forests is successful‹ and ›considering the results obtained so-far, the Netherlands does play a role‹.
The individual presentations gave additional insight, although it should be noted that the presentations were not designed to provide a complete overview of the achievements of research. The points offered have been summarised under Achievements in the boxes following each paper.

A further analysis of achievements mentioned by the speakers shows that much progress is reported from mono-disciplinary work that focuses on description, inventory, categorisation and providing technical solutions to problems, i.e. the fields where scientists traditionally excel. Examples are the steady (but admittedly too slow) progress in taxonomy and production of floras (Verhoeff), the inventory and description of indigenous social systems (Nkwi, Forte, Dijkman); of perceptions of local people on values of the forest and forest management; of traditional uses of plants (Forte, Nkwi) and animals (Hammond); the description and categorisation of ecological requirements of trees (Bongers); and the development of technical systems for the sustainable production of timber (ter Steege, van Leersum and van der Hout, Yasman).
Issues which are important for forest management and which have been raised on the international political agenda belong to a second category of achievements. Significant examples are biodiversity (Baas) and non-timber forest products (Forte, Hammond).
Thirdly, there are examples of successful integration and anchoring of research in the political, social and economic fabric of tropical countries, and the positive effects of this for the quality of life of forest-based people and the wise management and conservation of rain forests. It should be noted that for this category of achievements it may sometimes be impossible to attribute success specifically to Dutch funding or to research. Samper described the development of a national environmental authority in Colombia that is in charge of a research strategy and application of research results in policy. Smits showed that results of the Tropenbos-Indonesia programme are deeply integrated in forestry policy and guidelines in Indonesia. De Camino gave an example of the way in which research has guided the development of a forest management system by a concession holder in Brazil, and how scientific feedback mechanisms were incorporated in the forest management system. In the Philippines, improved community-based protection and conservation activities in a national park are the result of research (Araño and Persoon). However, there were also question marks put at the efficiency of research efforts for achieving these goals,

notably by Rijksen in the field of protection and a number of others on achieving social sustainability of forest management.

Fourthly, many instances were cited of training and education, both at the academic and at the vocational level; of enhancement of the capacities of local institutions to carry out research (Walcott, Smits, Nkwi); and of increasing awareness of stakeholders of the issues surrounding sustainable forest management and land use (Martínez).
Fewer successes were reported by the speakers on solving problems of a multidisciplinary nature, although many stated that progress is being made in the joint execution of research projects by scientists of different disciplines (Nkwi, Foahom, Martínez).

A somewhat different way of approaching the question whether research has achieved objectives of sustainable management and conservation of rain forests is to evaluate to what extent research objectives have aligned themselves to the policy guidelines of the Dutch government. The nine strategies of the Dutch policy paper on tropical rain forests (summarised by Verhoeff) seem to be an appropriate framework at an intermediate level of abstraction to which Dutch research efforts in the rain forest could be related. In this context, Verhoeff commented that there is a good attunement of the research projects with the defined priorities of Dutch policy on tropical rain forests. This means that policy and associated funds for research have successfully acted as instruments of direction (through conformation to national and international research agendas) and concentration (of activities at sites with integrated research objectives). Further, it has stimulated multidisciplinary and international (North-South) approaches to complex development problems. This has led to a decrease of basic research and a reduced influence of the (Dutch) research community itself on the research agenda. At the seminar it was clear that this was perceived to be different by some, showing that the process is not yet finished.

It seems justified to comment that at such a seminar there is a tendency to stress what is wrong in the management of tropical rain forests and what has gone wrong with research. The information need associated with the implementation of sustainable development systems is vast and often very specific to the locality where it is needed and to the requirements of the stakeholders. Information flows remain slow, even where mechanisms for effective communication of scientific results are in place (Martínez). The more information is being managed, the more complicated it becomes to retrieve the appropriate information at the right time and in the right place, even when it is there to be used. Further, the need for information is also a relative concept. Rarely a situation will be reached in which a user will conclude that no further information is needed. Similarly, there is a tendency for researchers to say that more information is required before definitive conclusions or recommendations can be reached.

These features may eventually prevent real advance in knowledge, and lead to misinterpretation of the real achievements of development oriented research. A more appropriate and fruitful approach to testing the impact of research is to test it against its own stated objectives. This approach encompasses the execution of a comparative impact study in the phase of project formulation and identification of objectives. This comparison evaluates the relative impacts of several scenarios of allocating funds and expertise, with at least three positive effects. The exercise will yield a clearer advance insight into the potential impact of the project; there will be a need to state the objectives in realistic and quantifiable ways (a need that was stressed by Lammerts van Bueren); and the objectives themselves will provide a suitable framework for testing the achievements at the end of the project. One scenario could be a ›null scenario‹ of investing no money and admitting autonomous developments to take place in the project area, a second scenario

could be to carry out the research programme with associated spin-off according to plan, and further scenarios could be to invest the same amount of funds in alternative projects in the same area.

3. IDENTIFY GAPS IN KNOWLEDGE AND APPROACH

One prominent issue at the seminar concerned the development of a research agenda. It is clear that there are many problems associated with the management of tropical rain forests, and many ways to organise research programmes dealing with them, but it is a challenge to develop an adequate research strategy prioritising the appropriate research questions. Jepma advocated to use a top-down approach. The problem is defined at a high level, and followed by a systematic identification of all factors that contribute to the problem. In this way a problem tree is developed, possible solutions proposed and priorities for research set. This method is not limiting, i.e. priorities for action or research may well be outside the scope of the disciplines that are presently carrying out research in the tropical rain forest, and may as well be outside the forest itself. Jepma stated that population growth contributed to deforestation to a much larger extent than many other problems identified at the seminar, and that therefore priority should be given to addressing the causes of population growth.

While this top-down approach is a useful exercise, it is also clear that researchable problems are found everywhere along the problem tree. A focus on the major problems and big issues leaves many others that are still obstacles to achieving sustainable management of tropical rain forests. An assessment of their relative importance and subsequent prioritisation would require a top-down analysis which starts at a lower level of the problem tree, viz. singling out those problems which are within the biophysical and social/socio-economical sciences.

Verhoeff and Sayer approached the issue of research strategies in a slightly different way. Verhoeff raised the question whether Dutch-funded research should focus on certain themes and thus play a more specific role in the international research community on tropical rain forests? This approach is somewhat at odds with developing integrated all-encompassing research programmes that follow from a top-down approach. Verhoeff=s question is in agreement with Sayer=s (and CIFOR=s) concept of comparative advantage, which assumes that optimum benefit can be derived when organisations and persons further extend their knowledge and capacities in fields that they are best equipped for (in financial or technical means, or by virtue of their historical development). Both views acknowledge that Dutch research cannot be seen in isolation from international research, and that strong points of Dutch research institutes (and researchers) should be further developed. In his presentation, Sayer argued that the Tropenbos comparative advantage might be its capacity to predict the response of rain forest systems to a variety of management interventions.

No exercise was carried out during the seminar of systematically identifying problem areas and proposing research programmes to address them. Several authors have gone to considerable lengths to do this for their own topics, in particular Nguiffo, Martínez, de Camino, Samper, Bongers and Baas. Their analyses should yield useful frameworks for setting up coherent and strategic research programmes. In most other contributions to the seminar at least some research needs were indicated or could be inferred from the analysis of problems. In Table 1 an overview is given of the most important and most frequently mentioned problem areas and associated research needs, without attempting to be complete. The recommendations have been grouped under several headings, and in many cases their scope has been generalised to some extent, in order to avoid too much specificity. Clearly, research programmes are only meaningful in their own specific setting, and global research agendas at best reflect common denominators of research needs. The grouping is not hierarchical and not part of any conceptual framework. The reader is referred to summaries given at the end of each presentation for the underlying problem analyses and research needs.

Table 1 Developmental problems in tropical rain forests and associated research actions that are required to relieve the problems, based on the papers presented at this seminar. Not all actions necessarily refer to research.

The legal and institutional setting

Problems identified by authors:
- Inadequate institutional and legal framework (e.g. length of concession rights) for forest management;
- Overlap in jurisdiction between government agencies;
- Improper (land use; forestry) planning mechanisms;
- Bureaucracy;
- Unequal access to natural resources for different groups within the population;
- Limited capacity for monitoring and enforcement of regulations.
- Lack of a mechanism to exchange information between researchers, planners, farmers and decision-makers.

Proposed research actions:
- Improve institutional (government and NGOs) and legal framework;
- Develop methodologies for land use planning, forest management and monitoring.

Land use

Problems identified by authors:
- Conflicting rights (e.g. people in conservation areas) and conflicting land use options (e.g. infrastructural projects and national parks);
- Deterioration of the quality of forest, agricultural land and soils as a consequence of inadequate land use (e.g. shifting cultivation).

Proposed research actions:
- Develop alternative and sustainable land use options;
- Develop mechanisms for assessing and planning optimum land use for forest lands.

Biodiversity and inventory

Problems identified by authors:
- Biodiversity is poorly described;
- The function of biodiversity is little understood;
- Appropriate knowledge is disproportionally distributed over taxa;
- Taxonomists are disproportionally distributed over the world (Martínez, Baas).

Proposed research actions:
- Identify and characterise the most threatened forest ecosystems (both flora and fauna) by carrying out inventory programmes with a focus on generating distributional information;
- Determine the minimum size of conservation areas needed to guarantee the integrity and functioning of forest ecosystems;

Table 1 Developmental problems in tropical rain forests and associated research actions that are required to relieve the problems, based on the papers presented at this seminar. Not all actions necessarily refer to research. (cont'd)

- Determine the relation between biodiversity and ecosystem functioning;
- Document the uses of biodiversity by traditional communities and study their management methods;
- Prioritise biodiversity research with emphasis on taxa that are of economic potential, are threatened or can be used as indicators and on high priority areas;
- Make existing knowledge accessible by constructing databases of collections and setting up gene banks;
- Develop the functional diversity concept;
- Develop monitoring programmes for important taxa.

Biophysical sciences (excluding forestry)

Problems identified by authors:

- Limited knowledge concerning mechanisms that govern growth and survival of plants (and animals);
- Lack of ecological base-line data;
- Poor ecological underpinning of silvicultural management;
- Little attention for the importance of plant-animal relationships for forest functioning.

Proposed research actions:

- Collect base-line data and develop an understanding of mechanisms underlying the structure and functioning of the forest ecosystem;
- Develop models as a tool to predict response of forest ecosystem to intervention;
- Develop monitoring systems for biodiversity and forest ecosystem functioning;
- Increase the understanding of population dynamics in fragments (primary forest remnants in secondary forests, forest islands in cultivated landscape).

Forestry

Problems identified by authors:

- Even though feasible harvesting systems have been developed, they are not applied;
- Application of silvicultural intervention may lead to an increase of undesired species that is much higher than the increase of desired species.

Proposed research actions:

- Design inventory techniques that improve estimation of volumes, defects;
- Optimise present best practices: inventory, planning, organisation, techniques for damage reduction;
- Incorporate biodiversity (and specifically plant-animal relations) and future silvicultural objectives in design of logging;
- Further develop various silvicultural treatments: compatibility with ecological requirements of species; natural regeneration; species choice; specificity of application; logging cycle; methods of tree elimination; effects of second felling; rehabilitation of logged-over and degraded forests; optimise replanting techniques;
- Carry out demonstration projects that show the applicability of improved forestry techniques.

Table 1 Developmental problems in tropical rain forests and associated research actions that are required to relieve the problems, based on the papers presented at this seminar. Not all actions necessarily refer to research. (cont'd)

- Develop cheap and reliable criteria and indicators for sound forest management; use these for monitoring forest practices;
- Develop models in the fields of ecology, forestry and forest economics, preferably on the basis of a GIS and at an individual tree level, leading to a forest expert system.

Economy
Problems identified by authors:
Limited information about
- The economical value of the forest, of biodiversity and of conservation;
- The contribution of indigenous economies to the national economy;
- The value of (lesser known, certified) timber and non-timber forest products on international markets;
- The costs and benefits of sustainable management systems.

Proposed research actions:
- Carry out studies addressing these issues.

Socio-economics
Problems identified by authors:
- Discordance between forest law and social organisation patterns of indigenous people;
- Different (and insufficiently known) perceptions of different actors on forest and forest management;
- Limited participation of indigenous communities in forest management and planning;
- Population increase.

Proposed research actions:
- Empowerment of various social units in order to stimulate meaningful input in forest use planning;
- Map spatial claims of various actors and determine zones of conflict about resources.

Methods and techniques
Proposed research actions:
- Compile and develop information on
- Properties of lesser known timber species;
- Safety aspects of logging;
- Improved sawmilling and drying techniques;
- Small-scale processing of forest products;
- Land-use planning techniques;
- GIS;
- Forest models.

3.1 Level of detail of research needs

It appears from Table 1 and the contributions during the seminar that for those problems that most require a multidisciplinary approach (here under the headings of institutional setting and socio-economics), the problem analysis and research agenda seems to be least concrete. This may reflect the complexity of the problems, and the number of parties involved in analysing and recognising the problem and setting the research agenda. In contrast, although monodisciplinary research (the

biophysical sciences, forest research) may sometimes incorrectly ignore its social and economic setting, the analysis of the problems and the research needs appear to be more concrete, which means that there is a better perspective for substantial progress in knowledge.

3.2 The need for models

The need to develop models in ecology, forestry, economy and other fields does not feature prominently on this list, although some contributions highlighted the importance of developing models as tools for the planning of management and predicting the effects of human intervention. This is remarkable for several reasons. First, the benefits of two scientific revolutions have started to become widespread, even in technologically less advanced countries: the computer revolution and, related to this, the statistical revolution. This means that advanced data analysis and modelling have become feasible.
Both forestry research in mega-diverse tropical rain forests, and multidisciplinary research with its multitude of criteria and sometimes incompatible research approaches require computer power and highly sophisticated statistical methods for making sufficient progress, if at all. The same is true for ›science that operates at the scale of landscapes, and that optimises the use of multiple products‹, as was advocated by Sayer.
One example: many silvicultural systems find their origin in research that was carried out in the first half of this century, aided by relatively simple analytical tools. Blanket analysis leads to blanket silviculture. One major conclusion of this seminar was that many of these systems do not work as they were intended to (because landscapes and species are not ›blanket‹), and a plea was made for a more individually based approach to forestry (Smits, Bongers, ter Steege, Yasman). This has a cost: a very large knowledge requirement. This can only be obtained from highly sophisticated analysis of very large datasets. A major trend in forest modelling is the development of improved individually-based growth models. At this moment such models only exist for the simpler forest communities of temperate regions, but there is much benefit to be had from developing such models for tropical forests.

Second, models provide an excellent means of structuring information needs and underpinning research priorities. This is alluded to Martínez for GIS-based land use models. What is more, this approach avoids the setting of research priorities without taking appropriate decisions for low-priority but still ›needed‹ research.

A third reason for emphasising the need for models is their potential for generalisation. Research, and particularly highly applied research, tends to respond to local problems, and produces local solutions. Ideally, it should be avoided to carry out similar studies in other, similarly local places. A modelling approach requires that underlying processes of the problems at stake are studied, and these are often of a more general nature. Models based on a mechanistic understanding of processes will have a much wider applicability than just the locality where they were built and calibrated, and this is a powerful means of avoiding unnecessary duplication of efforts.

3.3 Tropical rain forests are dynamical systems

Many biological (e.g., Bongers) and social (e.g., Dijkman) systems are of an inherently dynamic nature, not only on short time scales (such as El Niño effects on climate and fire regimes in Indonesia, Beek), but also on long time scales such as gradual changes in species composition of rain forest communities. Systems of sustainable forest management aim to achieve a situation that is implicitly stable: a certain level of timber production, a system of reliable NTFP production, a certain species composition. Depending on the level of human control over the system, it is not likely that stable situations can be attained or even exist. The species composition of tropical rain forests changes regardless of human interference; a multitude of motivations and incentives drives people around from one place to another; markets for forest commodities change as a result of new technologies and fashion. Sustainable management systems that do not acknowledge the dynamic nature of the underlying processes are bound to fail. This issue was little mentioned among the problems and research needs at the seminar, although there seems to be quite a large research challenge there. A proper understanding of dynamic systems requires that descriptive research (in taxonomy, biogeography, phytosociology, soil science, anthropology, etc.) is followed by research focusing on understanding the processes that define the dynamics of these systems. This should result in management systems which are process-based, i.e. systems that achieve management goals by influencing processes rather than manipulating outcomes. An example of this is forest management by manipulation of the light environment in forests, based on an understanding of light requirements of individual species, as described by Bongers.

3.4 Local issues and global issues

The information needs identified by the contributors reflect, logically, the context in which the contributor is working. Some of the information needs have a very wide field of applicability and a large range of potential beneficiaries, such as, e.g., the contribution of NTFP to national economies, while others are mainly relevant for the specific context for which they were identified, and have few potential users, such as, e.g., research on the marketability of certain lesser known timber species (de Camino). It is a relevant question where, on this scale, the responsibility of the international research community starts, and where the responsibility of the individual beneficiary ends. In his contribution, Sayer voiced the expectation that in the future ›research to support productivity increases and processing efficiency will be profitable and will be increasingly dominated by the private sector‹, whereas ›the role of public forest research institutes in the future should be to provide the scientific underpinnings for multiple use forest management with a heavy emphasis on environmental public goods and the equitable distribution of costs and benefits‹.

3.5 Semantic confusion and other misinterpretations

One obstacle in the advancement of research leading to sustainable management of tropical rain forests is the use of a dazzling number of terms and concepts which are confusing even to the scientific community itself. A number of examples will illustrate this point:

The information needs as presented by de Camino separate research into the ecology and population dynamics of species from research into the silviculture of these species. This distinction rather reflects a historical difference in approach between foresters and ecologists than a difference in nature between these research questions. The questions are nearly identical: the ecological question is about the mechanisms that determine the ecology of species, and the silvicultural question about ways to adjust these mechanisms to the advantage of the timber company. It is clear that a multidisciplinary and process-based approach is required.

In many policy documents a difference is made between timber and non-timber forest products. Also at the seminar, the workshop dealing with technical aspects of sustainable forestry focused on the study of timber forest products, while the workshop dealing with social aspects called for research on non-timber forest products. While the difference in focus is understandable from the different users of these two groups of forest products (companies for timber products, indigenous communities for non-timber products), the underlying research questions are essentially the same. In both cases, research is needed on the ecology (population dynamics) of the species, and on ways of sustainably producing the respective commodities. Dijkman pointed out that the commonly held notion that the extraction of non-timber forest products is sustainable while extraction of timber is not, is a myth. The result of the separation of these groups in different research disciplines is that little exchange of information occurs between the two, but there is much duplication of research. The bottom line is that research should be based on species groups that are defined on (in this case) biological grounds and not on socio-economic grounds (timber and non-timber forest products) or economic grounds (such as the commercial vs. non-commercial species grouping popular in forestry, see ter Steege).

The issue of biodiversity has entered the political centre stage (Baas). At the same time, the concept of biodiversity has widened so much, that it now seems to encompass the study of all systems that consist of more than two things. The most popular definition of biodiversity includes genetic, species and landscape aspects, as well as composition, process and function. Although it is laudable that the issues encapsulated in this definition of the term biodiversity have acquired much needed and overdue attention, the scientific debate, and, eventually, the political debate are better served by unambiguous terms. The term biodiversity now covers entirely different research agendas, and the use of it is frequently a cause of confusion or even conflict. Baas shortly alluded to this when he referred to ›specialists of various levels of biodiversity research‹ who ›see fit to claim their own branch of science to be the single Holy Grail to solve all the problems associated with the biodiversity crisis‹. The proper development of a research agenda (as was the objective of the seminar) would be greatly advanced by a clear definition of the research needs in the field of taxonomy and ecology of species.

An example of the unwarranted exchange of two concepts which are essentially different concerns sustainable management (which, in itself, is a term inviting controversy) and criteria and indicators. The development of a clear and cheap set of criteria and indicators is considered as a means of achieving sustainable management. While this is not untrue, criteria and indicators should only be considered as a practical surrogate to measuring the sustainability of management. However, neither the existence of a set of criteria and indicators, nor, indeed, compliance with the norms set by criteria and indicators, necessarily imply sustainable management. This depends on the adequacy of the criteria chosen (i.e., their quality as a surrogate), and this is still an issue requiring much attention. Sustainable management could be achieved without using criteria and indicators. Both issues merit research.

4. RECOMMENDATIONS TO IMPROVE COMMUNICATION; LINK BETWEEN RESEARCH AND POLICY

Effective scientific research was defined by Lammerts van Bueren as research that is relevant, scientifically sound, produces results that are accepted and applied, and whose application has a positive impact on tropical forest ecosystems and associated socio-economic systems. This is

rather ambitious for many research programmes, but there are certain pre-conditions, which, once satisfied, greatly increase the probability of achieving the desired objectives.

In the following two sections, two aspects of successful research programmes are examined: the relation between research and the societal demands to which it is responding (i.e. the relation with the outside world); and conditions to improve the research process itself (the internal organisation of research). Two workshops of experts were convened to formulate recommendations on these issues. For the purpose of the discussion, the conclusions of these workshops were redistributed to fit into these two topics.

A returning element in the discussions was the perceived inadequacy of researchers and research institutions to make their results available for users: policy makers, forest managers and forest users. Research has not led to improved land use and conservation (Martínez). From the various contributors the following possible causes for this lack of application of results could be extracted:

10 There is no problem;
20 The problem is ill-defined, so no proper research questions can be developed;
30 The research programme is not relevant to the problem;
40 The research is improperly conducted;
50 The research questions can not be solved;
60 There are good results but they are not properly communicated to the users;
70 There is proper communication but the users do not understand the results, or had higher expectations of (the effects of) the results;
80 The users understand the results but have no interest in changing their behaviour, or incentives to change;
90 The users understand the results but there is no mechanism in place that adapts policies on the basis of new research insights;
100 There is a mechanism in place but there is no perceived or real profit to be gained from adopting new policies or methods.

(It is good to note that (certain forms of) research lead to deteriorated land use practices and a reduced conservation of natural resources, which shows that there *is* some impact of research on land use and conservation, and that users do know how to find their way to research results once a certain benefit is to be expected. This may be a cynical twist to a sombre story, but it may also indicate that one should consider the entire chain of mechanisms that eventually leads to the application or non-application of research results.)

Characteristics of programmes that fail in one or more of these aspects of communication between researchers and users were identified by the participants as follows: dominance of the research community and limited involvement and influence of the various stakeholders (policy makers, local communities, users, private companies) in setting the research agenda; a low priority given to social issues in matters relating to sustainable land use; and limited institutional counterparting between North and South, either resulting from a lack of interest or from limited institutional capacity. The dominance of researchers in setting the research agenda in some cases leads to a conflict between the personal interests of the researcher and societal demands. Another potential hazard to the success of research programmes was mentioned to be the shortage of well-trained scientists in developing countries (Samper, Baas). As local researchers are, theoretically, in a better position to fathom societal research demands, this shortage increases the probability of misguided research programmes. Finally, non-transparent procedures of identifying research needs and setting the objectives and priorities inevitably lead to a loss of commitment of the parties, and a reduced sense of ownership. In each research programme priorities need to be set and compromises found. Once the procedure to do that is unclear, the process is more often than not perceived to be biased, and the resulting decisions and research results are not endorsed.

The conclusions of the expert workshop, plus some additional points that emerged during the main sessions are summarised in Table 2.

Table 2 Conclusions of the expert workshop developing policy recommendations for improving the link between research and policy, extended with conclusions forthcoming from the papers presented at the meeting.

1. Strengthening the local capacity to identify possible problems and to manage the forest.
   - Social research needs to be focused on strengthening the capacity of local communities in forest management (participatory management plans). Hence, social research is mostly applied research, on request or in cooperation with local organisations (governmental or non-governmental).
   - Strengthening local capacity requires the understanding of local perceptions of the value of the forest, local knowledge, current utilisation systems and tenure arrangements. Participatory Resource Analysis (PRA) is an important tool for increasing this understanding.
   - The meaningful involvement of local researchers requires extra attention for training and the stimulation of a sense of ownership to the programme.
   - Strengthening the local capacity also requires making local communities less dependent through social organisation, by giving them the possibility to set the rules, by making them researchers (and turn this into cash) and by making them aware of their rights and obligations.
   - Research is needed on the ways local communities can benefit from sustainable forest management by exploiting markets for timber and non-timber forest products at different scale levels and by identifying opportunities in the forest industry.
   - Research is needed on the development of alternative land use options to relieve pressure on primary forest. The social sciences can play an important role in using participatory techniques (PRA, PTD) to develop viable options.
   - The development of management plans need to be based on guidelines from policy makers with respect to land use management options, priority areas etc.
   - A win-win situation should be created in research programmes, with clearly identifiable benefits to all parties involved.
   - National research institutions need to be developed (or strengthened) that, with strong political support, develop the national research agenda, coordinate research, and translate research results into extension, training and recommendations for politicians. The reader is referred to the contribution of Samper for the example of Colombia.
   - Research institutes should support private companies and NGOs and use a positive environment with motivated people to expand their research capacities.

Table 2 Conclusions of the expert workshop developing policy recommendations for improving the link between research and policy, extended with conclusions forthcoming from the papers presented at the meeting. (cont'd)

- Fundamental research is needed to supplement the applied research by private companies and NGOs in order to develop sustainable long-term management strategies and care for the public goods. These two ›streams‹ of research programmes need to be closely interlinked. Financial support is needed to support private organisations, and to implement fundamental research.
- More attention needs to be paid to the impact of logging on local communities and sustainable forest management.

3. Recognition of the role of research as a policy instrument.
   - Researchers should become aware of the role of research as a policy instrument. It is just one of the instruments that a policy maker uses in developing a policy. How does research relate to other instruments, such as legislation and price policies? There should be insight in a country's key players, and their specific interests and motives need to be charted.
   - How to ›sell‹ preliminary research results? This requires additional skills of a researcher and external support with, e.g., public relations. Many speakers mentioned the need to organise workshops between researchers and policy makers as well as in villages (Nkwi).
   - The necessity of integrating results was frequently mentioned: aggregating and further translation of complex research issues in terms that are suitable and understandable for stakeholders.
   - Lobbyists and media are needed to promote the important points made by scientists among policy makers.
   - A clear distinction should be made between the rules regarding tropical forest land use themselves, and their compliance.
   - Support may be needed by the national government in the process of certification.
4. The development of an information management system linking different disciplines at different scale levels.
   - National or regional research institutes should serve as platforms for information exchange between researchers, planners, users and decision makers.
   - The development of an approach (for land use planning and GIS) by a group of institutions is an important strategy to direct the research process towards priorities and integrating results of existing research and local knowledge. It must be linked to local policies, programmes and specific problems.
5. Linking Dutch and international research and policy development.
   - Forestry research institutes should focus on multiple forest management (while production forestry will be dominated by the private sector). Attention is needed for environmental public goods and equitable distribution of costs and benefits.
   - The main contribution of Dutch research is to develop the capacity to predict the response of forest ecosystems to a variety of management interventions.

Table 2 Conclusions of the expert workshop developing policy recommendations for improving the link between research and policy, extended with conclusions forthcoming from the papers presented at the meeting. (cont'd)

- The role of CIFOR should be to generate options for institutional and policy interventions through seminars and workshops, e.g. ›Making forest policy work‹, on the role of research and information in supporting policy making; partnership models; trade issues; forest certification. Also, through the electronic mailing list on policy issues and the discussion paper series.

The issues mentioned under the first heading all concern the proper identification of the problems to be investigated, and the meaningful involvement of local communities, researchers and policy makers into this process. The development of an information management system (4) agrees well with the comments made above about the role of models. In (4), the example of models for land use planning is used, but the same approach could be used for other issues.

5. RECOMMENDATIONS TO IMPROVE THE PRE-CONDITIONS FOR EFFECTIVE RESEARCH

The development of systems of sustainable management of tropical rain forests and the improvement of the socio-economic conditions of forest-dependent people is a complex issue requiring complex, multi-faceted and multi-stage research programmes. A clear concept of the research needs and strong integration of various, sometimes very different scientific disciplines are required. A lack of integration of research, poor compatibility and communication between disciplines and dominance by certain disciplines were problems that were frequently mentioned during the seminar. Other aspects received less attention, but are equally important for organising effective research (realisation of different requirements of research).

Many authors stressed the importance of multidisciplinary research. The issue of multidisciplinarity strongly focused on the contribution of social sciences to research programmes. Verhoeff, Nkwi and Jepma mentioned the poor balance between biophysical (too much) and social sciences (too little). The relation between social and biophysical sciences is marred by differences in ›language‹ and approaches. Social sciences often utilise qualitative research methods, which are difficult to integrate with the quantitative methods used in the biophysical sciences (Nkwi). Note, however, that Dijkman showed examples of quantitative approaches by socio-economic researchers. The seminar produced few answers to solve these problems. Nkwi suggested to organise workshops in which biophysical scientists are trained in socio-economic research methods. Further, several contributors and the experts at the expert meeting stressed that sufficient funds should be made available to set up the structures that are required to optimise the integration within research programmes. It seems reasonable to state that successful multidisciplinary research depends on two important conditions. First, the research objectives (and associated outputs) should be formulated in clear and preferably quantifiable terms. Second, the actual research (in the field) should be designed in such a way that the participating researchers and/or disciplines are not competing with each other (for space, time, people, etc.). Too often it is forgotten that the execution of one project may preclude the execution of another.

It seems justified to note that multidisciplinary research also concerns research projects within the biophysical sciences and within the social sciences. The issue whether these programmes encounter similar problems as integrated social and biophysical programmes received little attention.

The seminar was not so positive about monodisciplinary work. Monodisciplinary research was perceived to be insensitive to conditions and demands from outside the discipline, and the nature of the problems in tropical rain forests would not allow monodisciplinary research. It is very likely that this

attitude will be reconsidered once research programmes will be formulated on the base of a clear and systematic conceptual analysis of the problems. At that stage it will be evident that some research objectives need to be achieved with multidisciplinary approaches, while others require a monodisciplinary approach. This approach will produce results that will be integrated with information from other projects at a much later stage (or at a higher level in the problem tree) than the results of multidisciplinary research. In certain aspects, monodisciplinary research may have advantages over multidisciplinary research. It does not require the sizeable input of funds, time (meetings) and managerial expertise that is needed to maintain the multidisciplinary structure itself. These assets can be used for making scientific progress. Further, as was also noted before when discussing the research agendas, in monodisciplinary research it is often easier to formulate detailed information needs and the requirements to meet these. This will also increase the probability of success.

Apart from the balance between societal and biophysical sciences, many other unbalances were observed in research programmes: domineering personal interests of researchers vs. societal needs (Walcott); the quest for new data vs. the utilisation of existing data (e.g. in botanical and zoological collections: Baas; or in earlier research findings (duplication of research): Verhoeff). Funds were considered too little for: research and land-use planning (Martínez), species and habitat conservation (Rijksen); and development of sustainable logging methods in primary forests (de Camino); but too much to governmental organisations and too little to NGOs (Rijksen). The balance between ›basic‹ and ›applied‹ research is often perceived to be wrong (too basic: Faohom; possibly too much applied research: Verhoeff; too little research on mechanisms: Bongers). In most cases, the solution was sought by improving the mechanisms of defining research programmes and prioritising objectives in research and management.

Table 3 Conclusions of the expert workshop on developing recommendations for improving the preconditions for effective research, extended with conclusions forthcoming from the papers presented at the meeting.

1. Research should be translated into training programmes to be coordinated by a national forestry institute.
• Researchers of scientific institutions should work together with forest managers on the same site.
• Training is required for forest workers (as crucial managers of the forest).
• Training of students should be contracted to local institutions.
2. Collaboration of research institutes should be based on partnership.
• Collaboration of research institutes should be based on equal partnership with mutual benefits to all partners in terms of desired output.

Table 3 Conclusions of the expert workshop on developing recommendations for improving the preconditions for effective research, extended with conclusions forthcoming from the papers presented at the meeting. (cont=d)

- Strong lines of communication between on-site research teams and regional and national authorities are imperative.
- Research programmes should be strongly linked to organisations with operational responsibilities. Such organisations should have a long and positive history and some political backstopping (power).
- A network of all key stakeholders should be set up in each country.

1 The expertise and structure of research institutes should be focused on interdisciplinary research.

- The training of students should be contracted to the participating institutions in order to obtain their meaningful participation.
- The local institutions should be held accountable for their own performance.
- More attention needs to be paid to applied research on demand of local communities and local organisations.
- New approaches and techniques such as Participatory Technology Development (PTD), Participatory Learning and Action (PLA) and Participatory Rural Appraisal (PRA) should be used to develop research programmes.
- Research topics and funding should be flexible.
- Experiences and approaches from community forestry should be used.

4. Research as interdisciplinary work.

- The difference in perception and expression between researchers of different disciplines should be bridged. This will cost time, logistic support and funds for the integration of results.
- ›Hard= and ›soft= systems need to be linked.
- Common objectives need to be set using e.g. OOPP and PRA techniques.
- Most research is implemented by PhD students. They need additional time to integrate their work and to make it applicable. Research should become less dependent on PhD programmes.
- Interdisciplinary work should be rewarded.

5. The interaction between policy strategies and research agendas.

- The role of national policy in defining research programmes should be increased (rather than emphasising the role of research in formulating policy)
- Beneficiaries of research should have a greater input in the choice between alternative research projects.
- Research priorities and policy design should be based on a top-down analysis. Bottom-up approaches should fit into a top-down policy.
- Due attention needs to be paid to the analysis of the underlying causes of forest exploitation in order to find appropriate strategies for solutions.
- Macro-economic research is needed on the international linkages between ecosystems and economic systems.

Table 3 Conclusions of the expert workshop on developing recommendations for improving the preconditions for effective research, extended with conclusions forthcoming from the papers presented at the meeting. (cont=d)

6. Clearing house.
- There is a great need for the establishment of a central project registration and advice centre on research efforts on the national and European level.

1. (Inter)national exchange of knowledge and information should be stimulated by funding study trips, newsletters, workshops, etc.

DISCUSSION AND INTEGRATION

Achievements
- Much progress in mono-disciplinary work that focuses on description, inventory, categorisation and providing technical solutions to specific problems.
- Progress in taxonomy and production of floras.
- Progress in the inventory and description of indigenous social systems.
- Progress in the inventory and description of perceptions of local people on values of the forest and forest management.
- Progress in the inventory and description of traditional uses of plants and animals.
- Progress in the description and categorisation of ecological requirements of trees.
- Progress in the development of technical systems for the sustainable production of timber.
- ABiodiversity@ and Anon-timber forest products@, among other issues were raised on the international political agenda.
- Several examples of successful integration of research in the political, social and economic fabric of tropical countries, with positive effects on the quality of life of forest-based people and the wise management and conservation of rain forests.
- Training and education have led to increased local capacity to carry out research and to achieve sustainable forest management.

Challenges and Problems; Information Needs
- Administrative and legal frameworks inadequate for carrying out sustainable forest management.
- Improper land use planning and land use plans lead to deteriorating quality of forests.
- Biodiversity of the tropical rain forest is inadequately catalogued.
- Poor knowledge of the mechanisms leading to proper forest management.
- Feasible harvesting systems are not applied.
- The economics of sustainable forest management including non-timber forest products are poorly known.
- Perceptions of various users on forest and forest management are different and poorly acknowledged.

DISCUSSION AND INTEGRATION (cont'd)

Points for Future Research

- Develop the legal and institutional framework that is conducive to appropriate land use planning.
- Study mechanisms for improving land use planing and land use.
- Collect strategic information about biodiversity, make it accessible and develop capacity in identification.
- Carry out monitoring and associated modelling studies describing ecosystem processes.
- Carry out demonstration projects showing the feasibility of low impact harvesting techniques.
- More attention for economic aspects of sustainable utilisation and conservation of rain forests.
- Study mechanisms to empower actors in forest management to increase support for sustainable forest management.

Conclusions

- Modelling approaches followed as tools for the planning of management and predicting the effects of human intervention.
- Sustainable forest management systems should acknowledge the dynamic nature of forests and forest use.
- The potential impact of research programmes should be evaluated in advance by carrying out a comparative impact assessment of alternative research options.
- Dominance of research community and limited involvement of other stakeholders lead to failing research programmes.
- Programme formulation should be transparent, involve all stakeholders and build partnerships with responsibilities to all parties involved.
- Monodisciplinary work is perceived to be insensitive to conditions and demands from outside the discipline, and the nature of the problems in tropical rain forests requires multi-disciplinary research.