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DEFORESTATION OR DEVELOPMENT IN THE THIRD WORLD?

Edited by

MATTI PALO & JYRKI SALMI



HELSINKI 1987

METSÄNTUTKIMUSLAITOS
Kirjasto



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Metsäntutkimuslaitos on maa- ja metsätalousministeriön alainen vuonna 1917 perustettu valtion tutkimuslaitos. Sen päätehtävänä on Suomen metsätaloutta sekä metsävarojen ja metsien tarkoituksenmukaista käyttöä edistävä tutkimus. Metsäntutkimustyötä tehdään lähes 800 hengen voimin yhdeksällä tutkimusosastolla ja yhdeksällä tutkimus- ja koeasemalla. Tutkimus- ja koetoimintaa varten laitoksella on hallinnassa valtionmetsiä yhteensä n. 150 000 hehtaaria, jotka on jaettu 17 koealueeseen ja joihin sisältyy kaksi kansallis- ja viisi luonnonpuistoa. Kenttäkokeita on käynnissä maan kaikissa osissa.

The Finnish Forest Research Institute, established in 1917, is a state research institution subordinated to the Ministry of Agriculture and Forestry. Its main task is to carry out research work to support the development of forestry and the expedient use of forest resourses and forests. The work is carried out by means of 800 persons in nine research departments and nine research stations. The institute administers state-owned forests of 150 000 hectares for research purposes, including two national parks and five strict nature reserves. Field experiments are in progress in all parts of the country.

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ABSTRACT

Deforestation of the tropical forests, one of the most serious problems of our time, is assumed to be a complex ecological and socio-economical process maintained by a number of indirect and direct human and natural factors which are most difficult to control. The importance of the human factors is emphasized. A long-term historical model of man's role in the ecological processes in Africa is presented. The key role of economic and technological innovations is stressed. The future prospects of tropical forests are sketched with pilot scenarios of deforestation. Strong negative correlations between forest coverage and total population density were confirmed in cross-sectional country-wise analyses. Using the available population growth predictions and making different assumptions according to the regression function the total forest area of 17.6 million km^2 in 1980 of 60 tropical countries was anticipated to decline by 45 %, 30 % or 16 % until 2025. The declines of 30 and 45 % are related to the reviewed theoretical frame. The deforestation of 16 % is close to the continuity of the present rate, which is mostly assumed by other authors. The supposed accelerated speed of the tropical deforestation will not slacken until the described negative feedback loops strengthen at the later stage of the deforestation process. Furthermore, there is a danger that these negative feedback loops will not become strong enough or that they will be ignored by policy makers. As an example, the forest sector development in Latin America is reviewed. Despite appreciable development in some areas, the actual overall situation is severely criticized: The natural forests are depleted at an accelerated speed without respective benefits. Finally, a five-year plan for a further research project in the field of deforestation and development in The Third World is presented.

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CONTENTS

	Page
Preface	5
Deforestation or development: an overview by M. Palo and J. Salmi	7
PART I: Pilot findings on deforestation	13
1. Man's role in the ecological processes in Africa: towards a long-term historical model by A. Siiriäinen	15
2. Deforestation in the tropics: pilot scenarios based on quantitative analyses by M. Palo, G. Mery and J. Salmi	53
3. Deforestation perspectives for the tropics: a provisional theory with pilot applications by M. Palo	107
PART II: Pilot findings on development	141
4. Latin American forest sector development: a short-term review and prospects by G. Mery	143
PART III: Future research	221
5. Deforestation and development perspectives in developing countries - A research project plan for 1987 - 1991 by M. Palo, G. Mery and J. Salmi	223

PREFACE

During my recent consulting work for FAO in four developing countries I came into personal contact with the problems surrounding the forest-based economic development in the tropics with its consequent deforestation, erosion and social costs. Coming from a country where forestry is subject to effective public controls with a particular common concern of its long-term sustained and progressive yield, my work in developing countries left myself with a deep concern for the future survival of the once vast tropical forests which seemed to be rapidly disappearing in the wake of mismanagement. This subjective concern has resulted in the formulation of the present study in which the causes of the deforestation of tropical and subtropical forests will be identified and related to the positive and negative aspects of forest-based economic development.

International Institute for Applied Systems Analysis (IIASA) in Austria had a particular Forest Sector Project during 1980-1985. I was invited by the project leader first to give a seminar and later on to write a review article on perspectives of tropical deforestation. This activity was a final impetus to mobilize the present study. A close contact with my colleague Gerardo Mery from Chile, contemporarily working in Finland, convinced us that the problem of tropical deforestation was not only one of the most relevant and challenging for the world community but also most complicated by its interdisciplinary nature and poor quality of data.

The core team of the pilot study consisted of Dr. Markku Kanninen, of the Society of Forestry in Finland, Mr. Gerardo Mery, M. Sc. (For.), Dr. Ashley Selby and myself, of the Finnish Forest Research Institute. The team designed and followed up the pilot study during 1986. A meeting of about 20 advisory and cooperative parties was held in May 1986 in Helsinki. Mr. Jyrki Salmi M. Sc. (For.) participated in the study as an active researcher. Mery and Salmi visited FAO Forestry Department in Rome in order to collect data and information. I presented papers on deforestation and forest-

based development in the World Congresses in Ljubljana (IUFRO) and in New Delhi (IEA) during the pilot study year of 1986. Cooperation was established between the pilot study team and professor Ari Siiriäinen, of University of Helsinki and professor P.-O. Johansson, of the Swedish University of Agricultural Sciences.

The pilot study of 1986 was financed by the Finnish Forest Research Institute and The Academy of Finland. The project benefited from the discussions or correspondence with the following researchers: Dr. F. William Burley, The World Resources Institute, Washington, D. C., USA, Dr. Peter Freiherr von Fürstenberg, Deutscher Forstverein, Federal Republic of Germany, Dr. Alan Grainger, University of Oxford, UK, Mr. Ole Hofstad, Agricultural University of Norway, Ås, Dr. Kari Keipi, The Inter-American Development Bank, Washington, D.C. USA, Mr. Bengt Kriström, The Swedish University of Agricultural Sciences, Umeå, Sweden, Mr. Jean-Paul Lanly, FAO Forestry Department, Rome, Italy, Dr. Norman Myers, Oxford, UK, professor Sten Nilsson, IIASA, Laxenburg, Austria, Mr. Simon Rietbergen, International Institute for Environment and Development, London, UK, Dr. Markku Simula, University of Helsinki, and Dr. K.D. Singh, FAO Forestry Department, Rome, Italy. Ashley Selby and John Derome checked the English language of this report. Mrs. Eila Iltanen took care of typing most of the text and Ms. Maija Kuusijärvi drew most of the figures. On behalf of the project team I wish to extend our gratitude to all the persons and organizations who contributed to the accomplishment of our pilot study and of this report.

Helsinki, September 1987

Matti Palo
Professor
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DEFORESTATION OR DEVELOPMENT: AN OVERVIEW

Matti Palo and Jyrki Salmi

The present publication introduces a report on a pilot study of "Forest-based socio-economic development and deforestation in developing countries " carried out at The Finnish Forest Research Institute during 1986. The main purpose of the pilot study was to examine in detail the potential and restrictions of a major research project in this field. Such a plan was aimed to consist of a specification in respect to applicable theories, methods, regions, case study countries, empirical data and future cooperation. Parallel to this plan further analyses on theoretical aspects of deforestation and on deforestation scenarios as well as review of forest-based development were aimed.

The scope of this report is a wide one both regionally and by the subject matter. It implies an application of a rather holistic approach in each of the five papers. The report has been edited into three parts: the first one consists of pilot findings on deforestation, the second one of pilot findings on forest-based development and the third one of a proposal for a future research project. The first part is emphasized having three papers. The papers have to contend into comparative analyses of individual countries. The pilot study could not be extended into case studies of particular countries or their districts.

Ari Siiriäinen, in the first essay, creates archeological and historical background for the rest of the report. He focuses specifically the roles of increases in population, social organizations, economy and subsistence strategies and technological innovations in African deforestation and desertification. Siiriäinen introduces a long-term historical model to describe the human impacts on these adverse ecological processes over the past 6 000 years. His model is based mostly on archeological and palaebotanical studies. The

particular roles of economic and technological innovations and their interrelationships with various cultural and behavioral variables are stressed.

Agricultural innovations are consisted of the domestication of plants and animals. On the other hand, breakthroughs in iron technology are examples of technological innovations. Siiriäinen's main idea is to divide the past six thousand years into five periods according to the discoveries and diffusions of these innovations. Thus each period is typified with such subsistences as pastoralism, mixed cultivation with pastoralism and cultivation. Small and large scale iron production further promotes the identification of the historical periods.

Iron production was a most important innovation which was independently developed in Central Africa during the first centuries A. D. Iron technology provided effective tools for forest clearing and without doubt it was the most important pre-requisite for the migrations from 300 to 1 000 A.D. and for the intensification of the economic activities since then. Iron production required also great amounts of fuel in the form of charcoal. Accordingly, iron production as a factor in the deforestation process should not be underestimated. Siiriäinen views the recent alarming situations in deforestation and in desertification as a combination of a steep short-term (i.e. colonial) and a more gently sloping long-term (i.e. precolonial) trends of causal processes. The stabilizing of these deteriorating trends of the processes is an absolute precondition for a more balanced future development in Africa according to Ari Siiriäinen's essay.

The second essay of the report is produced jointly by Matti Palo, Gerardo Mery and Jyrki Salmi and focuses on pilot scenarios of tropical deforestation. The work is based on cross-sectional analysis of 33 variables in 72 tropical countries which were divided into five groups. The analysis relied on existing data from various international sources such as FAO, World Bank, United Nations and UNEP. However,

one serious problem encountered was the inadequate quality of certain information, for instance the data on the annual deforested areas were found unreliable. Thus forest coverage was measured as the share of total forest area from the total land area and applied as a "negative" proxy for deforestation.

Strong negative correlation coefficients between total forest coverage and total population density were obtained for 60 countries. In eight arid African countries no equal correlation was found. The regression models determined by the statistical analysis were employed in creating three alternative scenarios (B, C and D) of future tropical deforestation of 60 countries, and a fourth one (A) was obtained by assuming the present area of deforestation, as estimated by FAO, fixed also in the future. Scenarios C and D had non-linear function forms and were more closely related to the theoretical frame reviewed here than Scenarios A and B with linear function forms. The total forest area in 60 tropical countries analyzed in this paper was 17.6 million km^2 in 1980. It was anticipated to decline by 30 % and 45 % by scenarios C and D, respectively, until 2025. The present deforestation pace has been mostly assumed by other authors to continue and this would indicate a reduction of - 18 % (Scenario A), result which is close to that given by Scenario B (- 16 %).

In the last essay of the first part of the report Matti Palo introduces a provisional theory of tropical deforestation which was applied as a framework for scenario-making in the previous essay. Palo first reviews the dubious quality of the existing deforestation statistics. He concludes that forest areas at a certain point of time have been estimated more precisely than deforestation areas between two subsequent points of time.

The provisional theory of tropical deforestation comprises twenty propositions which are inductive generalizations and interdisciplinary. They cover both closed and open natural forests. The provisional theory views tropical deforestation

as a vicious circle in the following way. Population pressure, environmental deterioration in the form of deforestation and soil erosion and rural depression are the basic factors. Together with inadequate land-use and forest policies, and with apparent market failures in the economic system and with lost forest-based development opportunities, a vicious circle of continuous and accelerating rural depression and deforestation can be identified.

Besides a few positive cases, there exist a large number of developing countries in which heavy utilization of their forests has not produced any real forest-based economic development through industrialization. Quite often forest-based industrialization has not yet been seriously tried. In many countries most of the development potential has, in effect, been exported via huge amounts of logs. When forest industrialization has been tried it often has been badly planned and managed.

Palo concludes that deforestation in the tropical forests will expand at an accelerated speed until the existing negative feedback loops strengthen at a later stage of the process. This forecast will be valid unless corruption and actual forest policy and population growth can be checked, land reforms can be mobilized, agriculture on existing arable lands and pasture can be intensified, or controlled economic growth per capita can be mobilized within other industries and urban regions. In the tropical countries most liable to extensive future deforestation these reservations are not valid in the foreseeable future, unless a radical change in the attitudes toward deforestation by the national governments and by the individuals occurs.

In the second part of the report Gerardo Mery reviews forest sector development in Latin America during the past twenty years and outlines prospects up to the year 2000. The importance of the natural forest resources of 1 billion hectares in 1980 in emphasized. Consequently the large-scale deforestation, which by 1980 had reached 5.4 million hectares annually and the extensive degradation of the forests is one

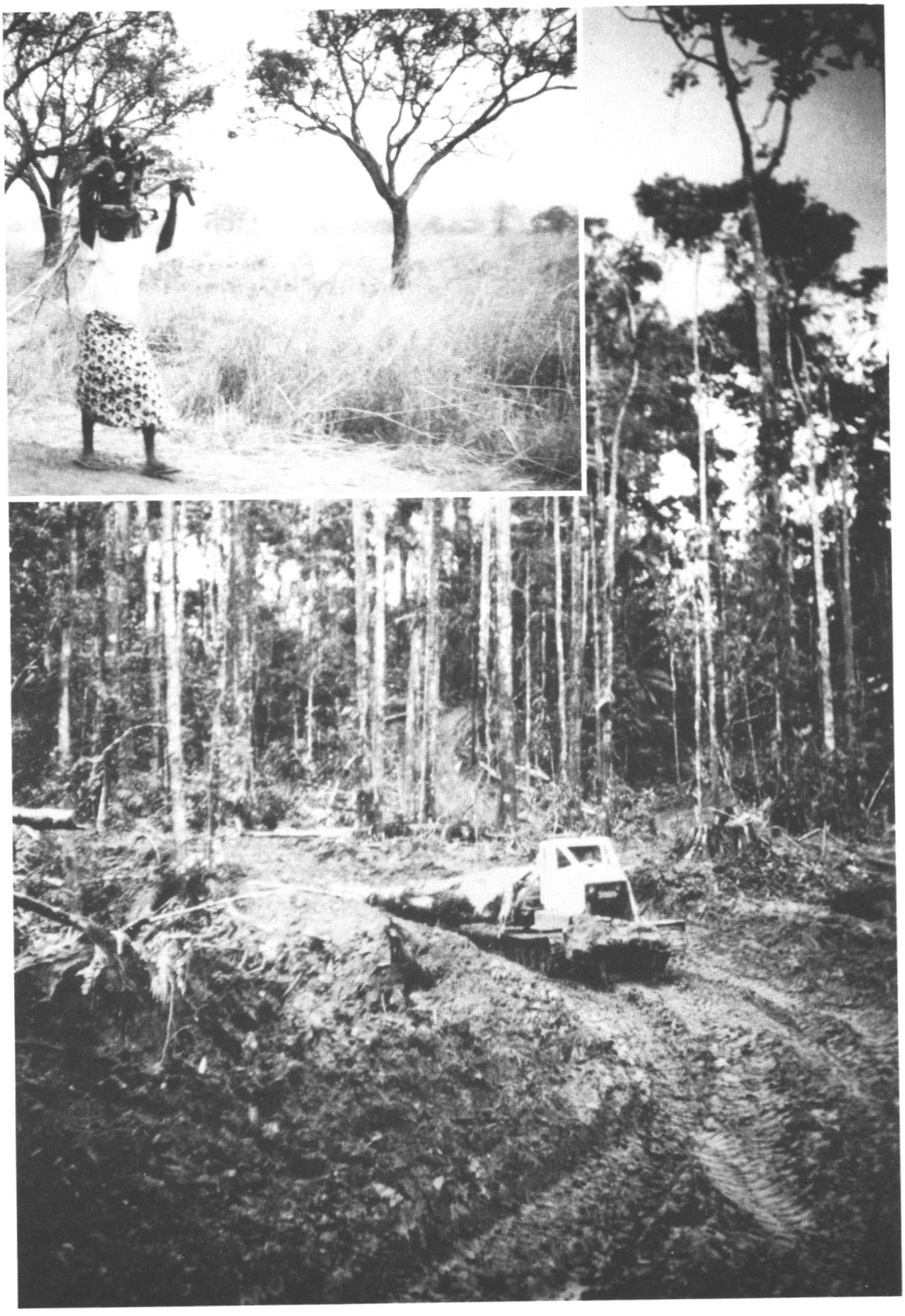
of the major concerns of the author. Although the forest plantation activities have increased in Latin America, they do not compensate the losses of deforestation. The fuel wood continues to be the major category of the annual removals of 340 million m^3. The production, imports, exports and apparent consumption of sawnwood, wood-based panels wood pulp and paper paperboard are described and analyzed.

Gerardo Mery presents severe criticism on the pattern of development prevailing in the forest sectors of the 27 Latin American countries under his focus. He argues that mismanagement and overexploitation, on one hand, and underutilization of forest resources, on the other hand, have poorly contributed to the socio-economic development of the whole region. While Latin American holds about one fifth of the world's forests by area and has more forest hectars per capita (3 ha/capita) than the other continents, its forests have played only a limited role in the economic growth during the past few decades. In 1980 the imports of forest products reached US $ 2 500 million in contrast to the respective exports of US $ 1 600 million. Consequently, only five Latin American countries were net exporters in forest products. The second part of this report will be complemented later on by Matti Palo in a separate publication where he will revisit the theory of forest-based development with a fiew case studies.

Finally, in the third part of the report, Matti Palo, Gerardo Mery and Jyrki Salmi outline a plan for a further research project in the field of deforestation and development in developing countries. Having executed a pilot study during 1986 it was decided to launch a major research project on the topic. The project would verify the direct and indirect factors which explain the deforestation phenomenon by specifically identified country groups, and identify critical factors of forest-based socio-economic development. Profound case studies of a few countries and comparative country analyses will be executed.

Refined deforestation scenarios up to the year 2025 and beyond will be produced by country groups, and eventually also by countries. The social costs and benefits of deforestation will be analyzed. Finally policy analyses will focus on formulating policy programs to control deforestation. The project is planned to last five years and the participating institutions are The Finnish Forest Research Institute (Division of Social Economics of Forestry), The University of Helsinki (Department of Archeology) and The Swedish University of Agricultural Sciences (Department of Economics of Natural Resources, Umeå). A network of collaborators is under establishment.

PART I: Pilot findings on deforestation



PHOTOS: MATTI PALO (PHILIPPINES & NIGERIA)

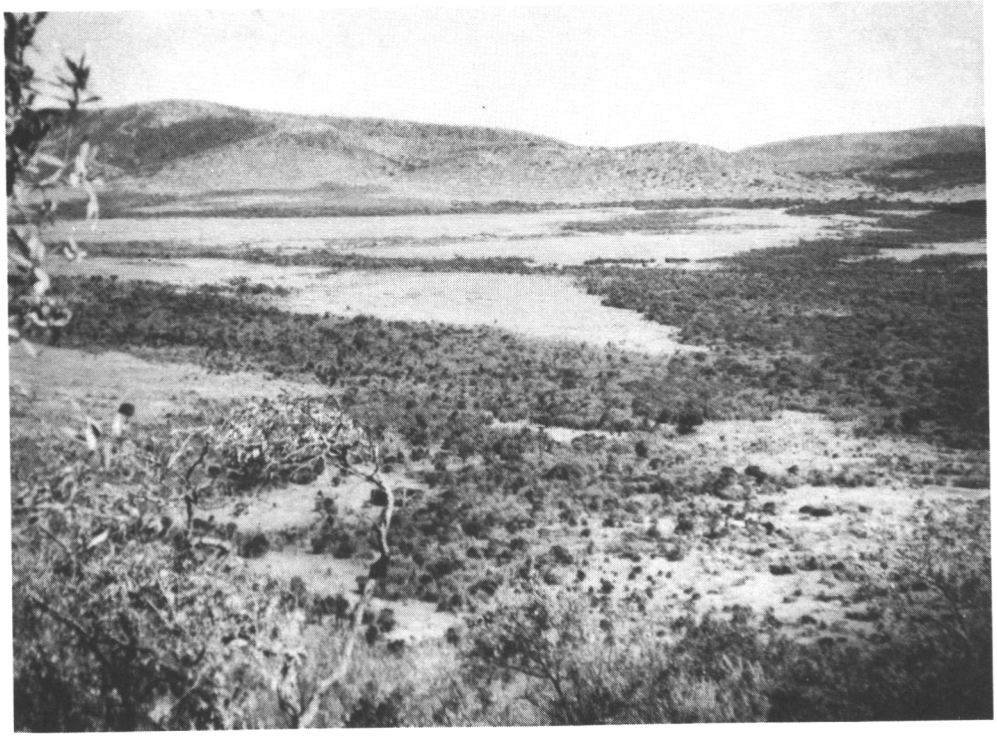


PHOTO: ARI SIIRIÄINEN (KENYA)

MAN'S ROLE IN THE ECOLOGICAL PROCESSES IN AFRICA: TOWARDS A LONG-TERM HISTORICAL MODEL

Ari Siiriäinen

ABSTRACT

One of the relevant theoretical frames of reference to study the current ecological problems in Africa is obviously a comprehensive systemic model in which as many cultural and culture ecological processes as possible are taken into account in a historical perspective. In this article a long-term historical model, stretching over the past 6000 years and basing mostly on archaeological and palaeobotanical studies, is presented emphasising economical innovations and their inter-relationships with various cultural and behavioral variables. The most dramatic consequences of the processes described in the model are deforestation, soil degradation and erosion. The stabilizing of the worsening trends of the processes is an absolute precondition for a more balanced economical and ecological future in Africa. Careful and considerate manipulation of cultural and social practices is also required in order to minimize the inevitable ecological deterioration at least in areas under the worst stress such as in Sahel and certain heavily populated areas in Ethiopia and eastern Africa.

Keywords: Africa, archaeology, deforestation, desertification, palaeobotany, pastoralism

CONTENTS

		Page
1.	INTRODUCTION	16
2.	FROM PAST TO FUTURE	18
3.	BACKGROUND MODELS	21
4.	THE SYSTEMIC MODEL	26
5.	THE HISTORICAL MODEL	28
6.	CONCLUSIONS	45
	REFERENCES	48

1. INTRODUCTION

When you are traveling in the more prosperous rural areas in Africa you will find the people extremely vital and full of initiative, their social and cultural framework solid, and their economy rational and functional. If you consider the precolonial history of the African continent you will find that the social, technological and economic development even in sub-Saharan Africa has always been in the hands of the Africans themselves: all important innovations have been achieved within the context of the indigenous African culture.

By this I want to emphasize that there can be no structural idiosyncrasies whatsoever in the African societies and cultures which would deterministically drive the continent into the environmental difficulties it is facing right now despite the opinions so often heard from the so-called developed world. But at the same time we have to realize that, as the development in Africa has undergone processes in principle similar to the development everywhere else, its consequences must also have been similar. Thus, when I now examine the historical processes leading towards the current cultural ecological situation, I shall use a simple systems approach which I consider valid and fruitful in a large-scale study, admitting at the same time that in small-scale regional and local studies a more specific approach might be appropriate.

It is hardly necessary here to emphasize the importance of man's impact on the environment in the current ecological processes in Africa. Man is, and indeed has been for at least the past six thousand years, a central factor in most ecosystems. I dare argue, however, that only little is known of the real effects of man's role in initiating crucial processes and in contributing to the current ones, in Africa or in any other part of the world for that matter (eg. Baker 1977, Caldwell 1977, Grove 1977).

I single out two interconnected factors which can be used as parameters in detecting environmental trends in Africa and which, moreover, can be inferred either directly or indirectly from the data material according to which historical processes are reconstructed, viz. deforestation and desertification. From numerous reports in which the current environmental trends in Africa are investigated we learn alarming facts that the rate of deforestation in tropical Africa is 3.7 millions of hectares per year and that an area of 6.9 millions of sq. km in sub-Saharan Africa is threatened by severe desertification (eg. Grainger 1982, Palo 1984, Stiles 1984, Kassas 1985, Allen & Barnes 1985, Glantz & Katz 1985, Caufield 1985, Timberlake 1985). From this kind of depressing information the following complex problems emerge when measures to control the development in Africa are considered:

(1) How do the current trends relate to the short-term and long-term processes; i.e., are they controllable or not?
(2) What is the role of human culture in the ecological systems that ultimately initiated and are now maintaining the processes?

(3) Can these systems be oriented towards more balanced cultural and economical practices?

(4) Is it possible to distinguish cultural ecological areas or niches in which control measures could lead towards more balanced subsistence strategies?

While questions 3 and 4 are more operative issues and require anthropological expertise, I feel that answering questions 1 and 2 is an inevitable precondition for sound socio-economic planning to combat famine in Africa; there are too many examples of development operations which have failed due to poor understanding of long-term cultural-historical and cultural-ecological processes.

2. FROM PAST TO FUTURE

There are, in principle, two methods of obtaining relevant information from history for current planning, the trend method and the analogy method.

(1) The trend method. We can detect certain processes and try to work out trends in these and then propose extrapolations into the future. Data from several points are of course needed; the density of observations on the time axis determines the accuracy of the reconstruction of the process. Several processes may be operating simultaneously, each with its own "wave-length", which renders the extrapolation extremely difficult (Fig. 1 illustrates four subprocesses each with a regular "wave-length"; the combined process becomes even more complicated if we suppose that at least some of the processes follow irregular "wave-lengths"). In any point of time different subprocesses may have either similar (eg. t2) or different (eg. t1) trends, and thus a short-term process might at a given point of time be rapidly increasing while a long-term process is slowly decreasing (eg. t3). In this survey I am interested in long-term environmental man/nature processes within a timespan of 5000 to 6000 years which I consider it vital to recognize in the current African situation as they provide us with knowledge about some of the slowest and consequently the least controllable processes. It should be pointed out here that the trend method is an empirical procedure and not prediction in the systemic sense (cf. Allen 1985).

(2) The analogy method. Although history never repeats itself - as each historical situation is a function or combination of so many processes that there never exists a combination which has previously occurred - it still is informative to analyze particular past situations in order to seek functional solutions to be modified and integrated in the plans for the future. This I call the method of modified analogies.

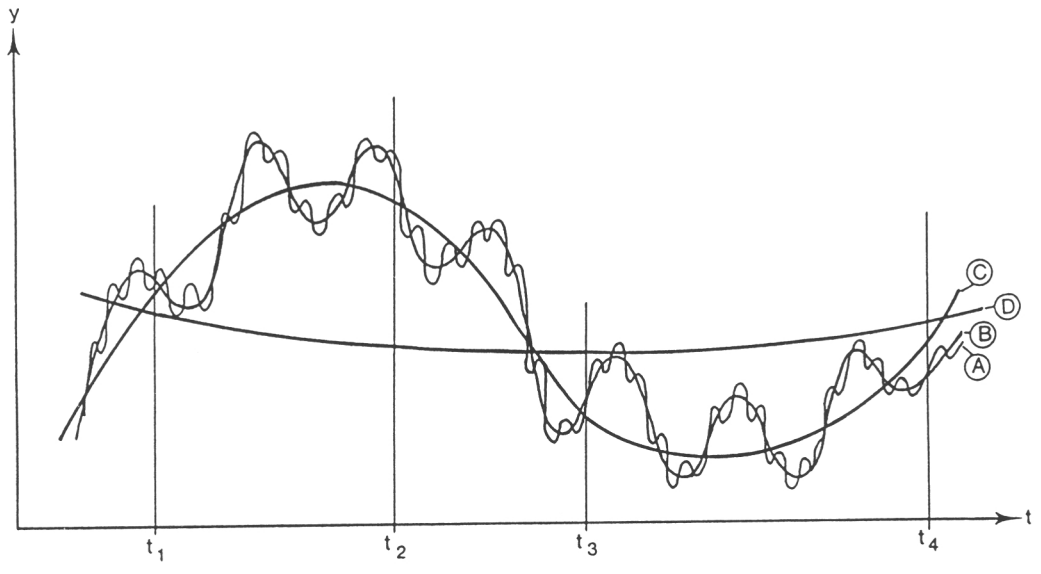


Figure 1. Fluctuations in the historical subprocesses.

Using historical processes and situations to guide future environmental planning calls for the use of cultural ecological models and rules. Here I want to caution against falling into the pitfall of environmental determinism and to stress that cultures and behavioral options are generally flexible enough to avoid short-term environmental catastrophes. But it is also certainly true that especially long-term processes are less controllable by cultural adaptive mechanisms than short-term processes and therefore include deterministic elements.

In this paper my intention is to present our current knowledge of the man/nature relationships in the African precolonial past as a tentative model including elements relevant for the issues of deforestation and desertification. The model is strictly descriptive and not predictive, but I hope it will graphically illustrate how certain cultural

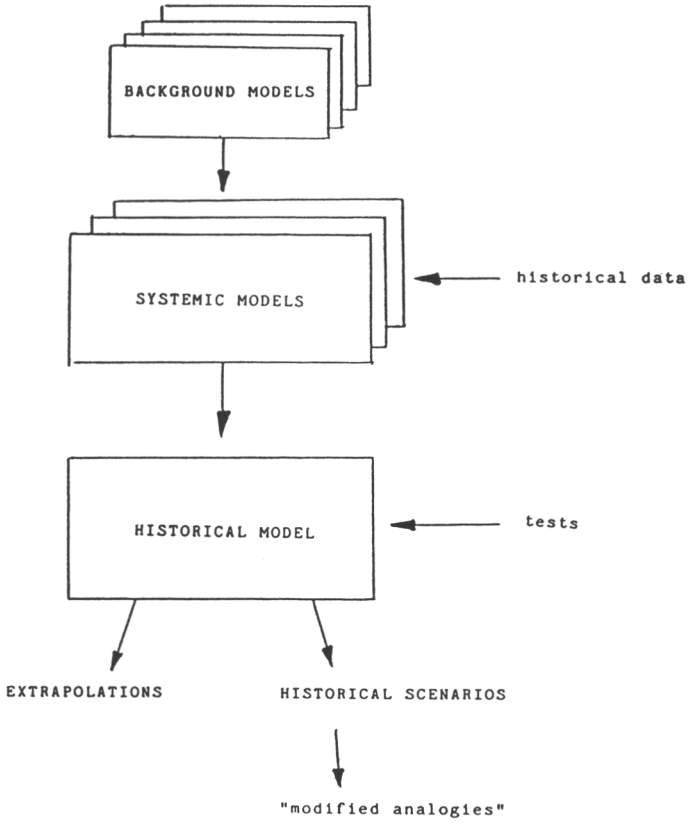


Figure 2. The principle of the model we are building.

ecological systems still operating in Africa have originated and how they constitute the basis for many socio-cultural and economic systems in the continent. Because the future must be planned with those systems as a starting-point, the model might have relevance for the planners. - Fig. 2 shows the principle of the model.

3. BACKGROUND MODELS

The background consists of several fairly simple basic cultural ecological models. I present here, briefly, three such general models.

In the first model, the socio-cultural system can be understood as a network of four subsystems: economy, material culture, religion and social culture (Fig. 3, modified from Clarke 1968; cf. also Gibbon 1984). This system is interacting with its natural environment through its subsystems "material culture" and "economy" which together constitute the resource utilization subsystem of a culture. The respective agents in the interaction are technology and subsistence strategy, and thus the vertical axis in the diagram determines the essential factors and variables in any cultural ecological model. These factors must be understood as variables and the model as a dynamic system: thus a change in any of the subsystem variables results in adaptive changes in each of the remaining variables. As a complete equilibrium is never fully achieved within the cultural system as a whole, or between it and its environment, the whole system is in a constant state of dynamic change.

In this model the two axes determine the dynamism of the cultural system: the vertical axis includes innovative elements and the horizontal axis conservative elements. In each cultural system one of the two axes dominates. In Africa, we might broadly argue, the cultivating societies are dominated by the vertical axis whereas in the pastoral and foraging societies the horizontal axis dominates.

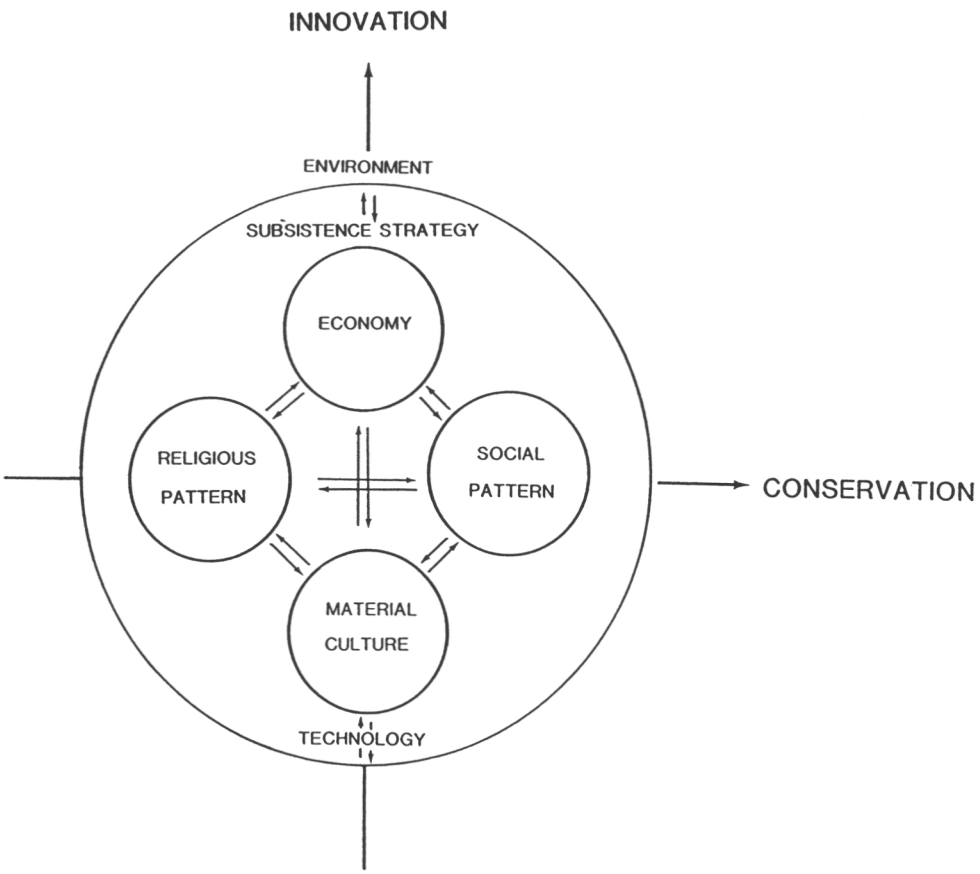


Figure 3. The socio-cultural system.

When investigating historical long-term dynamism in this kind of system we can obtain fairly reliable independent data for each of the variables through which the vertical axis traverses, viz. for environment, subsistence strategy, economy, material culture and technology. In Africa, the disciplines providing such data include archaeology, palaeoecology, oral history and historical linguistics. Each of these disciplines is capable of revealing and dating relevant past innovations which reflect interesting changes within the cultural system. Also, the important cognitive functions of cultural systems (the horizontal axis in Fig. 3) can be inferred from the archaeological evidence using ethnographical and historical models (eg. Hodder 1982).

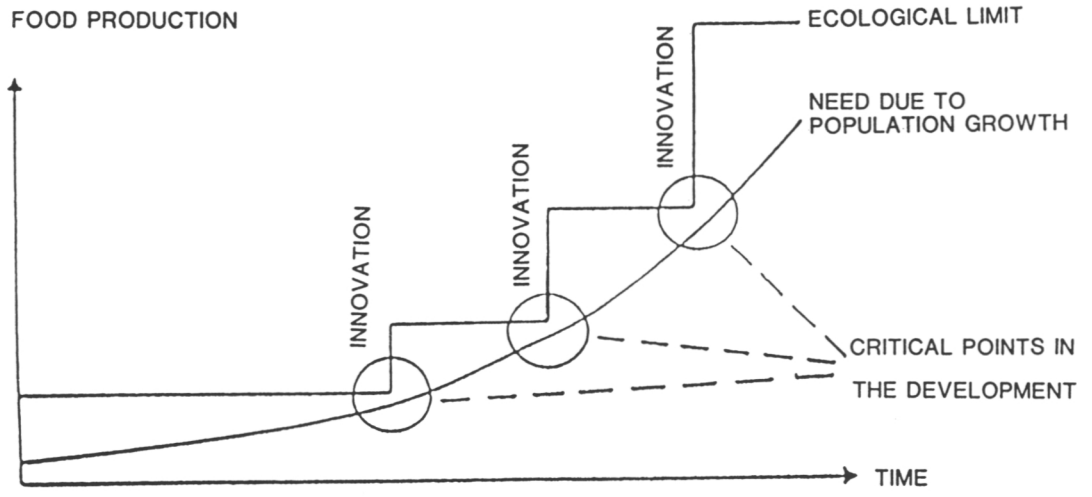


Figure 4. Innovations and the growth of food production.

The mention of innovations brings me to my second basic background model. Fig. 4 illustrates the importance of innovations - technical and economical - as a driving force in the cultural ecological change (or development, if one prefers). The diagram is again self-explanatory. We assume a growing population with its increasing need of food and other resources approaching the ecological limit, or the carrying capacity, of the environment. New innovations will be required, either borrowed from neighboring cultures or developed independently, in order to artificially increase production, i.e. to raise the carrying capacity of the environment (see Spratt 1982 concerning the innovation theories in archaeology).

No clear patterns can be distinguished in the temporal occurrence of innovations beyond the notion that there certainly exist short innovative spells which lead to longer adaptive periods. According to the paradigm of dissipative structures and complex systems (eg. Allen 1985), innovations can be seen as disturbing factors which direct the cultural system into a new evolutionary path ("bifurcation") after a period of increasing instability.

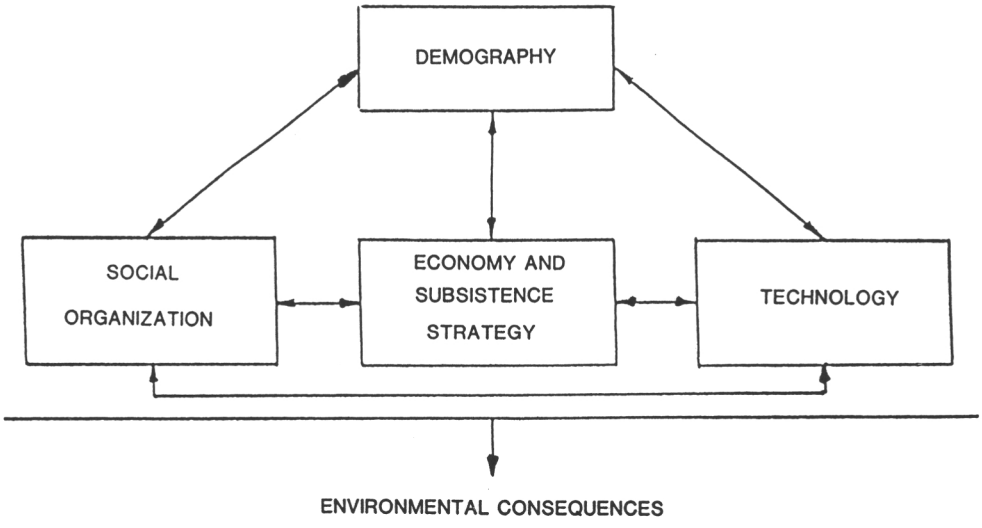


Figure 5. Demography and the environmental consequences.

Geographically, innovations occur mostly close to marginal areas where the ecological strain is most severe, and thence they spread into areas where the innovations are economically, technically and socially functional. As a further general feature we might note that due to the cumulative effect each innovation seems to be more complicated and dramatic than the previous one. This, however, must be understood as a very general remark which cannot be taken for granted in each individual case, as even simple innovations may affect the process considerably.

The third background model (Fig. 5) brings one more essential factor into the discussion, namely demography, which in historical contexts simply means the size of the human populations. Although it is not clear whether demography can be used in cultural ecological reasoning as an independent or a dependent variable, its connections to other ecological factors are indisputable: it is not possible to understand cultural ecological processes without taking demographical factors into account (eg. Hardesty 1977, Hassan 1981, Butzer 1982, Palo 1984).

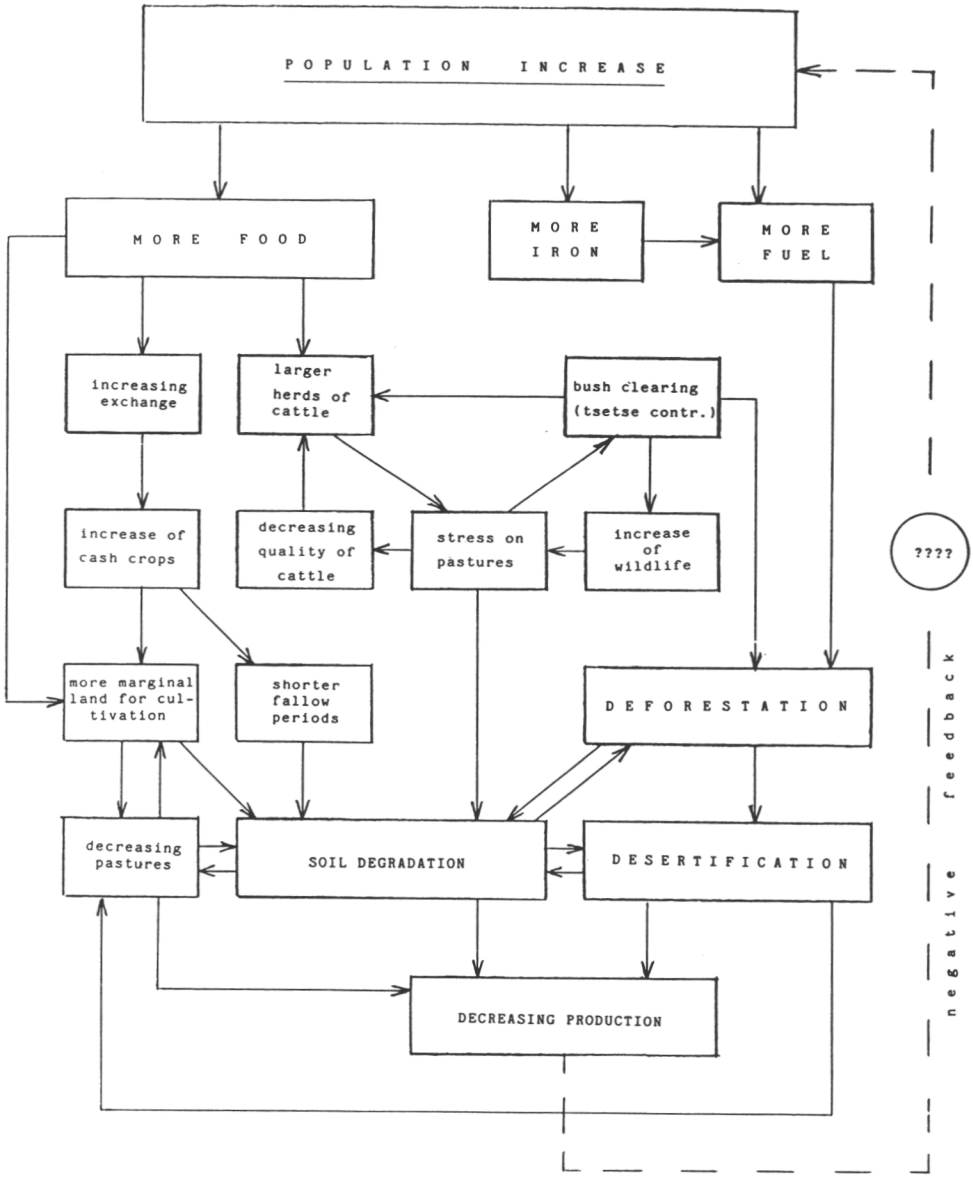


Figure 6. The systemic model of deforestation and desertification

4. THE SYSTEMIC MODEL

While the background models generally describe structures of human cultures, their connections with the natural environment and mechanisms in the cultural dynamism, in the systemic models the essential variables are selected and analyzed, and their classifications are presented as well as causal networks proposed.

When investigating cultural ecological processes essential variables can be chosen from any of the elements presented in the background models; indeed a comprehensive study should include all the variables. But as I am here dealing only with one sector in the man/nature interaction, namely man's role in deforestation and desertification, I shall give priority to economy and subsistence strategies. As a regulatory variable I take demography, being fully aware, however, that it may not be an independent variable (Cowgill 1975).

If we take an increasing population and consider those consequences which, through a network of rather straightforward connections, lead to deforestation and desertification, we arrive at models such as presented in Fig. 6. These systemic ahistorical models admittedly include many self-evident connections, but immediately a host of critical questions arise: Do empirical data indicate that such connections really exist? Would the consequences be reversed had we the opposite initial premise, a decreasing population? How would the cognitive variables of our first background model (Fig. 3), which were here ignored, affect the model if they had been taken into account? etc. Without entering too deeply into these issues, I briefly answer the first question positively: yes, we have empirical evidence that these connections are real in Africa. My answer to the second question is negative, as there are other factors besides population pressure operating through the same connections towards the same consequences. These include the inclination of almost all societies to raise their standard

of living by increasing production (here I am referring to the so-called optimizing strategies, as opposed to the more rare satisfying strategies which do not strive at optimal economic results; Simon 1957). The third question is a complex one and answering it would lead to a profound anthropological analysis and take us outside the topic of this paper. The current social and religious world-view structures have been largely formed during hundreds and thousands of years, and therefore it is unlikely that they would - at least without radical structural changes - adapt very rapidly to changing situations. Such changes would probably merely maintain and strengthen the system.

5. THE HISTORICAL MODEL

Let us now proceed from these basic models towards a particular historical model for Africa. As a starting-point, I choose a basic systemic model which includes those essential factors that can be arranged into an ecologically interesting causal combination network and that can be furnished with data from archaeological and palaeoecological investigations. This model also includes some elementary factors from the social elements of a culture (Fig. 7). It is not possible here to analyze the model in detail, but it should be noted that in the light of the background model in Fig. 4, the feedback from the "cultural responses" to further economical and technological innovations and straight to further consequences suggests that the model has deterministic cumulative ("snowball") effects.

Each variable included into the historical model must be considered in three dimensions: temporal or chronological dimension, spatial or geographical dimension, and intensity. The following table summarizes the main variables giving a gross classification for the intensity of each mode of economy and for technology (cf. Fig. 7). The duration variable will be measured in class-intervals according to the available dating methods (in Africa the precolonial chronology is based mainly on radiocarbon dating which provide an accuracy of c. 100 years).

To develop the systemic model in Fig. 7 towards a dynamic historical model one has to "feed in" historical data by choosing innovations relevant in culture historical and cultural ecological respects, date them and detect their origin as well as follow their geographical distribution and spread. Economic innovations divide the past six thousand years into five periods, each with a characteristic set of economy and subsistence strategies. In the chronological diagram (Fig. 8) which summarises the main information, three continuous lines traverse two or more periods. These are the

ECONOMY

	hunting & gathering	cattle keeping & cultivating	cultivating & pastoralism	pastoralism
extensive	extensive hunting and gathering	shifting (slash and burn) cult.	-	nomadic
intensive	intensive hunting and gathering	rotating	transhumance	transhumance
specialized	specialized hunting and gathering	permanent	sedentary	sedentary

TECHNOLOGY

stone technology
small-scale iron production
large-scale iron production

three modes or strategies still practiced in the rural economies of Africa (I have omitted hunting and gathering in compiling this summary diagram as uninteresting with regard to the cultural-ecological processes).

All of the economic modes have an ancient history in Africa, the cultivation dominated mode being the most recent, being slightly over 2000 years in age. Each of the innovations affected the man/nature relationship, and each one contributed as well to the deforestation and desertification rate (cf. Fig. 6).

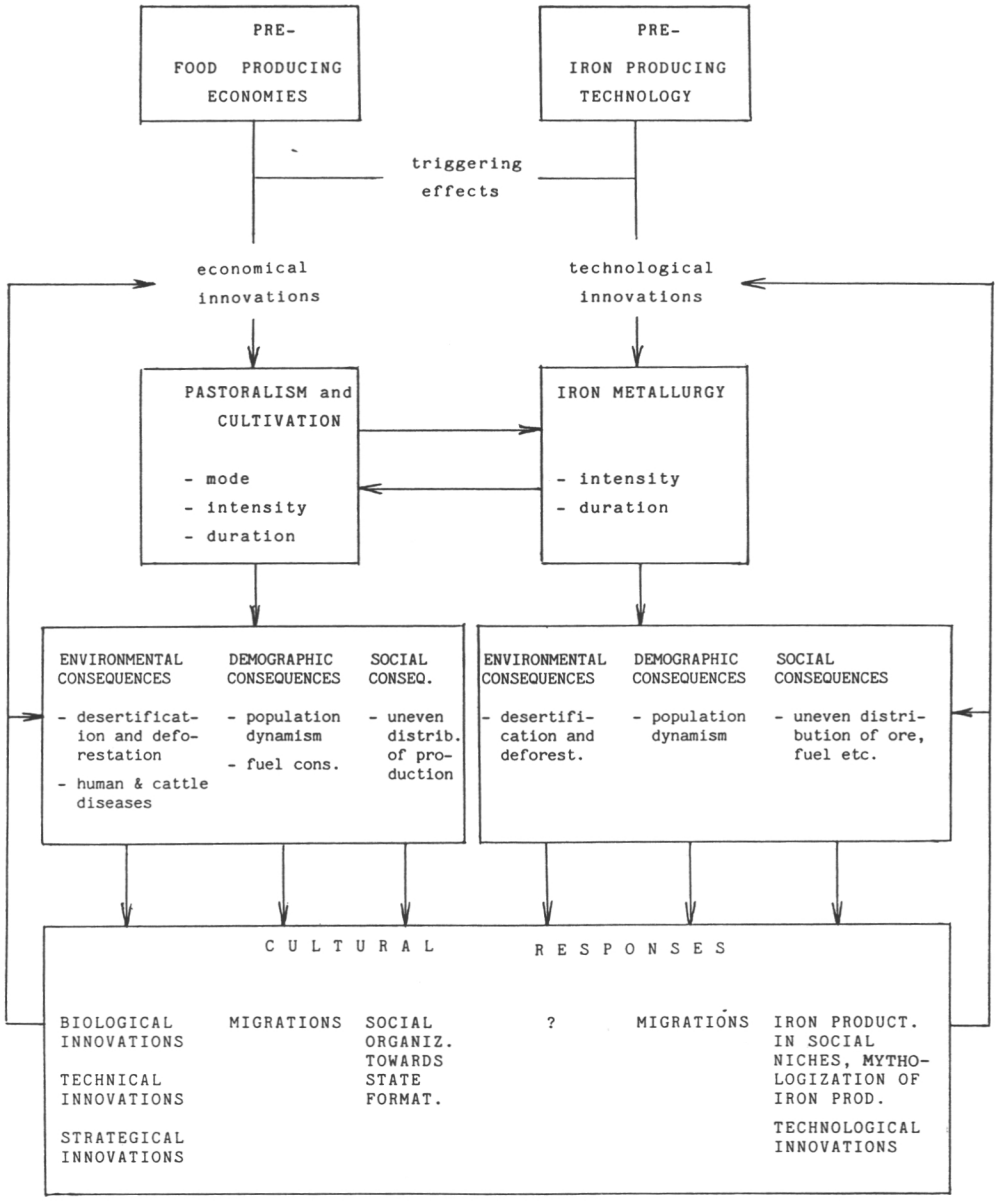


Figure 7. The modified systemic model of deforestation and desertification.

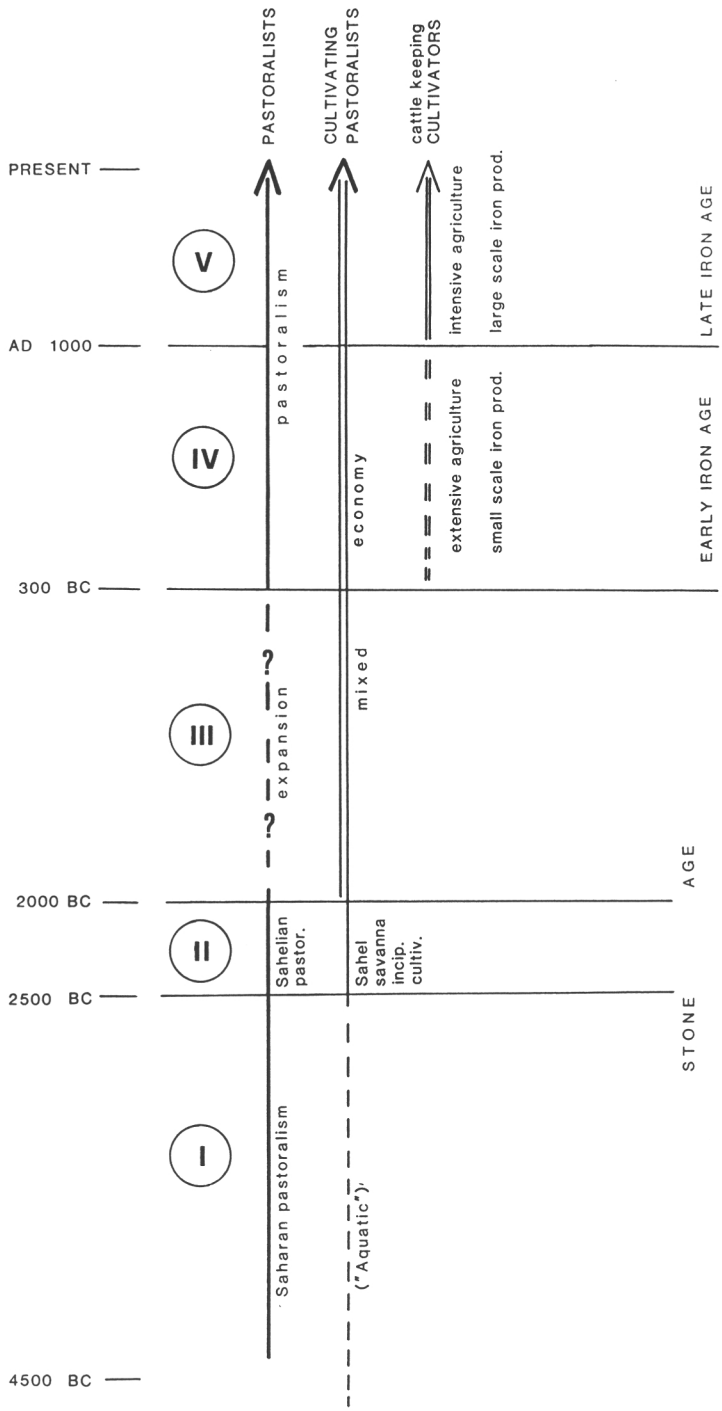


Figure 8. The five economical modes in the rural Africa.

Periods I to III. It has been argued that Saharan pastoralism already triggered off the desertification process during the fourth and third millennia BC. Indeed there is ample geological, geomorphological and palynological evidence that the last pluvial climatic period, with the savanna belt and permanent rivers and lakes extending over the Sahara, came to an end at the same time as the African cattle (Bos primigenius africanus) was domesticated in northwest Africa (according to the archaeological and osteological evidence, Shaw 1977, Clark 1980a and b). Our chronology is not yet detailed enough to indicate which occurred first, the deterioration of the climate or the domestication of cattle, and therefore their causal relationship cannot yet be deduced. Was the economic innovation a human response to the deteriorating environment or the beginning desertification a consequence of the new mode of economy. The overall process was sufficiently slow that it will be extremely difficult to give a definitive answer to this problem. It is probably best to view the economic impact as an agent, not a cause, in an otherwise purely climatic slow desiccation process which nevertheless accelerated the trend towards the final desertification of the Sahara.

The cultural-ecological process which led to the domestication of cattle is not fully understood. In the view of the abundance of large mammals available for hunting and the resources in the rivers and lakes, there can hardly have been a shortage of meat and, since projectile points are among the commonest artifacts found on the sites, hunting appears to have remained a preferred activity among the pastoralists. Probably the favorable ecological situation in the late Pleistocene - early Holocene Sahara resulted in an increase in the human population density, and incipient cattle breeding certainly accelerated the process. As the climate became drier and grazing affected the vegetation, there can be no doubt that the importance of cattle steadily increased. Thus it is reasonable to conclude that cattle started to represent a source of wealth and a means of establishing individual group identity. The central elements, of which were eventually to lead to the "bovine centered"

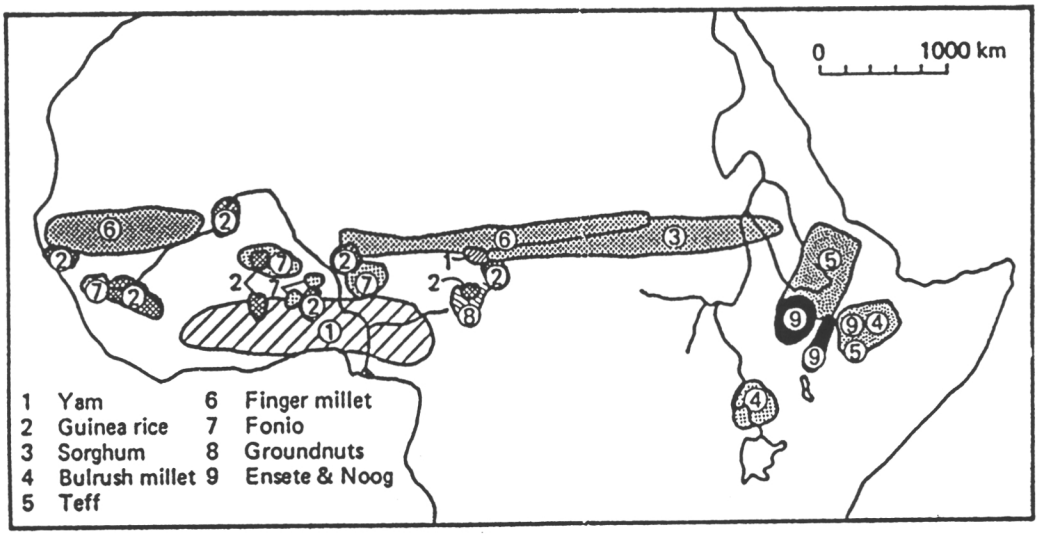


Figure 9. The probable areas of initial domestication of indigenous African crops (after Harlan, 1971).

social, cultural and organizational situations, have their roots deep in the very early stage of pastoralism in northern Africa (Clark 1980a).

Archaeological finds show unambiguously that the cultivating economy prior to c. 2500 BC (i.e. during period I in Fig. 8) had a long local adaptive process in the southern Sahara and Sahel. This has been denoted the "Aquatic" stage and it was characterized by an intensive utilization of lacustrine and riverine resources as well as indigenous wild grasses (Sutton 1974, Phillipson 1977). During the third millennium BC these grasses were domesticated within the Sahelian zone and the Ethiopian highlands, and the period of food production (Sahelian period II in Fig. 8) thus started there independently about 2500 BC (Harlan 1971, Harlan et al. 1976). The principal crops of the early cultivators were sorghum, millet, finger millet, fonio, teff, groundnut, guinea rice, yam, noog and ensete (the areas of domestication according to Harlan 1971 are shown in Fig. 9).

There is convincing evidence that the desiccation of the Sahara reached a stage, around 2000 BC at the latest, when pastoralism no longer ensured a livelihood even for a diminished population. Some of the pastoralists retreated to the highlands of central and southern Sahara, Hoggar-Tassili and Tibesti, where the rainfall was still sufficient to maintain adequate pastures. But the main pressure was along the desert margins and above all the central Nile valley around Khartoum, the Sahel zone between and around the Niger bend, and Lake Chad (Clark 1976, 1980a and b). In these areas mixed economic strategies developed ranging from a pure pastoralism to a pure cultivation economy (period III in Fig. 8). It is conceivable that this economic process was rather peaceful, at least in the beginning - when no competition for space occurred, as both the Sahelian cultivators and the Saharan pastoralists could benefit from the interaction in the form of food exchange and manuring of fields. But the penetration of the pastoralists into the Sahelian zone about 2500 BC created, together with the incipient cultivators there, an ecosystem which is still prevailing in the Sahel to-day, although naturally in a degraded form (Clark 1980 a and b).

Recently acquired linguistic, archaeological and osteological evidence shows that early ovicaprid and cattle economies had already spread as far south as Botswana, Zimbabwe and Namibia, or possibly even further south, during the latter half of the last millennium BC. Here it was an economic innovation adopted by the local hunter-gatherers from the northern pastoralists through much the same processes as in the Sahel involving a stage of intensive foraging and the use of riverine and lacustrine resources (Ehret 1982b, Denbow 1986).

Periods IV and V. While periods I to III are interesting, offering as they do insights into the earliest stages of man's impact into the environment, periods IV and V include extremely important innovations in respect to the deforestation and desertification in most of sub-Saharan

Africa. The principal element is again the economy, which in fact determines the periods in the diagram.

During the last centuries BC a new mode of extensive economy emerged in the northern margins of the central African tropical forests. This mode is characterized by shifting cultivation of indigenous crops basing on a forest clearing strategy. After a few years' cultivation the clearings were abandoned as soil fertility weakened below a feasible yield level. After a fallow period of 15 to 20 years fertility had recovered so that a new cultivation spell was possible (Ruthenberg 1980). During the first 500 years AD this mode of cultivation spread rather rapidly into large areas in sub-Saharan Africa down to the Zambezi valley in the south. There is substantial evidence to show that this spreading can be correlated with the migration of the speakers of the Bantu languages, as postulated by linguists (Guthrie 1967, Greenberg 1972, Soper 1971 and 1982, Phillipson 1977, Ehret 1982a). The driving force of the migrations was a steady - but probably not very rapid and certainly not always continuous - population increase combined with the extensivity of the economy (see Collett 1982 on the mechanism of the migration).

The role of demographic growth, as such, in the systems was obviously rather weak in preindustrial societies. It is surely misleading to view "population pressure" as a triggering factor for technological or other innovations, but it should be realized that especially within socially non-complex low-technology systems - in which surplus populations cannot easily be absorbed permanently into the production activities - even a slight net population increase leads to disequilibrium states in the systems (Hassan 1981). If space is available, emigration is a likely consequence, but after the ecologically feasible niche is filled other adaptive measures are needed such as cultural control of reproduction or technological and/or economical innovations to increase yields.

No later than about 1000 AD, the available area for the extensive shifting cultivation was completely populated and a new type of economy emerged combined with new socio-cultural patterns. This has been called intensive and specialized cultivation (Sutton 1985) (period V in Fig. 8). A stage of relative overpopulation was reached with increasing food and energy requirements. The agricultural development that ensued was an adoption of new methods that made possible a more intensive land-use through soil conservation, irrigation systems and fertilization. Indeed in various parts of Africa archaeological occurrences of elaborate irrigation and terracing systems can be dated to the early second millennium AD (Sutton 1984, 1985).

Besides the innovations in the economy, those in technology also contributed considerably to deforestation during periods IV abd V. Iron was an extremely important innovation which, according to the latest evidence, was independently developed in central Africa towards the end of period III (Schmidt 1981, 1983, Schmidt & Childs 1985). Iron technology provided efficient tools for forest clearing and without doubt it was the most important pre-requisite for the migrations during period IV and for the economic intensification during period V (Shaw 1981, Sutton 1981).

Iron production requires a relatively simple technology and raw-material in the tropical and subtropical lateritic soils is abundantly available. However, in iron production great amounts of fuel in the form of charcoal are consumed. Especially the innovation of pre-heating the iron furnaces - which in itself is a fuel efficient technology - makes high iron yields possible. There was a clear boom in iron production especially in eastern and central Africa in the beginning of period V and the production remained high till the end of the precolonial period. Thus precolonial iron production should by no means be underestimated as a factor in the deforestation process at least in the marginal forest areas in Africa (Schmidt & Childs 1985).

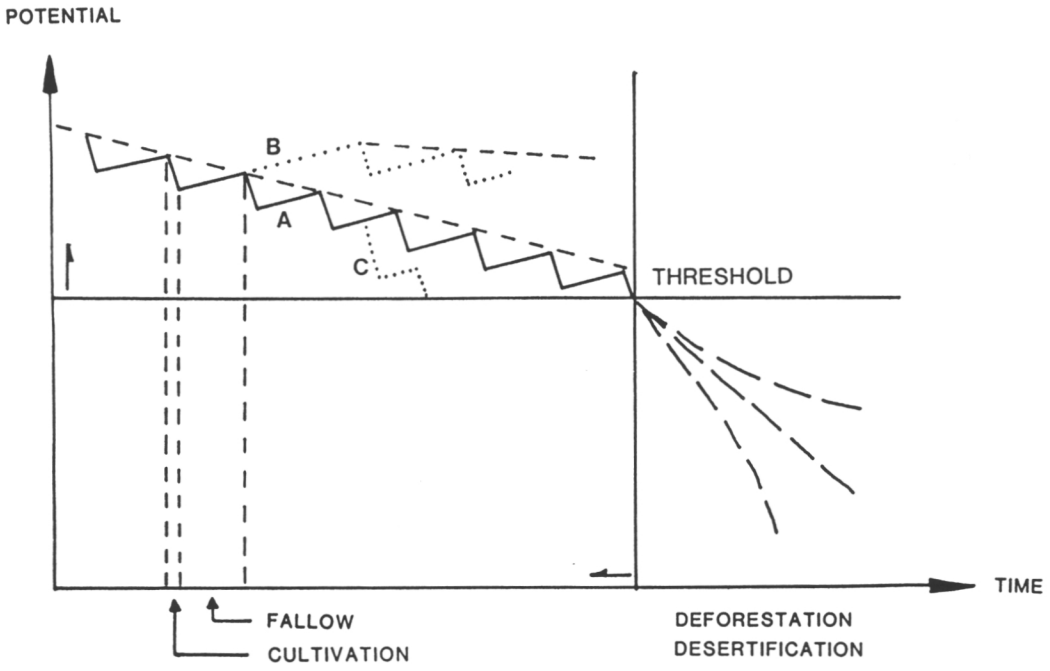


Figure 10. Environmental trend in sub-Saharan Africa within the past 2000 years.

Figure 10 illustrates, in a highly summarizing manner, the environmental trend in sub-Saharan Africa within at least the past 2000 years (i.e. periods IV and V). The increasing economic and technological activity - following the increasing population pressure - has steadily weakened the environmental potential, even if we allow a constant fallow period after each utilization period (eg. Guillemin 1956, Herrera et al. 1981). Inevitably such a trend will lead to a point, or to a potentiality level, below which the natural regeneration process can no longer operate, and below which manipulation is needed such as forest planting or sand dune stabilization, etc. Beyond this point we can speak about deforestation and desertification, but the process leading to these dramatic manifestations was in fact started long ago and has developed during many centuries. It is also important to notice that the threshold level itself is a variable whose position on the time axis is dependent on several factors, such as the natural basic environmental potential and the mode and duration of the human impact. Thus the level varies in different areas: it is a geographical variable.

The above economic innovations emerged and spread in societies whose subsistence was based mainly on cultivation; pastoralist and other cattle dominated societies did not experience such dramatic developmental impulses. However, all important innovations had an indirect effect on the pastoralists. The expansions of the cultivators put severe pressure on the grazing lands, thereby reducing the flexibility of the nomadic migrations. This created competition for land between societies, which in certain areas is still one of the main rural problems. In Kenya for example, the official policy is still to transfer land from the traditional grazing areas of the pastoralists to the cultivators, which of course causes bitterness among the former. Where cultivation is highly mechanized, as in some large private wheat farms, the erosion of topsoil is proceeding rapidly.

In many instances, the cultivating and pastoralist societies adapted to mutual interaction positively, creating permanent or recurrent symbiotic systems. During the fallow periods the cultivators allowed the pastoralists to graze cattle on the cultivated areas to let the dung fertilize the soil and so speed up its recovery (a certain kind of inter-tribal ley farming; cf. Ruthenberg 1980). During and after severe cattle plague epidemics, the cultivating societies could absorb into their production systems nomads who had lost their cattle until they had regained their economic independence. Thus, in situations where both subsistence strategies were still able to function without too heavy stress on land, the interaction could develop into positive and mutually beneficial relationships. It is sometimes argued that this interaction resulted in some areas in hyper-pastoralism - represented to-day by certain pastoralist sections like the pastoral Maasai and related tribes in eastern Africa - in which cultivation is a detested activity (Gifford et al. 1980, Robertshaw & Collett 1983). However, it is also conceivable that this kind of socio-economic practice has a more ancient history in Africa. In many pastoral societies, in which cultivation is a minor but integrated economic element, the importance of cattle in both cultural and ritual respects,

considerably exceeds its economic importance, even in areas where interaction with iron using societies has been minimal or non-existent, as for instance among the Southern Sudanese Nilotes (Dinka, Nuer). In these societies cattle are viewed as "property on hoof" and nearly every element in the social culture is valued in terms of cattle (Southall 1976).

According to the model in Fig. 7, there are certain cultural responses to the inevitable consequences of economical and technological development. Some of these responses have been aimed at ecological control of the environment. An example is crop succession in the slash-and-burn fields, whereby the natural vegetation was left to grow even during the utilization period of the cultivations and each year a new taller and more competitive crop was planted to compete with the natural vegetation. Burning could therefore be avoided for many years and the soil could recover more rapidly (Sanchez 1976). The extensive and repetitive burning of bush by the pastoralists to reduce the tsetse and to widen the pastures also belonged to these effective control measures. A historically important innovation was the adoption of a new disease and drought resistant species of cattle, the Asian Bos indicus or humped Zebu, which slowly reached the Sahel and East African pastoralists towards the end of period IV and which was later cross-bred with the African cattle (Sanga) (Hrbek 1977). A similar ecologically important innovation, adopted by the eastern and central African cultivators, was banana, which was introduced by Indonesians settling Madagascar at this time and which later became the staple food in many parts of Africa (Phillipson 1977).

Some of the responses were social or even political in character, such as the state forming process which profoundly affected almost all the African societies and tribes and which still can be clearly detected behind the thin screen of colonial and post-colonial organizations (Garlake 1978, Hassan 1981). A very informative cognitive theory, recently developed by Huffman (1986) using ethnographic and oral historical models, emphasizes the role of wealth accumulation and distribution patterns within the early South African

Bantu societies in the social organization during period IV. The emergence of extensive trade systems which linked the interior (with its copper and gold resources) with the coast, and thus with the initial European trade contacts, created a new social mode during the 11th or 12th centuries AD. This mode, called the Zimbabwe type of society, was characterized by a divine kingship with a central bureaucracy and by a clear social stratification with a controlled distribution of wealth. During the same centuries similar profound social readaptations occurred everywhere in sub-Saharan Africa (eg. Shinnie 1971). Thus the African state formation is undoubtedly one of the most important culture historical processes, and its social, demographical and ecological consequences should be thoroughly analyzed in order to understand the genuine African cultural idiosyncracies.

Before drawing conclusions relating to the issues raised in the project description, a few remarks should be made about the above discussion. The models presented, and especially the more complex models in Figs. 6 to 8, are by no means final or fixed constructions. I have presented them here to indicate that archaeological evidence can be arranged in a manner that reveals systemic long-term processes which help us to understand the recent economical, ecological, social and even political situations in Africa. By means of these types of models we can increase not only the particular information about cultural ecological processes in Africa, but also our general knowledge of those processes in any part of the world. These models will obviously never be completed and research will remain a continuous process of model construction, modification and testing.

I have been discussing my topic mostly from a chronological point of view. There is, however, the important spatial or geographical aspect which should always be taken into consideration. This aspect includes such issues as trade, migrations, diffusion of innovations etc. The investigation of these issues results in a series of maps illustrating the direction and pace of the spread of a phenomenon. The maps in Figs. 11 to 13 show how certain profound innovations have

spread in Africa from north to south and how the Sahelian zone has formed an ancient centre of food production and economic activity. As we already saw, the migrations during the early period IV started from Sahel. Fig. 11 shows the Saharan pastoralist spreading south, and the "Aquatic" zone where intensive hunting and gathering led to incipient cultivation. In Fig. 12, the early cultivation zone is indicated as well as the further penetration of the pastoralists southward. Fig. 13 shows how the early iron producers migrated through the tropical forests and finally reached southern Africa.

Owing to my approach, I have drawn my basic models from economical and ecological anthropology. I am not going to enter the difficult task of testing these models - suffice it to say that they are essentially empirical models being constantly tested in ecological and anthropological fieldwork (eg. Hardesty 1977). I am here more concerned about my tentative historical model which rests on the anthropological models: Is it testable? Certainly, some of the archaeological results themselves tend to confirm the validity of the processes indicated in Fig. 7. The migrations during period IV and the social fragmentation during period V, so clearly reflected in the archaeological material, undoubtedly presuppose a demographic pressure from the early food production periods onwards (eg. Phillipson 1985).

However, if we look for a more reliable basis for testing the historical model, independent of the archaeological evidence, we find it for example from certain palynological and other palaeoecological investigations carried out mainly in Ethiopia and eastern Africa (Hamilton 1982, Morrison & Hamilton 1974, Gasse & Street 1978). In several peatbog and lake bottom sediments the pollen statistics show a rapid decrease of trees and an increase of grasses both c. 2000 and c. 1000 years ago corresponding to the lower boundaries of periods IV and V in Fig. 8. These environmental discontinuities have been assigned by the investigators to human activities and especially to forest clearance and extensive grazing of cattle (Hamilton 1982).

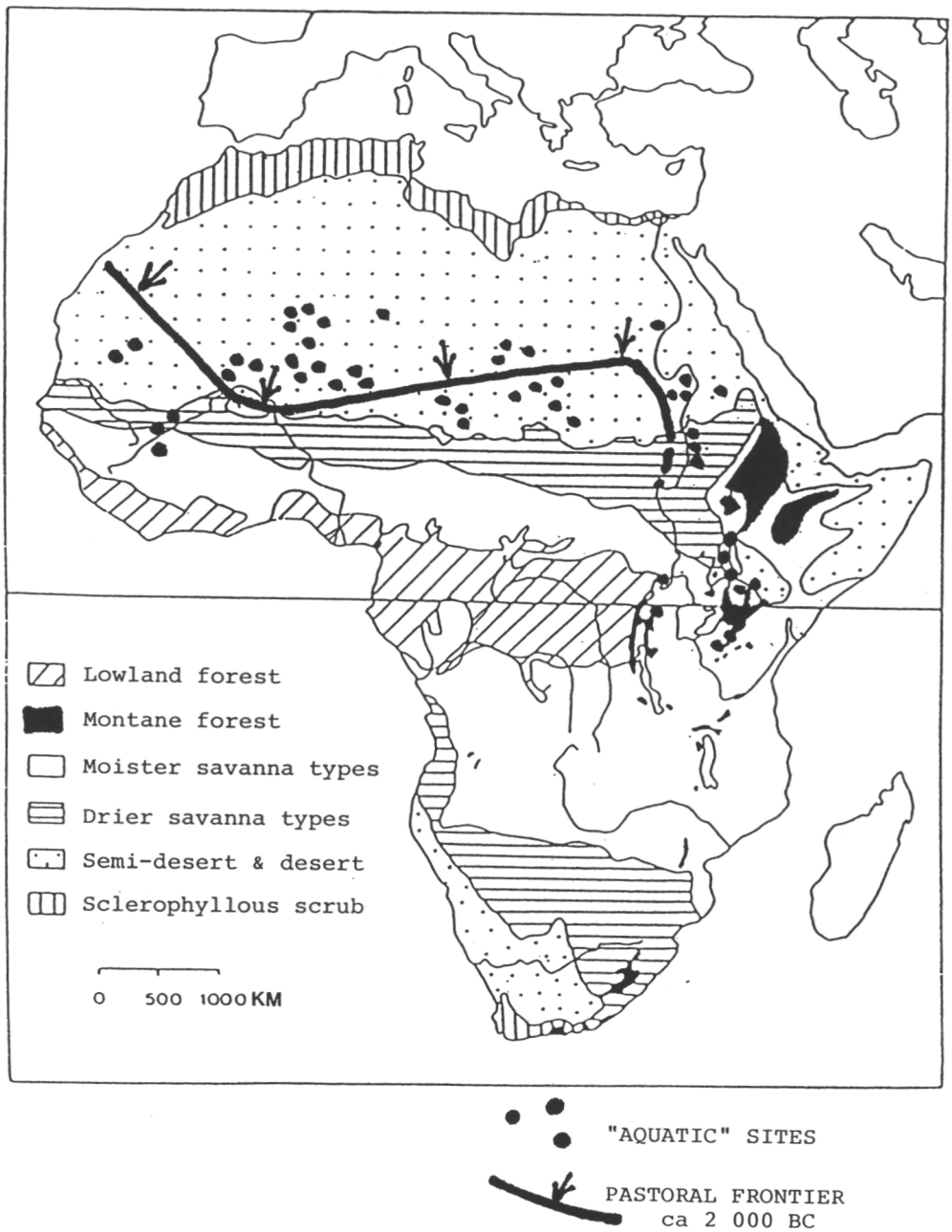


Figure 11. Spread of Saharan pastoralism and the "aquatic" zones.

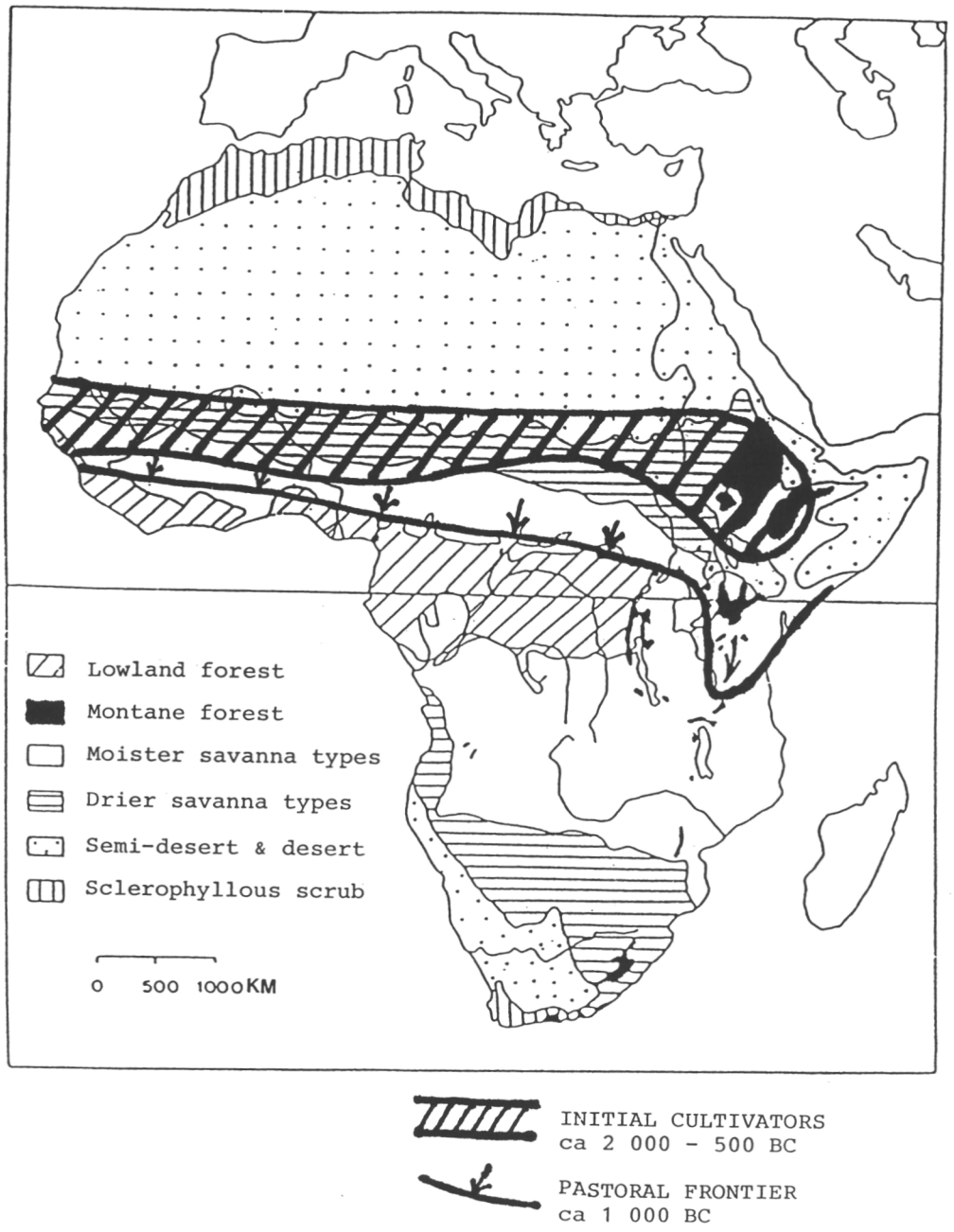


Figure 12. Early cultivation zone and the pastoral frontier in ca. 1000 BC.

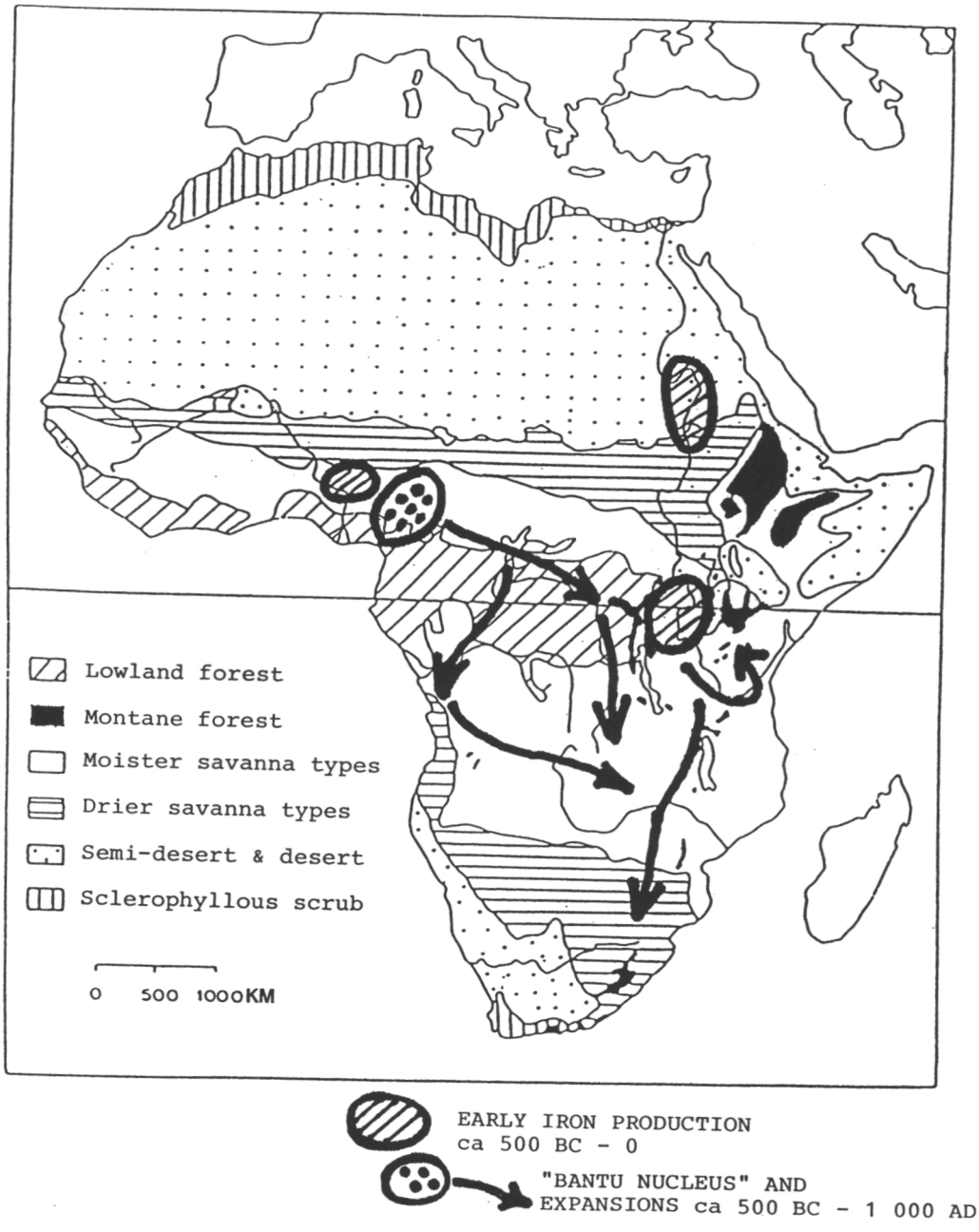


Figure 13. Early iron production and its spreading.

6. CONCLUSIONS

On a general level, we have seen that in Africa all the essential cultural ecological and economic innovations are autochthonous (i.e. achieved within the African cultural matrix itself), and they have led to similar environmental and social consequences as everywhere else in the world. Thus Africa has always been essentially a self-sufficient continent in every respect. As this relatively isolated situation prevailed in large parts of sub-Saharan Africa until the eve of the colonial period, the European impact must inevitably have had dramatic effects.

In his comprehensive ecological and economical analysis of the precolonial/colonial interface in eastern Africa, Helge Kjekshus (1977) showed that a marked turn towards a worsening situation occurred during the latter half of the 19th century in such phenomena as erosion, agricultural production and social integrity. From this I conclude that the recent alarming trend might be seen as a combination of a steep short-term (i.e. colonial) and a more gently sloping long-term (i.e. precolonial) component trend (cf. t2 in Fig. 1). As a precolonial historian, I regard this a sufficient basis to avoid too dramatic technological, economical or social interventions at least in more remote areas in Africa (eg. big dams like the Assuan, Volta or Kariba dams, or water-course manipulation like the Jonglei Canal in the southern Sudan; cf. Scudder 1980).

I would also point out that massive straightforward aid campaigns, while helpful in a short-term perspective, inevitably have negative long-term effects as they undermine the genuine African economical self-sufficiency and, moreover, must also have socially disintegrating effects as well (eg. Arnold 1985). Following this, my recommendation on a very general level is that in rural Africa economic systems should be developed which deviate as little as possible from the traditional production systems and distribution networks; I do not deny, however, the need of a careful and considerate

control of the demographic, energy and infrastructure systems (family planning, fuel-efficient heating and cooking, communication networks, food storage and conservation, education etc.).

Perhaps a dual economy with certain areas devoted to "modernization" and certain others reserved for more traditional land-use might be the most applicable; the latter areas could be marginal zones with less environmental potential where only pastoralists are able to live with their traditionally oriented economies and cultures. I feel that if demographic control is put into effect in agricultural areas and their societies, some of the central issues will be solved in large parts of Africa. The real problems, arising directly from droughts and being manifested immediately as famines, would then concern pastoralists in the drought-sensitive areas.

On the state level, where the important planning decisions are made, I would stress the need for taking into consideration the ancient economic strategies, as well as the social and political structures. We have seen that cultivators and pastoralists have been living in a mutually beneficial symbiotic relationship in the Sahel zone for at least three millennia and that a "bovine centered"culture might have even more ancient roots. I feel that radical efforts to convert pastoralists to full-time cultivators or even to sedentary mixed farmers/pastoralists will not lead to economically or socially stable results, at least without considerable resistance against its economic and political implications (Frantz 1975, Gulliver 1975, Lewis 1975).

Pastoralism is the only feasible basis for subsistence in arid and many semi-arid regions. It should be encouraged and carefully directed in ecologically suitable areas towards a transhumantic mode with separate dry and wet season grazing grounds. This was obviously the original strategy in the Sahelian-Ethiopian zone and in northern East Africa (eg. Smith 1980, Connah 1981, Hall 1985). At the same time, part-time cultivation could be encouraged on an ecologically

feasible scale and with ecologically feasible crops (Brandström et al. 1979).

Pastoralists should be allowed to arrange their wet season and dry season grazing by themselves under minimal outside control to avoid too heavy disputes, and measures to prevent erosion should be undertaken; for instance, by distributing watering places (dams, water-holes) so that no massive gatherings of animals occur (cf. Groeneveld 1968, Topps 1977, Pratt & Gwynne 1978). Cattle might be replaced by camels whenever it is both ecologically and socially feasible (in Somalia, Chad and in northern Kenya there are good experiences of this; Stiles 1983, Somali Camel Research Project of the Scandinavian Institute of African Studies and the Somali Academy of Sciences and Arts, directed by Dr. Anders Hjort, Uppsala). Also, whenever modern political boundaries traverse traditional grazing lands or separate wet season and dry season pastures, pastoralists should be allowed to cross the boundaries - an international agreement should be reached to this effect.

Governments should be urged to create regional and local development plans instead of, or in addition to, state-wide ones, so that local ecological, special social and historical features can be taken into account. This would promote sympathy among local inhabitants towards the development plans and also reduce tension between the people and the central bureaucracy (eg. Lamprey & Yussuf 1981).

One of the most severe obstacles in the balanced economical development in Africa is undoubtedly tribalism; tribalism also creates conditions for corruption (Gould & Amaro-Reyes 1983). I feel that tribalism is such an integrated feature in the African societies, with its deep roots in the precolonial history, that it cannot easily be weeded out. Perhaps its negative effects could be minimized by the above-mentioned local development plans.

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DEFORESTATION IN THE TROPICS: PILOT SCENARIOS BASED ON QUANTITATIVE ANALYSES

Matti Palo, Gerardo Mery and Jyrki Salmi

ABSTRACT

The purpose of the paper was to create deforestation scenarios for the tropics. The cross-sectional analyses of 1980 were based on 33 variables and 72 tropical countries, which were divided into five subgroups. Strong negative correlation coefficients between total forest coverage (the deforestation variable) and total population density were obtained for 60 countries. In eight arid African countries no such correlation was found. The regression models determined by the statistical analysis were employed in creating three alternative scenarios (B, C and D) of future tropical deforestation in 60 countries, and a fourth one (A) was obtained by assuming the present area of deforestation to remain static also in the future. Scenarios C and D had non-linear function forms and were more closely related to the theoretical frame reviewed here than Scenarios A and B with linear function forms. The total forest area in the 60 tropical countries analyzed in this paper was 17.6 million km^2 in 1980. According to scenarios C and D, this is expected to decline by 30 % and 45 % respectively, until 2025. Most other authors assume that the present deforestation rate will continue indicating a reduction of - 18 % (Scenario A), a result that is close to the one given by Scenario B (- 16 %).

Key words: deforestation, quantitative analysis, scenarios, tropical countries.

CONTENTS Page

1. INTRODUCTION 54
2. MATERIAL AND METHOD 56
   21. Empirical data 56
   22. Modelling experiments 59
   23. Scenario models 70
3. RESULTS OF THE PILOT SCENARIOS 79
4. DISCUSSION 86
   REFERENCES 91
   ANNEXES 94

1. INTRODUCTION

The clearance of forest areas has historically mainly been a result of the joint actions of natural events, such as lightening, storms, floods, volcanos and prolonged droughts, and man. Although the depressing consequences of deforestation were already known more than two thousand years ago, e.g. as stated by Plato in his Criteas in 400 B.C. (e.g. Poore 1976), this process has recently been expanding at an alarming rate - especially during the last four decades- mainly due to the human disruption of natural forest ecosystems.

A number of scientists, research centres and international institutes have made dedicated efforts to study the deforestation process that acutely affects most of the developing countries. There is a wide agreement about the main agents of deforestation and the negative consequences that this process usually generate in the published research, although the exact nature of the processes has remained rather unclear. However, diverging concepts and definitions of deforestation have often been used, and hence there is no agreement about its magnitude and rate of increase.

The term 'forest' as applied in forestry, in biology or in ecology has no universally adopted single definition. However, the contents of this term hold a key position for consistent deforestation analyses. Forest ecosystems are characterized by a more or less dense and extensive tree cover. Consequently, tree dominance in a given plant association is the decisive factor in distinguishing such an association from the other types of ecosystem. (E.g. Ford-Robertson 1971.)

Deforestation, as referred to in this paper, removes a previous forest area from the adopted forest classification because the area loses the listed criteria of a forest ecosystem. Consequently, degradation, i.e. the impoverishment of forest coverage and floristic composition of a forest by partial elimination of trees, has to be differentiated from

deforestation. Accordingly, deforestation is used in this paper in the strict sense of the complete clearance of existing forests and their replacement by other forms of land use. Since deforestation of tropical forests often has an irreversible nature (e.g. Eyre 1975, UNESCO, UNEP & FAO 1978), the policy decisions affecting its spread are crucial.

According to the last assessment of forest resources in the tropics by FAO (FAO & UNEP 1981a,b,c; Lanly 1982), the deforestation of closed and open forests in 76 countries was estimated to be, for the period 1981-85, 11.3 million hectares per annum. 45 % of this was due to shifting cultivation and 55 % to conversion of tropical forests into uses like permanent agriculture, pasture fields, urban areas, water reservoirs, brushland, deserts, etc. No estimate of degradation was given.

The purpose of this paper is to analyze quantitatively tropical deforestation on the basis of the provisional theoretical framework presented by Palo (1984, 1987) using empirical cross- sectional data by countries. More specifically, the aim is to produce pilot scenarios on tropical deforestation up to the year 2025 for 72 tropical countries as a whole, and divided into continental groups. The analyses presented here are based on 33 variables, but the ultimate scenario-making is restricted to a few of the most relevant variables, e.g. forest coverage as a measure of deforestation (dependent variable) and population density (independent variable) as an indirect variable to measure a number of more direct variables affecting deforestation. The empirical data refer to the year 1980. The paper gives parallel results with the previous one presented by Palo and Mery (1986), but with more regression experiments and further refinements in the country grouping and with some corrections to the key variables.

2. MATERIAL AND METHOD

21. Empirical data

The assumed causes of tropical deforestation are depicted here using the frame model of Figure 1. Population pressure and political factors are the major indirect factors identified, whereas economic development, traditional factors, duration of human impact and natural factors are assumed to be the major direct factors affecting the area of deforestation. In this frame model only one-way causal relationships are depicted, although mutual interactions (feedback) among these factors are known to exist. This restriction is due to the lack of empirical data and to the simple analytical tools that were applied in estimating future scenarios for tropical deforestation. A pure econometric approach was avoided because of the multi-disciplinary nature of the deforestation processes. The frame model guided the selection of empirical variables.

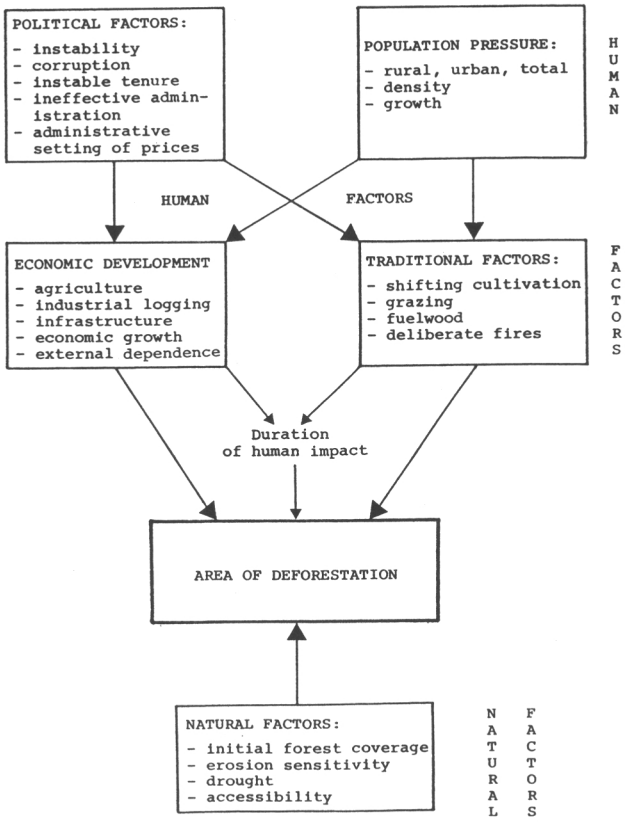


Figure 1. Theoretical frame of tropical deforestation (Palo 1984).

The following problems arose with the empirical data:

- Time series for most of the key variables were not available. More specifically, sequential estimates of deforestation were missing. Consequently, the analyses were based on cross-sectional observations from 1980.

- The various assessments of tropical deforestation published recently have produced widely differing results (Sommer 1976, Persson 1977, Lanly & Clement 1979, Barney 1980, Myers 1980, FAO & UNEP 1981).

- A sequential forest inventory of a given area could provide a solid basis on which to make an accurate appraisal of the changes in forest areas. However, most of the deforestation estimates are secondary approximations that are usually based on rough comparisons of available data. Therefore, the annual deforestation rate variable - the most valid dependent variable for the purposes of this study - was laid aside (Annex 6). Instead, the forest coverage variable, measured as the percentage of the forest area out of the total land area, was applied in the analyses (see Palo 1984, 1987a).

- The units of the input data matrix were observations made by country (see Annex 6). Due to their heterogeneous characteristics and size the countries were grouped into more homogeneous subsets and only relative variables, instead of absolute ones, were employed. About 60 different variables were initially studied. The 33 derived relative variables, which were analyzed more closely, are listed in Annex 1.

The empirical investigation of the relationships between variables was initially based on the data from the 76 countries included in the FAO/UNEP assessment of 1981. However, the list was subsequently revised since at least half of each analyzed country had to be located in the tropical zone. Four countries did not match this criterion, Bangladesh, Bhutan, Nepal and Pakistan and hence were

omitted. Trinidad and Tobago was eliminated for specific reasons (Annex 4), and Mauritania, which had been omitted by FAO/UNEP (1981), was reincorporated in the original list (Pelleck 1983). The set of 72 countries (see Annex 6) thus obtained was reduced again following residual analysis (as explained in the next Section). Accordingly, 68 countries (Annex 2) were included in the final analyses.

In order to establish more homogeneous groups of countries for further statistical analyses, geographical proximity was considered to reflect similarity in the natural and human factors affecting deforestation. Consequently, a division by continents was firstly applied. But in the case of Africa, due to the high number of countries and their heterogeneity, a further subgrouping was executed. Three subgroups based on the dominant physiognomic characteristics of the forests, were formed. The subgroups were subsequently revised using climatic data, but only a few countries were subsequently reallocated into different groups. Accordingly, a total of five subgroups were established as follows:

A.	Latin American countries	(21)
B.	Asian countries	(11)
C.	Moist African countries	(14)
D.	Semi-Moist African countries	(14)
E.	Arid African countries	(8)
	Total number of countries (A - E)	68

Most of the forest and land area observations were gathered from the FAO & UNEP assessment (1981 a, b, c). Population figures were collected from United Nations (1982), and socio-economic variables were extracted from World Bank (1981) and FAO Production Yearbook (1984). The total forest area variable was composed of closed and open natural broadleaved forest and natural coniferous forest.

After a thorough data checking, the validity of the forest coverage variable was increased by making some modifications to the original land area data: the areas where no forest has existed for a long period were deducted. Consequently, the following types of land were subtracted from the land area observations: urban areas, mountain tops, deserts and swamps (World Atlas of Agriculture).

22. Modelling experiments

A regular econometric approach would try to specify supply and demand functions of the particular market under investigation. Alternatively, the economic theory of land rent could provide guidelines for specification of the econometric model of changes in land-uses, as done by Alig (1986) for the United States. In the case of tropical deforestation a standard econometric approach was not feasible due to the absence of distortions in the price mechanism, and to the dominating role of externalities. The tropical deforestation process is strongly intersectoral and interdisciplinary by its basic character. Although profits, prices and costs may also play some role in deforestation, their role is indirect to such a degree that their operationalization was not considered feasible in this pilot analysis.

A tropical deforestation process is notoriously complex, variable and dynamic. In many cases the process is continuously supported and stimulated, and no equilibrium is reached until all accessible forests have been cleared. Our modelling experiments rely on the existing provisional theoretical framework of tropical deforestation (Palo 1984, 1987) and on simple analytical tools of correlation and regression analyses.

According to our basic hypotheses (Figure 1), the primary model was shaped into the following form (1):

(1) DE = f(ES, AR, AC, SC, GR, FG, AP, LO, FM, ED, LT, FA, MM, PO)
+ + + + + + + + - + + + - +

where,

DE = Forest area deforested in year t
Natural factors:
ES = Erosion sensitivity and soil quality
AR = Aridity of the climate
AC = Accessibility of the forest area
Traditional factors:
SC = Shifting cultivation
GR = Grazing
FG = Fuelwood gathering
Economic development factors:
AP = Permanent agriculture
LO = Industrial logging
FM = Forest management
ED = Economic development (e.g. GNP per capita)
Political factors:
LT = Land tenure
FA = Forest and other administration
MM = Market mechanism
Population factors:
PO = Population pressure

The assumed signs of the effects (Palo 1987) are shown under the variables. Most of them are self-explanatory. However, some variables require additional explanation.

SC: Erosion sensitivity and the poorness of some tropical soils make the man-nature relationship hazardous and fragile, especially as a consequence of shifting cultivation. Aboriginal people with a long tradition in shifting cultivation have inherited a substantial knowledge in the field. They try to avoid slashing and burning the steepest slopes, which are too erosion-sensitive. They also apply a reasonable fallow period after a couple of years cultivation, so that the site can recover its forest growth. However, as a result the growing population pressure the landless rural and urban poor migrants, without any tradition and ecological knowledge of the local conditions, have increasingly invaded the forests. They tend to slash and burn every inch of forest. Due to growing population densities on the forest, areas the fallow periods tend to become shorter. Neither can the aboriginal people any longer practice their traditional sustainable shifting cultivation.

LO: The dominant form of industrial logging in the natural tropical forest is a selective procedure. After selective logging most of the trees usually remain standing, because only mature commercial species are removed ("creamed"). If selective logging is implemented in accordance with some silvicultural regimes, no deforestation occurs. Only the modification of natural stands takes place, and the next logging in favourable conditions may be executed within a cutting cycle of 20-40 years. However, industrial logging increases deforestation primarily in an indirect fashion by opening up previously inaccessible forest areas for other deforestation agents, but also directly when logging roads and extraction tracks cause erosion, as well as in the more rare cases of clear felling.

ED: In the least developed countries the only pressures upon the forests are usually the traditional factors, such as shifting cultivation, grazing and fuelwood gathering. Along with the economic development new pressures appear and land becomes a scarce factor. Often poorly controlled or uncontrolled clearing for agricultural purposes and industrial logging, as well as forest clearing for infrastructure, industrial and settlement purposes, all contribute towards increasing deforestation. A part of this deforestation is unavoidable, but another part could be avoided through more effective control. However, after a certain stage of economic development and urbanization, the increasing pressure upon the forests could become stabilized. Intensive forest management activities and also the growing needs for recreation and conservation areas could set an end to deforestation. The process might even become reversed, leading to the future expansion of forest areas. Such evidence exists among developed countries, but under present developing country circumstances this is still most unlikely.

LT: Under an unstable or highly skewed and concentrated land tenure situation, irrational or short sighted devastation and burning of forests might occur. Such a situation also tends to delay or to prevent intensification of agricultural

production on permanent areas, and thus promote shifting cultivation and grazing on woodlands. Moreover, the skewness of tenure is one reason for the high number of landless people, and in this way cause more pressure on shifting cultivation and grazing.

FA: Forestry and other relevant branches of government administration have a crucial operative role in the deforestation processes. Shortages of experienced staff, institutions, funds, vehicles and instruments, as well as prevailing corruption, often deteriorate the effectiveness and efficiency of the public administrations. However, effective control of industrial logging and various forms of forest clearing for economic development purposes would prevent a considerable portion of the present deforestation.

MM: Market mechanisms at present play a minor role in tropical forestry. Stumpage prices are mostly fixed administratively at a lower level than would result from market mechanisms. Along with the increasing deforestation and increasing scarcity of remaining natural forest more effectively working market mechanisms would have a countering effect on deforestation by automatically increasing stumpage prices and thus also making the pecuniary value of a hectar of natural forest more worth protecting.

PO: Increasing population pressure increases deforestation indirectly through traditional, economic development and the political factors explained above. This was identified as a separate factor here due to its dominating position as a driving force for the whole deforestation process and because of the easy access of empirical data.

In short, deforestation is a complicated process and tightly tied up with the local socio-economical and ecological situations. The construction of models on a global or continental basis would have required simplifications because, at this level of aggregation, some causes of deforestation have an inherent contradictory nature. Also the paucity of data,i.e. the lack of time series, missing values

and low reliability of some of the identified variables, forced us to simplify the model. Consequently, the following assumptions (cf. Figure 1) were considered in the choice of variables for the modelling exercises:

- The actual forest coverage as a "negative" proxy for deforestation was chosen as the dependent variable in our cross-sectional analysis for the reasons presented above.

- An attempt was made to quantify erosion sensitivity and soil quality, aridity of the climate, accessibility of the forest area, forest management, land tenure, administration and market mechanism questions, but after various trials and exercises these aspects were left for later and more thorough case study analysis.

- The share of forest fallow area out of the total forest area was assumed to reflect the impact of shifting cultivation on the forests.

- The livestock production index was chosen as an estimate for the pastoralist (grazing) pattern of land use.

- The fuelwood production per forest hectare was chosen as a fuelwood variable.

- The agricultural area and food production per capita were assumed to reflect the role of permanent agriculture on deforestation.

- Industrial roundwood production per forest hectare and exports of forest products per forest area were assumed to reflect the industrial logging activity.

- GNP per capita and GDP per land area were chosen as the economic development variables.

- It was noticed that rural population density and total population density were separately correlated, rather strongly and negatively, with forest coverage in the

Table 1. Correlation matrix of 13 deforestation variables (Annex 1) for 60 tropical countries (eight arid African countries excluded) in 1980.

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Forest coverage	Total population density	Rural population density	Share of forest fallow area	GNP per capita	GDP per land area	Relative industrial roundwood production	Forest product exports per forest area	Agricultural area coverage	Food production per capita	Livestock production index	Population growth	Relative fuelwood production
1.	1.00												
2.	-0.78	1.00											
3.	-0.77	0.97	1.00										
4.	-0.38	0.32	0.28	1.00									
5.	-0.14	-0.08	-0.16	-0.06	1.00								
6.	-0.55	0.64	0.51	0.32	0.36	1.00							
7.	-0.48	0.55	0.58	0.19	-0.01	0.26	1.00						
8.	-0.00	0.06	0.03	0.25	0.22	0.25	0.24	1.00					
9.	-0.71	0.44	0.46	0.01	0.07	0.28	0.24	-0.17	1.00				
10.	-0.48	0.32	0.30	0.07	0.48	0.36	0.18	0.21	0.27	1.00			
11.	-0.20	0.12	0.12	0.02	0.34	0.23	-0.02	0.13	0.26	0.58	1.00		
12.	0.00	-0.20	-0.17	0.10	0.07	-0.13	-0.01	-0.02	0.00	0.08	-0.07	1.00	
13.	-0.51	0.48	0.54	0.14	-0.12	0.12	0.77	-0.06	0.39	0.11	-0.04	-0.01	1.00

Table 2. Correlation coefficients between forest coverage and population density by groups of 68 tropical countries.

	Region[1]	Number of countries	Correlation coefficient[2] between forest coverage and total population density		
			original	semi-log	log-log
A	Latin America	21	-0.82	-0.89	-0.80
B	Asia	11	-0.97	-0.98	-0.96
C	Africa	36	-0.48	-0.35	-0.36
C1	Moist Africa	14	-0.81	-0.69	-0.64
C2	Semi-moist Africa	14	-0.76	-0.78	-0.62
C3	Arid Africa	8	-0.05	-0.15	-0.18
D	Closed forest dominating groups A+B+C1	46	-0.81	-0.81	-0.70
E	Tropics excl.arid Africa A+B+C1+C2	60	-0.78	-0.78	-0.64
F	Total tropics	68	-0.63	-0.57	-0.51

1) See Annex 1 for list of countries

2) All coefficients statistically significant at 1 % level except group C3

various tropical regions, except in the arid group (Table 1-2, Figure 2). All the correlation coefficients were statistically significant and rather high taking into account the fact that they were derived from cross-sectional data. The signs of the coefficients were systematically negative, and supported the hypothesis. Total and rural population densities were mutually strongly correlated (+0.97) among all the 68 tropical countries. Consequently, and in accordance with the provisional theory (Figure 1), total population density (instead of rural) was applied in the further analyses.

Population variables, natural factors and socio-economic development variables as listed in Figure 1 were analyzed using simple correlation and regression techniques. The signs and magnitudes of the correlation coefficients were compared with the hypotheses (Palo 1987). The most interesting relationships were defined through an iterative process utilizing correlation matrices (see Tables 1 and 2). The construction of various regression models was carried out accordingly. An attempt was made to build explanative models by different aggregates of countries. The primary model (1) became specified in the following form (see also Annex 5):

(2) $FC_t=f(FF_t,LP_t,FW_t,AG_t,FP_t,IW_t,EX_t,GN_t,GD_t,PD_t,PG_t)$

(expected)	-	-	-	-	-	-	-	-	-	-	-
(estimated)*	-	+/-	-	-	-	-	+	-	-/+	-	-

where,

FC_t= Forest coverage in the year t
FF_t= Share of forest fallow
LP_t= Livestock production index
FW_t= Relative fuelwood production
AG_t= Agricultural area coverage
FP_t= Food production per capita
IW_t= Relative industrial roundwood production
EX_t= Forest product exports per forest area
GN_t= GNP per capita
GD_t= GDP per land area
PD_t= Population density
PG_t= Population growth

*The number of observations varied between 11 and 60

(For simplicity, only the estimated results obtained from models (2)-(6) using linear functions are presented here, although experiments with nonlinear functions were also executed.)

The expected signs are shown in the first line below the model (2), and the signs of the estimated models in the second line. The estimated signs were mostly consistent with the hypotheses. However, the variable "forest product exports per forest area" has an opposite sign in relation to the expected one. An explanation is readily available: the countries which still have large existing forest resources

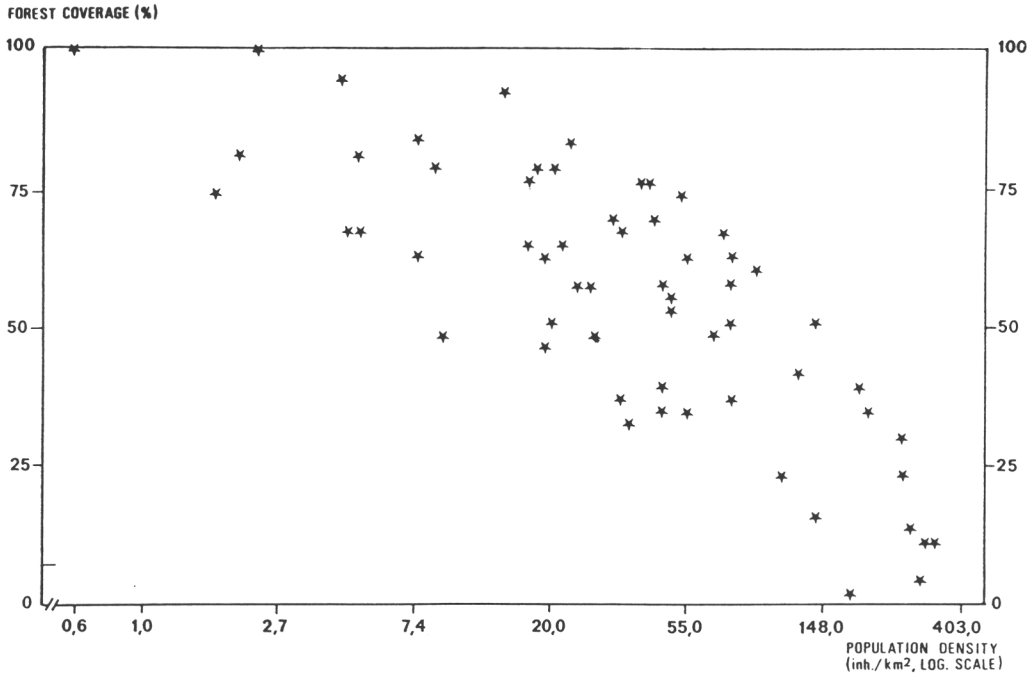


Figure 2. Correlation between forest coverage and total population density in 60 (r = -0.78) tropical countries, 1980.

are exporting roundwood and some processed forest products. Those countries with limited forest resources consume all of their wood production themselves.

Due to strong multicolinearity in the basic model of 11 independent variables (2) (see Annex 5, and Table 1), a number of its variations where this problem was avoided were tested. The following ones are interesting examples:

Population density:

In the group of 60 tropical countries (arid african countries excluded, Annex 2) the correlation coefficient between forest coverage and population density was -0.78 (Figure 2). The model was estimated to have the following form (3):

(3) FC = 71.21 -0.22PD

t-statistics: 27.35 -9.50
R^2: 0.60
F-statistics: 90.21
where, FC = Forest coverage
PD = Population density

The negative signs of both the correlation and regression coefficients were in accordance with the hypothesis. This "obvious" relationship was statistically significant at all levels of aggregation. Within Asian, Latin-American and Moist African country groups the model produced even higher R^2 values: 0.93, 0.66 and 0.63 respectively.

Population growth rate:

In the group of Moist African countries (14 observations) the correlation coefficient between forest coverage and population growth rate was -0.59. The model (4) was estimated to be:

(4) FC = 110.98 -17.91PG

t-statistics: 5.24 -2.40
R^2: 0.27
F-statistics: 5.76

where, FC = Forest coverage
PG = Population growth

The negative sign of the correlation and regression coefficients was in accordance with the hypothesis. The results could be interpreted as indicating that the indirect pressure of the growing population is directed towards deforestation in Moist African countries especially (Figure 1).

Index of food production per capita:

In the group of low income countries (GNP per capita less than USD 500; 45 observations) the correlation coefficient

between forest coverage and index of food production per capita was -0.55. The model was estimated as follows:

(5) FC = 75.15 -0.36FP

t-statistics: 11.09 -4.34
R^2: 0.29
F-statistics: 18.87

where, FC = Forest coverage
FP = Food production per capita index

The signs of the coefficients were in accordance with the hypothesis. The level of significance passed 1 %. The results could be interpreted to mean that the increment in food production in the poorest countries has mainly been achieved by clearing new fields and by increasing shifting cultivation, as well as by expanding grazing, at the expense of forests. It must be borne in mind that the capital intensity of agriculture in these countries is low.

GNP per capita:

In the Asian country group (11 observations) the following model (6) was obtained:

(6) FC = 85.42 -0.23PD -0.64GN

t-statistics: 28.46 -13.20 -1.94
R^2: 0.95
F-statistics: 87.50

where, FC = Forest coverage
PD = Population density
GN = GNP per capita

The signs of both regression coefficients were in accordance with the hypothesis. The results could be interpreted to indicate that, in addition to the pressure of the population, the pressure of overall economic activity on deforestation is high in Asian countries especially. However, the statistical significance of the GNP-variable was rather low.

It was also found that the population density within the group of countries where the GNP per capita surpasses USD 500 is considerably better correlated with forest coverage than within the low income country group. Moreover, within the country group with large absolute forest areas the correlation between population density and forest coverage was worse than that within countries with relatively limited forest areas. The colonial history (in the form of different master countries) does not appear to explain the differences existing between the forest coverages of different countries.

Several other attempts were carried out with, however, only limited success. A list of models which were tested and rejected is given in Annex 3.

23. Scenario models

While the theoretical bases of the deforestation phenomenon are still provisional and the phenomenon varies strongly by continent, country, district and locality, and since the empirical data are inaccurate, no scientific predictions about future rates of tropical deforestation are feasible. Faced with the specific needs of policy measures designed to control deforestation, it was decided to adopt an approach in which alternative scenarios, instead of predictions, were made. Here the reader or the policy-maker himself will have the final say about which scenario alternative to select when the basis of each scenario are presented.

Some of the regression models were also used for scenario-making purposes. It should be borne in mind that a good explanative model is not necessarily a good predictive one. The latter demands independent variables which have to fulfil the following prerequisites: the variables must have a predictive value, while being external to the system concerned or predictions available. Furthermore, a reasonable statistical relationship with the dependent variable (Fig. 2-6) and a sufficient coverage of the data (the lack of statistics is notorious especially in the case of the

developing tropical countries under study) are the other necessary criteria in choosing independent variables for prediction models.

This being the case, the total population density was the only valid independent variable remaining for scenario analyses. The increase in total population density was assumed to accelerate future deforestation indirectly through a number of political, economic and traditional factors, in combination with the natural factors (Figure 1). The regression of population density on forest coverage was assumed to have a varying content and/or stress of direct deforestation factors by different country groups. Hence, a similar increase in population density may cause different deforestation effects in each country group.

The perspectives of tropical deforestation were analyzed by creating four alternative scenarios. Tropical deforestation scenarios were analyzed for the period 1980-2025 because countrywise population predictions (United Nations 1982) were available up to the end of the period.

The regression models used for scenario-making were constructed separately by the country groups (Annex 2) described in the previous Section, each group having its own scenario for the years 2000 and 2025. Nevertheless, a new attempt to obtain more homogeneous groups was made prior to the start of the scenario-making applications . A residual analysis was executed in order to determine the most striking outliers, i.e those countries which did not fit well enough with the regression model. The following results were achieved by this procedure:

-In the Latin American group Cuba was eliminated due to its strong outlier position (Fig. 3; Annex 4). The standard error of the regression model was reduced by 8 % and the adjusted R^2 increased from 0.62 to 0.66 through this elimination. Trinidad and Tobago had alredy been rejected in a previous phase.

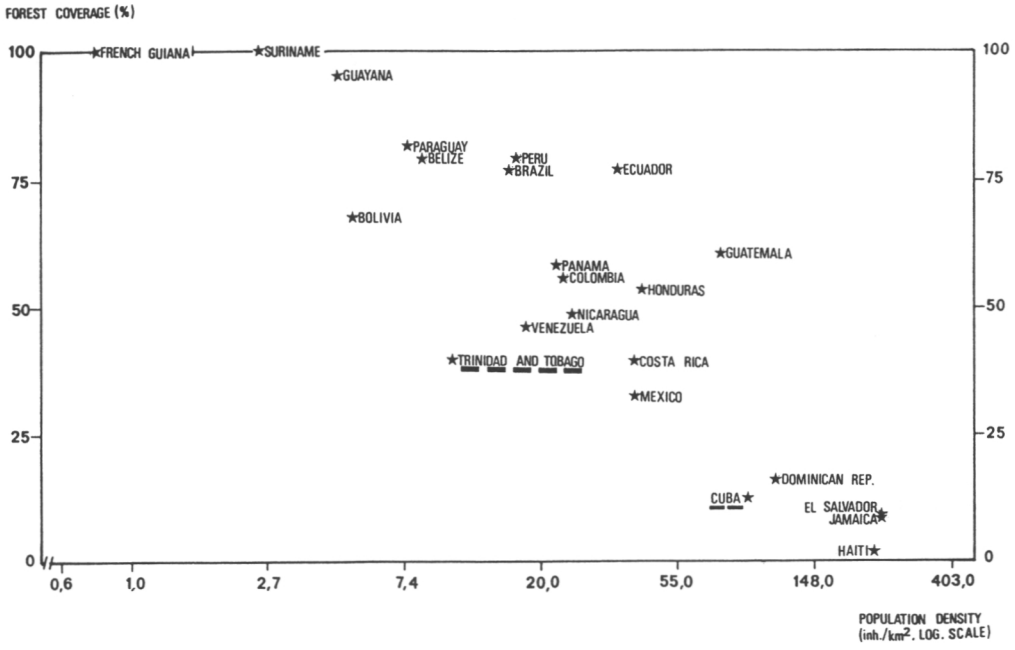


Figure 3. Correlation between forest coverage and total population density in 21 (r = -0.89) + 2 Latin American countries in 1980.

-Papua New Guinea was dropped from the Asian group due to its outlier position (Fig. 4, Annex 4). The standard error of the regression was reduced by 17 %, and the adjusted R^2 increased from 0.91 to 0.98.

- No outlier was eliminated in the group of Moist African countries, although the variance among the countries was somewhat higher than that in the previous groups (Fig. 5).

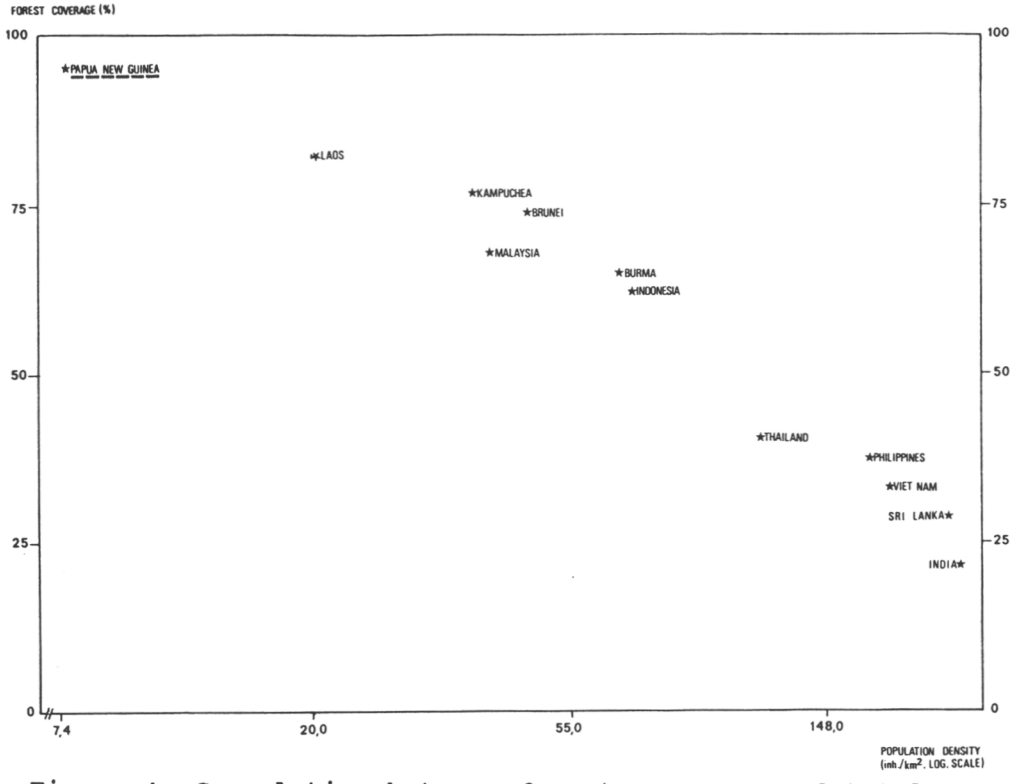


Figure 4. Correlation between forest coverage and total population density in 11 (r = -0.98) + 1 Asian countries in 1980.

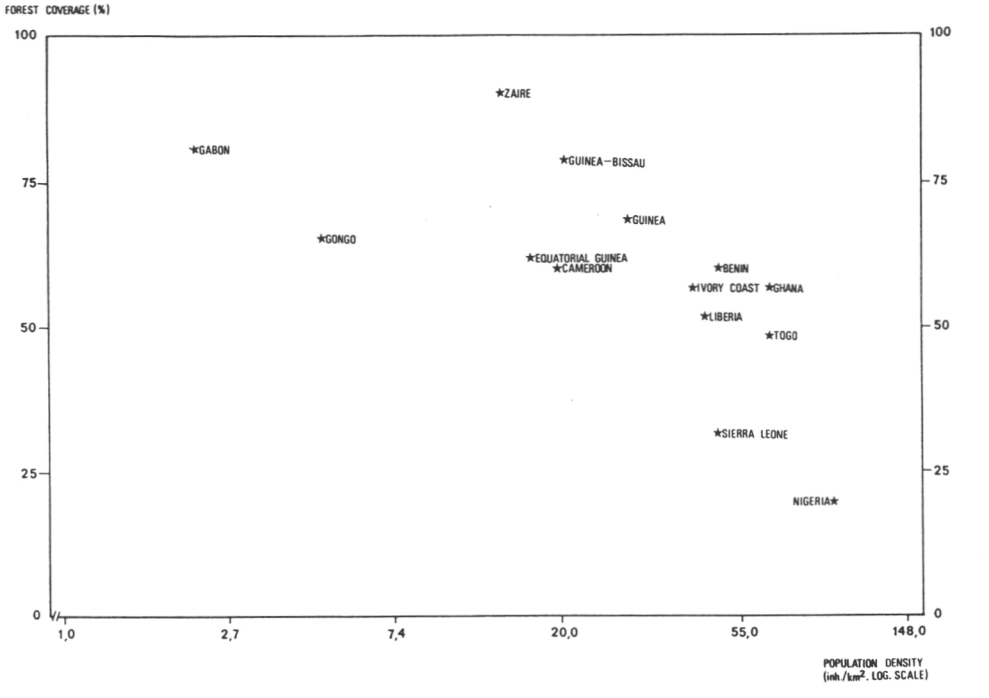


Figure 5. Correlation between forest coverage and total population density in 14 (r = -0.69) Moist African countries in 1980.

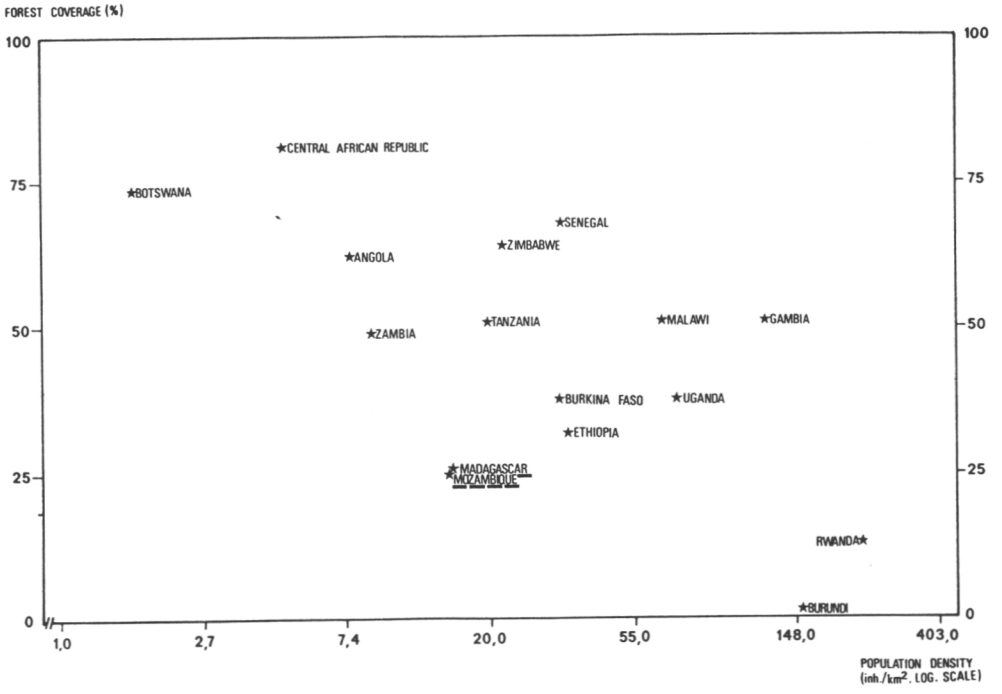


Figure 6. Correlation between forest coverage and total population density in 14 (r = -0.78) + 2 Semi-moist African countries in 1980.

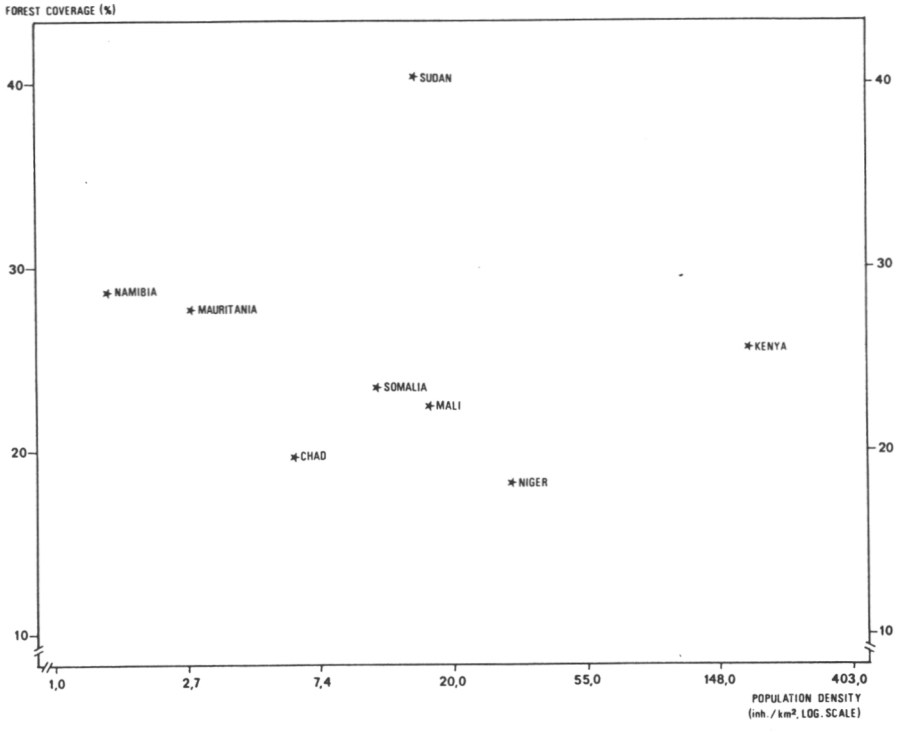


Figure 7. Correlation between forest coverage and total population density in 8 (r = -0.15) arid African countries in 1980.

-In the group of Semi-moist African countries Madagascar and Mozambique were eliminated as outliers (Fig. 6; Annex 4). The standard error of the regression was subsequently reduced by 15 %, and the adjusted R^2 increased from 0.35 to 0.54.

-The relationship between population density and forest coverage among eight arid African countries appeared to be weak and diverging from the other groups (Fig. 7). Since the regression model did not fit well in the arid African group no scenario was made for the group. Further regrouping would probably be beneficial.

The following scenarios were constructed according to the arrangement of countries by subgroups and on the basis of cross sectional data for 1980:

(i) Scenario A was based on Lanly's (1982, p. 101) view of a linear development: "In the matter of deforestation the most expedient solution would be to suppose a linear development, at the global level, up to the year 2000, by deducting 20 times the area cleared yearly between 1981 and 1985, from the area of forest formations existing in 1980,..." Scenario A was considered to serve as a basic simple reference for the other three scenarios, which were based more on the theoretical considerations of this paper.

(ii) Scenario B was based on the application of a linear regression model by country groups. The equations applied have the same form as equation (3).

The scenarios A and B are related to each other through the linear deforestation assumption. However, according to the theoretical frame reviewed in this paper, a non-linear relationship between forest coverage and total population density would be more relevant. The assumption of non-linear deforestation resembles the lower part of the declining curve of Figure 8. Accordingly, two new scenario-models, C and D, were created as follows:

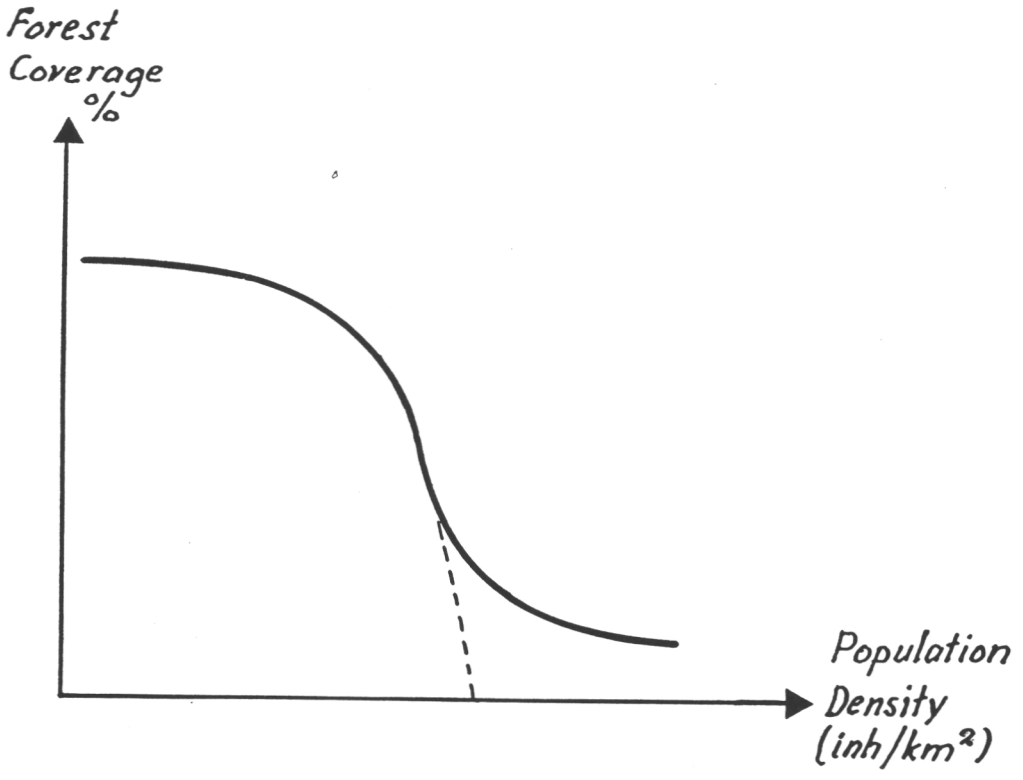


Figure 8. Theoretical decreasing logistic and collapse functions for tropical deforestation (Palo 1984).

(iii) Scenario C was analogous in application with scenario B, but instead of a linear relationship, non-linear equations (7) of the following type were adopted:

$$(7) \quad FC = e^{a} PD^{-b}$$

where,

FC = forest coverage for the year t + n
PD = total population density prediction for the year t + n
a,b = parameters estimated by linear regression analysis
e = base of the natural logarithms

(iv) Scenario D was analogous in application with scenario C. Non-linear equations of type (8) were adopted.

(8) $e^{FC} = e^{a}\ PD^{-b}$

Symbols as in equation (7)

Scenario-making is mostly based on time series analyses, but it was not possible do so here. Time-series existed for the independent (population) but not for the dependent variable (deforestation). The rationale of applying cross-sectional data to estimate the regression equations lies in the dynamism inherent in such country groups. Each group consists of 11-21 countries at different levels of socio-economic development. It is assumed that this intergroup dynamism is reflected through estimated coefficients into scenarios.

Scenario models B, C and D were estimated by four country groups and based on the empirical cross-sectional data of 1980. The degrees of determination and statistical tests (t and F) gave satisfactory results (Table 3). The degrees of determination are considered as relatively strong, being estimated from a cross-sectional data and based on only one independent variable.

An algorithm was created for scenario production using the different regression models estimated for each country group. The algorithm first calculated weighted averages of population density predictions for the year 2000 and 2025 by country groups. The weighting was performed by taking into account the high variation of forest areas between countries. The national population density predictions were weighted by the respective forest areas in order to get unbiased country group averages. The weighted averages were further applied in the algorithm for solving the different equations. The forest coverage estimates for 2000 and 2025 were accordingly obtained. In subsequent calculations the algorithm also estimated the deforested areas and the total forest areas at these two points of time.

Table 3. The estimated regression equations of deforestation scenarios B, C, and D for four groups of the total of 60 tropical countries.

Group of countries	Number of countries	Critical t-values at risk of		Scenario B				Scenario C				Scenario D			
		1 %	0.1 %	Estimated equation y=	t^*	R^2	F	Estimated equation y=	t^*	R^2	F	Estimated equation ln y=	t^*	R^2	F
Latin America	21	2.86	3.88	73.821-0.232 x	-6.3	.66	39.7	111.31-16.57 lnx	-8.6	.78	73.9	5.320-0.471 lnx	-6.8	.62	33.1
Asia	11	3.25	4.78	82.695-0.225 x	-11.4	.93	131.1	169.80-25.39 lnx	-13.9	.95	192.2	6.257-0.516 lnx	-9.7	.90	94.0
Moist Africa	14	3.06	4.32	80.404-0.449 x	-4.9	.63	22.9	98.46-11.14 lnx	-3.3	.43	10.6	4.763-0.210 lnx	-2.9	.36	8.3
Semi-moist Africa	14	3.06	4.32	61.442-0.210 x	-4.0	.54	16.4	89.35-12.22 lnx	-4.3	.57	18.2	5.178-0.466 lnx	-2.7	.33	7.3
Total	60														

* t-values for the estimates of regression coefficients. One-sided testing due to empirical confirmation of hypothetical minus sign.

R^2 = adjusted degree of determination.

3. RESULTS OF THE PILOT SCENARIOS

The results of pilot scenarios were obtained using the models and method described in Section 23. The scenarios of the total forest area (Table 4), the forest coverage (Table 5) and deforestation are first presented as an index of the total forest area in 1980 (Table 6), deforestation as a percentage of the 1980 total forest area (Table 7) and annually deforested total forest areas (Table 8). The scenarios of total forest area are also introduced in Figures 9a - 9e.

The results of Tables 4-7 and Figures 9a-9e show that different models produced rather diverse scenarios by groups of countries, except in the case of Asia, where all the scenarios show a reduction of about 28 % in the total forest area between 1980 - 2025. According to the four scenarios, the total forest area of all the 60 tropical countries was estimated to decrease from 17.6 million km^2 in 1980 to 9.7-14.7 million km^2 by 2025 . Subsequently, the forest coverage in the 60 tropical countries was estimated to decline from 61 % to 33-51 % during the 45-year period under study. The total potentially deforested forest area in the 60 tropical countries will thus be in the order of 3-8 million km^2, the higher estimate being nearly of the same order of magnitude as the total forest area in the Soviet Union.

According to scenarios A, C and D, by 2025 the largest absolute deforested area will be located in Latin America, and according to scenario B in Africa. Scenarios C and D estimate a deforestation area to the order of 3-5 million km^2 for Latin America during 1980-2025 (Table 4). Even the lower estimate is close to the total forest area in USA or Canada, which illustrates the magnitude of this potential loss.

According to scenario A, Asia will be more affected in relative terms (Table 7) than the other continents, experiencing a reduction of 27 % in the total forest area between 1980-2025. Scenario B produces the highest equivalent

Table 4. Scenarios A - D on total forest area of 60 tropical countries for 2000 and 2025.

Group of countries	Number of countries	Base year	Total forest area (thousand km^2)							
			Scenario A		Scenario B		Scenario C		Scenario D	
		1980	2000	2025	2000	2025	2000	2025	2000	2025
Latin America	21	9014	8191	7161	8892	8324	7241	6220	5375	4324
Asia	11	2855	2516	2092	2800	2044	2493	2062	2338	2039
Moist Africa	14	3020	2818	2565	2616	1929	2421	2133	2276	2005
Semi-moist Africa	14	2688	2664	2634	(2731)	2431	2335	1953	1743	1305
Total Africa*)	28	5708	5482	5199	5347	4360	4756	4086	4019	3310
Grand Total	60	17577	16189	14452	17039	14728	14490	12368	11732	9673

*) Arid Africa excluded

Table 5. Scenarios A - D on forest coverage of 60 tropical countries for 2000 and 2025.

Group of countries	Number of countries	Base year	Forest coverage (%)							
			Scenario A		Scenario B		Scenario C		Scenario D	
		1980	2000	2025	2000	2025	2000	2025	2000	2025
Latin America	21	67	61	54	67	62	54	47	40	32
Asia	11	45	39	33	44	32	39	32	37	32
Moist Africa	14	70	66	60	61	45	57	50	53	47
Semi-Moist Africa	14	54	53	53	(55)	49	47	39	35	26
Total Africa*)	28	61	59	56	58	47	51	44	43	36
Grand total	60	61	56	50	59	51	50	43	40	33

*) Arid Africa excluded

Table 7. Deforestation as percentage of 1980 total forest area.

Group of countries	Number of countries	Deforestation (%) Scenario A 2000	Scenario A 2025	Scenario B 2000	Scenario B 2025	Scenario C 2000	Scenario C 2025	Scenario D 2000	Scenario D 2025
Latin America	21	9	21	1	8	20	31	40	52
Asia	11	12	27	2	28	13	28	18	29
Moist Africa	14	7	15	13	36	20	29	25	34
Semi-moist Africa	14	1	2	(2)**	10	13	27	35	51
Total Africa *)	28	4	9	6	24	17	28	30	42
Grand total	60	8	18	3	16	18	30	33	45

*) Arid Africa excluded

** This result represent an increasing of total forest area

Table 6. Deforestation scenarios A - D as indexes for 1980 - 2025 by groups of 60 tropical countries.

Group of countries	Number of countries	Base year	Indices for 1980 - 2025 (1980 = 100) Scenario A 2000	Scenario A 2025	Scenario B 2000	Scenario B 2025	Scenario C 2000	Scenario C 2025	Scenario D 2000	Scenario D 2025
		1980								
Latin America	21	100	91	79	99	92	80	69	60	48
Asia	11	100	88	73	98	72	87	72	82	71
Moist Africa	14	100	93	85	87	64	80	71	75	66
Semi-moist Africa	14	100	99	98	(102)	90	87	73	65	49
Total Africa*)	28	100	96	91	94	76	83	72	70	58
Grand total	60	100	92	82	97	84	82	70	67	55

*) Arid Africa excluded

Table 8. Deforested annual total forest areas (1 000 km^2) according to alternative scenarios.

	1980 - 2000				2000 - 2025			
	A	B	C	D	A	B	C	D
Latin America	41	6	89	182	41	23	41	42
Asia	17	3	18	26	17	30	17	12
Moist Africa	10	20	30	37	10	27	12	11
Semi-moist Africa	1	(-2)	18	47	1	12	15	18
Africa	11	18	48	84	11	39	27	29
Total	69	27	155	292	69	92	85	83

deforestation (36 %) for Moist Africa. Scenarios C and D again give different results: Latin America will experience the fastest deforestation (31 and 52 %).

The models of scenarios C and D are based on non-linear functions and are in that respect closer than scenarios A and B to the provisional theory of tropical deforestation (Palo 1984, 1987; Figure 8), applied as a framework for the empirical analyses of this paper. Furthermore, the models of scenario C have the highest statistical significance in the most of country groups (Table 2). The two case studies available with historical time series for the total forest area (1900-1974 for Parana and 1961-1982 for Thailand) both give empirical support to non-linear function forms (Pellico-Netto 1979; Bhumibhamon 1986).

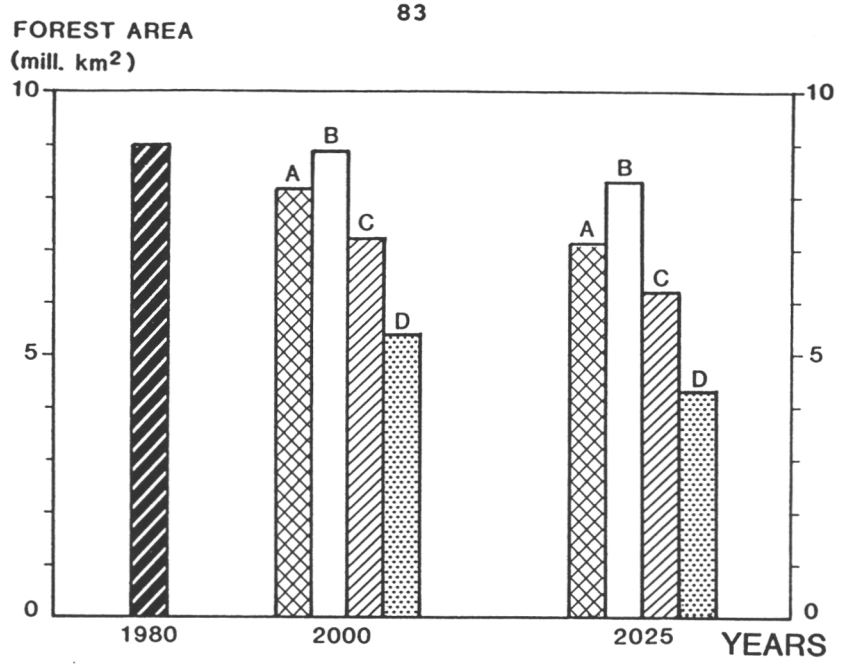


Figure 9 a. Scenarios A - D for the total forest area of 21 Latin American tropical countries in the years 2000 and 2025.

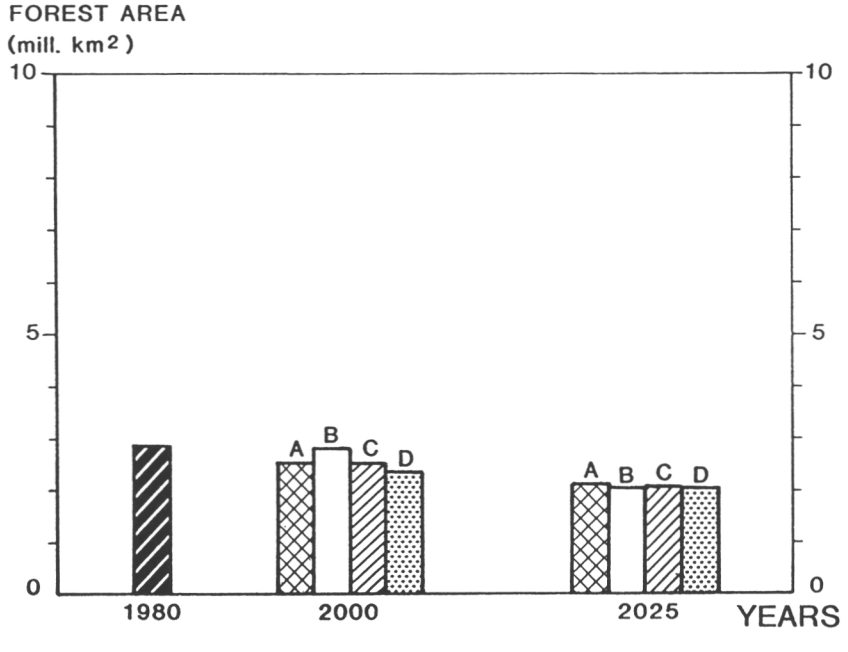


Figure 9 b. Scenarios A - D for the total forest area of 11 Asian tropical countries in the years 2000 and 2025.

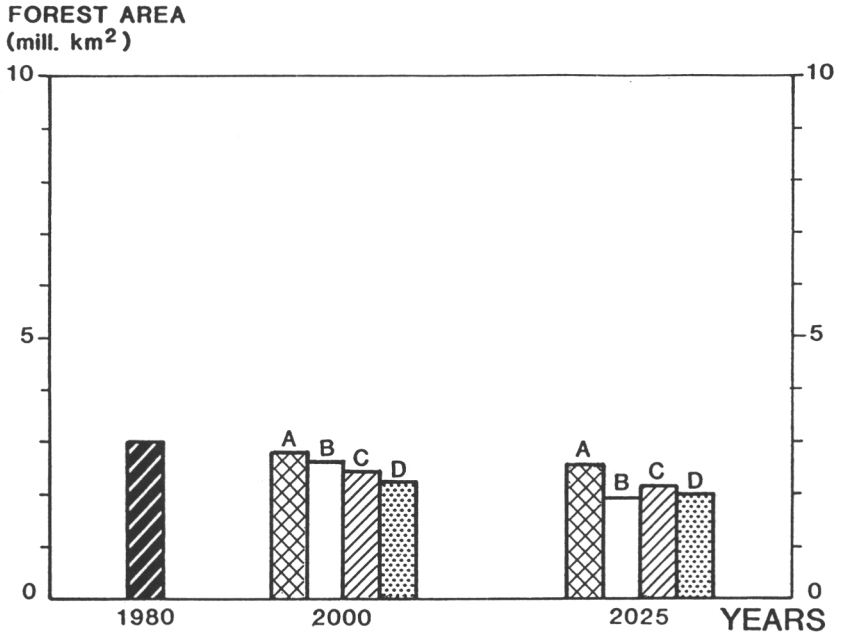


Figure 9 c. Scenarios A - D for the total forest area of 14 moist African tropical countries in the years 2000 and 2025.

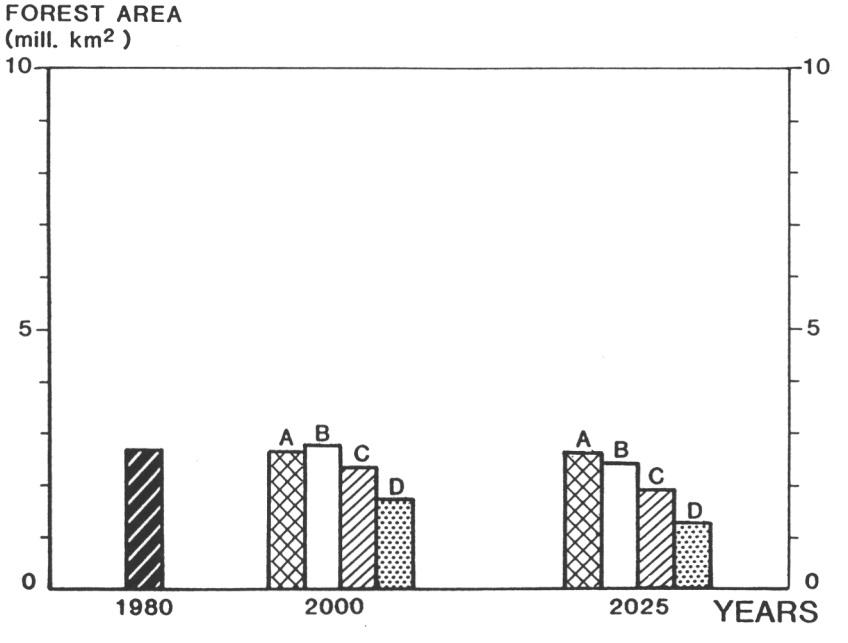


Figure 9 d. Scenarios A - D for the total forest area of 14 semi-moist African tropical countries in the years 2000 and 2025.

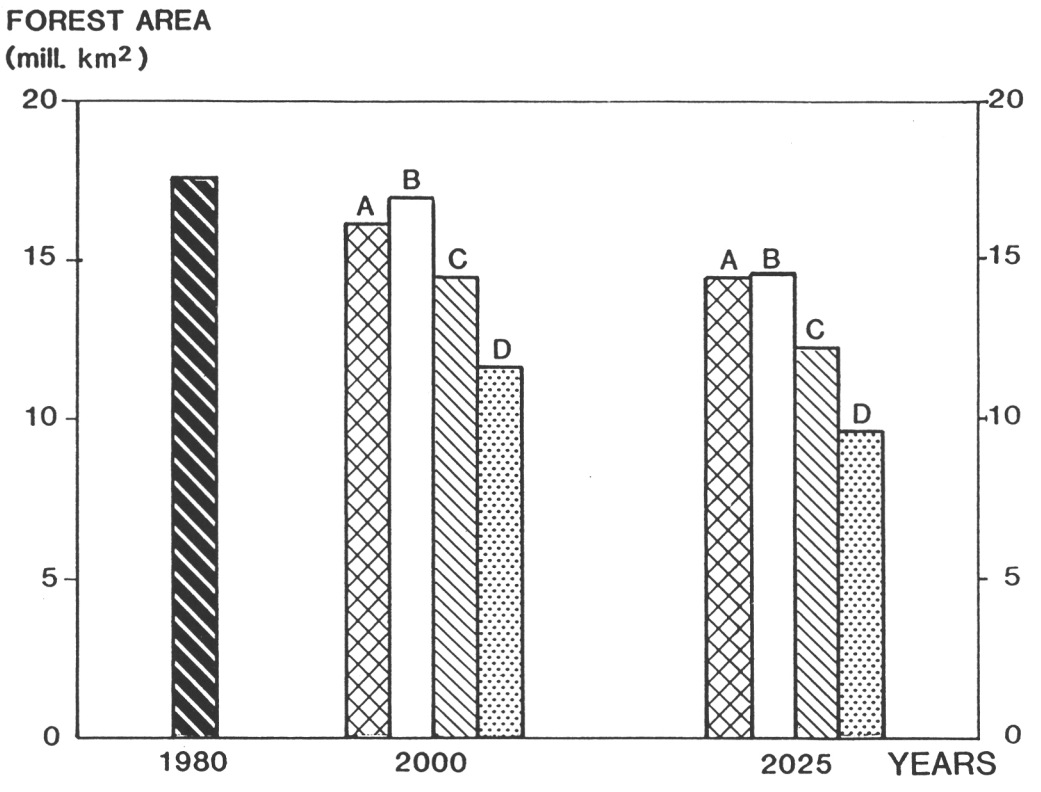


Figure 9 e. Scenarios A - D for the total forest area of 60 tropical countries in the years 2000 and 2025.

4. DISCUSSION

The deforestation scenarios presented in this paper have to be understood as pilot results. The assumed key role of population pressure as an indirect factor in tropical deforestation gained further confirmation in this paper. More analyses will be needed to test the fitness of some other feasible models, as well as of regression equations incorporating more than one independent variable.

No attempt was made in this paper to analyze the role of future artificial or natural forestation in the tropics. Lanly (1982, p. 97) estimated the ratio between the forest plantation area and total deforested area in 1981-1985 as 1:4.5 in tropical Asia, 1:10.5 in tropical America and 1:29 in tropical Africa. The plantations are mainly based on the introduction of exogenous species which are grown as monocultures, and therefore may have unknown ecological risks. It is predicted that the area of forest plantations in the tropics will expand, although mostly in different locations from the main front of natural forest destruction. Consequently, plantations rarely compensate for the losses either in the form of erosion protection or in nature conservation, caused by deforestation of natural tropical forests. The tropical plantations have, however, already been shown to have a remarkable potential for the future timber supply.

Analysis of the potential effects of deforestation on the future supplies of timber and fuelwood was also outside the scope of this paper. Expanding deforestation implies a naturally decreasing supply of these goods, but the ultimate effects on the markets or users depend on the establishment of plantations, import outlets, substitution and on relevant costs and prices. Similarly, no attempt was made to assess either the environmental or the other consequences of expanding tropical deforestation.

Forest coverage (the ratio of forest area to total land area) was used as a negative proxy to indicate deforestation in the

analyses of this paper. The ratio of deforested area to total forest area would have been more valid for this purpose, but the statistical accuracy of the available data appeared to be too low for further applications (Annex 6). Grainger (1984) has come to the same conclusion. The initial forest coverage by countries before the human impact on forest areas has apparently varied according to the natural conditions. In order to partially eliminate this problem the original land area data were corrected as explained above. One aim of grouping the countries was to facilitate elimination of this problem in the absence of data on the initial natural forest coverage.

Population density was originally measured in this paper using the ratio: number of inhabitants to total land area. The validity of this variable is also weakened by the fact that, owing to deserts, mountains etc., a certain proportion of many countries is uninhabitable. Therefore, the population pressure on the habitable parts of these countries is de facto higher than that indicated by the original population density variable. The validity was improved by relevant corrections to the land area variable.

The function form of equations (7) and (8) resembles the lower part of the decreasing logistic function of Figure 8 that asymptomatically approaches the x-axis. This form of deforestation function contains the assumption that the inaccessibility of the remaining forests and/or forestry administration, coupled with favorable socio-economic changes, will later on slow down and even stabilize the deforestation process (Figure 1). However, in a number of tropical countries this may never become true but instead deforestation may follow the true collapse function of Figure 8. Accordingly, even scenarios C and D in this paper may be too conservative.

Lugo et.al. (1981) analyzed the factors affecting deforestation in 31 countries of the Greater Caribbean region, 14 of which were covered in the paper in hand. They applied a simple semilog-linear regression equation with

forest coverage as a dependent and population density as an independent variable. The degree of determination was 62 % and the regression line was found to be decreasing. Their forest area data were mainly obtained from Persson (1974). Their results support the findings of this paper.

"The Global 2000" report (Barney 1980) predicted that the closed forest area in the Least Developed Countries (Tropics) will decrease from 11 mill. km^2 in 1979 to 7 mill. km^2 by 2000, i.e. by 40 % during the whole period. Barney et al. (1980) also based their scenarios on the predictions of population growth, but with no explicit specification of the exact method. Scenarios C and D in this paper produced reductions of 13-40 % in the Latin America, Asia and Moist Africa groups. However, owing to the nature of the approach used in this paper, the scenarios did not specify results by closed forests but by total forest area (closed + open). In these groups the closed forests were dominating.

Sedjo & Clawson (1983) strongly criticized the predictions of "The Global 2000" report. Their criticism was based primarily on the belief that the FAO/UNEP (1981) assessment of tropical deforestation produced reliable data about the pace of deforestation. However, Palo (1984) demonstrated that the quality of the data on deforested areas in particular was not adequate for scenario purposes. Sedjo & Clawson also disagreed with the accelerating nature of deforestation.

"A distinction is made between the different types of agricultural land use which replace forest cover and the underlying socio-economic mechanisms of deforestation, the most important of which was shown by international cross-sectional regression analysis to be population growth." This conclusion by Grainger (1986) on tropical rain forests is in full agreement with our findings. Grainger produced deforestation scenarios for the "humid tropics" (43 countries) during 1980-2020 as follows: high -20 % and low -10 %. These results only matched the lower estimates of our scenarios of a 8-52 % reduction during 1980-2025 in the group

of 46 countries having the closest coverage with "the humid tropics" (cf. above).

Our scenarios can be compared with the two available case studies incorporating historical time series on deforestation. The total natural forest area in Thailand decreased by 43 % during 1961-1982 (Bhumibhamon 1986). The total natural closed forests in Parana state (Brazil) decreased by 67 % during 1954-1974 and by 76 % during 1934-1974 (Pellico-Netto 1979). The two cases apparently represent rather heavy deforestation in a comparative perspective. Our highest deforestation scenarios were -40 % (20 years) and -52 % (40 years) for Latin America.

The pilot scenarios of this paper are based on simple regression models and on a theoretical framework. The methods have been described in detail so that the exercises can be replicated or modified. The approach can be criticized as being too simplistic, but it should be borne in mind that the paucity of data established rigorous constraints. It is also worth while remembering that rather simple models of GNP per capita as the independent variable were applied in the early years of the study of international demand for forest products.

One can ask whether cross-sectional countrywise data can be applied at all in scenario analyses. One aspect is that relevant time-series are lacking. Another pertinent aspect is that the economic and social development of 60 tropical countries in 1980 differ from each other remarkably. This type of cross-sectional data may, in fact, expose long-range trends in comparison to the normal time spans (10-20 years) used in econometric analysis . Rather recent examples where cross-sectional data only was applied for prediction do exist (e.g. FAO 1978). Furthermore, cross-sectional international regression analysis of 43 countries was recently executed in order to explain the causal mechanisms of tropical deforestation (Grainger 1986). A combined approach involving cross-sectional and time-series analyses (panel analysis) has recently become popular (e.g. Alig 1986; Gemert 1986).

Further investigations in the field covered by this paper are urgently required. The empirical data could be reorganized in such a way that the analyses focus separately on deforestation in closed and open forests owing to the diverging procèsses in each cases. The applicability of more integrated explanative models and logistic functions for scenario purposes could be further elaborated. More operational variables according to the framework of Figure 1 could be created. Case studies of individual countries might reveal new relevant aspects. Last, but not least, it should also be realized that the population predictions applied here are uncertain and will be revised now and then by the United Nations and by other relevant bodies.

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Annex 1. List of variables of the empirical analyses.

1. Natural forest coverage (%)
2. Closed forest coverage (%)
3. Open forest coverage (%)
4. Share of forest fallow (%)
5. Share of forest plantations (%)
6. Share of mean annual deforestation (%)
7. Corrected forest coverage (%)
8. Agricultural area coverage (%)
9. Index number of livestock production 1980
10. Index number of crop production 1980
11. Index number of agricultural production 1980
12. Total meat production by open forest area (kg/ha)
13. Cattle by open forest area (heads/ha)
14. Sheep and goats by open forest area (heads/ha)
15. Cattle by grazing land (heads/ha)
16. Sheep and goats by grazing land (heads/ha)
17. Production of industrial roundwood by forest area (m^3/ha)
18. Production of industrial roundwood by closed forest area (m^3/ha)
19. Production of fuelwood and charcoal by forest area (m^3/ha)
20. Production of fuelwood and charcoal by open forest area (m^3/ha)
21. Forest exports per forest area (USD/ha)
22. Forest exports per capita (USD/inh.)
23. Forest imports per capita (USD/inh.)
24. Share of industrial roundwood production 1984/Industrial roundwood production 1964 (%)
25. Rural population density 1980 (inh./km^2)
26. Total population density 1980 (inh./km^2)
27. Annual growth rate of total population 1980-85 (%)
28. Average annual rate of inflation 1970-80 (%)
29. Average index of food production per capita
30. Consumption of calories/capita/day (all foods) (cal.)
31. Energy consumption per capita 1980 (Kcal/inh.)
32. GNP per capita 1980 (USD 1980)
33. GDP per land area 1980 (USD 1980/km^2)

The sources of the data are the following:

Variables 1 - 6:

FAO & UNEP 1981. Tropical Forest Resources Assessment Project. Forest Resources of tropical Africa, Asia and Latin America. (Data:1980).

FAO 1984. FAO Production Yearbook 1983. Vol. 37. (Data:1980).

Variable 7: The same as variables 1 - 6 and:

World Atlas of Agriculture (Data:1950-1965).

Variables 8 - 16:

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Variables 17 - 20:

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Variables 21 - 24:

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Variables 25 - 27:

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Variables 28 - 33:

WORLD BANK 1981. World Development Report 1981. & WORLD BANK 1982. World Development Report 1982. (Data:1980, GDP was calculated as a two year (1979 and 1980) average).

Annex 2. List of 68 tropical countries and their abbreviations by country groups, as applied in this paper (ISO 3166).

A. 21 Latin American countries

BLZ	Belize
BOL	Bolivia
BRA	Brazil
COL	Colombia
CRI	Costa Rica
DOM	Dominican Republic
ECU	Ecuador
GTM	Guatemala
GUF	French Guiana
GUY	Guyana
HND	Honduras
HTI	Haiti
JAM	Jamaica
MEX	Mexico
NIC	Nicaragua
PAN	Panama
PER	Peru
PRY	Paraguay
SLV	El Salvador
SUR	Suriname
VEN	Venezuela

C. 14 Moist African countries

BEN	Benin
CIV	Ivory Coast
CMR	Cameroon, United Republic of
COG	Gongo
GAB	Gabon
GHA	Ghana
GIN	Guinea
GNB	Guinea-Bissau
GNQ	Equatorial Guinea
LBR	Liberia
NGA	Nigeria
SLE	Sierra Leone
TGO	Togo
ZAR	Zaire

B. 11. Asian countries

BRN	Brunei
BUR	Burma
IDN	Indonesia
IND	India
KHM	Kampuchea, Democratic
LAO	Lao People's Democratic Republic
LKA	Sri Lanka
MYS	Malaysia
PHL	Philippines
THA	Thailand
VNM	Viet Nam

D. 14 Semi-moist African countries

AGO	Angola
BDI	Burundi
BWA	Botswana
CAF	Central African Republic
ETH	Ethiopia
GMB	Gambia
HVO	Burkina Faso (formerly Upper Volta)
MWI	Malawi
RWA	Rwanda
SEN	Senegal
TZA	Tanzania, United Republic of
UGA	Uganda
ZMB	Zambia
ZWE	Zimbabwe

E. 8 Arid African countries

KEN	Kenya
MLI	Mali
MRT	Mauritania
NAM	Namibia
NER	Niger
SDN	Sudan
SOM	Somalia
TCD	Chad

Annex 3. List of regression models which were empirically estimated, tested and rejected on the basis of statistical insignificance.

(1) $FC = a + bFF$

(2) $FC = a + b_1PD + b_2FF$

(3) $FC = a + bGD$

(4) $FC = a + b_1PD + b_2GD$

(5) $FC = a + bGN$

(6) $FC = a + b_1GN + b_2GD$

(7) $FC = a + b_1GD + b_2FF$

(8) $FC = a + b_1PD + b_2IW$

(9) $FC = a + b_1PD + b_2FF + b_3IW$

(10) $FC = a + b_1PC + b_2AG$

(11) $FC = a + b_1PG + b_2LP$

(12) $FC = a + b_1EX$

where,
a,b = regression coefficients
FC = Forest coverage
PD = Population density
PG = Population growth
FF = Share of forest fallow
LP = Livestock production index
AG = Agricultural area coverage
IW = Relative industrial roundwood production
EX = Forest product exports per forest area
GN = GNP per capita
GD = GDP per land area

Annex 4. Special characterictics of five outlier countries

The original data was modified according to the criteria outlined in Section 2. The outliers were eliminated from the original data in order to obtain more homogeneous groups. This is an important condition for scenario-making applications. Accordingly, the total number of countries was reduced from 72 to 68. Trinidad and Tobago was first omitted from the data. Furthermore, a residual analysis was applied in every group of countries in order to identify the respective outliers. The following countries were subsequently eliminated: Papua New Guinea, Madagascar, Mozambique and Cuba.

Trinidad and Tobago

Trinidad and Tobago has a total area of 5 128 km^2 and the population amounted to 1.2 million inhabitants by 1980. These islands, located in the southernmost part of the Caribbean Sea, have a tropical climate with a high degree of humidity. Their relief demonstrates that their physiographic characteristics are an extension of the dominant one existing in the adjacent South American territories. The vegetation of the islands can be characterized as a luxuriant one and 41 % (2 080 km^2) of the country's total area was covered by closed forests in 1980 (FAO & UNEP 1981a).

The country has some peculiarities which clearly segregate it from the rest of the Latin American countries. These peculiar characteristics are well represented by some of its population and economic indicators in 1980. The population density at that time was 228 inhabitants by km^2, the annual population growth rate was 1.4 % and 78 % of the inhabitants lived in rural areas. These facts contrast with the Latin American standards: 11 inh./km^2, 2.4 % and 35 %, respectively (United Nations 1982). However, only 16 % the total labour force was employed in agriculture. On the other hand, the economic development of the islands, which has been based on

the petroleum industry (petroleum production and refining operations accounted for 50 % of GDP and 90 % of export incomes in 1980), has reached a clearly different position compared with the Latin American average indicators. The GNP per capita of Trinidad and Tobago amounted, in 1983, to 6850 (USD per capita, per year) and the annual growth rate of GNP has been rather moderate: 3.4 % on average from 1965-1983. The Latin American averages were 1867 USD/capita and 3.0 %, respectively (World Bank 1985).

The characteristics above summarize the most particular features of this republic and enabled us to state that Trinidad and Tobago clearly constitutes an outlier among the Latin American countries for the purpose of scenario-making. The deforestation pressure is relatively low.

Papua New Guinea (PNG)

This country was preliminary included in the Asian group. However, a more detailed inspection of its socio-economical and natural characteristics reveals clear differences with the other countries which constitute the Asian group. The mountainous and insular nature of Papua New Guinea obviously have a strong effect on the floristic composition of its forest resources, which are indeed quite diverse from those prevailing in the Asian countries. Unlike these latter countries, the population density of Papua New Guinea is low (6.6 inhabitants/km^2, on average). Another differentiating factor is its high forest coverage: 83 % (382 000 km^2) of the total land area of the country is covered by forests, an important part of which still remain untouched (FAO & UNEP 1981c). In addition, its socio-economical development has followed a very peculiar path. Due to the low population density the present rate of deforestation is assessed to be only 0.06 % (deforested area/total forest area).

Madagascar (MDG)

The deforestation process in this African island has already affected extensive areas. The population of the country, which reached 9.3 million inhabitants in 1980, is unevenly distributed. It is mainly concentrated in the central part of the country and also in the eastern costal region, were population density exceeds 100 inhabitants/km^2. In contrast, the population density of the western and southern parts reached only about 2 inhabitants/ km^2. The rural population represents 85 % of the total population. In spite of this concentration of the island's population in some regions, depletion of the forests is a rather scattered phenomenon.

The major part of the forests of Madagascar have been either converted into other uses - mainly for permanent agricultural cultivations or grazing - or affected by fire and shifting cultivation. Accordingly, primary forests have almost disappeared from the country's territory (FAO & UNEP 1981b, p. 282) and have been replaced by the "savoka" vegetal association in which bushes and bamboos prevail. Due to repeated fires this "savoka" is often subsequently degraded and converted into a savanna type ecosystem. As a result of this devastation process, the territory of Madagascar, which several decades ago was abundant in forest resources, has been rapidly denuded and in 1980 only 22 % (132 000 km^2) of its land area was covered by closed and open forests.

Mozambique (MOZ)

This African country seems to have too little forest in relation to its population. Mozambique has a total land area of 78.3 million ha. The prevailing land characteristic is a low-lying plateau of moderate height descending through a subplateau zone towards the Indian Ocean. Terrain with an altitude of less than 200 m makes up about 44 % of the total land of the country. The elongated form of Mozambique, which stretches over 2500 km along the Indian Ocean, imposes a high variability of climates and natural forest resources.

Mozambique has a subtropical climate in the south and a tropical one in the centre and in the north. About 80 % of the total land area is estimated to have forestry capability (Palo 1978). However, in 1980 only 20 % (154 000 km^2) was covered by closed and open forests (FAO & UNEP 1981b).

The population, which totalled 10.5 million inhabitants in 1980, is unevenly distributed: it is concentrated in the coastal region. The provinces of the interior are less densely populated. Nevertheless, the population density of the country as a whole is relatively low. Despite such a low average population density, the forest resources of the country have been severely affected by human intervention and only a few of the most remote areas have not been subject to some degree of depletion and degradation (FAO & UNEP 1981b, p. 329).

The main causes of deforestation and degradation of the forest are due to encroachment by agriculture, fire and overexploitation. It is said that one fifth to one quarter of the closed forests and woodlands of the country area was affected by human intervention during the 1970's (FAO & UNEP 1981b, p. 336). This estimate reveals the magnitude of accelerated forest depletion that is going on in Mozambique. This fact illustrates the extreme position reached by this country with respect to the advance of deforestation. The continuous internal wars which have raged since independence in 1975, as well as external aggression suffered by the country, have worsened the situation.

Cuba (CUB)

Cuba was eliminated from the Latin American group. The deforestation process had followed an exceptional pattern compared with the rest of the subcontinent. Deforestation started in Cuba earlier than in the other Latin American countries. It has been estimated that, at the beginning of the 19th century, 87 % of the Cuban total land area was still covered by forests. However, rapid deforestation

started at the end of the century and continued during the first decades of the present century. The following figures are illustrative: the total forest area existing in 1812 was reduced by 40 % up to 1900, and by 87 % up to 1946. In 1980 closed forests covered 13 % (14 550 km^2) of Cuba's total area (FAO & UNEP 1981a). The main factor influencing such a massive deforestation was the external demand for agricultural products. Cuba's geographical location favored the production and export of sugar cane, tobacco, bananas, etc. The export of highly valued timber (such as Swietenia spp., Cedrela spp. and Pinus spp.) also play some role in the rapid loss of the Cuban forests. Although the actual situation as regards Cuban forests is miserable the prospects are more promising. While there is not very much forest left to be cut down and forest plantation activities are rapidly increasing, the deforestation processes have apparantly reached a turning point in Cuba.

Annex 5. Estimated deforestation equation with 11 independent variables (see p. 14).

Dependent variable: Forest coverage in the year t(FC_t)

Independent variables	Deforestation equation (t-values)
constant	92.62 (11.79)
FF_t, share of forest fallow	-0.10 (-4.07)
LP_t, livestock production index	0.09 (1.84)
FW_t, relative fuelwood production	-0.04 (-0.36)
AG_t, agricultural area coverage	-0.53 (-6.87)
FP_t, food production per capita	-0.14 (-2.93)
IW_t, relat. indust. roundwood production	-1.61 (-0.47)
EX_t, forest products exports per forest area	0.10 (1.10)
GN_t, GNP per capita	-0.01 (-1.66)
GD_t, GDP per land area	1.16 (0.34)
PD_t, population density	-0.12 (-4.36)
PG_t, population growth	-0.63 (-0.26)
Adjusted R^2	0.85
F	30.76
Number of observations	60
Critical t-values at 1 % 2.66 and at 0.1 %	3.46

Annex 6. 72 tropical countries in the order of some key empirical variables, data from the year 1980, (Abr. see Annex 2).

			Total natural forest area (1 000 ha)			Forest plantation (1 000 ha)	The share of forest plantations of corrected land area
1.	BDI	o	28	1.	MAU	0	0.0
2.	HTI		48	2.	GNQ	0	0.0
3.	JAM		67	3.	HND	0	0.0
4.	SLV		141	4.	BWA	0	0.0
5.	RWA	o	211	5.	BRN	0	0.0
6.	GMB	o	215	6.	NAM	0	0.0
7.	BRN	o	323	7.	GNB	0	0.0
8.	DOM		629	8.	GUF	0	0.0
9.	GNQ		1295	9.	CAF	0	0.0
10.	BLZ		1446	10.	HTI	1	0.1
11.	CUB		1455	11.	GUY	1	0.0
12.	LKA		1659	12.	GMB	1	0.3
13.	TGO	o	1684	13.	NIC	1	0.0
14.	CRI		1798	14.	SLV	1	0.1
15.	LBR		2040	15.	MLI	1	0.0
16.	SLE	o	2055	16.	CRI	2	0.1
17.	GNB	o	2105	17.	GIN	2	0.0
18.	KEN	o	2195	18.	PRY	3	0.0
19.	NER	o	2900	19.	BLZ	3	0.2
20.	BEN	o	3867	20.	TCD	3	0.0
21.	HND		3997	21.	PAN	4	0.1
22.	PAN		4165	22.	DOM	5	0.1
23.	MWI	o	4271	23.	SLE	5	0.1
24.	NIC		4496	24.	NER	6	0.0
25.	GTM		4542	25.	LBR	6	0.2
26.	UGA	o	6000	26.	KHM	6	0.0
27.	HVO	o	7200	27.	SUR	8	0.1
28.	GHA	o	8693	28.	LAO	11	0.1
29.	MLI	o	8800	29.	SOM	11	0.1
30.	VNM		8910	30.	TGO	11	0.3
31.	GUF		8970	31.	HVO	12	0.1
32.	SOM	o	9050	32.	SEN	12	0.1
33.	PHL		9510	33.	JAM	12	1.9
34.	CIV	o	9834	34.	GTM	15	0.2
35.	GIN	o	10650	35.	BUR	16	0.0
36.	SEN	o	11045	36.	COG	16	0.1
37.	KHM		12268	37.	CMR	18	0.0
38.	LAO		13025	38.	GAB	19	0.1
39.	MDG		13200	39.	BEN	19	0.1
40.	TCD	o	13500	40.	BDI	19	0.9
41.	NGA	o	14750	41.	PNG	21	0.1
42.	THA		14775	42.	ZAR	22	0.0
43.	ECU		14800	43.	MOZ	25	0.0
44.	MAU	o	15134	44.	BOL	25	0.0
45.	MOZ	o	15435	45.	MYS	26	0.0
46.	SUR		15520	46.	RWA	29	1.7
47.	NAM	o	18420	47.	ZMB	38	0.1
48.	GUY		18500	48.	ECU	43	0.2
49.	ZWE	o	19900	49.	CIV	44	0.3
50.	GAB		20575	50.	UGA	45	0.3
51.	MYS		20995	51.	GHA	75	0.5
52.	COG		21340	52.	MWI	80	0.9
53.	CMR		25620	53.	PER	84	0.1
54.	ETH	o	26350	54.	COL	95	0.1
55.	ZMB	o	29510	55.	TZA	97	0.1
56.	BUR		31309	56.	ETH	98	0.1
57.	BWA	o	32560	57.	ZWE	100	0.3
58.	PRY	o	32710	58.	LKA	112	2.0
59.	VEN		35170	59.	THA	114	0.3
60.	CAF	o	36890	60.	VEN	124	0.2
61.	PNG		38175	61.	CUB	157	1.5
62.	TZA	o	42040	62.	AGO	157	0.2
63.	SDN	o	47650	63.	MEX	159	0.1
64.	MEX		48350	64.	NGA	163	0.2
65.	COL		52100	65.	KEN	180	2.1
66.	AGO	o	53600	66.	SDN	187	0.2
67.	IND		55794	67.	VNM	204	0.8
68.	BOL		68710	68.	MDG	266	0.5
69.	PER		70800	69.	PHL	300	1.2
70.	IDN		116895	70.	IDN	1918	1.0
71.	ZAR		177490	71.	IND	2068	0.8
72.	BRA		514480	72.	BRA	3855	0.6

o = Open forests dominated

	Corrected forest coverage (%)		Forest coverage (%) (FAO & UNEP 1981)
1.	BDI	1	1
2.	HTI	2	2
3.	SLV	10	7
4.	JAM	10	6
5.	RWA	12	8
6.	CUB	14	13
7.	DOM	16	13
8.	NER	18	2
9.	TCD	20	11
10.	MLI	22	7
11.	NGA	22	16
12.	IND	22	19
13.	SOM	23	14
14.	MOZ	25	20
15.	KEN	26	4
16.	MDG	26	23
17.	MAU	28	15
18.	NAM	29	22
19.	LKA	29	26
20.	ETH	31	24
21.	MEX	33	25
22.	SLE	33	28
23.	VNM	35	27
24.	UGA	36	30
25.	HVO	36	26
26.	PHL	38	32
27.	CRI	40	35
28.	SDN	40	20
29.	THA	41	29
30.	VEN	46	40
31.	ZMB	49	40
32.	NIC	49	35
33.	MWI	49	45
34.	GMB	51	23
35.	TGO	51	31
36.	TZA	51	47
37.	LBR	54	24
38.	HND	55	36
39.	COL	57	55
40.	PAN	58	55
41.	GHA	58	38
42.	CIV	59	31
43.	GTM	61	42
44.	AGO	62	43
45.	BEN	63	35
46.	IDN	63	61
47.	CMR	63	55
48.	GNQ	64	46
49.	ZWE	64	51
50.	BUR	66	48
51.	BOL	67	63
52.	COG	67	63
53.	SEN	68	58
54.	MYS	68	64
55.	GIN	70	43
56.	BWA	73	58
57.	BRN	75	61
58.	BRA	76	61
59.	KHM	77	69
60.	ECU	77	56
61.	PER	79	55
62.	BLZ	80	63
63.	GNB	80	75
64.	CAF	80	58
65.	GAB	82	80
66.	PRY	83	82
67.	LAO	83	56
68.	ZAR	92	78
69.	GUY	96	94
70.	PNG	96	85
71.	SUR	99	96
72.	GUF	100	99

	Annual deforestation (1 000 ha)	
1.	MAU	0
2.	ZWE	0
3.	NER	0
4.	TCD	0
5.	NAM	0
6.	HVO	0
7.	MLI	0
8.	SEN	0
9.	MWI	0
10.	BWA	0
11.	GMB	1
12.	GUF	1
13.	BDI	1
14.	BEN	2
15.	HTI	2
16.	TGO	2
17.	CUB	2
18.	JAM	2
19.	RWA	3
20.	GUY	3
21.	GNQ	3
22.	SUR	3
23.	DOM	3
24.	SOM	1
25.	CAF	5
26.	SLV	5
27.	SDN	5
28.	SLE	6
29.	BRN	7
30.	BLZ	9
31.	MOZ	10
32.	TZA	10
33.	UGA	10
34.	ETH	10
35.	GAB	15
36.	GNB	15
37.	KHM	15
38.	KEN	19
39.	PNG	21
40.	COG	22
41.	LKA	25
42.	GHA	27
43.	PAN	31
44.	GIN	36
45.	AGO	40
46.	ZMB	40
47.	LBR	41
48.	CRI	60
49.	VNM	65
50.	BOL	65
51.	CMR	80
52.	GTM	80
53.	HND	95
54.	BUR	96
55.	PHL	101
56.	NIC	111
57.	VEN	125
58.	LAO	125
59.	IND	147
60.	PRY	160
61.	MDG	165
62.	ZAR	167
63.	MYS	230
64.	PER	253
65.	NGA	285
66.	ECU	300
67.	CIV	310
68.	THA	333
69.	MEX	530
70.	IDN	550
71.	COL	800
72.	BRA	1480

	Annual deforestation per total forest area (%)	
1.	MAU	0.00
2.	MWI	0.00
3.	SEN	0.00
4.	HVO	0.00
5.	MLI	0.00
6.	ZWE	0.00
7.	NER	0.00
8.	NAM	0.00
9.	TCD	0.00
10.	BWA	0.00
11.	SDN	0.00
12.	SOM	0.01
13.	GUF	0.01
14.	CAF	0.01
15.	TZA	0.01
16.	ETH	0.01
17.	GUY	0.02
18.	MOZ	0.02
19.	SUR	0.02
20.	CUB	0.02
21.	BEN	0.03
22.	BDI	0.04
23.	AGO	0.05
24.	PNG	0.05
25.	IND	0.06
26.	TGO	0.06
27.	GAB	0.06
28.	UGA	0.06
29.	BOL	0.06
30.	ZMB	0.07
31.	COG	0.07
32.	DOM	0.08
33.	ZAR	0.09
34.	KHM	0.09
35.	SLE	0.10
36.	HTI	0.10
37.	GNQ	0.15
38.	VEN	0.16
39.	RWA	0.18
40.	GHA	0.18
41.	CMR	0.20
42.	BUR	0.20
43.	BRA	0.22
44.	KEN	0.22
45.	GMB	0.24
46.	GIN	0.24
47.	VNM	0.25
48.	PER	0.28
49.	JAM	0.29
50.	IDN	0.29
51.	MDG	0.33
52.	SLV	0.34
53.	MEX	0.36
54.	PHL	0.40
55.	PRY	0.40
56.	PAN	0.43
57.	NGA	0.43
58.	LKA	0.44
59.	BLZ	0.45
60.	GNB	0.57
61.	MYS	0.75
62.	LAO	0.80
63.	COL	0.87
64.	THA	0.91
65.	GTM	1.07
66.	LBR	1.08
67.	NIC	1.22
68.	HND	1.30
69.	CRI	1.33
70.	ECU	1.57
71.	BRN	1.63
72.	CIV	1.85

Total population density (inh./km^2) (land area corrected)

1.	GUF	0.7
2.	NAM	1.6
3.	BWA	1.8
4.	GAB	2.2
5.	SUR	2.5
6.	MAU	3.0
7.	GUY	4.6
8.	COG	4.8
9.	CAF	5.1
10.	BOL	5.4
11.	TCD	6.5
12.	PNG	7.9
13.	PRY	8.0
14.	AGO	8.2
15.	BLZ	8.9
16.	ZMB	9.5
17.	SOM	12.0
18.	ZAR	14.6
19.	SDN	15.6
20.	MOZ	17.1
21.	MDG	17.2
22.	MLI	17.5
23.	GNQ	17.8
24.	BRA	18.0
25.	PER	19.6
26.	VEN	20.3
27.	CMR	20.7
28.	GNB	21.7
29.	TZA	21.8
30.	ZWE	23.7
31.	LAO	23.8
32.	PAN	26.4
33.	COL	28.0
34.	NIC	30.0
35.	GIN	32.9
36.	NER	33.0
37.	SEN	34.9
38.	HVO	35.0
39.	ZMB	36.6
40.	ECU	41.9
41.	KHM	42.4
42.	MYS	45.8
43.	MEX	47.6
44.	CIV	47.9
45.	CRI	49.1
46.	HND	50.4
47.	LBR	52.0
48.	BRN	53.0
49.	SLE	56.4
50.	BEN	56.9
51.	MWI	71.2
52.	BUR	74.3
53.	GHA	77.9
54.	TGD	79.1
55.	IDN	79.2
56.	UGA	80.0
57.	CUB	94.2
58.	GTM	97.5
59.	NGA	116.5
60.	THA	129.2
61.	GMB	141.9
62.	DOM	150.0
63.	BDI	185.0
64.	KEN	192.2
65.	PHL	196.1
66.	VNM	208.8
67.	LKA	262.5
68.	IND	274.4
69.	RWA	279.7
70.	HTI	316.2
71.	JAM	316.2
72.	SLV	324.3

GNP per capita (USD)

	SOM	-
	GNQ	-
	GAB	-
	SUR	-
	BWA	-
	KHM	-
	BRN	-
	CUB	-
	NAM	-
	GMB	-
	VNM	-
	GUY	-
	GUF	-
	GNB	-
	BLZ	-
	LAO	-
1.	TCD	120
2.	ETH	140
3.	BUR	170
4.	MLI	190
5.	BDI	200
6.	RWA	200
7.	HVO	210
8.	ZAR	220
9.	MOZ	230
10.	MWI	230
11.	IND	240
12.	LKA	270
13.	HTI	270
14.	TZA	280
15.	SLE	280
16.	GIN	290
17.	GAF	300
18.	UGA	300
19.	BEN	310
20.	NER	330
21.	MDG	350
22.	TGO	410
23.	SDN	410
24.	KEN	420
25.	GHA	420
26.	IDN	430
27.	MAU	440
28.	SEN	450
29.	AGO	470
30.	LBR	530
31.	HND	560
32.	ZMB	560
33.	BOL	570
34.	ZWE	630
35.	SLV	660
36.	THA	670
37.	CMR	670
38.	PHL	690
39.	NIC	740
40.	PNG	780
41.	COG	900
42.	PER	930
43.	NGA	1010
44.	JAM	1040
45.	GTM	1080
46.	CIV	1150
47.	DOM	1160
48.	COL	1180
49.	ECU	1270
50.	PRY	1300
51.	MYS	1620
52.	PAN	1730
53.	CRI	1730
54.	BRA	2050
55.	MEX	2090
56.	VEN	3630

- = Data not available

Deforestation Perspectives for the Tropics: A Provisional Theory with Pilot Applications*

Matti Palo

Major changes in forest areas in the past have been caused by changes in climate, by human actions, and by combinations of the two. The sensitivity of the value of forest goods and services to changes in forests varies a great deal according to the scale, the intensity, and the type of these changes, which may be anything from a slight selective logging of undisturbed natural forests to a total clearance of trees and a subsequent transformation of the previous forest site into nonforest uses. In the debate so far, such changes have been termed deforestation or conversion, depletion, destruction, etc.

In English-language usages in various parts of the world, the word *forest* may be a synonym for a number of other expressions, such as bush, woodland, wood, woods, brushwood, thicket, scrub forest, shrub, etc. Even the term forest as used in forestry applications has no universally adopted single definition. The terminology published by the Society of American Foresters, which is also authorized by the Joint FAO/IUFRO Committee on Forestry Bibliography and Terminology (Ford-Robertson, 1971), gives, e.g., the following four definitions for the word forest:

(1) "Generally, an ecosystem characterized by more or less dense and extensive tree cover" (ecology).
(2) "More particularly, a plant community predominantly of trees and other woody vegetation, growing more or less closely together" (ecology).

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* Reprint from Dykstra, D. & Kallio, M. & Binkley, C. (Eds.) 1987. The global forest sector: An analytical perspective. Chapter 3, p. 57 - 89. IIASA & John Wiley. London.

(3) "An area managed for the production of timber and other forest produce, or maintained under woody vegetation for such indirect benefits as protection of catchment areas or recreation" (silviculture/management).
(4) "An area of land proclaimed to be forest under a Forest Act or Ordinance" (law/British Commonwealth).

If an analyst was to select one of these forest definitions and begin to plan the collection of information from a total area in a country that matches this definition, he or she would run into difficulties due to the lack of operational dimensions of these definitions.

Forests are often viewed as forest systems that fit different statistical planning situations. Basically, they comprise varying kinds of complex ecosystems. In different planning situations, different sets of components and relationships of a forest system are considered as relevant for observation.

The trees are the dominating component in a forest ecosystem. The appearance of trees varies from dense high forests to scrub and open lands according to increasing aridity, elevation, and latitude, but also to increasing humidity (bogs, peatlands). The system boundaries have to be demarcated still more precisely in this respect. Such indicators as the height of trees, their density, and minimum area are applied (e.g., Loetsch and Haller, 1964; Loetsch *et al.*, 1973; Persson, 1974, 1977b; Lanly, 1982). The average height of the trees in a forest during the climax (mature) stage is defined to be at least 5–8 m.

Forests are classified, according to the predominant tree species, as coniferous (gymnospermae in botanics, yielding softwood timber) or broadleaved (nonconiferous, angiospermae in botanics, yielding hardwood timber). Particularly in the case of broadleaved forests a further division into closed forests and open woodlands is applied.

Open woodland is sometimes defined to have a tree density, measured in tree crown coverage of land surface, in the range of 5–20% (e.g., Persson, 1974). According to another definition, open woodlands are mixed, broadleaved tree and gramineous formations with a continuous dense grass layer in which the tree synusia cover more than 10% of the land surface (e.g., Lanly, 1982; FAO and UNEP, 1981a–c). Forests are sometimes defined as closed when the crown coverage of trees exceeds 20% (e.g., Persson, 1974). Closed, broadleaved forests are also defined to cover, with various tree crown storeys and undergrowth, a high proportion of the ground and not to have a continuous dense grass layer that allows grazing and the spreading of fires (e.g., Lanly, 1982; FAO and UNEP, 1981a–c).

The minimum area limit for a forest is defined as approximately 5–10 hectares. This limit is needed to separate "real" large forests from islands of woodlands or scattered groups of trees. This is a technical criterion partly due to observation problems and partly to the fact that smaller patches of forests do not easily fit any commercial forestry. However, for community forestry or for ecological purposes even the small areas of forests can be identified as forests in so far as the other criteria discussed are fulfilled.

This aspect of forest dynamics also implies an important time element in the forest concept: a cut area, even bare land, is classified as forest insofar as it is likely that natural reforestation and succession toward the natural dynamic equilibrium state of forest will take place.

The classification of forests in the tropical zone is more difficult than elsewhere due to the high complexity and variety of tropical forests. A great number of classification systems are adopted by various national and international authorities (e.g., Lanly, 1982, pp 8–18). The situation makes consistent and precise assessments of tropical forest areas difficult. In a recent assessment by FAO and UNEP (1981a–c) a UNESCO classification system (*Figure 3.1*) was adopted in order to fit together forest area data from the various national and other classifications.

Deforestation, as referred to in this chapter, transforms a previous forest area out of the adopted forest classification (*Figure 3.1*) when the area no longer fulfills the listed criteria for a forest ecosystem. Accordingly, deforestation is used in this chapter in the strict sense of a complete clearance of forests and their replacement by other use of the land (Lanly, 1982, p 74). Deforestation of tropical forests often has an irreversible nature (e.g., Eyre, 1975; UNESCO *et al.*, 1978). Various degrees of *forest degradation*, however, often occur as a consequence of selective logging and other human actions or of natural factors (e.g., storms, lightning). A degraded forest area is assumed to recover from the disturbance within a reasonable period, but under a continuous stress degradation may ultimately cause deforestation.

Some deforestation seems unavoidable in view of the fast-growing human population, with its food, energy, shelter, and space requirements, while some deforestation remains avoidable provided that its locations, paces, and mechanisms are known and that adequate political will and administrative capability exist. It is assumed in this chapter that a considerable amount of future deforestation will, in the long term, cause more social opportunity costs through erosion, decreasing supply of wood, extinction of species, deteriorating landscapes, and other disbenefits than it will bring social benefits from the, often temporal, uses of deforested sites.

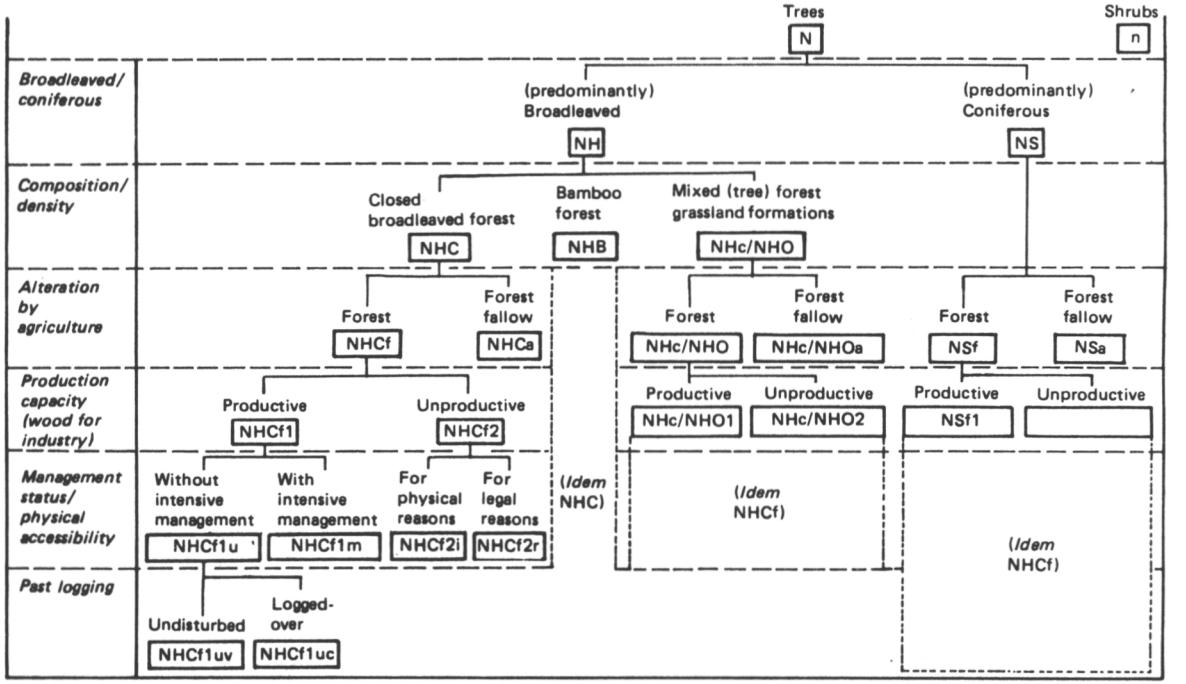


Figure 9.1 A UNESCO classification of natural forests in the tropics (applied by FAO and UNEP, 1981a–c, and by Lanly, 1982, p 11).

Deforestation is presently advancing fastest in the developing tropical countries. It has been a real threat to today's developed countries when under similar conditions, but under an industrial economy it has become stabilized, although a new threat has recently appeared in the form of air pollution and other related factors. Consequently, the focus of this chapter is primarily on the tropics.

The purpose of the chapter is, first, to review the quality of the existing deforestation statistics, especially in the tropics, second, to introduce a specific provisional theory of tropical deforestation, and, third, to present briefly the potential of the theory for empirical calculations. The establishment of future forest plantations, the potential role of future natural forestation, and empirical testing of the provisional theory are outside the scope of this chapter.

3.1. Quality of Deforestation Statistics

According to the last available estimate the closed and open forests in the tropics (76 countries) consisted of 1935×10^6 ha in 1980. From 1981 to 1985 an area of 11×10^6 ha was estimated to be deforested annually, of which 5×10^6 ha were lost mainly to shifting cultivation and 6×10^6 ha to conversion of tropical forests into other uses, such as more-or-less permanent fields and pastures, plantations, scrubs, impediments, deserts, various infrastructure uses, etc. (FAO and UNEP, 1981a–c).

The various assessments on tropical deforestation have generally differed widely in their results, due to different concepts and classifications of forests and definitions of deforestation. The principal inaccuracies, however, can be mainly attributed to shortcomings in the primary data used.

Objective, high-quality observation of tropical forest resources and their deforestation is scientifically problematic and, in practice, requires highly competent staff, funds, and other resources, and is a time-consuming undertaking (e.g., Lanly, 1973; Palo, 1978, 1983). The various existing estimates on tropical deforestation differ from each other considerably, as shown in *Table 3.1.*

FAO and UNEP agreed in 1973 to establish a joint program to monitor tropical deforestation. The project-formulation document proposed that such a monitoring system should be based mainly on satellite and SLAR (side-looking airborn radar) data (Grainger, 1984, p 46). In a pilot project to monitor tropical forest cover (Baltaxe, 1980) special attention was devoted to develop a sequential observation process based on remote sensing, along with adequate ground checks. The latest global assessment project (FAO and UNEP, 1981a–c; Lanly, 1982), however, could not produce such primary observations at two subsequent dates. Instead, only

Table 9.1. Comparison of existing estimates for tropical deforestation (10^6 ha per annum).[a]

	(FAO) Sommer, 1976	*(FAO) Persson, 1977b*	*(FAO) Lanly and Clement, 1979*	*FAO and UNEP, 1981a–c; Lanly, 1982*	*Barney, 1980; Myers, 1980*
Closed forests	11	7.5–18	6.8	7.5	18–20
Open forests	n.a.	5–10	3.1	3.8	n.a.
Total forests	n.a.	12.5–28	9.8	11.3	n.a.

[a] n.a. = not available.

secondary, derived, subjective approximations on deforestation were applied. Applying such an "observing process" enables only inadequate precision of deforestation data. This conclusion is based on elementary principles of forest inventory sampling (e.g., Loetsch and Haller, 1964; Loetsch *et al.*, 1973; Lanly, 1973, 1974). Grainger (1984, p 20) arrived at a similar conclusion: "Current estimates of the global rate of deforestation in the humid tropics are of doubtful accuracy."

Under the dynamic conditions encountered in the tropical forests recently and at present there is no accurate way: (1) to derive deforestation data from primary observations of forest areas, (2) to make *ex-post* forecasts (updating) to the end of 1980, and (3) to make *ex-ante* forecasts (predicting) up to the end of 1985 (as in FAO and UNEP, 1981a–c) without scientifically based mathematical models to explain and forecast the complex phenomenon of deforestation. Without such models only subjective, mechanistic "trends" can be approximated. Construction of such models requires assembling a relevant theoretical basis, as was attempted by Palo (1984) and as reviewed in the next section. Consequently, forest areas at a certain point of time have been estimated more precisely than deforestation areas during a period (between two subsequent points of time).

The inventory statistics concerning the forests of the industrialized countries are of considerably better quality and coverage in comparison with the developing countries. However, they also carry, to some extent, the same major shortcomings as outlined above. There exists no continuous, international monitoring system for follow-up of deforestation or increase in forest area.

3.2. Theoretical Frame of Tropical Deforestation

Considerably more effort has been given to assessment of tropical deforestation than to theoretical explanation of the phenomenon. Marsh (1874), Jacks and Whyte (1939), Pinchot (1947), Rostlund (1956), Eyre (1975), UNESCO *et al.* (1978), Baltaxe (1980), Myers (1980), Thirgood (1981),

Lugo *et al.* (1981), FAO and UNEP (1981a–c), Lanly (1982), Hallsworth (1982), and other authors give a number of explanations as to why deforestation in different tropical countries and regions is progressing. No systematic global theory of tropical deforestation has been found, although the phenomenon itself seems to be so complex that without a relevant theory the understanding and control of tropical deforestation will remain inadequate. Deforestation is a socioeconomic–environmental process that is, to a great extent, external to the traditional controls of markets and governments and, as a consequence, economics or political sciences as such cannot provide a sufficient theoretical basis.

Tropical forest inventories at the national and international levels have been based, explicitly or implicitly, on the theory of forest-based economic development (Westoby, 1962). The theory explains how the forest industries, when based on domestic commercial logging, lead to socioeconomic development through their backward and forward linkages. Recently, the relevance of the theory under developing-country conditions has been challenged (Westoby, 1978; Leslie, 1980; Douglas, 1983).

Only a few areas in the tropics have been identified for which a positive, general socioeconomic development can be explained by forest-based economic development. Instead, the serious consequences of uncontrolled logging, followed by shifting cultivation, and of other uncontrolled use and clearance of forests frequently occur in the tropics. Deforestation and the consequent erosion jointly initiate a kind of *antidevelopment* process hardly touched on in the numerous publications on economic development. On the other hand, it has been argued that due to many ecological constraints (e.g., climate, poor and erosion-sensitive soils, and animal and human health hazards) the development threshold is higher for tropical countries than for the temperate-zone countries when they entered the industrial stage (Kamarck, 1976). The tropics or tropical countries referred to in this chapter lie in the zone between the tropics of Cancer and Capricorn, on both sides of the Equator.

The aims of the provisional theory of tropical deforestation, as tentatively formulated by Palo (1984), are to explain this phenomenon and to guide future observation and forecasting, as well as to facilitate the effective control of tropical deforestation. The provisional theory of tropical deforestation is primarily based on the working experience of the author in four tropical countries (Palo, 1975, 1978, 1980, 1983; Palo and Olojede, 1982). It comprises the propositions described below.

Proposition 1

Deforestation in the tropics varies widely in space and time according to variations in socioeconomic and natural causal factors.

Proposition 2

Natural factors, such as changing climate, tornados, hurricanes, earthquakes, volcanos, lightning, and erosion, do not alone initiate a large-scale deforestation within *the time horizon of a human life.*

Although most of the causes for deforestation are man-made (e.g., Rostlund, 1956, p 639; Lugo *et al.*, 1981), the climatic changes have, through the ages, had pronounced effects on the scale and distribution of tropical forests. Current knowledge about paleoclimatology and the history of tropical climates in terms of deforestation is still small, but the instability of tropical forests against changes in climate over the *long term* has been adequately demonstrated. A decrease in the amount or regularity of precipitation under unchanged temperature and wind conditions can cause deforestation in arid and semiarid zones either by itself, if the effects are strong enough, or, more common, in combination with grazing, fuelwood gathering, or shifting cultivation. Climatic changes take place gradually during long periods of time, while the observation of their effects on tropical forests is problematic (UNESCO *et al.*, 1978, Ch 3).

The processes of desertification and desertization around the Sahara desert have been widely discussed recently. Statistical analysis of the existing historical data on climate has shown no systematic change, but only sequences of "dry" and "rainy" years. However, successive droughts have occurred in all epochs and cannot alone explain the accelerated desertization since World War II. Various human activities are considered to be the more basic causes of Saharan desertization (FAO, 1976).

Differences in the climates have undoubtedly greatly influenced the onset and spread of erosion, but climate is never (or only very seldom) the single cause of erosion (Jacks and Whyte, 1939, p 27). In erosion soil particles are carried away by the kinetic energy of water (rain, streamflow) and/or wind, which causes erosion only during dry periods. Erosivity refers to the effects of these two factors. The kinetic energy of tropical rains can be especially high, due to the high total annual precipitation in the humid tropics and to heavy, one-time rainfalls.

Erodability defines the resistance of soil against erosivity. Erodability is determined by the type of forest and other vegetation cover, by soil properties, and by the angle and length of slope (topography). Erodability indicates the inherent vulnerability of ecosystems to erosion. Sensitivity to the loss of soil by erosion at a particular site has been defined as erosivity $\times$ erodability.

The forest and other vegetation cover of the soil dominates all other factors in the control of erosion. Under forest cover erosion remains at a minimum level due to the protection of ground by (often multistoreys of)

tree canopies. This is especially the case under high and intensive rainfall, the impact of which can be so strong as to eliminate the resistance of various soil types. Accordingly, the preservation of forest plays a key role in erosion control in the tropics (UNESCO *et al.*, 1978, Chs 2, 12).

Erosion plays a strategic role in tropical deforestation in two respects. First, without sensitivity to erosion a cleared site would often be naturally reforested, if left alone, with no further human action occurring. Second, due to the widespread sensitivity to erosion in the tropics, the most serious consequences of deforestation materialize through erosion. Even wide-scale deforestation in temperate-zone countries (e.g., Britain and Denmark) in the past have often caused only relatively small environmental problems in comparison with the tropics, due to the lower erosion sensitivity of the more temperate locations. The consequences of deforestation and erosion, however, have been most serious also in many subtropical regions (e.g., Thirgood, 1981).

Proposition 3

Deforestation is caused by man primarily in *accessible forest areas.* Steep slopes, flooding, heavy rains, rough terrain, swamps, diseases, and remoteness from the existing infrastructure prevent or decrease accessibility (e.g., Rostlund, 1956, pp 649–650; Kamarck, 1976). Accessibility measures the physical and physiological stress to be overcome in order to reach a particular forest site for tree clearance. Overcoming increasing inaccessibility consumes an increasing amount of labor, animal, machine and material inputs, time, and costs:

> The term "inaccessible" as used in the inventories has meaning only in the economy of modern industrial culture: the term implies the economic impossibility of exploiting certain forests for industrial purposes because of difficult terrain, great distance to markets, or lack of means of transportation. But these forests are not physically inaccessible to man. Aboriginal peoples – hunters, food gatherers, fisher folk, cultivators – have lived in and affected them for a very long time (Rostlund, 1956, p 650).

Historically, man has populated the various life zones in the order of their accessibility and suitability to support life. In the tropical world, the open woodlands were most accessible to primitive men, hence their wide deforestation and degradation. The moist, closed tropical forests supported, until recently, only sparse populations of hunter–gatherers with no appreciable deforestation. However, advancements in medicine and technology have improved man's ability to overcome inaccessibility, even that

of moist, closed tropical forests. Still, inaccessibility, along with scarcity of forests, and often jointly with a growing sensitivity to erosion, has slowed the pace of deforestation.

Lugo *et al.* (1981, p 322) analyzed quantitatively the role of inaccessibility in the form of steep topography with a variation of forest coverage in 17 Caribbean island states. They found that the islands with steep topography had a larger share of forest coverage than the flat islands ($r = 0.77$). The relationship may refer also to the less desirable conditions for human habitation caused by the increasing moisture that accompanies elevation. Too-wet life zones are unfavorable to intensive agriculture.

Proposition 4

A number of forest-clearance and harvesting activities initiate deforestation either alone or jointly with natural factors, and also accelerate it jointly with natural factors. *The growth (growing needs) of the human population*, independently in the absence of economic development, and jointly with *poorly planned and uncontrolled economic development* (e.g., Leslie, 1980), are the driving forces behind these human activities. The role of these forces is accentuated in the tropics, along with a number of other factors, when compared with their role in the industrialized countries.

The negative relationship between forest coverage and population density has been recognized since the first systematic investigations of deforestation (e.g., Marsh, 1874):

> To sum up: the ancient human pressure on the forests of the world continues at the present time and in all probability will become more severe in the future. There are regional differences in the reasons for the pressure, but all have the same effect: the forests are losing ground, and it is generally the best and most accessible timberland that is being lost (Rostlund, 1956, p 633).

South and Southeast Asia were the objects of a study in which ten countries were analyzed to establish a correlation between the percentage of forest area (with respect to total land area) and the population density. The two essential variables appeared to be strongly negatively correlated by the rank of the countries (apparently no remarkable correlation was found between the original values of the variables): the higher the rank of population density, the lower the rank of forest coverage. The average growth of population in the ten countries was 2.7% in 1976–1977, in comparison with the world total of 1.9%. The whole region was projected to lose another 44×10^6 ha of natural, closed forest lands from 1975 to 2000 against a potential increase of 2×10^6 ha in forest plantations. Deforestation in the region was attributed to one or more of the following factors:

clearance for agriculture, shifting cultivation, increasing demand for fuelwood and other roundwood, considerable increase in livestock and grazing, and expansion of the urban, rural, industrial, communication, and transport systems (FAO, 1980b; Lanly and Clement, 1979).

The Philippines provides an illuminating case of population growth and deforestation. During the gathering and traditional shifting cultivation stages of development, until about the beginning of this century, no remarkable deforestation occurred. The population pressure did not exceed the carrying capacities of forest ecosystems. However, during the twentieth century major deforestation and forest degradation have taken place in the Philippines. The American colonization of the country brought in highly mechanized logging systems. The escalation of log exports also rapidly increased the scale of logging activities. After World War II the Government started to encourage the clearance of forests for agriculture. Strong demographic pressure (population growth for 1976–1977 was 3.3%) also expanded the shifting cultivation activities (*Figure 3.2*). These, along with a skewed land tenure, were reported as the major factors that have caused the high rate of deforestation and serious soil erosion (Palo, 1980).

Deforestation in the Wider Caribbean region was investigated by Lugo *et al.* (1981). The indigenous inhabitants of the islands had low population densities, did not practice intensive agriculture, and were living mainly on the coast. Consequently, they had little impact only on the forests. Large-scale human deforestation in the Caribbean islands began

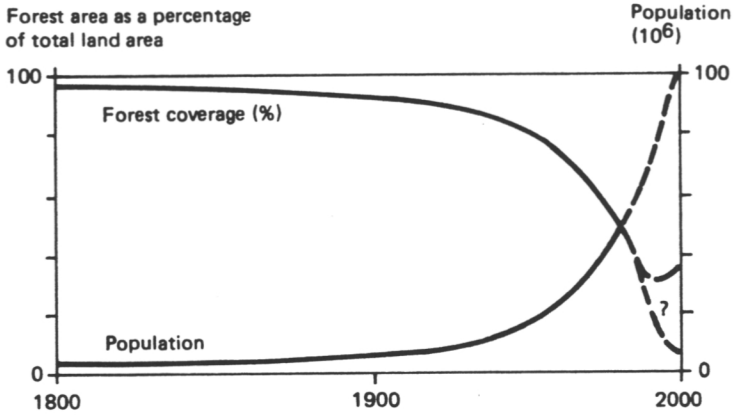


Figure 3.2 Scenario of forest coverage and human population changes in the Philippines, 1800–2000 (Palo, 1980).

only after the establishment of European colonialism. For the 32 countries in the Wider Caribbean an inverse logarithmic relationship between population density and forest coverage was computed as $r = -0.79$.

The amounts and densities of total and agricultural populations, as well as the total land and forest areas and forest coverages in the tropics are given in *Table 3.2.* At the regional and subregional level of the tropics the population densities and forest coverages can neither be strongly correlated nor can any clear distinction between total and agricultural population densities in relation to forest coverages be established. However, Lanly (1982, p 35) concluded, as numerous authors previously, that primarily the agricultural population density was strongly related to forest regression and degradation.

The cases above have given some empirical evidence about the statistical relationship between population density and forest coverage. The causal mechanism, however, is indirect, as pointed out at the beginning of this discussion of *Proposition 4*, and is often conditional to other concomitant factors, as described in the later propositions. Westoby (1985) was extremely critical of the application of population pressure as a sole independent variable of deforestation.

Lanly (1982, p 74), among numerous other authors, has pointed out that the selected industrial logging of unmanaged closed forests does not cause deforestation as defined above. However, such logging and construction of access roads directly cause deforestation on steep slopes when the activities are poorly planned, poorly controlled (the usual case), and heavily mechanized. Logging plays a far more important role as an indirect agent, such as when logging improves accessibility to closed forests and facilitates the large-scale spontaneous clearance of forests for cultivation, shifting cultivation, and grazing. These spontaneous activities and spontaneous

Table 3.2 Forest coverage and population by region in the tropics in 1980 (abbreviated from Lanly, 1982, p 34).[a]

Subregion/ region	*Total area (including inland waters)* (10^3 km^2)	*Area of closed and open forests (excluding fallows)* (10^3 km^2)	*Forest coverage*[b] (%)	*Total population*		*Agricultural population*	
				Inhabitants (10^6)	*Density*[c] (inhabitants/ km^2)	*Inhabitants* (10^6)	*Density*[d] (inhabitants/ km^2)
Central America and Mexico	2 472	669	27	93	37	37	15
CARICOM	254	202	79	4	17	1	3
Other Caribbean	445	265	59	22	50	10	22
Tropic South, Latin America	13 624	7 821	57	203	15	73	5
TROPICAL AMERICA	16 797	8 957	53	322	19	120	7
Northern Savanna Region	4 236	437	10	30	7	25	6
West Africa	2 121	557	26	114	54	65	31
Central Africa	5 328	3 359	63	48	9	35	7
East Africa and Madagascar	8 811	2 169	25	150	17	116	13
Tropical South Africa	1 399	510	36	2	1	1	1
TROPICAL AFRICA	21 895	7 031	32	344	16	242	11
South Asia	4 488	666	15	895	200	580	129
Continental Southeast Asia	1 192	476	40	83	70	54	46
Insular Southeast Asia	2 555	1 477	58	217	85	119	47
Centrally Planned Tropical Asia	752	364	48	65	86	46	61
Papua New Guinea	462	382	83	3	7	3	5
TROPICAL ASIA	9 449	3 365	36	1 263	134	803	85
Total 76 tropic countries	48 141	19 352	40	1 929	40	1 165	24

[a] Correlation coefficients, not given in Lanly, are -0.334 between forest coverage and total population density and -0.366 between forest coverage and agricultural population density.

[b] Area of closed and open forests x 100 divided by total area.

[c] Total inhabitants divided by total area.

[d] Agricultural inhabitants divided by total area.

fuelwood gathering also occur on a large scale in open woodlands. Lanly (1982, pp 81–83) estimates the share of shifting cultivation in total deforestation to be around 35% in tropical America, 50% in tropical Asia, and 70% in tropical Africa.

The nature of the deforestation process is somewhat different in the humid closed forests compared with the open woodlands of the tropics. Industrial logging and water erosion are typical in the former areas, whereas grazing and fires, fuelwood gathering, wind erosion, or the combination of wind and water erosion, are typical activities in the latter. Shifting cultivation and clearance for cultivation or other uses frequently occur in both closed and open forests.

The intensity and role of the various human factors that cause deforestation vary regionally, according to indirect factors such as population pressure and economic development. The annual growth of the total human population was 2.63% from 1975 to 1980 in the tropical countries. The size of population in the tropical, moist forest countries will double in 27 years (Myers, 1980, p 30). The consequences of this increasing demographic pressure appear as subsequent increases in the demands for food, energy, infrastructure, fibers, housing, and other commodities.

The need for an accelerated economic development is natural under such conditions of high population pressure. Agriculture-based economic development leads to more clearance of forests for cultivation and pasture as well as to an increase in the number of livestock, along with more intentional and wild fires. Forest-based economic development creates more access roads and industrial logging. Other kinds of economic development activities often require more clearance of forests for roads, reservoirs, communication, housing, factories, and other urban activities.

However, such deforestation activities, which are based on a planned economic development, play a minor role in the tropics. Planned forest clearance for agriculture is most common in tropical American countries. However, inadequate planning and control of implementation frequently diminish the predictive value of such plans. The share of such planned clearance for agriculture is apparently lower in tropical Asia and lowest in tropical Africa.

Proposition 5

Public ownership of varying kinds (federal, state, provincial, communal, tribal) is predominant in the tropical natural forests (Persson, 1974; Lanly, 1982, pp 49–55), with the politicians (and senior forestry administrators) fixing the timber prices administratively, mostly with long-term concessions (Schmithüsen, 1977; Gray, 1983). The politicians and logging contractors are often either in a joint partnership of timber business or linked together

by *corruption*. Under such circumstances the politicians tend to *fix low timber (stumpage) prices*, which facilitate high profits in logging or exports or in the processing of logs, the practice of which is beneficial for both parties. The phenomenon resembles the practice called the "soft state", which is typical for many developing nations:

> The soft state is characterized by social indiscipline that is manifested by deficiencies or willfull neglect of rules and directives by public officials and civil servants, and the collusion of government officials and top civil servants with powerful individuals and groups whose conduct they are supposed to regulate (Gould and Amaro-Reyes, 1983, p 18).

Low timber prices cause ample wastage of timber in logging and processing and thus accelerate future logging. The monetary values of forest stands also become low. There is not much economic incentive to protect such low-valued forests against encroachments, or for the effective control of logging, or for sustained-yield forest management. Fixed, low, undifferentiated prices have no self-regulative function and give no incentives to transfer to "noncommercial" dimensions or to other tree species. The increasing scarcity of timber is not reflected in prices. The whole causal chain, starting from fixed prices, adds one more deforestation factor.

The recent role of corruption has been discussed, e.g., by Myrdal (1968, pp 937–958), by Dasgupta (1982, p 12), by Douglas (1983, p 142), and most comprehensively by Gould and Amaro-Reyes (1983). Albion (1926) and Pinchot (1947) described the powerful effects of corruption on deforestation in the history of the UK and US. In the reports by the various organizations of the UN the existence and causal effects of corruption cannot be studied or mentioned for political reasons.

Generally, it has been observed that the monopoly position of government and the confusing networks of regulations and institutions promote corruption in developing countries (Gould and Amaro-Reyes, 1983, p 19). Predominant public ownership of forests and unclear institutional aspects in the administration of forests (*Proposition 15* below) create similar conditions for tropical forests. Furthermore, "the concentration of power – political, economic, and bureaucratic – together with conditions of widespread poverty, occasionally provides fertile ground for corruption" (Gould and Amaro-Reyes, 1983, p 21). These are only some of the factors that support the assumption that corruption is widespread among the forest administrations of the tropical countries, where also nondemocratic governments dominate.

In general, it has been argued that corruption leads to economic inefficiency and waste, because of its effects on the allocation of funds, on production, and on consumption. Corruption, on the other hand, has been

argued to generate conditions of violence, social unrest, and political instability. Furthermore, the effects of corruption are deemed cumulative and circular (Gould and Amaro-Reyes, 1983, pp 27–30).

Proposition 6

Although timber and some other goods and services harvested from public forests are priced, because of corruption and the lack of tradition and competent staff, as well as because of inadequate vehicles, instruments, and funds (e.g., McGaughey and Gregersen, 1983, p 171), *the public forest services are ineffective* in enforcing the required control of harvesting (e.g., McGaughey and Gregersen, 1983, pp 157–171; Palin, 1980). In such cases the unauthorized excess of quantities renders the price system inoperable. Furthermore, illegal logging frequently occurs under such circumstances. Also, a few timber buyers can exercise *monopsonistic power* to lower prices (e.g., McGaughey and Gregersen, 1983, p 53). The strengthening of forest administrations and other effective forest protection is thus hindered in tropical countries by widely practiced corruption.

Corruption generates administrative inefficiency and ineffectiveness in several ways. An atmosphere of distrust is created throughout all levels of public bureaucracies. Corruption also contributes to frustration on the part of otherwise professionally competent and honest civil servants. Under these circumstances senior administrators are discouraged from delegating authority, which is needed for successful implementation. Frequently, also, patronage and nepotism tend to fill the ranks of the civil service with inept and incompetent individuals (Gould and Amaro-Reyes, 1983, pp 28–33).

Proposition 7

Under the circumstances described in *Propositions 5 and 6*, timber, fuelwood, game, sites of forests (for clearance), and other forest-based commodities resemble *free goods*, as described in economics, in contrast of *scarce goods*. In the purchase of free goods no price needs to be paid. A household's total utility can always be increased by consuming more of any good that has a positive marginal utility. Hence, free goods will be consumed up to the point where their marginal utilities equal zero. However, the spatial character of forests always causes unavoidable harvesting costs for forest commodities.

Markets in general play a minor role in the distribution of forest commodities to consumers in tropical countries. Furthermore, markets are often ineffective because of widespread market failures, such as external

effects (erosion, extinction of species, etc.), lack of competition, and lack of countervailing powers (labor unions, farmers' unions, cooperatives, protective legislation, etc.), in addition to fixed prices. Consequently, a number of economic problems are apparent in developing countries.

In general, the commonly pronounced existence of external costs in tropical forestry creates a conflict between expected net private and social benefits. If the expected net private benefits of a forest area in an alternative use (e.g., in agriculture) exceed the expected net private benefits of the same forest area in a continuous forestry use, the particular forest area will be deforested and converted into the more privately favorable alternative use, although the expected net social benefits would indicate maintaining this particular forest area in a forestry use. Ineffective public forest service and other public administration result in the spread of this phenomenon.

The tropical deforestation situation often resembles the more generally known *problem of the commons* (e.g., Barney, 1980, p 332; Sedjo and Clawson, 1984, p 133), which has been formalized and dealt with in more detail by environmental economists (e.g., Dasgupta, 1982, pp 13–40). A common property has the following features:

(1) Free access.
(2) In the absence of binding mutual agreements each agent who harvests a common resource ignores the cost imposed on the others.
(3) No individual agent has the incentive to acquire sufficient information about the ecological implications of his or her actions.
(4) No individual agent has the incentive to save the resource and, consequently, the agents harvest as fast as they can and as much as they can up to the point where their marginal costs equal their marginal revenue.
(5) The problem of the commons has two consequences: ultimately, the profits of the agents will disappear and the resource will be overused in terms of the maximization of expected net social benefits.
(6) As the resource stock becomes depleted, the unit cost of the harvest typically rises since the agents have to travel farther afield or obtain less harvest at every attempt, and thus today's harvest rates impose an intertemporal externality on the future.
(7) Also serious income-distribution consequences can occur.

Accordingly, the practices discussed in *Propositions 5* and *6* increase the harvesting and clearance of forests in excess of that produced by market pricing. The increasing scarcity of forest resources is not reflected in higher prices and the prevailing pricing system gives no automatic control of deforestation.

Proposition 8

Forestry comprises both economic and noneconomic forest-based production. *Forestry is the joint production* of wood, game, erosion protection, conservation of species, control of water and climate, recreation, and other commodities. Joint production occurs whenever the same production facility (forest) produces simultaneously two or more products. Wood, game, and other goods collected are *private goods*, which in principle can be priced and distributed to firms and households and which, after use, are no longer available in a similar condition for other users. On the other hand, erosion protection and other services of forestry are *collective "goods"*, the pricing of which is difficult, and which cannot be used by one individual to render the good unavailable to another individual. When harvests of private goods increase, the production of collective goods decreases according to the relevant production functions.

Proposition 9

Although the high number of forest-based goods and services is well documented, *the value of natural forests*, as providers of protection, conservation, and other services, or the value of sustained-yield multiple-use forestry is not appreciated by governments or the public at large (*cf. Proposition 5* above). Forests are generally viewed as a hindrance to economic development. The problem is partly related to a lack of scientific and practical knowledge on how to manage the mixed, moist tropical forest. The long-term consequences of the external disbenefits created by excessive deforestation are not adequately known (e.g., Poore, 1976; UNESCO *et al.*, 1978; McGaughey and Gregersen, 1983, p 170).

Proposition 10

When firms and individuals *maximize their profits or utilities* in the short run (instead of maximizing the expected net social benefits) by increasing the harvest of private forestry goods or by increasing forest clearance in order to expand the production of private agricultural goods (food and other crops), they simultaneously, due to the joint production principle, decrease the production of collective forestry goods and create *external costs* or adverse externalities. Firms and individuals as logging contractors, fuelwood gatherers, shifting cultivators, forest-clearance farmers, or herdsmen have no immediate incentive to prevent erosion or other external disbenefits by better planning and controlling of their activities.

A specific characteristic of forestry externalities, such as erosion and the extinction of species, is that they are *unidirectional.* Normally, a given agent (or a set of agents) imposes an externality on another (or others), whereas reciprocal externalities are generated in situations that involve the use of common property resources, where each agent imposes externalities on all the others. Unidirectional externalities are determined both by physical circumstances and by the assignment of property rights. Deforestation in one country frequently causes even transnational unidirectional externalities. Both of these problems are especially difficult to solve (e.g., Dasgupta, 1982, pp 31–37).

Proposition 11

In developing tropical countries a *short-term planning horizon* prevails due to unstable political, economic, and demographic conditions, as well as to the lack of a planning tradition. Also cultural traditions hinder long-term planning of the future (the East African case is described, e.g., by Harjula, 1975). In contrast, the consequences of erosion, extinction of species, and other external disbenefits created by deforestation become more serious only over the *long term.*

Proposition 12

Private ownership of natural forests occurs to a lesser extent in the tropics, especially in certain Latin American countries for the more highly valued Araucaria and pine forests (Lanly, 1982, p 49). Private ownership of natural forests cannot prevent deforestation because of "over long" planning horizons (rotations) for sustained-yield forestry and because of the often high private *opportunity costs* for certain forest soils and for the capital frozen in the growing stock of trees. Illegal logging, or the threat of it, also accelerates clearance of private forests. Unstable political circumstances and uncertainty of tenure have the same effect.

Proposition 13

The number of *landless rural poor* is growing fast in most tropical countries (FAO, 1980a, 1984b). The alleviation of absolute rural poverty is associated with adequate economic growth, particularly an increase in per capita for agricultural production. But growth alone is not a sufficient condition. Unequal distribution of land (productive assets) and income do not allow the benefits of moderate or even fast economic growth to trickle down to

the poor; simultaneous and effective land reforms and other redistributive policies are necessary (FAO, 1984b, p xi; Dasgupta, 1982, pp 38–40). On the other hand, land reforms are effectively prevented or slowed down (FAO, 1984b) by large landowners who, jointly with leading politicians (World Bank, 1982, pp 84–85) and businessmen, form the *power elite* (e.g., Gould and Amaro-Reyes, 1983, p 18; Myrdal, 1957, p 59). Instead, under accumulating pressure from the rural poor, colonization schemes for public forests have been launched or, alternatively, free access to public forests has been allowed through the ineffective or total lack of protection of forests. The *status quo* in land ownership is often supported by various foreign powers and agencies (e.g., Myrdal, 1957, p 59).

Proposition 14

With the increasing scarcity of arable land, along with unemployment, malnutrition, and starvation, the rural poor have to find new solutions for *subsistence* by migration and by the legal or illegal excessive clearance of forest for shifting cultivation and "permanent" cultivation, or by excessive fuelwood gathering, grazing, and firing:

> These rural landless, whose numbers are increasing everywhere, have no option but to invade the remaining tropical forest in an endeavour to scratch a living from soils that are both unfamiliar and fragile. The cause of tropical deforestation lies behind them on the land from which they have been driven: millions of hectares of relatively good land [and] owned by a wealthy few producing the wrong crops for the wrong people at a low level of productivity. So long as the highly skewed distribution of land, wealth and power that characterizes most tropical forested countries endures, the battle to save the tropical forest will inevitably be a losing one (Westoby, 1985, p 57).

Property and tenure are systems of authority established by governments and cultural traditions. They form a set of right-to-control assets. They affect the bargaining powers of parties and thereby the distribution of income and wealth. Reallocations of property rights occur not only legally, but also by corruption, fraud, theft, and, on occasion, by violent robbery (e.g., Dasgupta, 1982, p 38). Under unstable political conditions, land speculation is widely practiced through withholding agricultural land from its previous use, by keeping productivity of agricultural lands at a low level in comparison with their actual potential, or by purchasing property rights to natural forests and woodlands for clearance for a specific short-term purpose. The distributional effects of land speculation are likely to take their toll on the landless (Horn, 1985, p 209) and thus aggregate the pressure toward deforestation.

Proposition 15

Colonialism created many social problems that are still acute in independent developing countries. Jacks and Whyte (1939) reported from South Africa that native reserves have usually been demarcated not, primarily, on a regional basis, but rather with the purpose of separating the land most suitable for European settlements. The naturally migrant native population has been suddenly forced to adopt a settled existence in too small and often inadequately fertile mountainous areas. In this way colonization deteriorated the subsistence of the native people and increased erosion. The authors refer also to the Philippines where, during the American colonial period, the establishment of large sugar-cane estates pushed native people to more remote areas. In Mozambique, where the population density is relatively low, the pressure of Portuguese colonization also caused considerable deterioration in subsistence and marked erosion problems. Mozambique did not become independent until 1975, which is why the consequences of colonization are quite fresh (Palo, 1978). Lugo *et al.* (1981) have described the effects of European colonialism on deforestation in the Caribbean region.

Proposition 16

Numerous *institutional aspects* promote deforestation. Typically, forests are controlled partly (forest reserves) by one or more public forestry authorities and partly by colonizational, agricultural, or other public authorities. Forests can also be administered by federal, state, provincial, or local community authorities. Effective and coordinated planning, implementation, and follow-up are problematic under such circumstances. The external costs of deforestation are also, basically, *intersectoral*, so no sectoral authority can take an integrated responsibility for control (e.g., McGaughey and Gregerson, 1983, pp 160–161). Research into deforestation is also hampered by the intersectoral and *interdisciplinary* nature of the topic.

Proposition 17

Automatic control by the market ("invisible hand") and planned control by the government are the two primary mechanisms expected to control socioeconomic development toward social well-being within national economies. Both of them fail to control deforestation in the tropics. Market mechanisms provide no negative feedback loops to check deforestation and governments are neither motivated nor able to control deforestation (*Propositions 5–11*).

Proposition 18

The causal factors of this proposition are linked together as various *causal chains or mechanisms.* The mechanisms comprise positive feedback loops which tend to accelerate the process of deforestation. The only effective negative feedback loops are caused by the inaccessibility of forests and by the successive reduction of forest areas. Inaccessibility has been gradually overcome by technological and medical progress and appears to be a braking force only in the later stages of the deforestation process (*cf. Proposition 9* above).

Causal chains with only positive feedback loops resemble "vicious circles", which have been described as follows: "It was clear ... that poverty and disease formed a vicious circle. Men and women were sick because they were poor; they became poorer because they were sick, and sicker because they were poorer [Myrdal, 1957, p 11]." The reference points to a circular and cumulative process, continuously pressing levels downward, in which one negative factor is, at the same time, both the cause and effect of another negative factor.

When a vicious circle system has more than two factors, as in the tropical deforestation case, it becomes more complicated and even more difficult to stop or control. The system itself has no tendency toward self-stabilization (no negative feedback loops), but instead it is constantly moving away from a kind of initial equilibrium. A natural change in such a system does not bring forth countervailing changes but supporting changes, which move the system in the same direction as the first change, but much further. Under such circular causation a social process tends to become cumulative and often to gather speed at an accelerating rate (Myrdal, 1957, p 13).

The provisional theory of tropical deforestation as formulated in *Propositions 1–16* can be viewed as a vicious circle in the following way. Population growth and environmental deterioration in the form of deforestation and soil erosion are the basic factors. Together with inadequate land-use and forest policies, and with apparent market failures in the economic system and with lost forest-based development opportunities, a vicious circle of continuous and accelerating rural depression and deforestation can be identified (*Figure 9.3*).

Leslie (1980) points out that, besides a few positive cases, there exist a large number of developing countries in which heavy utilization of their forests has not produced any real forest-based economic development through industrialization. Quite often forest-based industrialization has not yet been seriously tried. In many countries most of the development potential has, in effect, been exported via huge amounts of logs. When

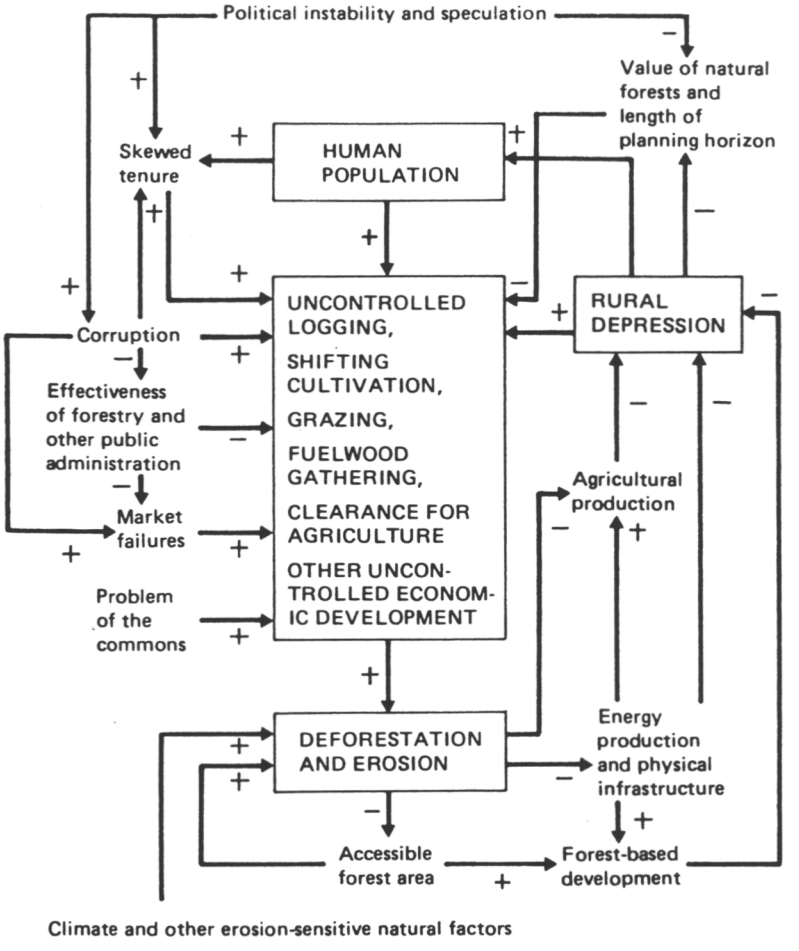


Figure 3.3 The vicious circle of population pressure, deforestation, and rural depression in the tropics.

forest industrialization has been tried it often has been badly planned and managed.

Proposition 19

Deforestation as a mathematical process is described by the reduction of an initial forest area of a certain class ($FA_{i,t}$) into a final forest area of the same class ($FA_{i,t+n}$) during a number of years (n). If the annual relative

rate of deforestation ($p\%$) is assumed *constant during a certain period*, the final forest area of that period can be estimated by *discounting the initial forest area into the final date* as follows:

$$FA_{i,t+n} = FA_{i,t} \cdot (1+p/100)^{-n} \tag{3.1}$$

and then the area of deforestation (AD) is found by subtraction:

$$\sum_{t}^{t+n} AD_i = FA_{i,t} - FA_{i,t+n} \tag{3.2}$$

According to the above, if a *constant annual percentage of deforestation* is applied in the same area for successive years (*ceteris paribus*), this leads to successively decreasing annual areas of (absolute) deforestation. On the other hand, if *a constant annual area of deforestation* is applied for successive years (*ceteris paribus*), this leads in turn to successively increasing annual percentages of (relative) deforestation. In the latter case, the annual percentage of deforestation equals 100 during the last year of the total process and later deforestation can take place only if new forestation occurs.

Proposition 20

According to *Propositions 17* to *19*, *deforestation in the tropical forests will expand at an accelerated speed* until the existing negative feedback loops strengthen at a later stage of the process. This forecast will be valid unless corruption and actual forest policy and population growth can be checked, land reforms can be mobilized, agriculture on existing arable lands and pastures can be intensified, or controlled economic growth per capita can be mobilized within other industries and urban regions. In the tropical countries most liable to extensive future deforestation these reservations are not valid in the foreseeable future, unless a *radical change in the attitudes* toward deforestation by the national governments and by the individuals occurs.

A required change in attitudes could be caused by *radically improving the observation and monitoring of tropical deforestation* as well as by *radically increasing investigations into the causes and consequences of tropical deforestation*, and by effectively transmitting the results. In this way *a major part of likely future deforestation could be avoided or postponed*, if the national governments and the international organizations have *enough political will and power*. Unavoidable deforestation could also be effectively

controlled in order to minimize its external disbenefits. When future costs and benefits are uncertain and when current investment decisions are irrevocable (as is the case with expansion of the exploitation of tropical, natural closed forests), current resource usage ought to be more "conservative" than when the decisions are not irrevocable, since a more "conservative" resource-exploitation policy enables the planner to maintain greater future flexibility (Dasgupta, 1982, p 200).

This provisional theory for tropical deforestation has been created in a field in which no theory previously existed. It is interdisciplinary by nature and, as such, it can be regarded as provisional and flexible to future revisions. The theory has been shaped so that it is global and covers both the *developing tropical countries* and the closed and open natural forests. Most of the propositions are *inductive generalizations*, with the relevancy and intensity of different causal factors varying according to countries and major classes of forests. Pilot empirical analyses based on this theory have been encouraging, but the main results will be published elsewhere (Palo and Mery, 1985). Only a few empirical findings are presented in the next section.

3.3. Potential for Empirical Applications

The tentative empirical analysis was based on 72 tropical countries, which lie (at least about half of the territory of each country) within the tropics of Capricorn and Cancer. All forest area variables were based on the recent FAO and UNEP (1981a–c) assessments. The total forest area variable was composed of closed and open, natural, broadleaved forest and of natural coniferous forest. GNP and energy variables are taken from World Bank (1981) and population variables from United Nations (1982). The land area data were derived from FAO and UNEP (1981a–c) and FAO (1984a). Correlation computations were based both on the original variables and on their logarithmic transformations. In order to analyze countries of varying sizes the dependent and independent variables were transformed from absolute into relative figures.

Three alternatives were analyzed for a dependent variable of deforestation. The area of deforestation in relation to total land area and to total forest area, as well as the total forest area in relation to total land area, were examined [*Figure 3.4(a)*]. The last one clearly correlated the best with the key independent variables of population densities, which is expected because of the poor accuracy of deforested-area statistics in comparison with forest area statistics (Section 3.1). Accordingly, forest coverage (total forest area/total land area) was applied as a dependent variable, the validity of which was improved by grouping the countries.

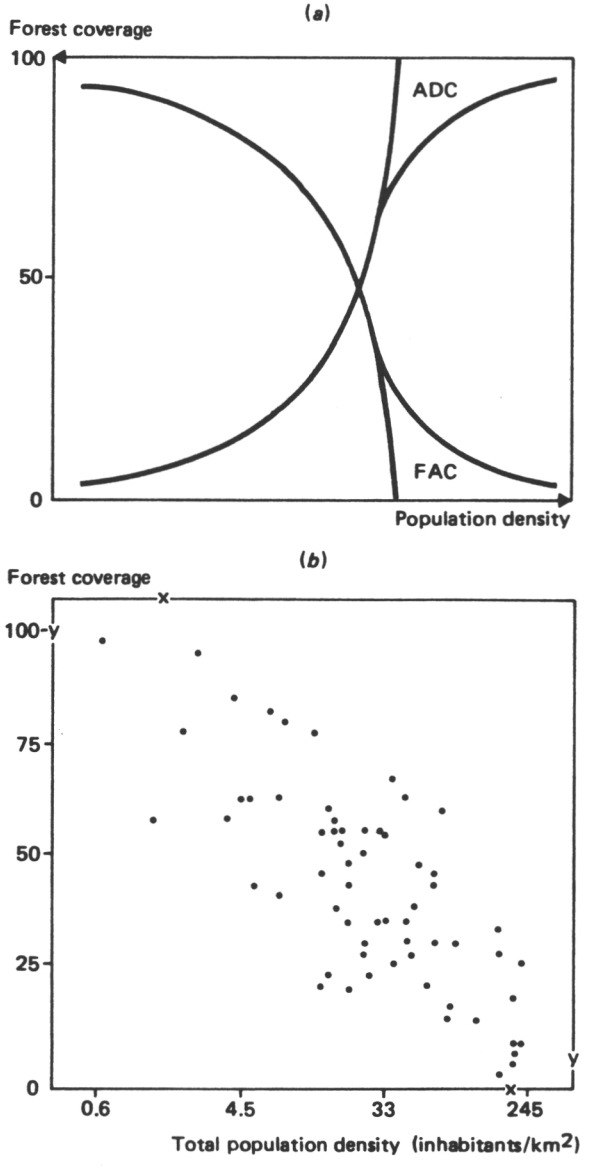


Figure 3.4 (*a*) Coverages of forest areas (FAC) and deforested areas (ADC) from total land areas as theoretical functions of population density (Palo, 1984). (*b*) Correlations of 64 tropical countries in 1980.

In order to establish more homogeneous groups of countries for further analyses, geographical proximity was considered to reflect a similarity in the natural and human factors that affect deforestation (*Figure 3.3*). First, a division by continents was applied. Africa is the most heterogeneous continent and has the highest number of countries (38). Therefore, a subgrouping was executed, with the first African group being defined as 12 moist African countries, which contain the moist and predominantly closed forests occupying the western zone from Zaire in the south to Sierra Leone in the north (e.g., Persson, 1975, p 19). The second group comprises the eight most arid countries. The remaining 18 semi-moist countries were included in the third African group (Persson, 1977a).

The correlation coefficient between total forest coverage and total population density was –0.47 among the 72 tropical countries, –0.76 among the subgroup of 64 tropical countries [*Figure 3.4(b)*] and –0.84 among the subgroup of 46 tropical Latin American, Asian, and moist African countries (in most of them closed forests dominate). The equivalent correlation coefficients by the three further subgroups of the 46 countries were –0.95, –0.88, and –0.83. Also, negative coefficients (–0.65, –0.55) were computed for the 18 semimoist African and the eight arid African countries, where open forests dominate. *Total* population density correlated with forest coverage either more strongly or at about the same level as *rural* population density (no statistically significant difference between the two), which can be regarded as a novel empirical finding in contrast with previous explanations (e.g., Lanly, 1982, p 35). Semi-log transformations (the original dependent variable versus log of the independent variable) produced mostly higher correlation coefficients than original variables or their log–log transformations. Parallel data from Paranà in Brazil (a time series of nine observations, $r = -0.99$) and from 22 European countries ($r = -0.86$) confirmed the negative relationship between forest coverage and population density found in the tropics.

Future tropical deforestation was analyzed tentatively using five alternative scenarios (*Figure 3.5*), three of which were based on the regression of forest coverage with total population density (B, D, and E), one assumed the present deforestation areas fixed into the future (A; Palo, 1984), and one assumed that the relative future deforestation rate over five-year periods was equal to the relative future population growth [C; equations (3.1) and (3.2) above; Palo, 1984]. Scenarios C, D, and E had nonlinear functional forms and followed more closely the provisional theory of tropical deforestation. Scenarios A and B had linear functional forms. Scenarios B to E were based on the available population predictions [see Palo and Mery (1985) for more details].

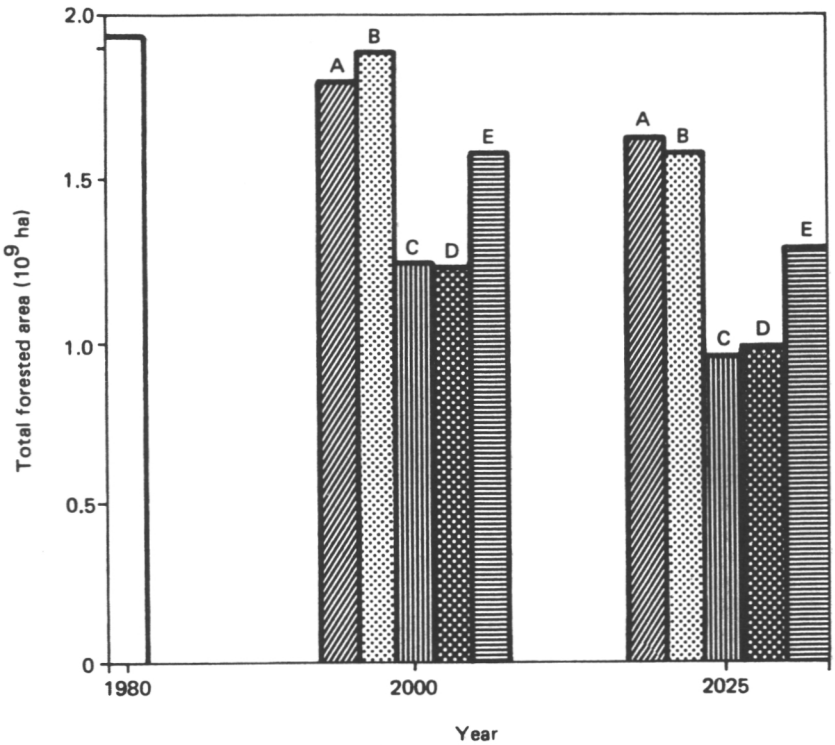


Figure 3.5 Alternative, pilot scenarios for deforestation of tropical closed and open forests (see text for description of A–E).

The total forest area in the 72 tropical countries analyzed here was 1944×10^6 ha in 1980. By 2025, it is predicted to decline by –51, –50, and –34% in scenarios C, D, and E, respectively. The present deforestation pace has been assumed by most other authors to continue, which would indicate a reduction of –17% (scenario A in *Figure 3.5*).

3.4. Discussion

The provisional theory of tropical deforestation has to be further elaborated, but as it is now it already fulfills the purpose of guiding observation, prediction, and control. The fitness of the theory for subtropical, developing countries is likely, but has to be tested further. No attempt has

been made here to analyze the role of future artificial or natural forestation in the tropics. It was also outside our scope to analyze the potential effects of deforestation on the future supplies of timber and fuelwood.

A decrease in forest coverage (the ratio of forest area to total land area) indicates deforestation in this analysis. The ratio of deforested area to total forest area would have been more valid for the purpose, but its statistical accuracy appeared too low for further application. The initial forest coverages in countries before human impacts on forest areas have apparently varied according to natural circumstances. One aim of grouping the countries was to eliminate satisfactorily this problem, in the absence of data on the initial national forest coverages.

Population density was measured by the ratio between number of inhabitants and total land area. The validity of this variable is weakened by the fact that, due to deserts, mountains, etc., a particular share of many countries is uninhabitable. Therefore, the population pressure on the inhabitable parts of these countries is *de facto* higher than shown by the applied population density variable. The validity could be improved by the relevant corrections.

The deforestation scenarios have to be understood as pilot results. More analyses will be needed to test the fitness of some other feasible function forms, as well as of regression equations with more than one independent variable.

The assumed key role of population growth in tropical deforestation has been given further confirmation here. Furthermore, similar negative correlations in the parallel material of Paranà and industrialized countries have strengthened the hypothesis and have given greater reliance on the consistency of this relationship in the further economic development of the currently developing countries.

The strong, empirical negative correlations between forest coverage and total population density, and the scenarios based on this regression gain more relevance in the light of a correlation matrix of 59 variables representing the various factors of *Figure 3.3* (Palo and Mery, 1985). The other key variables, such as gross national (or domestic) product variables, grazing and other agricultural variables, as well as a fuelwood and other roundwood production variables, were all strongly positively correlated with the total population density variable. Thus, population pressure as described in the theory of Section 3.2 and in *Figure 3.3* appeared to be a most powerful indirect variable in the tropical deforestation process.

In contrast to general opinion, but according to the hypothesis of the provisional theory (Section 3.2, *Proposition 4*), the five relative GNP and GDP variables correlated mostly negatively with the dependent forest coverage variable. The correlation coefficients varied between 0.00 and –0.43 among the 72 tropical countries, between –0.13 and –0.60 among the 46

tropical countries, between –0.13 and –0.68 among the 12 moist West African countries (Palo and Mery, 1985). These results are supported by Allen and Barnes (1985) who computed correlation coefficients of –0.18 and –0.27 between deforestation and two GNP per capita variables among 28 tropical countries.

It has been shown here that theoretically based, relevant, empirical quantitative analysis concerning tropical deforestation is feasible, even by applying the available data for tropical forests when deforested areas are substituted for forest coverages. In contrast, Grainger (1984) argued that such an analysis would be feasible only after objective, international monitoring systems are created to produce more valid and reliable deforestation data. The strong requirements for such a monitoring system, as well as expanding quantitative analyses on the projections and consequences of tropical deforestation, are also emphasized here, but some analyses can also be implemented immediately.

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PART II: Pilot findings on development



PHOTO: MATTI PALO (NIGERIA)

LATIN AMERICAN FOREST SECTOR DEVELOPMENT: A SHORT-TERM REVIEW AND PROSPECTS.

by

Gerardo Mery

ABSTRACT

The main purpose of this paper is to present a review of Latin American forest resources in 1980 and to expose the trends in production, consumption and external trade of forest products during the last twenty years.
The vast and heterogeneous natural forest resources of these countries are described according to the prevailing forest types. Tables containing detailed information by country are also included. The natural forest covered about 1 billion ha in 1980, 70 % of which were closed forests. It is these forests which have been affected by tremendous deforestation which, by 1980, had reached 5.4 million ha annually. Degradation is also extensive. At the same time removals account for 340 million m^3 annually. Approximately 74 % of such removals were destined for fuelwood and charcoal production. Forest plantation activities have increased. However, they do not compensate for deforestation losses.
The production, imports, exports and apparent consumption of sawnwood, wood-based panels, wood pulp and paper and paperboard are described and analyzed. Also, their growth levels during the last twenty years and prospects up to the year 2000 are exposed.
Severe criticism of the development pattern prevailing in the forest sector of these countries are presented in the conclusions. Depletion and overexploitation of forest resources can be demonstrated, and yet the benefits of forest resources to local economies remains almost totally undeveloped. Finally, it is stated that a significant improvement in the role played by forestry and forest industry in Latin America cannot taken place without a structural change in these societies.

Keywords: Latin America, forest resources, deforestation, forest industry products.

CONTENTS

		page
1.	INTRODUCTION	
11.	Background	145
12.	Overview of physiographic and population features	148
13.	Aims and Method	152
2.	ACTUAL FOREST RESOURCES	
21.	Forest types	157
22.	Natural woody vegetation	161
23.	Deforestation and degradation	166
24.	Removals	173
25.	Forest plantations	176
26.	Institutional aspects	179
3.	FOREST INDUSTRY PRODUCTS	
31.	Sawnwood	184
32.	Wood-based panels	190
33.	Wood Pulp	192
34.	Paper and Paperboard	194
4.	DISCUSSION AND CONCLUSIONS	
41.	Discussion	197
42.	Conclusions	199
	ACKNOWLEDGMENTS	204
	REFERENCES	204
	ANNEXES	209

1. INTRODUCTION

11. Background

Forests have played an important role for the people of Latin America for thousands of years. The hunting and gathering societies obtained from the forest different kinds of goods and services, which were essential for their survival and welfare, such as shelter and food (edible plants and game), wood, fuelwood, medicines, etc. During that time, the impact of the human race on forest devastation can be assumed as being very marginal (Vitale 1983).

The first domesticated wild plant species in Latin America date back to about 7000 - 3000 B.C. (Denevan 1980). However, the gradual and slow change from hunting and gathering societies to agriculture ones did not culminate until 1500-1000 B.C. The establishment of such sedentary populations marked the first significant conversion of forest land for agricultural purposes. The phenomenon was mainly confined to relatively limited areas where the population was relatively dense: Central Mexico, Yucatan and the valleys of the Central Andes. However, signs of farming activities have also been detected in the tropical lowlands and highlands.

The native people of Latin America did not employ draft animals in their agricultural practices. The tools commonly used were the foot plow, the spade (called by the Incas **chaquitaclla** and **coa**, respectively) and several kinds of digging stick. This meant that cultivation practices were highly labour intensive. In spite of the fact that cultivation was also carried out on an extensive scale, intensive cultivation methods prevailed. Terracing, irrigation, raised fields, soil amelioration, stable shifting cultivations and house gardens were agricultural techniques employed by different nations in this subcontinent, in accordance with and adapting to the prevailing environmental conditions. Denevan (1980) stated that the techniques used by the native farmers "were effective, relatively stable ecologically,

moderately productive and often supported large populations". This does not mean that mismanagement of natural resources ever ocurred. Extensive erosion affected Central Mexico, Yucatan and some Andean areas before the Spaniards' arrival.

Another factor which caused forest destruction was mining and, to a less extent, pottery activities. By the time the Spaniards arrived, some of the native inhabitants of Latin America - notably the Incas, Mayas and Aztecs and other peoples - had already mastered complex metallurgy and pottery techniques, as sophisticated as those found any where in the world (Vitale 1983). The production of such goods required large amounts of fuelwood and charcoal for metal smelting and firing the clay. The fuelwood destined to supply energy for these productive activities result in significant forest devastation, only in the arid, semiarid and mountainous regions.

The European conquest at the end of the 15th century caused considerable changes in the conversion of forest land into other uses. The immediate consequences of the european colonization (Furtado 1970, Galeano 1970, Gligo & Morello 1979, Vitale 1983) were:

- Massive fall in the Indian population as a result of the introduction of European diseases, their exploitation as a labour force under inhuman working conditions, and the subjugation wars. It is estimated that the native population decreased from about 70 million in 1492 to less than 5 million by 1600 . Between the 16th and 19th centuries several million African slaves were brought to the subcontinent as a new source of labour. Furthermore, the illusion that rapid fortunes could be made attracted new waves of European settlers. Consequently, a new population, principally composed of half-castes and mulattos, soon emerged.

- A profound change in the whole economic system: the natural economy of the native peoples, which was mainly oriented to cover their own domestic needs, was transformed into an export-oriented economy, the main export products

being metals (gold and silver) and agricultural goods (sugar, cacao, wheat, meat, etc). With the passing of time, the range of raw materials exported gradually expanded.

- Introduction of new agricultural tools and techniques, such as new crops (e.g. wheat, sugarcane, rice, bananas, coffee), livestock (cattle, horses, sheep, goats), new tools (ox-pulled plows) and the replacement of the earlier labour-intensive agriculture by extensive monocultures or grazing destined for the European markets. Consequently, extensive forest areas were converted for agricultural or other kinds of use, even to the extent of desertification (Donoso & Grez 1985).

Almost five centuries have elapsed from the time when the European conquerors produced the turning point in the socio-economic life of the Latin American nations. During this period, the countries attained their "political independence" and economic development has taken place in several areas, aiming at to obtain a place in the world market for primary products and to substitute imports. The process has leading to a situation characterized by a polarization between a modern market-economy sector and a subsistence-economy sector which employ traditional techniques. This dualism has recently been modified by the foundation of new productive enterprises which have incorporated highly complex technology (Furtado 1970). However, the basic characteristic of their economy has been maintained: they continue to be dependent on external economies and to be exporters of raw materials for the world markets. The devastation of their forest resources, far from being halted, is actually a dramatic fact for most of these countries, and threatens the optimistic prospects for the forest sector to contribute to socio-economical development, as pointed out by several authors (e.g. Westoby 1962, Gregory 1965, McGaughey & Gregersen 1983, Salcedo 1983, Keipi 1985).

12. Overview of physiographic and population features.

Prior to a description of Latin American forest resources, a brief summary is given of some important population and forest site characteristics.

Due to the considerable territorial expanse of this sub-continent, it possesses a wide variety of climatic and topographic features that are combined with a great diversity of geological formations and soils. The interaction between these elements generates a large number of different forest site types and floristic formations.

The Latin American countries cover an area of approximately 20.2 million km^2 (excluding inland water), the larger part of which lies in the Southern Hemisphere. The Equator crosses the region close to its widest territory, and the tropical zone comprises more than 70 % of the total land surface.
The most noteworthy physiographic components of the sub-continent (shown on the map in Annex 5) are :

A) The Andes Mountains: adjacent to the South Pacific coast, with a natural prolongation in the Central American and Caribbean mountains and in the western and eastern Sierra Madre in Mexico.

B) The large basins of the Amazon, Orinoco, Parana and Del Plata rivers and their adjacent plains.

C) The plateaux of Brazil, Argentina, Guyana, Mexico, Patagonia and of the Andes' "sierras".

The climate also varies considerably, ranging from moist and hypermoist tropical warm climates on the Brazilian coast and Central America, to tropical and subtropical arid and semi-arid regions in Central and Northern Mexico, on the Atlantic Venezuelan coast, in northeastern part of Brazil, in the Chaco region of Paraguay and Argentina, as well as an extensive desert in the northernmost part of Chile on the border with Peru. Tropical and subtropical moist cold

climates occur at diverse latitudes along the Andes Mountains. Temperate regions are dominant in large areas of Mexico, Argentina, Uruguay and Chile. Cold steppe and tundra climates are found in the southernmost part of Chile and Argentina, and also in the mountains over 3 000 m.a.s.l. Ocean currents markedly influence the coastal climates of several countries (e.g. the Gulf Stream and the Humbolt Current). The main climatic zones are shown on the map in Figure 11 (Annex 5).

In 1980, the Latin American population had reached approximately 358 million (United Nations 1982), consisting of roughly 45 % halfcaste and mulatto, 33 % white, 15 % black and 7 % indian. The population density is, as a whole, rather low: 18 inhabitants/ km^2, (see Table 1). However, in Central America and Mexico the population density exceeds 44 inhabitants/km^2. The most densely populated countries have over 200 inhabitants/km^2. They are: El Salvador, Trinidad and Tobago, Haiti and Jamaica. Less densely populated countries (less than 10 inhabitants /km^2) are French Guiana, Suriname, Guyana, Bolivia, Belize, Paraguay and Argentina.
The mean annual rate of population growth for the period 1980-1985 is 2.4 % for the whole subcontinent, being higher in Central America and Mexico (2.6 %) and lower in the temperate South American region (1.6 %).

Rapid urbanization is another characteristic of most Latin American countries. This process, in which the population become concentrated in a few urban centers, was a combined result of the lack of opportunities for rural inhabitants and the increasing demand for industrial manpower in the cities. This has caused a massive migration from the countryside into the urban areas. The phenomenon has accelerated in the last three decades (Figure 1). In 1980, more than 65 % of the Latin American population was living in urban centers, and in almost all countries the urban population growth rate was higher than the rural one (Table 7, Annex 3).

Table 1. Land area, population density and selected forestry data of Latin American countries in the early 1980's.

	Land Area (mill. ha) (1)	Popul. Density (inh/ km^2) (2)	Forest Cove- rage (%) (3)	Forest per ca- pita (ha/cap) (4)	Total Volume (mill. m^3) (5)	Produc- tive Forest (%) (6)
Mexico	192.3	36	25	1	3196	64
Guatemala	10.8	67	42	1	441	76
Belize	2.2	7	63	9	67	73
Honduras	11.2	33	36	1	293	86
El Salvador	2.1	232	7	0	6	33
Nicaragua	11.9	23	38	2	549	95
Costa Rica	5.1	44	35	1	181	85
Panama	7.6	25	55	2	567	86
Bahamas	1.0	24	26	1	23	52
Cuba	11.4	85	13	0	80	78
Haiti	2.8	211	2	0	2	50
Dominican Rep.	4.8	123	13	0	26	92
Jamaica	1.1	202	6	0	7	86
Trinidad Tob.	0.5	228	41	0	27	81
Subtotal 1	264.9	44	27	1	5465	73
Colombia	103.9	25	50	2	5497	92
Venezuela	88.2	18	40	2	3745	73
Guyana	19.7	4	94	21	2790	82
Suriname	16.1	2	96	40	2846	92
French Guiana	8.9	1	99	145	2460	89
Brazil	845.6	14	67	5	59235	89
Ecuador	27.7	9	53	2	1577	86
Peru	128.0	14	55	4	11367	72
Bolivia	108.4	5	63	12	4121	76
Paraguay	39.7	8	82	10	3213	10
Subtotal 2	1386.3	14	64	4	96851	83
Chile	74.9	15	21	1	787	70
Argentina	273.7	10	7	1	1264	75
Uruguay	17.3	17	3	0	18	100
Subtotal 3	365.9	11	10	1	2069	73
Total	2017.1	18	49	3	104385	83

Source: (1) and (3) Lanly (1982); (2) United Nations (1982); (5) and (6) FAO (1984).

Note: the symbols used in the tables are explained in Annex 1.

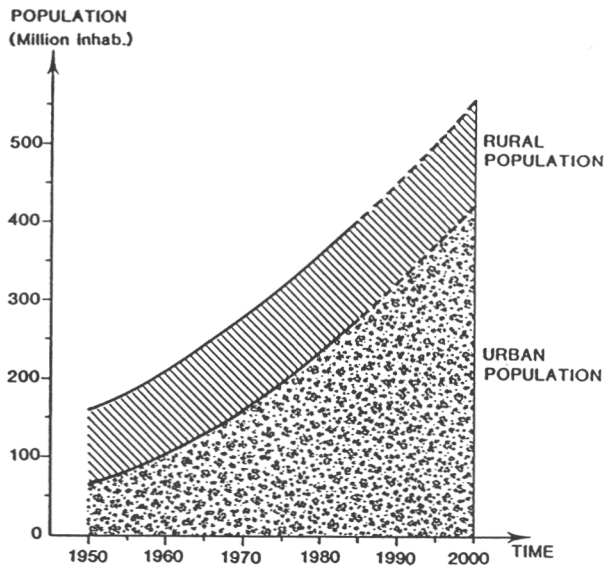


Figure 1. Urban and rural population development in Latin America during the period 1950 - 2000, according to the data in UN 1982.

In some countries the rural population growth rate has been negative, e.g. in Cuba, Chile, Argentina, Colombia, Uruguay and Brazil.

This urban concentration of population has manifold consequences, which have clear implications on the forest sector:

- an acutely imbalanced regional development of the country,
- a steady increase in the demand for forest products,
- an increase in environmental pollution problems, specially in the large cities and their environs,
- serious shortages of energy and water supply in the cities,
- conversion of agricultural land to urban areas and infrastructure facilities, and
- an increasing pressure on the use of the forests located close to the cities for recreative purposes.

13. Aims and Method

The main purpose of this paper is to present a summarized overview of Latin American forest resources in 1980, and a short description of the main forest products that they have generated during the 20 year period up to the year 1983. The growth of production, imports and exports of these products is also analyzed and figures for apparent consumption presented. Finally, some comments are added concerning the short range perspectives.

This review is far from being complete. It attempts only to take a balanced look at the actual situation of the Latin American forest sector, its trends during the past twenty years and some of its main constraints.

The concept of forest sector used in this review has been employed in the same broad sense it commonly receives in Latin American countries: the summation of forest resources with their primary industrial processing and commercialization, mainly consisting of production, distribution and consumption of the following products: sawnwood, wood-based panels, wood pulp and paper.

This paper is based on information concerning quantitative data, features, problems and tendencies prevailing in the Latin American forest sector. Such information is distributed through a large number of issues published by countries, international agencies or individual researchers.

Twenty six countries and one territory (French Guiana) are included in this synthesis (Figure 2). These countries embrace an area of 20.2 million km^2 (excluding inland water), and represent 99.85 % of the existing territorial area between 32^{o} 45' North (the northern point of the North Mexican border) and 55^{o} 50' South (corresponding to the latitude of Cape Horn). More than 70 % of this land surface is located between the Tropics of Cancer and Capricorn.
The data are listed separately, by country, but their summation and the subtotal of the three groups are also



1 Mexico	10 Cuba	19 French Guiana
2 Guatemala	11 Haiti	20 Brazil
3 Belize	12 Dominican Republic	21 Ecuador
4 Honduras	13 Jamaica	22 Peru
5 El Salvador	14 Trinidad Tobago	23 Bolivia
6 Nicaragua	15 Colombia	24 Paraguay
7 Costa Rica	16 Venezuela	25 Chile
8 Panama	17 Guyana	26 Argentina
9 Bahamas	18 Suriname	27 Uruguay

Figure 2. Location of the twenty six countries and one territory included in this paper.

given. The countries are listed in the tables of this study in accordance with geographical ranking, from north to south. Three regions were formed:

1. Central America, Mexico and the Caribbean region: this first region contains fourteen countries accounting for 13 % of the Latin American total land area and also 13 % of its forest area. These countries have the highest sub-continental population densities, averaging about 44 inhabitants/km^2. This region is formed by the following countries: Mexico, Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Bahamas, Cuba, Haiti, Dominican Republic, Jamaica and Trinidad and Tobago.

2. Tropical South America region: formed by ten countries with 68,7 % of the subcontinents' land area and 81 % of its natural forest area. The population density of these countries averages 14 inhabitants/km^2. The countries of this second region are: Colombia, Venezuela, Guyana, Suriname, French Guiana, Brazil, Ecuador, Peru, Bolivia and Paraguay.

3. Temperate South America: includes three countries, Chile, Argentina and Uruguay, that account for 18,2 % of the Latin American total land area and 6 % of its forest area. This is the region with the lowest population density, 11,2 inhabitants/km^2 .

A complete list of the countries and territories not included in this paper is found in Annex 4.

The low quality of most of the forest sector data available for Latin American countries is the main constraint to the drawing of highly reliable conclusions.

The features of Latin American forests, by country and by group of countries, have been summarized in a descriptive way. A distinction has been drawn between the following different woody vegetation types: closed forest, open forest,

shrub, other woody vegetation and man-made plantations. Such a distinction is based on the classification and definitions used by FAO & UNEP (1981), and on data recently published by the United Nations' Food and Agriculture Organization, FAO (1984) (Table 2).

A review of deforestation, degradation, removals, plantations and some institutional aspects of forestry has been included. However, only brief comments are made on the future trends in forest resources.

The analysis of the forest industry products generated by Latin American countries refers to the following products: sawnwood, wood-based panels, wood pulp and paper and paperboard. This analysis, made by country and by country group, is based on FAO data (FAO 1976, 1985 a) and embraces the twenty year period, 1963 - 1983. The production, imports, exports and apparent consumption of these products have been reviewed for this period. Due to the high annual variation existing in most of these variables, average values for the last three years have been used for describing their present situation.

The change in, or growth of, every analyzed variable have been studied during the twenty-year period (1963 - 1983), and also during the last five-year period (1979 - 1983). Growth was calculated as the annual average rate, determined according to the following equation (1):

$$(1) \quad i = [(V_n - V_o)^{1/n}] - 1$$

in which:

i = annual average growth rate
V_n = final value of the variable
V_o = initial value of the variable
n = number of years of the period

The final and the initial values for the twenty-year period calculation were the average of the last three years in the period and the average of the first three years, respectively, due to the high variation in the figures.

The apparent domestic consumption by product and by country was roughly defined according to the following equation (2):

(2) Apparent Consumption = (Production + Imports) - Exports

Comments concerning the short-range perspectives (up to the year 2000) of the forest products analyzed in this paper are also included. They are principally based on FAO projections (FAO 1986).

2. ACTUAL FOREST RESOURCES

21. Forest types

Forest can be defined as an ecosystem characterized by a more or less dense and extensive tree cover (Ford-Robertson 1971). The forests of a continent can be grouped according to their composition and other relevant characteristics, into different types.

Latin America contains a wide variety of forest types, ranging from very wet rainforests to arid forests. Figure 3 indicates the main forest types of this subcontinent in highly generalized form (Cartographic Laboratory of the University of Wisconsin-Madison, cited by Denevan 1980). A more detailed vegetation map of South America is presented in Figure 12 (Annex 6).

Figure 3 shows that tropical forests and seasonal forests constitute the prevailing type in the subcontinent, specially in the northernmost part of South America and in Central America, the Caribbean region and Mexico. Also mixed subtropical and mixed temperate forests - called mid-latitude mixed forests in Figure 3 - cover vast areas in southern Brazil, Paraguay, Uruguay, northern Argentina and southern Chile. Open forests and tropical savannas are extensive in Brazil, Venezuela, Colombia, the coastal region of the Guyanas and Central America. Formations dominated by shrubs are found in the northeast of Brazil, in Mexico, in the Chaco region (Argentina, Paraguay and Bolivia) and in the central part of Chile.

The next two sections in this chapter concerns the natural woody vegetation types of Latin America, as defined and estimated by FAO & UNEP (1981) and Lanly (1982), who subdivided them into the following main classes:

i) Closed forests,
ii) Open or mixed forests,
iii) Forest fallow of closed forests, and
iv) Shrub formations.

i) Closed forests: forests with closed canopy, which have not been cleared in recent years and in which the undergrowth does not include a continuous dense grass layer. They are often multistoreyed forests and may be constituted by mixed or pure stands (the latter are very scarce but valuable). This type may include rainforests, very humid forests, seasonal or "monsoon" forests, premontane forests, mixed temperate moist forests, temperate and humid cold forests, tropical or temperate coniferous forests, etc.
This type has been subdivided into broadleaved closed forests and coniferous closed forests, according to their species composition and dominance.

ii) Open or mixed forests: mixed broadleaved forest - grassland formations, which have an understorey of continuous dense grass of which more than 10 % must be covered by the canopy tree projections.

iii) Forest fallow of closed forest: stands derived from the clearing of patches of closed forests, consisting of a mosaic of secondary forests in different phases of reconstitution.

iv) Shrub formations: in which the predominant vegetation consists of shrubs. The estimated area covered by this type of vegetal association, 170 million ha, is only a rough approximation because it is difficult to make distinctions between them and open sclerophyllous forests and savanna formations. Of the area covered by shrubs in Latin America, 80 % is concentrated in the arid and semiarid lands of Mexico, Northeast Brazil and North Argentina.

Total natural woody vegetation is the sum of the above four types of woody vegetation. Table 2 shows that 64 % of Latin America's total land area is covered by woody or shrub formations. Of this total - i.e. total natural woody vegetation - 54 % corresponds to closed forests, 24 % is covered by open forests, 9 % is under closed forest fallow and 13 % under shrub formations and open forest fallow.

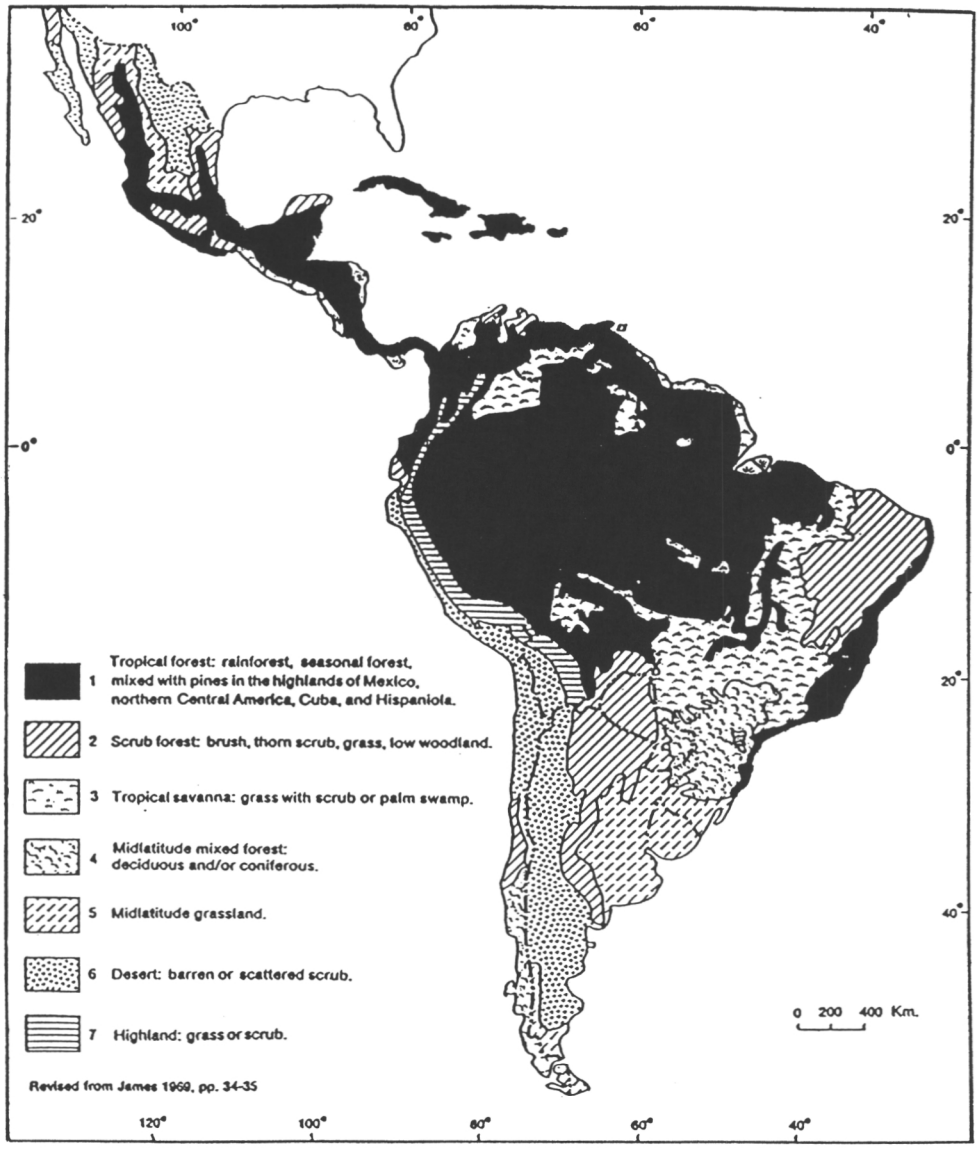


Figure 3. Main forest types of Latin America.

Source: Cartographic Laboratory, University of Wisconsin-Madison (cited by Denevan 1980).

Table 2. Estimated area of woody vegetation in Latin American countries in the early 1980's.

	Natural Closed Forest	Natur. Open Forest	Closed & Open Forest	Share broad_ leaved	Total woody veget.	Plan- tati- ons	Annual rate of defor.
	-------1000 (ha)-------			(%)	--1000 (ha)--		(%)
Mexico	46250	2100	48350	59	133850	159	1.2
Guatemala	4442	100	4542	85	6407	16	1.8
Belize	1354	92	1446	93	2017	3	0.7
Honduras	3797	200	3997	51	5897	0	2.5
El Salvador	141	0	141	72	456	2	3.2
Nicaragua	4496	0	4496	93	6076	1	2.5
Costa Rica	1638	160	1798	100	2038	3	3.7
Panama	4165	0	4165	100	4289	4	0.7
Bahamas	#	#	263	#	263	#	#
Cuba	1455	0	1455	83	2460	157	0.1
Haiti	48	0	48	76	144	1	3.8
Dominican Rep.	629	0	629	70	950	6	0.5
Jamaica	67	0	67	90	453	13	2.2
Trinidad Tob.	208	0	208	97	271	16	0.6
Subtotal 1	68690	2652	71605	67	165571	381	1.4
Colombia	46400	5700	52100	100	66100	95	1.7
Venezuela	31870	3300	35170	100	47940	125	0.4
Guyana	18475	25	18500	100	18815	1	0.0
Suriname	14830	690	15520	100	15990	9	0.0
French Guiana	8900	70	8970	100	9052	1	0.0
Brazil	357480	211200	568680	100	676300	855	0.4
Ecuador	14250	550	14800	100	18200	43	2.1
Peru	69680	1120	70800	100	79300	84	0.4
Bolivia	44010	24700	68710	100	78810	26	0.2
Paraguay	4070	28640	32710	100	35980	3	3.9
Subtotal 2	609965	275995	885960	100	1046487	4242	0.5
Chile	10900~	4560~	15460	93	16792	830*	0.5~
Argentina	6675~	13640~	20315	97	60015	530*	0.5~
Uruguay	420~	139~	559	96	1117	150*	0.2~
Subtotal 3	17995~	18339~	36334	96	77924	1510*	0.5~
Total	696650	296986	993899	97	1289982	6133	0.6

Source: FAO & UNEP (1981) and FAO (1984).

Forest plantations were also included in an additional item in Table 2. They cover an area of 6.1 million ha, which is equivalent to 0.3 % of the total land area of this sub-continent, and 0.5 % of natural woody vegetation. The mean annual rate of deforestation in Latin America reaches 0.6 percent.

The respective volume growth of these forest types is almost unknown. Since the available growth information is scarce and often refers only to some selected species, general conclusions cannot be drawn. However, the broadleaved forests have a higher volume growth than coniferous ones. It is estimated that the growth of the commercial volume in the tropical natural forest is less than 1 m^3/ha/year (FAO & UNEP 1981).

22. Natural Woody vegetation

When describing natural forest resources in Latin America the following type of forest associations deserve special attention: i) broadleaved closed formations, ii) forests dominated by conifers, and iii) open forests. Of course, the diversity within each of these associations is wide.

i) Broadleaved closed formations:

Broadleaved closed formations are the dominant forest of Latin American and they are widespread over an area of 680 million ha. These formations comprise a number of different types of forest: the tropical rain forests, the diverse premontane forests which covers the slopes of the Andean mountains, the temperate rain forests of southern Chile and Argentina and the deciduous summer forests of Patagonia and Tierra del Fuego. However, the moist tropical lowland forests are the most abundant broadleaved closed formations. These types of forest form very complex ecosystems, composed of a great variety of woody vegetation, epiphytes and other plant species that give shelter to a rich fauna. Polunin (1960) states that there are over 2500 different tree species in the Amazonian forests alone. These luxuriant evergreen forests

are also characterized by their high density and multistory development. These heterogeneous forests occur mainly in flat or rolling areas with weak seasonal variations and high annual precipitation (which may reach more than 4 000 mm. annually).

A significant part of these tropical rain forests are located in areas of difficult access: e.g. the Amazonian basin, and also in the Orinoco and Parana basins. They can also be found in Mexico, Central American and Caribbean countries, in the eastern coastal region of South America below the Tropic of Capricorn and, westward along the Pacific Ocean coast of Colombia and Ecuador. It is even possible to find this type of forest in some Andean submontane areas, in places where the transition to broadleaved deciduous forests commonly occurs.

The main factor affecting the distribution of closed forests appears to be moisture, the annual amount of rainfall and its seasonal distribution. These complex ecosystems are, in their natural conditions, in a dynamic equilibrium and disruptive human intervention can easily exceed the capacity of closed forest regulatory processes and destroy their equilibrium (Myers 1980).

Brazil has more than 50 % of the Latin American broadleaved closed forests and Peru, Colombia, Mexico, Bolivia and Venezuela are also countries in which this vegetal association is abundant. It is estimated that almost 80 % of these forests are productive. The main reasons for non-productivity are physical (FAO & UNEP 1981).

Although a high proportion of this formation consists of primary forests, there are also extensive areas of secondary forests which have originated from shifting cultivation or selective cuttings of a few commercial species, and consequently an extraction of low woody volume from the former virgin natural forests. Their density is usually high, the stem volume varying between 100 and 300 m^3/ha, and it is

indeed rare to find this type of forest under any kind of management system.

Most of the internal dynamic development aspects and the potential use of these vast forest resources are still being studied.

The forest fallow of this association - not included in the column "Natural closed forests" of Table 2 - accounts for about 15 % of this forest type. The countries most affected by shifting cultivation are Jamaica, Paraguay, Mexico and Cuba. However, it is practiced extensively in almost all tropical countries of Latin American.

ii) Forests Dominated by Conifers

These forests cover approximately 28 million ha, being mostly closed forests (more than 70 %). Coniferous forests are found in mountainous regions in humid subtropical climates, in wet temperate maritime climates and even on cold sites of the Andes mountains where they are often mixed with temperate hardwood species. They can also be found in tropical regions where drought restricts the growing season to part of the year. Coniferous forests usually form extensive associations which contain relatively fewer species than the broadleaved dominated forests. Forests dominated by one or less than three coniferous species are common.

There are four important sets of coniferous forests in Latin America. The major set is formed by the pine forests - several native pine species - of Mexico, Central America and the Caribbean region, constituting more than 80 % of the Latin American coniferous forests. The Araucaria angustifolia forests that are located on the border between Brazil and Argentina have earlier been a very important source of timber for those countries, but are now confined to a restricted area. There is a small residual area covered by Podocarpus forest along the border between Peru and Ecuador, and a remnant of Araucaria araucana forests in the southern region of Chile.

It is estimated that while 60 % of coniferous forests are productive, over 90 % of them are secondary formations generated by at least one intervention of the primary forest. The majority of these forests could be characterized as sparse and strongly affected by overexploitation, overgrazing, forest fires, insects and diseases (FAO & UNEP 1981). The conversion and degradation of coniferous forests are even greater than the corresponding processes that have affected broadleaved forests. An extreme case are the Araucaria angustifolia forests, which have been reduced in area by 90 % during the last 50 years (FAO & UNEP 1981).

Few of the coniferous dominated forests in Latin America are under any form of management. It has been estimated that of pine forests, only half a million ha are managed in three countries: Nicaragua, Cuba and Honduras (FAO & UNEP 1981). There are also some minor managed areas of Araucaria forests in Brazil and Argentina. The mean volume of all coniferous forests is estimated at 75 m^3/ha (McGaughey & Gregersen 1983).

Natural regeneration of some of the coniferous dominated forests is difficult - e.g. the Araucaria and Podocarpus genus - and there has been a particularly rapid change in land use in the area occupied formerly by Araucaria angustifolia forests. Consequently, we can infer that the coniferous dominated forest fallow covers very few areas in South America. However, in the Central American and Caribbean countries the situation is quite different. Mexico has large areas of coniferous forest fallow. The area of fallow is proportionally even larger in Haiti, Belize and the Dominican Republic.

iii) Open Forests

Open forests correspond to less complex vegetal associations than the closed ones, and are usually present in regions with lower humidity and with higher seasonal variation (at least with a marked dry season). These forests have usually a lower density and height than the broadleaved closed formations.

This means that a higher proportion of the light reaches the forest floor, thus permitting development of a dense undergrowth. The existence of such a continuous herbaceous vegetation provides easy access for cattle into the forests. Open formations are also prone to forest fires.

It is possible to state broadly that the ecosystems of open forests are structurally more simple and less fragile than those of closed forests and, consequently, they are more resistant to human intervention. Even so, an important share of these forests have been overexploited and degraded by overgrazing or fire and they can be classified as old or young secondary forests. However, sometimes there are difficulties in distinguishing these kinds of forest from the savanna and shrub formations. They can be delimited by considering the physiognomical characteristics of the vegetal associations. An important aspect is the determination of the dominant vegetation: trees, shrubs or herbaceous communities. However, the repeated fires that usually affect these types of association at variable intervals, make the distinction more difficult. Once the original forest has been repeatedly burned, several vital characteristics of the ecosystem, essential for its regeneration, are irreversible altered and the natural secondary succession may tend towards savanna, which is maintained as such as a permanent disclimax (Sarmiento & Monasterio 1975).

These open forests, also called mixed woody associations, include different forest types: Brazilian "cerrado" formation, savanna forests, "chaqueño" forests, most of the "caatinga" and "pantanal" associations, part of "mezquitales" forests and the sclerophyllous forests of Central Chile. Even part of the Andes montane forests and Patogonian forest can be considered as open formations. Brazil has more than 70 % of the almost 300 million ha of Latin American open forests, while Paraguay is the only subcontinental country in which this kind of forest is dominant (it constitutes almost 80 % of this country's woody vegetation). Open forests also cover considerable areas of Bolivia and Argentina. The open forests of those four countries account for almost 95 % of Latin

American open forests. On the other hand, this type of formation is missing in several Central American countries. The column "Natural open forests" in Table 2 includes open forest fallow.

23. Deforestation and degradation

The deforestation concept employed in this work is defined as the felling of closed and open forests for a use other than forestry. The usual result of such forest clearance is the immediate conversion of cleared land to uses like permanent agricultural, grazing or infrastructure constructions, or its abandonment after some years of shifting cultivation. The latter usually leads to the eventual establishment of a secondary forest, initially characterized by a few pioneer plant and animal species; diversification occurs later.

The deforestation percentages included in Table 2 are derived from FAO & UNEP (1981). These figures have been selected in spite of the criticism they have received (e.g. Palo & Mery 1986). Although the figures are lower than those presented by other researchers (Sommer 1976, Persson 1977, Lanly & Clement 1979, Myers 1980), they are the most detailed, uptodate figures available and have been compiled after an extensive recollection and checking of the information.

The deforestation of tropical Latin American closed forests is estimated to have reached 4,3 million ha annually for the period 1976-1980 in all 27 countries. This represents an annual deforestation rate of 0,6 percent. The projected annual deforestation of closed forests for the period 1981-1985 would have reached 4,6 million ha in this tropical zone, the annual deforestation in open forests being estimated at 1 million ha. Adding the annual deforestation of temperate South America - estimated in this study at 0.16 million ha - the total annual deforestation in the Latin American countries during the period 1981-85 is estimated at 5.7 million ha, and equivalent to an annual deforestation rate of 0.6 percent in closed and open forests.

The deforestation phenomenon is more intense in coniferous forests, where it has reached an annual rate of 1,25 % (FAO & UNEP 1981). In the scarce, pure broadleaved stands this rate is even higher.

In the remaining forest types there are, and have been, other important disruptive processes, but only very crude estimates of these are available.

Deforestation is specially serious in Paraguay, Haiti, Costa Rica and El Salvador. In these countries, the annual rate of closed forest clearance is over 3 percent. Deforestation is also severe in Honduras, Nicaragua, Jamaica, Ecuador, Guatemala and Colombia, countries in which the annual rate exceeds 1,5 percent. Deforestation is insignificant only in Guyana, French Guiana and Suriname. In the remaining countries, the annual rate varies from 0.1 to 1.5 percent.

Deforestation produces both benefits and drawbacks, according to the interest of the individuals affected. The balance between both potential effects is jeopardized by the fact that they are not evenly distributed, either in time or in space (Poore 1976).

The clearance of a patch of forest may release more land for temporary or permanent agricultural cultivation, land for grazing, sites for settlement, roads, etc; activities which may be considered to be beneficial because they may promote a socio-economical development in the region.

Of the drawbacks, the following are typical: loss of valuable commercial forests, erosion and rapid loss of soil fertility - at least in areas not suitable for sustainable agriculture or grazing - increasing shortages of industrial roundwood supplies, shortages of firewood, extinction of species and consequently reduction of the genetic pool, environmental deterioration, etc. These disbenefits often lead to the emigration of the indigenous people as a result of being deprived of the environment in which they have traditionally lived. This, in turn, leads to unemployment for poor peasants

and landless rural workers, and to a reduction in the income levels of the local population. There are also a large number of indirect effects of deforestation that are difficult to evaluate, such as the impact on the atmospheric carbon dioxide balance (Woodwell et al. 1983), microclimatic changes, and the alternate succession of floods and droughts, etc.

Deforestation caused by natural agents, e.g. diseases, insects, natural fires, prolonged droughts, storms, floods, volcanic eruptions, etc., is very limited in comparison with that due to human actions.

A high proportion of the disruptive human activities that have caused rapid disappearance of forests are unplanned and usually follow a slash-and-burn pattern of land use that produces serious damage to the natural vegetation, animal life and causes changes in the carrying capacity of soils. Deforestation is doubtless a very complex phenomenon that requires a comprehensive view in order to gain a full understanding. This was Palo's (1984) target when he formulated a provisional theory of tropical deforestation. He describes five main groups of factors considered to affect deforestation : economic development, population pressure, political factors, traditional factors and natural factors. Deforestation is also assumed to be a cumulative and even accelerating process. Some of the assumptions of this theory have been supported by the results of tentative correlations analyses performed by Palo & Mery (1986).

Researchers do not always differentiate between the causes and agents of deforestation. Shifting cultivation, overgrazing, and firewood gathering are usually mentioned as the main "causes" of deforestation (e.g.: Watters 1971, Myers 1980, Lanly 1982 and 1985, Allen & Barnes 1985). However, they are merely agents or the direct results of the socio-economic rural inhabitant's behaviour caused by the dramatic constraints existing in the rural side of these under-developed societies. Deforestation ought to be basically considered as a socio-economical problem (Westoby 1978 b,

Simula 1986, Mery 1986). The real causes lying behind these agents, pushing them in one direction or another, have to be identified if we wish to make decisive steps towards the reduction of this problem.

Six causal factors should be stressed when we speak about deforestation in Latin American countries: underdevelopment, the skewness in the land ownership distribution, the low commercial value of most natural forests, the external national debt, political instability and institutional weaknesses.

1) Most of the Latin American countries are affected by socio -economic underdevelopment and certain colonial or neocolonial development phenomena, such as the cash-crop criterion: the rapid attainment of profits without due consideration to the actual misuse of the natural resources and its future consequences. These phenomena are a result of the short-term planning horizons imposed by the dominant economical and political paradigm, and by the pressures of external forces interested in maintaining the situation. These forces, well represented by the international financing agencies and by the leading conglomerates in the international forest product markets, obtain profitable advantages from the prevailing, extremely inequitable trade relationship between developing countries - exporters of primary products - and developed ones - exporters of processed products.

2) The history of land settlement has followed a specific pattern in each country. However, it has produced a common result in most of them: a distinct skewness in the land ownership distribution. This uneven historical pattern of land ownership has been reinforced by the prevailing export-oriented agriculture and cattle raising, the main goal of which is to produce exportable goods and high profits. Consequently, the production of less profitable goods aimed at satisfying the domestic requirements of the country is often neglected. The wide extent of such businesses - well illustrated by Myers (1981) - has turned

land into a valuable commodity and has led to a rapid concentration of land in the hands of a few landowners, who commonly operate on an extensive basis to avoid higher investments. Therefore, the number of rural poor deprived of agricultural land has increased in almost all Latin American countries. Most of the rural landless have to survive by choosing between two options: to go into the virgin forest and practice shifting cultivation, or emigrate to the slums of the cities with the hope of escaping starvation (Spears & Ayensu 1984).

3) With the increasing scarcity of arable land and rural development, the low monetary value of natural forests is a direct cause of their rapid conversion into agricultural or grazing land irrespective of the land's carrying capacity. The main factors preventing the commercial utilization of natural forests are:
i) their floristic composition: diversified tree associations are typically associated with tropical and subtropical areas and most of them have a very limited commercial volume per unit area. After selective cutting-when profitable - the natural forests are often considered to be unproductive,
ii) high exploitation cost per unit area due to the low yield and scarcity of required transport infrastructure (roads, railway network, harbour facilities, etc.), and
iii) the lack of research and gaps in the technological development of most Latin American countries has led to a heavy reliance on technologies imported from developed countries. Such transferred technologies are very often poorly adapted to the characteristics of the natural forest resources of this subcontinent, and hinder their more complete utilization.

4) The burden of external debt that affects most Latin American countries has forced their governments to promote exports, and to produce substitutes of traditionally imported products, with a minimum of investments. In the case of forest products, the non-tangible benefits generated by natural forests are disregarded. However, an

export boom has not occurred due to the remoteness of most natural forests and the lack of infrastructure. Another important factor is the lack of competitiveness of commercial forest products harvested from natural forests. These forest products cannot compete with the prices of plantation forest products both in the internal and external markets, except for a few highly valued species or some special products. The usual existence of monopsonistic purchase-sale powers in both markets aggravate the situation. A tendency to replace areas covered by natural forest with forest plantations of fast-growing species is increasing.

5) The political instability and the precarious development of democracy reinforces the tendencies and "values" described above, and are often reflected in the growth of corruptive elements. Of numerous examples of the latter, only the following need be mentioned:
i) government officials often fix the timber prices of state-owned forests at a low level, or allow illegal exploitation in public forests in exchange for personal gain,
ii) lack of effective control of regulations concerning cutting and reforestation, and
iii) arbitrary distribution of forest concessions. These facts are often direct consequences of the partnership between politicians and timber company businessmen, big land-owners and the military elite.

6) Institutional weaknesses and lack of research further hinder the development of ways and means of solving the deforestation problem. Effective planning and the implementation of programs of improved alternative uses of forest resources under management are problematic and slow.

One difference between deforestation and degradation should be stressed. Degradation may be defined as the partial elimination of the tree cover, producing a forest which partially covers the site but which in structure and

floristic composition is poorer than the original virgin forest (the climax vegetation). This phenomenon often leads to soil denudation. Many soils, like tropical podzols, lateritic soils or soils on steep slopes, need to be covered by a permanent tree canopy that protects them from direct solar radiation and from the impact of raindrops. Vegetal degradation often produces rapid changes in the structure and biological composition of the soil, as well as the soil's microclimate and its moisture retention capacity. Different degrees of nutrient losses (through leaching), compactation, run-off and flash floods during the rainy season, as well as erosion, may be the final results of this process. Furthermore, it must be borne in mind that in the majority of these tropical and subtropical ecosystems most of the available nutrients are generated by the rapid decomposition of the biomass, and the soils have only a residual fertility. When this biomass is burned, the direct result is the accumulation of ash - rich in mineral elements - on the soil surface, which is often rapidly lost through the action of water or wind erosion. Consequently, vegetal degradation leads to a reduction in site fertility and often causes a backward step in the vegetal association succession, recuperation from which may be slow or unpredictable. Under a stress caused by continuous human intervention, degradation may ultimately cause deforestation.

This process is generated by much the same forces that are promoting deforestation. Of the main agents of degradation, the following should be mentioned: the uncontrolled use of fire, overgrazing, excessive fuelwood gathering and selective cuttings. Also some natural agents influence degradation, but their impact is of minor importance.
There are no reliable quantitative estimates of the area affected by degradation, but there is strong evidence that its consequences are affecting extensive areas in all kinds of forest regimes.

24. Removals

The removals statistics of Latin American countries are not very reliable. The volumes extracted for fuelwood and charcoal production are only rough estimates, and FAO's industrial roundwood statistics do not include the volumes that have been logged illegally; volumes which in some countries can be significant.
However, it is possible to state that most (about 74 %) of removals made in these countries are destined for energy consumption. The total roundwood production of Latin American countries reached approximately 340 million m^3 in the early 1980's. A sustained increase in roundwood production has been observed during the period 1963 - 1983 for the whole sub-continent, the annual average growth rate for the period being 1.8 percent.

The harvesting methods vary from country to country, as well as regionally inside each country according to the type of forest and the product that is being harvested. Most removals aimed at producing fuelwood are made by gathering small trees, shrubs or harvesting wastes. The industrial production of fuelwood and charcoal often uses heavy equipment.

The estimate of total fuelwood and charcoal production in the early 1980's was approximately 250 million m^3. The share of fuelwood out of the total roundwood production has diminished from 86 % in 1963 to 73 % in the 1980's, and the proportion of this combustible in total energy consumption has declined from 29 % in 1970 to 21 % in 1980 (according to the Latin American Energy Organization, cited by Keipi 1985). However, the absolute quantity of fuelwood production has slightly increased at a rate of 1,1 % annually during the last 20 years.

The countries which have higher fuelwood consumption figures per inhabitant are: Paraguay, Brazil, Honduras and French Guyana (1.4, 1.3, 1.1 and 1.1 m^3/capita/year, respectively).
It is necessary to bear in mind that fuelwood gathering has

been shown to be an important deforestation and degradation agent, especially in open forests.

Most fuelwood consumers are rural dwellers that use it for heating their homes and cooking. FAO figures concerning the actual scarcity of fuelwood and especially the prospects for the near future, give cause for concern: "the number of rural people who cannot obtain enough fuelwood or can do it only by cutting wood faster than it is growing" was 161 million in Latin America in 1980, but may reach 342 million by the year 2000 (FAO 1985 c). Fuelwood shortage is specially acute on the Andean plateaux, in the more arid regions and around villages and cities. Behind the statistics of fuelwood scarcity, there is a human drama (women and children, who are usually responsible for heating and cooking, being the first to suffer), which has many-sided effects in the whole rural socio-economical system.

Fuelwood is rarely used as a source of industrial energy. The most notable exception is Brazil, where it is estimated that around 38 million m^3 of wood are harvested annually for industrial purposes (mainly for the iron and steel industry).

The annual average industrial roundwood production during 1981-83 was 90 million m^3, a quantity which has increased during the last twenty years at an annual rate of 4.8 % (Table 6.1, Annex 2). The annual industrial roundwood production per hectare of productive closed forest in tropical America is only 0.06 m^3/ha/year (FAO & UNEP 1981). This is 1/18 of European production: a clear sign that the Latin American forests are underutilized.

Virtually all the industrial roundwood production is destined for internal consumption (Figure 4, in which production and consumption curves overlap), except for Chile which is unique in being a net exporter (about 0.8 million m^3/year).
The main producers of industrial roundwood in the early's 1980's were Brazil (64 %), Chile and Mexico. These three countries together account for 80 % of the total production (Figure 7 A).

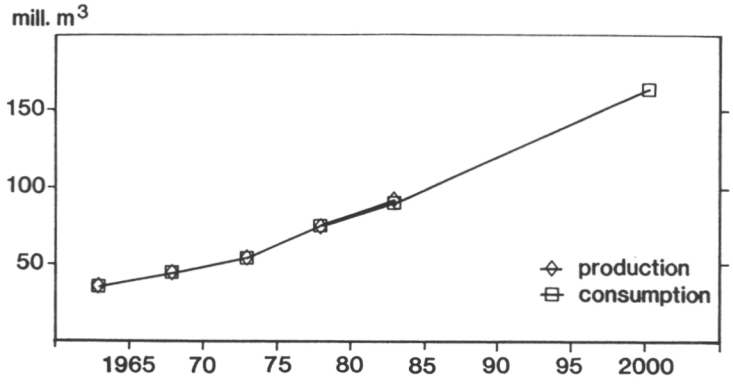


Figure 4. Industrial roundwood production and apparent consumption of Latin American countries during the period 1963 - 83, and projections up to the year 2000.
Source: FAO (1976, 1985 a, 1986).

It should be pointed out that a decrease in the rate of production has occurred during the last five year period, 1979 - 1983. Imports are insignificant.

The extraction of trees for industry affects different species according to their final use: broadleaved species from tropical or temperate forests are mainly raw material for sawmills, veneer and plywood mills. Their extraction is often highly selective (commonly 5 - 15 m^3/ha), but the loggers commonly use heavy equipment that can cause considerable disruption to these forest ecosystems. According to Myers (1981) half of a logged stand can be damaged beyond recovery.
Roundwood for pulp mills and wood-based panel factories are mainly harvested from forest plantations or coniferous forests. These forests also supply about 50 % of sawlogs. Clearcutting is the most common harvesting technique in the pure stands.

The prospects up to the year 2000 reveal that the production of industrial roundwood will continue increasing at a rate of about 5 % annually, and the supply will be in balance with

the national consumption. However, the ratio between hardwood and softwood (actually 4:3) will probably change, mainly due to the exhaustion of pine forests in Mexico and Central America and araucaria forests in Brazil and Argentina. Some of these countries have become, or will very soon become, net importers of softwood. The main sources from which they could be supplied are the Chilean Pinus radiata plantations and the Central American pine stands or some source outside Latin America.

25. Forest plantations

Most of Latin American forest types will regenerate naturally after clearance if they are left untouched. But, for how long a time it takes for a succession to reestablish something similar to the original climax type, remains an open question. In practice, this successional process often produces a secondary forest, provided that devastating erosion does not occur after the clearance. Due to the high diversification of most of the climax types occurring in tropical and subtropical areas, as well as to the existence of some impediments to natural regeneration - like inefficient dispersal mechanisms of a number of species or the short period of seed viability in others (Poor 1976) - secondary forests tend to diversify slowly and consequently they often persist for long periods (Polunin 1960, Gómez-Pompa et al 1972, Poore 1976). Unfortunately, there are no figures on the areas that are annually regenerated naturally in this subcontinent.

The statistics concerning forest plantations are reliable, and the planted areas have increased steadily during the last twenty years. The total amount of plantations in 1980 comprised 6.1 million ha (FAO & UNEP 1981), the annual amount of plantations being actually about 0.64 million ha.
However, these efforts are not enough to compensate for the losses of tree cover caused by deforestation. Table 3 shows the projected rate of forest plantations for 1981-1985 estimated by FAO (cited by The Inter-American Development Bank 1983), compared with the areas annually deforested in

Table 3. Comparison between annual planted and deforested area in Latin America.

	Estimated area of annual		
	Deforestation (1000 ha)	Plantations (1000 ha)	Annual Plantation/Deforestation Ratio
Central America, Mexico and Caribbean	940	42	1:23
Tropical South America	4140	440	1:9
Temperate South America	160	160	1:1
Total	5240	642	1:8

Source: Inter-American Development Bank (1983) and FAO & UNEP (1981).

1980 (FAO & UNEP 1981), by groups of countries. The ratio is only acceptable in the temperate region of South America and it is quite unfavorable in the others regions.

Forest plantations in Latin America are highly concentrated: Brazil has approximately 60 % of the total area planted, and 85 % of these plantations have been established in Brazil, Chile and Argentina (Table 2).

Most plantations are young, and they have been established to supply industry with roundwood for wood pulp, woodbased panels and industrial charcoal production. Sawlogs are also supplied. Forest plantations with a protective or conservation role account for less than 10 % of the total area planted, and cover extensive areas only in Mexico, Peru and Bolivia.

The major part of industrial plantations form compact and rather extensive mass of rapid growing exotic species. Plantations of coniferous species amount to 42 %, mainly consisting of P. caribea, P. radiata, P. elliottii, P. taeda, P. patula and P. oocarpa. Also Cupressus spp and Araucaria

angustifolia have been planted. The most used broadleaved species are Eucalyptus spp., Populus spp, Alnus spp and Salix spp (FAO & UNEP 1981).

The yields of the forest plantations vary widely, according to species, site, management practices adopted and other relevant characteristics, but they are generally fairly high. For example, Eucalyptus spp may exceed 60 m^3 per hectare per year in plantations established on good sites and managed using adequate systems (Galvao & do Couto 1983). Yields of most of forest plantations could be further improved if better planting and management techniques would be applied.

While the area covered by industrial plantations is less than 1 % of the total productive forest area, these plantations are nowadays providing 30 % of the industrial roundwood produced in the whole subcontinent (Keipi 1982). One reason for this high productivity is that the plantations are located in regions of easy access, they are usually established around the centers of industrial consumption and they are not in regions where deforestation is serious (Lanly 1982). They also yield a high volume of homogeneous fibre material per unit area and usually have a short rotation period. Further, they often cover extensive continuous areas. These facts lead to a drastic reduction in management and harvesting costs in comparison with those of natural forests (Salcedo 1983).

Special government programs of subsidies, tax exemptions or legal dispositions for non-expropriation of planted lands have had an important impact in promoting forest plantations. It is estimated that the rate of annual reforestation and afforestation will continue increasing, so that by the year 2000 more than 50 % of the total industrial roundwood production will be supplied by these artificially regenerated forests.

It must be emphasized that reforestation or afforestation programs are important in supplying raw material for forest industries. This obviously places less cutting pressure on

the natural forests. However, most of the plantation activities are implemented on land recently covered by natural forests. The projects aiming at recuperating already uncovered areas - like AMCEL in Brazil (McDonald & Fernandes 1984) - are scarce. Therefore, reforestation cannot, in isolation, be considered as a remedial policy to halt or compensate for deforestation, but as a complementary measure.

The successful plantation experience carried out in Latin America (e.g. Lanly & Clement 1979, Galvao & do Couto 1983, Hornick et al 1984, McDonald & Fernandes 1984, Silva-Reis 1986) is now facing considerable risks: the tendency to substitute natural vegetation with high-yielding exotic species has been adopted with no proper consideration of possible adverse ecological or pathological effects that may result from the use of monocultures (Salcedo 1983).

26. Institutional aspects

Virtually all Latin American countries have formulated their forest laws and/or other legal decrees that regulate forestry, and created their public forestry organizations some decades ago. However, institutional problems acutely affect the forest sector in most of these countries. These problems are, nevertheless, part of wider ones which affect the whole institutional framework of these countries. The main problems being the low development of democracy, political instability and socio-economical underdevelopment.

The main institutional constraints in the forest sector are the following:

i) lack of well-defined policy of national forest development,
ii) deficiencies in their forest laws and regulations,
iii) serious constraints in their public forestry administrations,
iv) unequal distribution of the forests and forest industries ownership, and

v) shortage of funds and staff.

In virtually all Latin American countries there is only partial, contradictory and often obsolete information about the extent, characteristics and potential of their forest resources. Under such conditions, little value is set on the formulation of a realistic national policy for forest development. It is also difficult to legislate on a topic based on insufficient information. Consequently, shortcomings in the forestry laws and legal statutes are common (Prats Llauradó & Speidel 1981, McGaughey & Gregersen 1983, Keipi 1985).

The performance of public forestry administrations is limited by several problems. According to the same authors cited above, the following limitations are typical :

i) the goals and tasks are not matched with adequate funds,
ii) legal controls are unrealistic,
iii) forest technicians and trained workers are in short supply,
iv) coordination and links with other public services are weak,
v) tasks overlap or strategies with other public administrations are contradictory - often the case with the ministries of agriculture and industry,
vi) the distribution of policies and tasks between central and regional organizations often lead to conflicts, and
vii) there is excessive concentration of available resources in the central unit to the detriment of the regional and local offices.

As result of such constraints, the ability of the public forestry administration to promote, plan, propose norms, control and administrate the public forests is often poor.
The universities and forest research institutes have increased in number and extension during the last twenty years in most Latin American countries. As result of this, the number of foresters has considerable increased. The scientific investigations on forestry have also expanded.

Nevertheless, most of forestry research programs concentrate on topics like reforestation or afforestation trials with exotic species, silvicultural treatment of plantations, management alternatives for man-made forests, timber processing and other topics mainly related to exotic species.

Very often several matters related to natural forests and the forest-based socio-economic development remain uncovered.

In spite of the fact that vocational-level training in forestry and the establishment of intermediate-level forest technicians has expanded during the last two decades, these countries very often suffer from a scarcity of forest technicians and trained manpower.

Data concerning the property system prevailing in Latin American countries is often scarce. State, private and community ownership are combined in a variety of ways in the different countries. While almost all countries have laws and regulations concerning forest ownership, they very seldom operate in practice. Extensive logging operations are often performed in areas declared as National Parks or under special management. This is the result of allowing timber concessions in such areas, or through illegal felling or spontaneous settlements.

In spite of the unreliability of the ownership data, it is possible to affirm that public ownership prevails in Latin America. Approximately 80 % of Latin American forests are declared to be in public ownership (McGaughey & Gregersen 1983). However, the majority of the coniferous forest areas of Mexico and Central America are owned by private owners or communities (FAO & UNEP 1981). In the same publication it is also stated that almost all forests in El Salvador and Haiti, and 75 % of the Paraguayan forests are private. The majority of forest plantations are privately owned.

A tendency towards increasing private ownership has been observed during the last few decades in several countries. This is due to the colonization - planned or very often

spontaneous- that has taken place in several countries. Similarly, a concentration of large areas into the hands of a few owners has recently occurred in several countries. The consequences of agrarian reform programs that have occurred in some countries have not produced any marked effects on the forest property structure.

More than 40 million ha have been declared as national parks, forest reserves and forest under special regimes, but only a few are operating adequately. However, the number of such units is actually increasing.

If a very simple definition of forest management is applied, such as the strict application of regulations on logging, silvicultural treatment and protection against forest fires and diseases, it is evident that most natural forests in Latin America are not subjected to any sort of management plan (FAO & UNEP 1981). The lack of management is especially marked in the case of broadleaved forests. However, there are signs of intensification of some management activities - specially logging control, fire prevention, national parks management plans - in several countries. At the same time, it must be said that an important share of forest plantations are subjected to some sort of forest treatment (usually extensive ones).

3. FOREST INDUSTRY PRODUCTS

The forest industry products briefly analyzed in the following paragraphs are sawnwood, wood-based panels, wood pulp and paper and paperboard. These broad categories of products were selected because they are the most significant ones in the forest economy of Latin American countries. This is not to say that the other products generated by the forests are not valuable. On the contrary, very often the production or collection of commodities like fruits, gums, resins, oils, mushrooms, medicinal plants, fodder and forage, vegetal fibers, game meat, recreational services and facilities, etc., are very important for the rural economy and welfare of local inhabitants. They are omitted from this review because country-wise statistics for them are not available. For the same reason, the intangible benefits provided by the forests, that is, their indirect ecological or social benefits, cannot be included.

The analyses, carried out for each commodity separately, are summarized. They examine production, apparent consumption, imports and exports of these four groups of products during the twenty year period 1963-83. The data were gathered from FAO's Yearbook of Forest Products (several volumes) and they are partially contained in Tables 6.2 - 6.5 (Annex 2). Also, brief comments concerning the short-range future production and trade prospects, according to FAO's (1986) world outlook projection, are given.

However, prior to starting such analyses by product, it is interesting to consider some general tendencies of the development of forest industries in Latin America.
In general terms, the development has followed the general pattern prevailing in developing countries (Kiljunen 1986): it has been strongly home-market oriented. The national demand for forest products has been basically satisfied by domestic production, even in the case of the main importing countries. Only two countries have emerged as net exporters, namely Brazil and Chile.

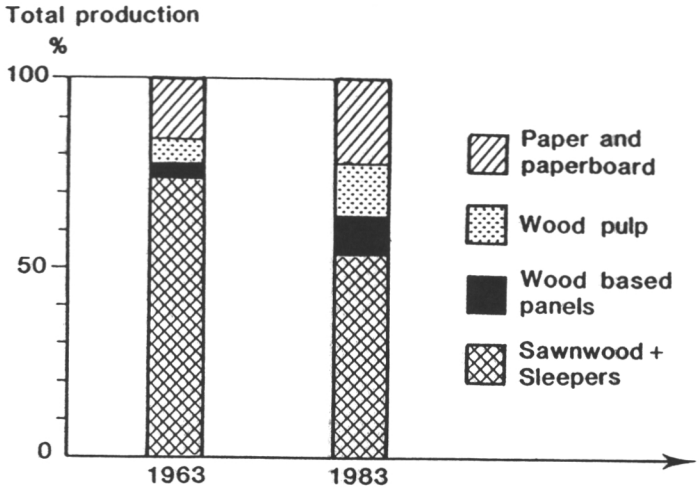


Figure 5. Forest product composition of Latin America in 1963 and 1983.
Data source: FAO (1976 and 1985 a).

During the last twenty years, production has more than doubled in almost every broad category of forest industry products. However, since consumption has expanded at the same pace or even faster, the balance between production and consumption has suffered only minor changes.

The forest industries are mainly concentrated in the mechanical wood processing sector (Fig. 5, which presents a rough estimation based on FAO's data). Consequently, the majority of the products are characterized by their relatively low value-added content. However, the global structure of the forest industries has started to be reshaped: upgrading in favour of more processed products is taking place (Fig. 5). Nevertheless, the degree of specialization still remains very low.

31. Sawnwood

Most of the industrial roundwood yielded by Latin American forests was utilized in sawnwood production, and gave employment to the major part of industrial forestry labour force. There are about 16000 sawmills, most of which are small, equipped with obsolete machinery and working inef-

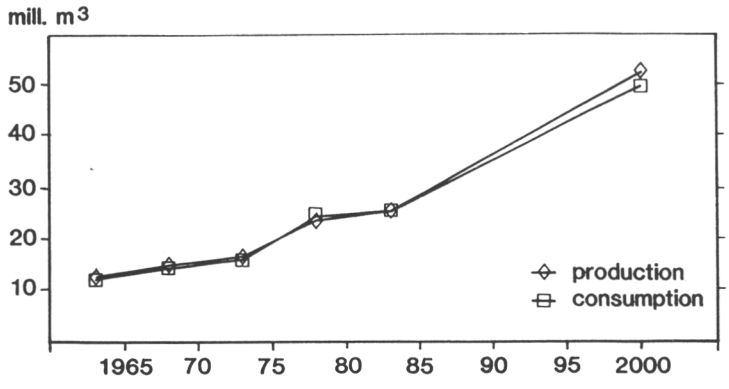


Figure 6. Sawnwood production and apparent consumption of Latin American countries during the period 1963 - 83 and projections up to the year 2000. Data source: FAO (1976, 1985 a, 1986).

ficiently (Salcedo 1983).

The total amount of sawnwood and sleepers produced by the twenty seven countries reached 25 million m^3 in 1983 (Table 6.2, Annex 2). It is surprising to note that half of the total is sawn softwood, despite the fact that coniferous forests constitute only 3 % of closed and open forests and coniferous plantations covered no more than 3 million ha at the beginning of 1980's.

There has been an increasing trend towards sawnwood production (3.5 % annually) during the last twenty years (Figure 6). The rate of increase in Tropical South America has been especially high (4.5 % annually). In Temperate South America the annual trend is more moderate (1.5 %), and in Central America it is only 1 percent. The major sawnwood producers during the early 80's were: Brazil (62 %), Mexico, Chile and Argentina (Figure 7 A). These four countries accounted for 79 % of the subcontinent's total sawnwood production.

The ratio sawn hardwood/softwood has remained almost constant during the 20 year period. However, it is probable that the proportion of softwood will start to decline as a consequence of the depletion of Brazilian araucaria and Mexican pine

forests. The fact that only half of the total production is hardwood clearly points to the underutilization of hardwood forests.

The main softwood producers are Brazil (68 %), Chile and Mexico. They account for 92 % of the total. The main hardwood producers are Brazil (62 %), Ecuador, Argentina, Colombia and Paraguay, accounting for 85 % of total hardwood production.

In spite of some variations in the ratio of sawnwood production to apparent consumption during the period 1963-83, it is possible to argue that most of the sawnwood production is destined for domestic consumption. This is especially clear in the case of hardwood.

The external trade in sawnwood is rather modest (less than 10 % of total production) and is mainly confined within the region. The exports exceed imports in Tropical South America, but the ratio annual export/import is unfavorable in Central America and Mexico (Table 4). Brazil, Chile and Honduras have been modest net exporters of sawn softwood but, due to the already increasing scarcity of exploitable coniferous forests, the situation is changing. It is assumed that the future shortage of sawn softwood will be met by coniferous plantations, and by hardwood substitutes for some specific applications. For this reason, the projected hardwood exports (2.6 million m^3 in 1990) will surely decline (McGaughey & Gregersen 1983). In any case, FAO's projections point out that production will exceed consumption (Figure 6). However, these forecasts are rather dependent on Brazilian production and consumption owing to the key role played by this country in the sawnwood production (63 %) and trade (25 %) of the whole subcontinent.

Table 4. Exports, imports and trade balance values (US dollars) by product and region in 1983.

Commodity	Region	Exports	Imports	Trade Balance	Annual Exp./Imp. ratio
		--- million US dollars ---			
Industrial Roundwood	Cent. Am.	5.0	18.5	- 13.5	1 : 3.7
	Trop. SA.	7.9	22.4	- 14.5	1 : 2.8
	Temp. SA.	34.8	2.3	+ 32.5	15 : 1
	Total LA.	47.7	43.2	+ 4.5	1.1: 1
Sawnwood & Sleepers	Cent. Am.	28.8	255.2	- 226.4	1 : 9
	Trop. SA.	257.2	36.1	+ 221.1	7.1: 1
	Temp. SA.	66.1	54.8	+ 11.3	1.2: 1
	Total LA.	352.1	346.1	+ 6.0	1 : 1
Wood-based Panels	Cent. Am.	19.6	51.4	- 31.8	1 : 2.6
	Trop. SA.	170.4	46.5	+ 123.9	3.7: 1
	Temp. SA.	12.6	3.9	+ 8.7	3.2: 1
	Total LA.	202.6	101.8	+ 100.8	2 : 1
Wood Pulp	Cent. Am.	0	109.7	- 109.7	1 : 110
	Trop. SA.	310.7	139.3	+ 171.4	2.2: 1
	Temp. SA.	156.4	77.5	+ 78.9	2 : 1
	Total LA.	467.1	326.5	+ 140.6	1.4: 1
Paper and Paperboard	Cent. Am.	44.9	641.1	- 596.2	1 : 14.3
	Trop. SA.	255.1	482.6	- 227.5	1 : 1.9
	Temp. SA.	59.8	132.8	- 73.0	1 : 2.2
	Total LA.	359.8	1256.5	- 896.7	1 : 3.5
Total	Cent. Am.	98.3	1075.9	- 997.6	1 : 11
	Trop. SA.	1001.3	726.9	+ 274.4	1.4: 1
	Temp. SA.	329.7	271.3	+ 58.4	1.2: 1
Grand	Total LA.	1429.3	2074.1	- 644.8	1 : 1.5

Data source: FAO 1985 a.

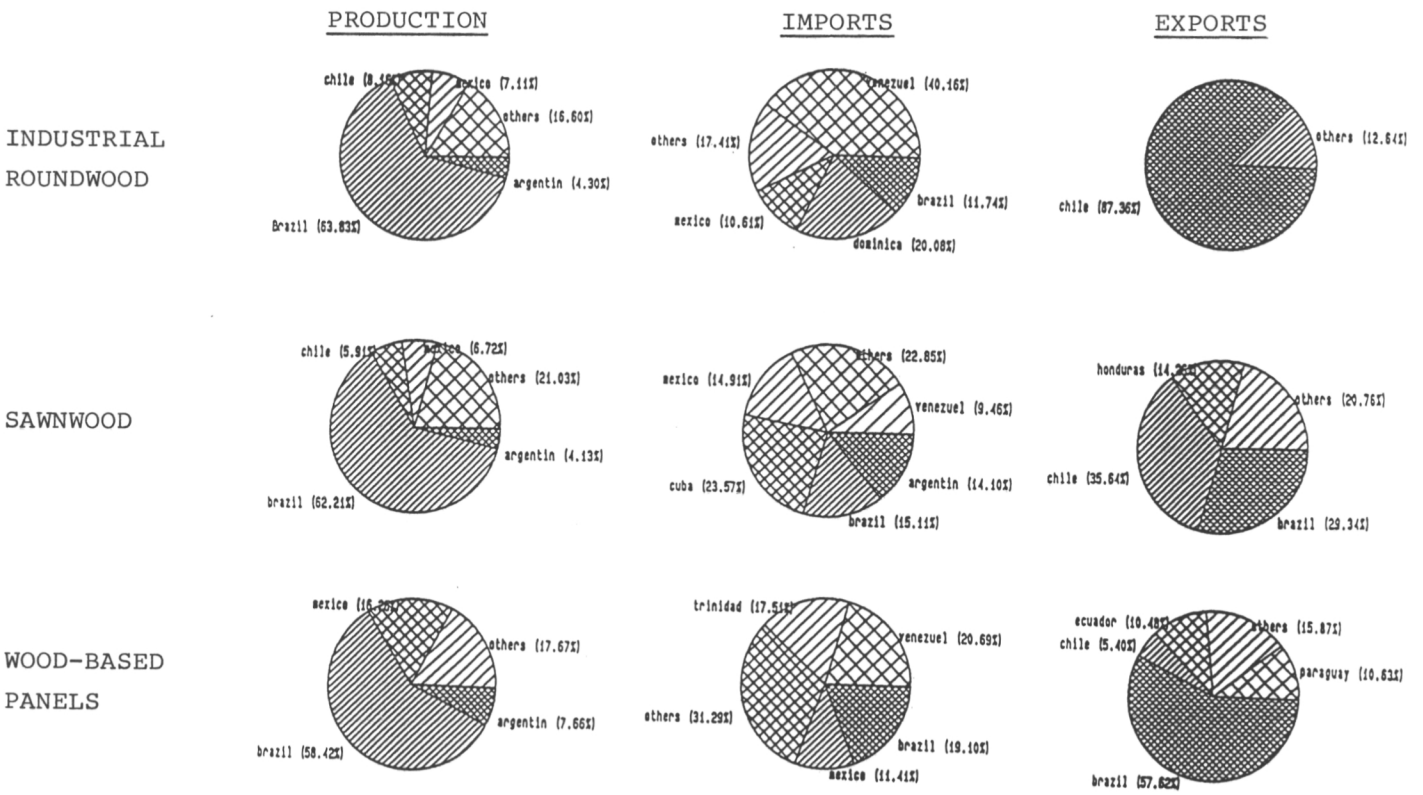


Figure 7.A. Participation of selected countries in the total production, imports and exports of Industrial Roundwood, Sawnwood and Wood-based Panels in Latin America at early 1980's.

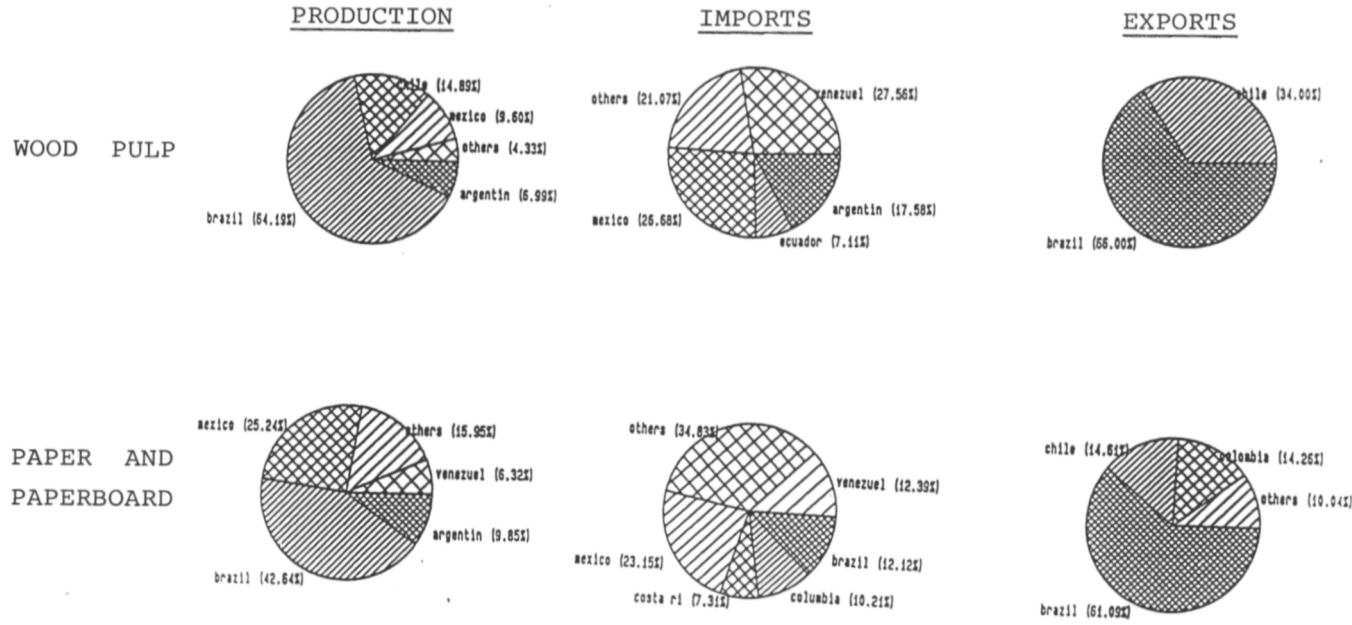


Figure 7.B. Participation of selected countries in the total production, imports and exports of Wood Pulp and Paper and Paperboard in Latin America at early 1980's.

32. Wood-based panels

Wood-based panels include veneer sheets, plywood, particle board and fibreboard.
Despite the fact that wood-based panels production has increased sixfold during the past twenty years (at an annual average increase rate of 9.4 %) their relative importance in the whole of Latin America's forest production is still low. This can be explained by the long tradition of sawnwood in the building industry. Its prices compete rather favorably with that of panels. However, the forecast for wood-based panels production indicates considerable expansion, although those of future consumption are even higher (Figure 8).

Most of the particle board and fibreboard are produced by rather recently built mills which employ modern technology. The majority are supplied from forest plantations and compete with the wood pulp industry for raw material. In contrast, most of the veneer sheet and plywood factories are old and utilize natural hardwood species as their raw material.

The total production of wood-based panels reached 4,5 million m^3 in the year 1983 (Table 6.3, Annex 2). Of this, 33 % was particle board production, 23 % fibreboard, and the remainder plywood and veneer sheet production (35 % and 9 % respectively). Particle board is the most rapidly expanding of those three items, even though its markets are mainly restricted to meeting domestic demand due to its high transport costs. The other items have potential overseas markets, especially the fiberboard panels (which have been increasingly exported by Brazil).

The main producers of plywood are Brazil (57 %) and Mexico. They account for 77 % of Latin America's production. Brazil, Mexico and Argentina account for 83 % of the subcontinent's particle board production, while Brazil itself accounts for 81 % of all the fibreboard production. The participation of selected countries in the total production, imports and exports of wood-based panels is presented in Figure 7 A.

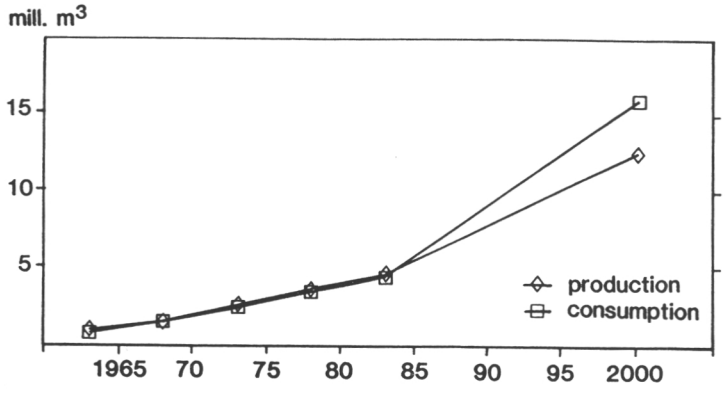


Figure 8. Wood-based panels production and apparent consumption of Latin American countries during the period 1963 - 83, and projections up to the year 2000.
Data source: FAO (1976, 1985 a, 1986).

The external trade of wood-based panels is reduced. The exports exceed imports in all the regions except in Central America and Mexico (Table 4). FAO's forecasts indicate that the situation in which regional consumption is almost totally covered by domestic production is changing, and by the year 2000 a substantial deficit will exist in some of these commodities (Figure 8). This is contrary to the view of McGaughey & Gregersen (1983), who claim that Latin America will continue being a small net exporter of plywood and that a marked expansion of fibreboard production will take place on the bases of its competitiveness on international markets. The present author agrees with this last view because of the deep recession suffered by the building industry of most Latin American countries during the 1980's, and the promising prospects for international trade, specially in fibreboard panels.

33. Wood Pulp

This aggregate includes the following commodities: mechanical, semi-chemical, chemical and dissolving wood pulp. The most important is chemical pulp, which accounts for 84 % of Latin America's wood pulp production. The share of mechanical pulp is 9 %, that of semi-chemical 6 % and dissolving 1 % percent.

The total wood pulp production reached 5.3 million MT in 1983, but only a few countries contributed to this total: Brazil (64%), Chile, Mexico and Argentina together produced 96 % of the subcontinent's total (Figure 7 B). The expansion of wood pulp production during the period 1963 -1983 was tremendous, the average annual rate of increase being 8.2 percent. The most rapidly growing commodities were chemical wood pulp and semichemical wood pulp.

The main chemical wood pulp producers are Brazil (67 %), Chile and Mexico. They account for 89 % of the total production of Latin America. The main producers of mechanical wood pulp are Brazil (51 %) and Chile (30 %). The main producers of semi-chemical wood pulp are Argentina (55 %) and Brazil (34 %).

The efforts made by some countries to utilize fibrous plant materials other than wood, such as bagasse, cotton linters, textile wastes, etc, have been significant: 0.8 million MT in 1983. The main producers of other fibre pulp are Mexico, Brazil, Peru, Colombia and Argentina.

The production of wood pulp in each country depends greatly on domestic utilization and export prospects. The wood pulp produced in Latin America has proved to be competitive in the international markets, both in the case of short and long fiber wood pulp. Most of the wood pulp produced by Brazil is based on roundwood from hardwood plantations (Eucalyptus spp.) and is a short fibre wood pulp. In contrast, almost all of that produced in Chile is derived from softwood species (Pinus radiata) and is a long fibre pulp. Brazil and Chile

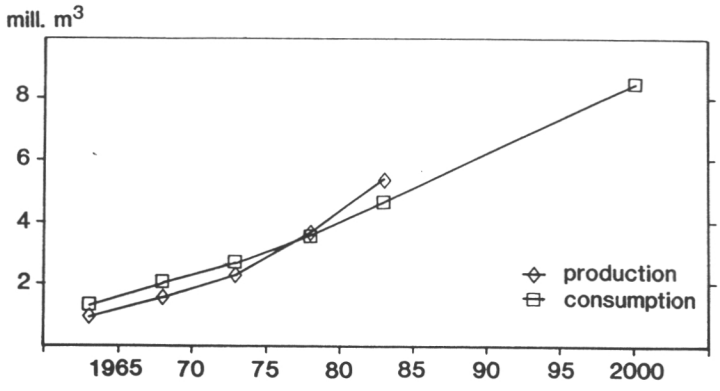


Figure 9. Wood pulp production and apparent consumption of Latin American countries during the period 1963 - 83, and projections up to the year 2000. Data source: FAO (1976, 1985 a, 1986).

are the only exporters, having already reached exports of about 1.5 million MT per year.

Considering the subcontinent as a whole, there has been a clear tendency towards reaching self-sufficiency in the supply of wood pulp. The traditional deficit was surpassed at the end of the 1960's and a slight surplus has since been the norm (Figure 9). However, producer countries are few and most of the smaller countries are net importers (Table 6.4, Annex 2), although the majority of them have forests which could be utilized for wood pulp production. The amount of capital required to establish a medium or large-sized pulpmill is relatively high compared with the creation of other forest industries. Considering the endemic scarcity of capital prevailing in the developing countries, capital investment has been the main constraint to the expansion of the wood pulp production, especially in these non-producer countries. The external trade balance of this commodity in Latin America is positive (Table 4).

Prospects indicate that wood pulp consumption will continue expanding more or less at the same rate as now (6.4 % annually). Brazilian Eucalyptus wood pulp exports will continue to grow, while Chile's exports can increase only at

the end of 1990's. There are no available forecast, on a continental basis, for future production of this commodity.

34. Paper and Paperboard

The following commodities are embraced by this aggregate: newsprint, printing and writing paper, other paper and paperboard (FAO 1985 a).

The production of paper and paperboard reached 7.7 million MT annually in the early 1980's (Table 6.5, Annex 2). The main producers of these commodities at that time were Brazil (43 %), Mexico (25 %), Argentina (10 %) and Venezuela (6 %), countries which together accounts for 84 % of Latin American production (Figure 7 B).

Other paper and paperboard (which include household and sanitary paper, special thin paper, wrapping and packing paper and paperboard, construction paper and paperboard and others) are the most important item in the whole aggregate (70 %). Outstanding countries in the production of these commodities are: Brazil (42 %), Mexico (26 %), Argentina (9 %) and Venezuela (8 %).

The share of the other important items out of the total production of this aggregate are: printing and writing paper 23 % and newsprint 7 % percent. The main producers of printing and other writing paper are Brazil (52 %), Mexico (22 %) and Argentina (9 %). The share of newsprint production in the whole aggregate has decreased from almost 30 % at the beginning of 1960's to 7 % twenty years later. The price level and the increasing shortage of long fiber wood pulp, the raw material traditionally used in its manufacture, seem to be the main cause of the decrease. The share of newsprint production is evenly distributed between Argentina, Mexico and Chile (27 % each).

A production deficit during the last decades is apparent for the figures for paper and paperboard consumption and produc-

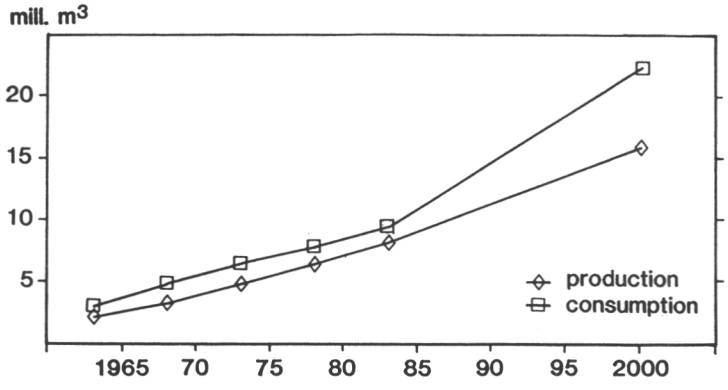


Figure 10. Paper and Paperboard production and apparent consumption of Latin American countries during the period 1963 - 83, and projections up to the year 2000.
Data source: FAO (1976, 1985 a, 1986).

tion time series for this subcontinent (Figure 10). In spite of the sharp increase in paper and paperboard production during the last twenty years - at an average annual rate of about 7 percent - the shortage of these commodities has persisted during the whole period. The deficit reaches different magnitudes among the diverse items in this aggregate and, of course, they vary from country to country. National production of newsprint and other paper and paper-board is insufficient to satisfy the national demand in most of these twenty seven countries (especially in the case of the expanding consumption of kraft paper and corrugated board items). On the other hand, the subcontinent is virtually self-sufficient with respect to printing and writing paper.

The total imports of paper and paperboard in the early 1980's was 2.1 million MT annually, while exports only reached a level of 0.6 million MT per year. Such a gap is the main cause of Latin America's negative trade balance in forest products (Table 4). Only Brazil and Chile can be identified as actual net exporters (Figure 7 B).

The same constraint that limits the production of wood pulp is affecting the production of paper and paperboard: i.e. the

relatively high investment capital required for the establishment of paper mills. Another constraint that is hindering the development of this industry stems from the direct link between pulp supply and paper manufacture: the scarcity of wood pulp producers in Latin America.

The apparent consumption of paper and paperboard has sharply increased in these countries during the last twenty years: from about 14 m^3/capita/year in the early 1960's to about 26 m^3/capita/year in the early 1980's. However, these averages are far from the developed world standards (the average consumption in Europe was about 100 m^3/capita/year in 1980). Only a few countries have consumption figures over 40 m^3/capita/year, e.g. Costa Rica, Panama and Venezuela (63, 51 and 46 m^3/capita/year, respectively), while there are some other countries which have extremely low averages, e.g. Haiti, Bolivia, Nicaragua and Paraguay (1, 3, 5 and 8 m^3/capita/year, respectively).

According to FAO forecasts, the difference between consumption and production will continue to expand during the period 1980 - 2000 (Figure 10). Consequently, Latin America will remain a net importer of these commodities during the next few years. However, two possible exceptions could emerge: Brazil could become a major kraftliner exporter (McGaughey & Gregersen 1983) and Chile could increase, to a limited extent, its exports of newsprint within the region, although not until the end of the century when the availability of softwood in this country will increase.
The prospects of eventual Latin American exports of printing and writing paper are not good, owing to poor competitiveness in the international markets.

4. DISCUSSION AND CONCLUSIONS

41. Discussion

Most of the natural resource statistics presented in this study were gathered from two extensive and conscientious works (FAO & UNEP 1981, FAO 1984) that contain fairly recent figures. However, they ought to be considered with certain reservations. There is no country in the subcontinent that has regularly undertaken national forest inventories. Most of the inventories refer to areas destined, usually, for industrial development and consequently of limited extension. Therefore, the national estimates by countries are mainly based on a heterogeneous mass of local forest inventories, forest maps and surveys, some of them of doubtful reliability. They often fail to cover extensive regions, being consequently very difficult to summarize. The results are usually less than representative of the country in question, yielding only rough estimates (Sommer 1976, Persson 1977).
Differences in the classification systems and definitions employed in the available information present additional problems of interpretation.
These constraints also affect the FAO's forest resources statistics. This is not to say that FAO does not make a competent job of appraisal and scrutiny with the information that they receive, but as Persson (1977) stated: "FAO must trust in the information submitted by a governmental agency. FAO cannot, without permission, change data submitted to them by a member government". However, it is necessary to bear in mind that the reliability has improved, especially during recent decades. New techniques of forest inventory and mapping have become available through remote sensing (aerial photographs, satellite imagery, radar, etc.). These technologies have made economically feasible the assessment of vast areas not previously surveyed, or the updating of obsolete information.

These new approaches and improvements have enabled the acquisition of better knowledge concerning the location,

extent and composition of the forest resources of these countries. This knowledge has had a positive effect on the data supplied by FAO & UNEP (1981) and FAO (1984), on which this report has been based. Additionally, other relevant data sources were also consulted (e.g: Hueck 1966, Persson 1974, Sommer 1976, Walter 1979, Lanly 1982, Centeno 1984).

The statistics concerning forest products exhibit many of the same limitations. In the case of firewood data, in particular, there is a remarkable paucity of reliable information. The data concerning industrial roundwood production may also be affected by illegal cutting, which in some countries may reach significant levels. However, it is evident that production statistics are more rigorous, especially forest product trade statistics.

The lack of time series for forest product consumption in Latin America necessitates the use of rough estimates, calculated by product and by country according to the standard procedure used in several publications (e.g: FAO's forestry statistics publications), represented by equation 2 (page 14). These estimates do not include any attempt at correction for the amount of finished products kept in stocks or their losses. Consequently, these consumption estimates, called "apparent consumption" in this work, must be considered cautiously.

Most projections cited in this work are based on FAO's forecasts (FAO 1986). The publication also presented the "Chase Econometrics 1986 Long Term International Forecast" data which, compared with FAO projections, are much more conservative with respect to production, imports, exports and consumption trends. No estimates have been included for FAO's missing values for production trends of industrial roundwood and wood pulp.
The projections may be optimistic since they do not probably take into account the consequences of the economic recession in Latin America during 1982-1985, which Bitar (1986) has qualified as " the most severe economic and social crisis since the 1930's".

42. Conclusions

On the basis of the review made in the preceding chapters, it is possible to conclude that the development path followed by the forest sector of Latin American countries has led to a paradox (Mery 1980): while these countries hold approximately one fifth of the worlds forests by area and have more hectares of forest per capita than the countries of other continents (nearly 3 ha/cap., Table 1), their forests have played a limited role in the economic growth during the past few decades (Table 5). At the same time, the long term survival of the world's largest closed broadleaved forest reserve is today seriously threatened by deforestation and degradation, which, in 1980, had reached a level of 5.3 million ha per year, according to FAO & UNEP's (1981) estimates. Unfortunately, the role of forest destruction in the improvement or deterioration of the economic conditions of these nations has been poorly reported.

Numerous authors (e.g. Gregory 1965, McGaughey & Gregersen 1983, Salcedo 1983, Keipi 1985) have argued in recent years about the important role that forest sector must play in Latin American economic development. In spite of their promising auguries and some successful export experiences made recently by Brazil and Chile, the general sectoral trends point in quite another direction. In addition to the rapid deforestation that is going-on in these countries, their trade balance of forest products gives a negative result. In 1980 the imports of forest products reached US $ 2500 million dollars, while exports were only US $ 1600 million dollars (FAO 1985 b). Table 4, which includes only the five forest products reviewed in this paper, reveals that the trade balance in 1983 was negative by 645 million dollars for the whole subcontinent. This means an export/import ratio of 1:1.5 . However, the same ratio for the Central America and Mexico region is even more unfavorable (1:11), and the paper and paperboard trade balance is negative in the whole sub-continent, its ratio being 1:3.5 . On the other hand, the FAO's projections (1986) indicate that the deficit of paper

Table 5. Participation of Latin America in the world production, imports, exports and apparent consumption of forest products in 1983.

	Industrial Roundwood	Sawnwood	Wood-based panels	Wood pulp	Paper and paperboard
World	100.0	100.0	100.0	100.0	100.0
Latin American Production	6.3	5.6	4.4	4.2	4.6
Latin American Imports	0.3	2.4	2.0	3.8	5.3
Latin American Exports	1.1	2.4	4.1	7.2	1.9
Latin American Apparent Consumption	6.2	5.6	4.0	3.6	5.3

Data source: FAO 1985 a.

and paperboard will increase, at least up to the year 2000 (Figure 10), and an unfavorable gap between consumption and production for wood-based panels (Figure 8) is forecasted for 1985 - 2000. A positive trend is expected only in the case of sawnwood production and consumption (Figure 6). There are no complete projections for wood pulp and industrial roundwood.

Depletion, misuse, overexploitation and underutilization of forest resources combine to produce the gloomy picture that, with a few exceptions, characterizes the forest sector in most of these twenty seven countries. However, the real tragedy is revealed when it is realized that the contribution of the forest sector to the socio-economical development of Latin American countries is even poorer. The domestic consumption of most forest products is still low, far from the world standards and several negative trends can be easily identified, for example:

- The shortage of fuelwood is critical and the prospects for the near future are even bleaker.

- Wood has not adequately contributed to solving the vast housing problem in the region; the number of people deprived of decent accommodation is increasing in each of these countries.
- The unemployment in rural areas is a chronic problem which especially afflicts the poor farmers and landless people. Forest undertakings have -with a few exceptions - poorly contributed to the alleviation of this human drama which affects millions of people in these 27 countries.
- Forestry has failed to support and diversify agricultural development. This problem ought to receive top priority in countries which very often cannot provide enough food for their own people, despite the creation of an export oriented agricultural sector.
- The urban inhabitants suffer from a scarcity of accessible green areas for recreation; their cities are often affected by air and water pollution; urban forestry has been widely neglected if not completely ignored.
- The appraisal of the environmental consequences of deforestation is a hidden or secondary problem for most people, who are mainly worried about their own difficult subsistence problems.

On the other hand, a few positive trends can be detected, for example:

- The increasing rate of reforestation and afforestation.
- The recent - though timid - modifications observed in the structure of forest industries in favour of products with a higher value-added content.
- The successful export operations of plantation-based pulp and particle board mills, which have penetrated into the respective international market.
- Advances in some institutional aspects (which have been pointed out in section 2.6). The increasing expansion of universities and forest research institutes and therefore of foresters and skilled professional staff, deserves mention.
- The growing concern in some public circles about deforestation and environmental issues.

Has the forest sector of Latin American countries really failed in promoting socio-economic development, both on the local as well as the national level? Westoby (1962) noted that the forest sector has "considerable flexibility both as to scale of operations and technology; industries with pronounced backward and forward linkages, ensuring that their growth would exercise a multiplier effect on the whole economy; industries which located near the wood resource, offered the prospect of creating new poles of development", thereby indicating that the forest sector has a positive role to play in the fight against backwardness. It is beyond the scope of this summarized overview to go deeply into answering this open question, or to propose remedial policies. However, a few comments cannot be avoided.

It is possible to find, in several recent publications (e.g: Gregory 1965, McGaughey & Gregersen 1983, Salcedo 1983, Keipi 1985, FAO 1985 d) a diagnostic of the main constraints that are preventing the forest sector from making a larger contribution to the socio-economic development of the region. However, these diagnostics fail to find the links between these sectoral limitations and the broader, national, socio-economic ones. The remedial policies contained in these publications are mainly based on proposals which consider an autonomous development of forestry and forest industry, isolated from the development of other economic sectors. Neither of proposals stress the necessary closed link that must exist between agricultural and forestry expansion, and rural socio-economic development. Nor is the potential role of natural forests in rural development discussed in depth.

In the author's opinion most of the constraints affecting the forest sector have their roots in the socio-economic structural problems of Latin American societies. Therefore, a significant change in the contribution made by the forest sector to the general welfare of their people cannot take place without a more general change in these societies.
A structural change which secures the long-term interests of the nations must prevail over short-term private interests. A structural change must aim at reducing present inequalities

and must allow the spread of the benefits obtained from economical growth. A structural change which must make it possible to overcome the increasing dependence of these countries on investment project decisions taken by the boards of directors of transnational corporations, with goals very often diverse from those of these nations; to overcome dependence on the transference of foreign technologies and dependence on overseas markets. A structural change must permit the implementation of forest policies oriented at stopping uncontrolled deforestation and to promote a more rational and sustained use of forest land and forest resources.

Such a course will facilitate the adoption of policies of land reform pursuing a more equitable land ownership distribution and confering a real opportunity for peasants and landless peoples to participate actively in the rural development process (Simula 1986). This would, in the short term, "do more to relieve pressure on forest lands than any other simple policy intervention or any conceivable level of investment in forest resources development" (Spears & Ayensu, cited by Westoby 1985).

In Latin American countries the forest sector as a whole must be aimed at reducing rural poverty and satisfying these countries' most urgent domestic needs. The conversion of forest areas into agricultural use must be rationally planned and effectively supported by governmental institutions. The productivity of forests, both natural and plantations, must be increased on a sustained basis, and they must provide employment and goods for rural populations as well as for the nation as a whole.

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ANNEX 1

Symbols used in the tables.

= Unknown figure
* = Unofficial figure
F = FAO estimate
~ = Author's estimate
Th.m^3 = Thousand cubic meters
MT = Metric ton
PRO = Production
PRO3 = Annual production average for the period 1981-83
GPRO20 = Annual average growth rate of production for the twenty-year period 1963-83
IMP = Imports
IMP3 = Annual import average for the period 1981-83
GIMP20 = Annual average growth rate of imports for the period 1963-83
EXP = Exports
EXP3 = Annual export average for the period 1981-83
GEXP20 = Annual average growth rate of exports for the period 1963-83
CON = Apparent consumption
CON3 = Annual apparent consumption average for the period 1981-83
GCON20 = Annual average growth rate of apparent consumption for the period 1963-83
n = Number of years in the calculation period
Cent. Am. = Central America, Mexico and the Caribbean region
Trop. SA. = Tropical South America
Temp. SA. = Temperate South America
Total LA. = Total of Latin American countries

ANNEX 2

Table 6.1.- Production, imports, exports and consumption of industrial roundwood in Latin American countries, 1963 - 1983.

Country	Pro3 ($Th.m^3$)	Gpro20 (%)	Imp3 ($Th.m^3$)	Gimp20 (%)	Exp3 ($Th.m^3$)	Gexp20 (%)	Con3 ($Th.m^3$)	Gcon20 (%)
Mexico	6407	3.0	28	1.6	0	2.0	6435	3.0
Guatemala	185	-2.9	4	7.6	0	-11.7	189	-2.7
Belize	38	-2.8	0	-6.7	0	-1.4	37	-3.1
Honduras	997	0.8	0	0.0	22	-2.8	975	0.9
El Salvador	112	0.7	0	0.0	0	0.0	112	0.6
Nicaragua	880	5.1	11	6.7	5	-4.4	886	5.3
Costa Rica	1145	4.5	2	2.6	0	-4.8	1147	4.5
Panama	339	5.2	13	7.6	0	-2.5	352	5.3
Bahamas	115	-5.3	0	0.0	0	-25.2	115	12.6
Cuba	385	0.3	0	-1.4	0	0.0	385	0.3
Haiti	239	0.1	0	0.0	0	-6.7	239	0.2
Dominican Rep	9	-16.4	53	22.0	0	-5.3	62	-7.9
Jamaica	35	13.7	2	-3.0	0	0.0	37	9.2
Trinidad Tob	61	-2.2	5	0.7	0	0.0	66	-2.0
Subtotal 1	10946	2.1	118	5.4	28	-12.4	11036	2.4
Colombia	2767	-0.1	0	0.0	0	-19.7	2767	0.1
Venezuela	636	2.5	106	10.0	0	5.6	742	3.1
Guyana	189	-0.1	0	-11.4	24	0.8	165	-0.5
Suriname	256	0.6	0	-11.7	18	-0.4	238	0.4
French Guiana	188	10.3	0	0.0	30	4.7	158	12.2
Brazil	57513	6.4	31	6.8	8	-8.3	57536	6.4
Ecuador	2153	5.0	0	0.0	0	0.0	2153	5.0
Peru	1337	4.2	1	-5.3	0	0.0	1337	4.2
Bolivia	233	5.1	0	0.0	0	2.0	233	5.0
Paraguay	2412	6.8	0	0.0	0	-23.5	2412	8.
Subtotal 2	67683	5.7	137	4.9	80	-7.6	67740	5.8
Chile	7352	3.9	0	0.0	760	39.3	6592	3.3
Argentina	3874	3.1	8	-14.9	2	-10.3	3880	2.7
Uruguay	251	0.9	0	-15.0	0	0.0	252	0.3
Subtotal 3	11477	3.5	9	-14.9	762	20.7	10724	3.0
Total	90107	4.8	264	-0.9	870	0.4	89501	4.8

Data source: FAO (1976, 1981 and 1985 a).

Table 6.2.- Production, imports, exports and consumption of sawnwood and sleepers in Latin American countries, 1963 - 1983.

Country	Pro3 (Th.m^3)	Gpro20 (%)	Imp3 (Th.m^3)	Gimp20 (%)	Exp3 (Th.m^3)	Gexp20 (%)	Con3 (Th.m^3)	Gcon20 (%)
Mexico	1712	1.6	312	13.8	11	-5.0	2013	2.4
Guatemala	123	-0.3	0	-5.3	17	0.6	107	-0.4
Belize	38	0.1	1	1.4	4	-7.6	35	4.1
Honduras	501	-0.7	0	-4.1	299	2.2	202	-3.2
El Salvador	44	5.6	9	-8.3	0	-3.4	53	-1.1
Nicaragua	342	5.0	0	0.0	5	-10.2	338	7.1
Costa Rica	430	2.1	7	8.4	4	0.4	433	2.1
Panama	53	0.4	7	-0.7	0	5.6	60	0.3
Bahamas	0	-8.8	32	0.6	0	2.0	33	-0.2
Cuba	108	-2.2	493	4.1	0	0.0	601	2.2
Haiti	14	-0.9	11	6.7	0	0.0	25	1.2
Dominican Rep	0	-20.8	79	24.4	0	5.6	79	-1.4
Jamaica	25	24.1	85	1.6	0	0.0	110	2.9
Trinidad Tob	30	-1.7	191	7.3	0	0.0	220	4.7
Subtotal 1	3420	1.0	1228	5.1	341	0.5	4308	1.9
Colombia	816	-1.1	3	11.0	5	-11.0	813	-0.8
Venezuela	260	0.4	198	15.6	0	-1.4	458	3.0
Guyana	70	0.3	0	-2.5	14	-1.2	56	0.6
Suriname	62	2.0	0	0.0	14	6.8	48	1.2
French Guiana	19	4.9	0	0.0	6	6.6	13	4.2
Brazil	15852	5.0	316	33.3	615	-2.1	15553	5.8
Ecuador	982	5.2	0	0.0	12	-6.0	970	5.7
Peru	602	6.2	21	-7.1	7	1.1	616	4.3
Bolivia	129	6.7	0	0.0	40	11.8	89	5.4
Paraguay	655	9.3	0	0.0	293	12.0	362	7.8
Subtotal 2	19446	4.5	538	8.6	1005	-0.4	18979	5.1
Chile	1507	2.0	0	-1.4	747	13.7	760	-1.2
Argentina	1052	1.1	295	-3.1	3	-1.4	1344	-0.2
Uruguay	54	-1.3	31	-4.4	0	0.0	86	-2.7
Subtotal 3	2614	1.5	326	-3.3	750	13.3	2189	-0.7
Total	25480	3.5	2092	2.9	2096	1.8	25476	3.6

Data source: FAO (1976, 1981 and 1985 a).

Table 6.3.- Production, imports, exports and consumption of wood-based panels in Latin American countries, 1963 - 1983.

Country	Pro3 (Th.m^3)	Gpro20 (%)	Imp3 (Th.m^3)	Gimp20 (%)	Exp3 (Th.m^3)	Gexp20 (%)	Con3 (Th.m^3)	Gcon20 (%)
Mexico	734	11.6	43	13.1	7	-1.1	770	12.2
Guatemala	6	1.3	4	13.2	0	-6.7	10	5.0
Belize	0	0.0	2	0.0	0	5.6	2	0.9
Honduras	8	7.2	0	5.6	4	7.2	5	3.9
El Salvador	0	0.0	6	4.4	0	0.0	6	4.4
Nicaragua	17	2.3	0	5.6	5	8.4	13	1.2
Costa Rica	54	7.5	1	-2.0	22	5.6	32	9.4
Panama	14	7.4	2	5.6	1	-2.0	15	6.9
Bahamas	0	0.0	5	8.4	0	0.0	5	8.4
Cuba	19	-4.9	29	5.6	0	0.0	48	-1.3
Haiti	0	0.0	0	0.0	0	0.0	0	0.0
Dominican Rep	0	0.0	7	10.2	0	0.0	7	10.2
Jamaica	4	7.2	19	7.3	0	0.0	23	8.3
Trinidad Tob	0	0.0	66	14.1	0	0.0	66	14.1
Subtotal 1	856	8.5	186	9.5	39	3.8	1002	9.0
Colombia	117	4.2	24	17.3	3	-0.5	139	5.4
Venezuela	135	11.5	78	19.2	0	0.0	213	13.2
Guyana	0	5.6	0	-3.4	0	0.0	0	-4.1
Suriname	26	-2.1	0	5.6	17	-3.6	9	3.3
French Guiana	0	0.0	0	0.0	0	0.0	0	0.0
Brazil	2639	10.6	72	23.8	363	17.0	2347	10.2
Ecuador	110	19.7	0	0.0	66	30.2	44	15.0
Peru	64	14.9	0	-9.7	8	11.0	56	8.2
Bolivia	25	19.8	0	0.0	3	5.6	22	19.0
Paraguay	69	18.5	0	0.0	67	23.4	2	-0.8
Subtotal 2	3184	10.0	176	14.2	527	12.1	2833	9.9
Chile	118	7.3	0	-2.5	34	26.0	84	5.3
Argentina	346	7.7	14	14.2	30	18.5	331	7.5
Uruguay	13	3.1	1	-5.3	0	0.0	14	1.3
Subtotal 3	477	7.4	16	5.2	64	30.1	429	6.6
Total	4517	9.4	377	10.9	630	11.4	4264	9.2

Data source: FAO (1976, 1981 and 1985 a).

Table 6.4.- Production, imports, exports and consumption of wood pulp in Latin American countries, 1963 - 1983.

Country	Pro3 ($Th.m^3$)	Gpro20 (%)	Imp3 ($Th.m^3$)	Gimp20 (%)	Exp3 ($Th.m^3$)	Gexp20 (%)	Con3 ($Th.m^3$)	Gcon20 (%)
Mexico	474	4.6	214	7.1	0	0.0	688	5.3
Guatemala	0	0.0	10	5.3	0	0.0	10	5.3
Belize	0	0.0	0	0.0	0	0.0	0	0.0
Honduras	0	0.0	0	0.0	0	0.0	0	0.0
El Salvador	0	0.0	0	0.0	0	0.0	0	0.0
Nicaragua	0	0.0	0	0.0	0	0.0	0	0.0
Costa Rica	3	5.6	5	8.4	0	0.0	8	11.0
Panama	0	0.0	2	2.6	0	0.0	2	2.6
Bahamas	0	0.0	0	0.0	0	0.0	0	0.0
Cuba	0	0.0	40	-0.1	0	0.0	40	-0.1
Haiti	0	0.0	0	0.0	0	0.0	0	0.0
Dominican Rep	0	0.0	4	7.2	0	0.0	4	7.2
Jamaica	0	0.0	0	0.0	0	0.0	0	0.0
Trinidad Tob	0	0.0	0	-5.3	0	0.0	0	-5.3
Subtotal 1	477	4.7	275	5.2	1	0.0	752	4.9
Colombia	118	10.4	57	0.9	0	0.0	176	5.1
Venezuela	56	22.3	221	6.0	0	0.0	277	7.2
Guyana	0	0.0	0	0.0	0	0.0	0	0.0
Suriname	0	0.0	0	0.0	0	0.0	0	0.0
French Guiana	0	0.0	0	0.0	0	0.0	0	0.0
Brazil	3169	10.7	20	-4.3	921	26.3	2268	8.4
Ecuador	0	0.0	57	22.4	0	0.0	57	22.4
Peru	15	14.5	24	1.6	0	0.0	39	4.1
Bolivia	0	0.0	0	0.0	0	0.0	0	0.0
Paraguay	0	0.0	0	0.0	0	0.0	0	0.0
Subtotal 2	3358	10.8	379	3.7	921	26.3	2816	8.0
Chile	735	8.0	0	-9.0	475	18.0	261	2.9
Argentina	345	8.5	141	0.7	0	0.0	486	4.8
Uruguay	22	10.5	6	-4.3	0	0.0	28	2.4
Subtotal 3	1102	8.2	147	0.1	475	18.0	775	4.0
Total	4937	9.2	802	3.2	1395	22.0	4343	6.4

Data source: FAO (1976, 1981 and 1985 a).

Table 6.5.- Production, imports, exports and consumption of paper and paperboard in Latin American countries, 1963 - 1983.

Country	Pro3 (Th.m^3)	Gpro20 (%)	Imp3 (Th.m^3)	Gimp20 (%)	Exp3 (Th.m^3)	Gexp20 (%)	Con3 (Th.m^3)	Gcon20 (%)
Mexico	1945	7.3	424	6.8	13	20.1	2357	7.2
Guatemala	19	7.3	75	10.8	12	13.4	81	9.1
Belize	0	0.0	2	2.6	0	0.0	2	2.6
Honduras	0	0.0	61	7.9	0	0.0	61	7.9
El Salvador	16	14.9	44	3.9	2	3.5	58	5.1
Nicaragua	0	0.0	14	4.8	0	0.0	14	4.8
Costa Rica	17	9.1	134	8.3	11	12.6	140	8.0
Panama	43	20.7	55	3.1	2	5.6	96	6.0
Bahamas	0	0.0	2	3.5	0	0.0	2	3.5
Cuba	73	-1.2	131	4.7	0	0.0	204	1.7
Haiti	0	0.0	6	7.8	0	0.0	6	7.8
Dominican Rep	9	7.8	57	8.1	0	0.0	66	8.1
Jamaica	15	14.6	36	1.9	0	-5.3	51	3.7
Trinidad Tob	0	0.0	43	5.8	0	0.0	42	5.7
Subtotal 1	2138	6.7	1083	6.2	41	20.5	3180	6.5
Colombia	380	6.6	187	5.7	81	24.5	486	5.5
Venezuela	487	7.4	227	4.8	0	0.0	714	6.4
Guyana	0	0.0	7	1.8	0	0.0	7	1.8
Suriname	0	0.0	14	10.1	0	0.0	14	10.1
French Guiana	0	0.0	0	0.0	0	0.0	0	0.0
Brazil	3286	8.4	222	3.4	347	34.0	3161	7.3
Ecuador	33	19.1	65	3.2	0	0.0	98	5.3
Peru	230	6.9	58	1.4	2	3.5	286	5.1
Bolivia	0	2.0	18	6.6	0	0.0	19	6.2
Paraguay	13	16.0	14	7.4	0	0.0	27	10.0
Subtotal 2	4429	8.0	811	4.2	429	35.4	4811	6.8
Chile	336	4.5	51	9.5	83	4.9	304	4.9
Argentina	759	3.6	133	-1.0	8	17.0	884	2.6
Uruguay	43	1.7	18	-1.5	6	9.7	55	0.0
Subtotal 3	1139	3.8	202	0.2	97	5.7	1244	2.9
Total	7706	6.8	2096	4.5	568	15.3	9234	5.9

Data source: FAO (1976, 1981 and 1985 a).

ANNEX 3

TABLE 7. Population data and economic indicators of Latin American countries in the early's 1980.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mexico	69752	33	2.9	2240	3.2	28	1332	1380
Guatemala	7262	61	2.9	1120	2.1	10	178	#
Belize	162	50	2.5	1140	#	8	#	#
Honduras	3691	64	3.4	670	0.6	9	204	317
El Salvador	4797	59	2.9	710	-0.2	12	190	#
Nicaragua	2733	47	3.3	880	-1.8	17	292	1464
Costa Rica	2213	57	2.3	1020	2.1	23	609	1853
Panama	1896	46	2.2	2120	2.9	7	2089	7120
Bahamas	241	46	2.1	4060	#	#	#	#
Cuba	9732	35	0.6	#	#	#	1042	#
Haiti	5809	75	2.5	300	1.1	8	55	#
Dominican Rep	5947	49	2.4	1370	3.9	9	407	488
Jamaica	2188	59	1.5	1300	-0.5	16	980	#
Trinidad Tob.	1168	78	1.4	6850	3.4	16	5191	#
Subtotal 1	117591	42	2.6	1862	2.4	22	1050	
Colombia	25794	30	2.1	1430	3.2	24	786	419
Venezuela	15620	17	3.3	3840	1.5	12	2295	2343
Guyana	883	78	2.1	520	#	8	#	#
Suriname	388	55	2.7	3420	#	10	#	#
French Guiana	62	29	1.9	#	#	#	#	#
Brazil	122320	33	2.3	1880	5.0	64	745	850
Ecuador	8021	55	3.1	1420	4.6	17	675	860
Peru	17625	33	2.8	1040	0.1	52	550	199
Bolivia	5570	67	2.7	510	0.6	35	292	1170
Paraguay	3168	61	3.0	1410	4.5	13	187	#
Subtotal 2	199451	34	2.5	1833	3.9	50	831	
Chile	11104	19	1.7	1870	-0.1	86	755	1801
Argentina	27036	18	1.2	2070	0.5	168	1460	1849
Uruguay	2924	16	0.8	2490	2.0	51	776	1607
Subtotal 3	41064	18	1.3	2045	0.4	137	1221	
Total	358106	35	2.4	1867	3.0	52	948	

(1) Population 1980 (1000 inh.). Source: United Nations (1982)
(2) Rural Population (%). Source: United Nations (1982).
(3) Annual Population Growth Rate (%). Source: UNited Nations (1982).
(4) GNP/capita (US $ 1983). Source: World Bank (1985).
(5) Annual Growth Rate of GNP: average 1965-1983 (%). Source: The World Bank (1985).
(6) Annual inflation: average 1973-1983 (%). Source: The World Bank (1985).
(7) Energy Consumption per capita 1983 (Kcal/cap). Source: The World Bank (1985).
(8) External debt 1985 per capita (USD/cap). Source: Agencia ALA, cited by Hales (1985).

ANNEX 4

The Latin American countries, territories or colonies which have not been included in the present paper, due mainly to their small territorial area, are the following:

Anguilla, Antigua, Barbados, British Virgin Islands, Canal Area (Panama), Cayman Islands, Dominica, Grenada, Guadalupe, Malvinas Islands, Martinique, Montserrat, Netherlands Antilles, Puerto Rico, St. Kitts-Navis, St. Lucia, St. Vincent-Grenadines, Turks and Caicos Islands and Virgin Islands.

The area summation of all these countries or territories accounts for 0,15 % of the total Latin American land area.

ANNEX 5



Figure 11. Location of the most noteworthy physiographic components and main climatic zones of Latin America.

ANNEX 6

There are several publications in which a detailed classification of the Latin American forests is exposed. One of such publications is "Die Wälder Südamerikas" of Prof. Kurt Hueck (1966), which contains the following map:

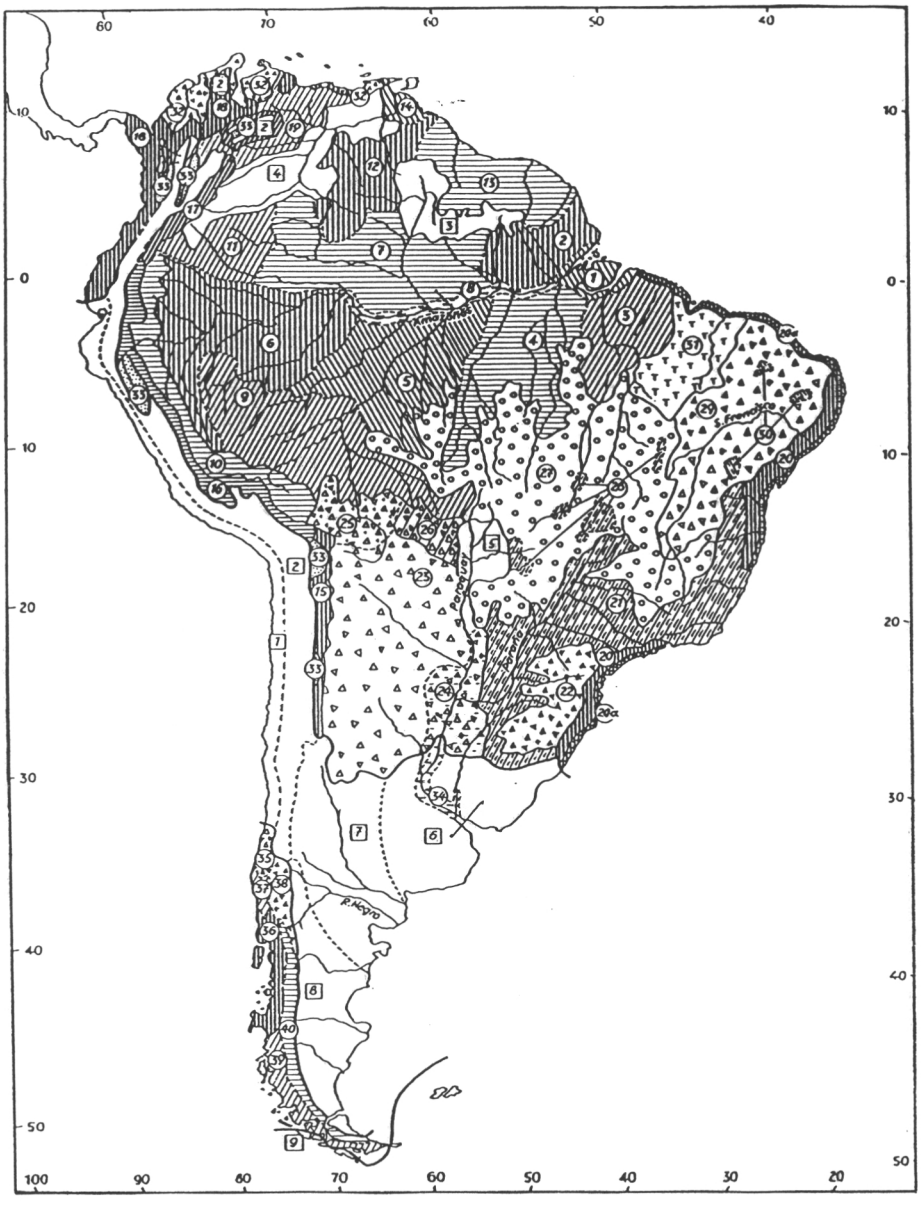


Figure 12. Main forest types of Latin America (Hueck 1966).

In Figure 12, two different classifications were made by the author:

The first refers to diverse types of forest-dominated ecosystems, which are represented by numbers in circles:

1 - 14: Forests of the Amazon and Orinoco basins.
15 - 17: Andean forests.
18: Rain forests of the Pacific and Caribbean region.
19: The Colombian and Venezuelan "alisio" forests.
20: Brazilian coastal rain forests.
20 a: The coastal region of Brazil.
21: Southeastern Brazilian forests.
22: Southern Brazilian Araucaria forests.
23 - 24: Forests of the Chaco and adjacent regions.
25: The savannas of Santa Cruz and Trinidad.
26: Forests of the Velasco mountainous highlands.
27 - 28: The central Brazilian region of Campos Cerrados.
29 - 30: The northeast Brazilian region of Caatinga.
31: The Orbignya martiana region.
32: The dry forests of the Caribbean zone of Colombia and Venezuela.
33: The Andean dry valleys.
34: The region of the lower Parana river and its delta.
35: The subtropical deciduous and dry forests.
36: The Valdivian rain forests.
37: Forests dominated by Nothofagus obliqua and Nothofagus procera.
38: The Araucaria forests on the border of Chile and Argentina.
39: The evergreen forests of Patagonia and Magallanes.
40: The summergreen forests of Patagonia and Magallanes.

The second refers to barren zones or regions covered by savannas or sparse forests, which are represented by numbers in rectangles:

1: The coastal deserts of the Pacific.
2: The tops of the Andes mountains.
3: The savannas of the high plateau of the Guyana region.
4: The "Llanos" of the Orinoco river.
5: The "Pantanal" of Mato Grosso.
6: The "Pampa" region.
7: The "Monte" region.
8: The steppe and desert of Patagonia.
9. The superhumid coastal border of the Fire Land and the subartic islands.

PART III: Future research

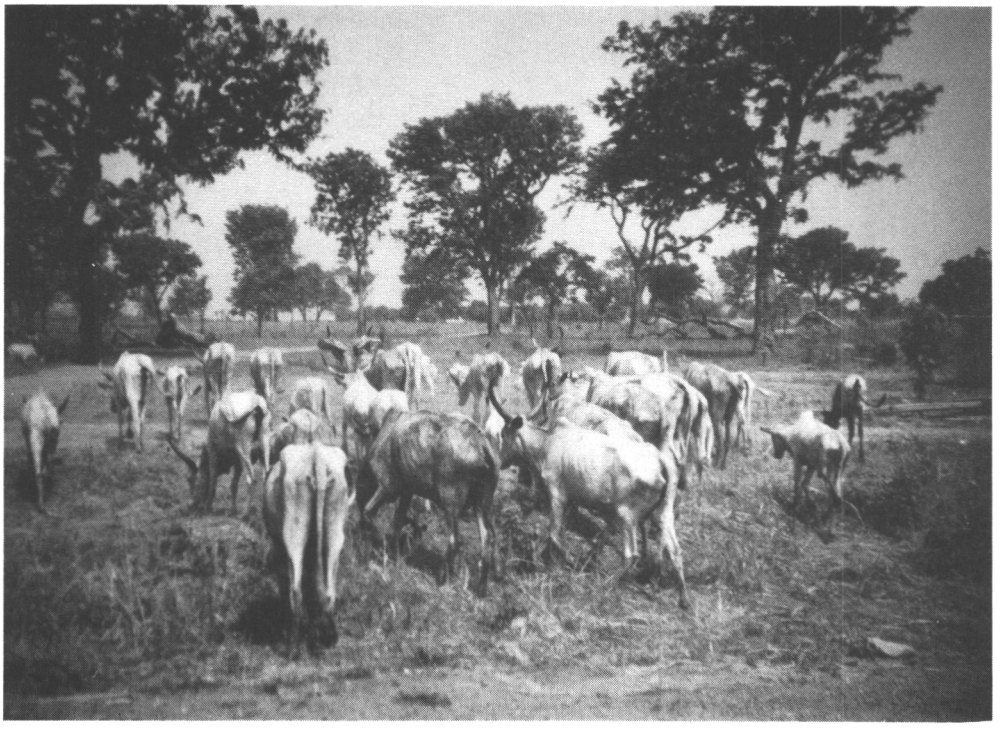


PHOTO: MATTI PALO (NIGERIA)



PHOTO: JYRKI SALMI (MEXICO)

D E F O R E S T A T I O N

AND DEVELOPMENT PERSPECTIVES IN DEVELOPING COUNTRIES - A RESEARCH PROJECT PLAN FOR 1987 - 1991

Matti Palo, Gerardo Mery and Jyrki Salmi

ABSTRACT

Having executed a pilot study during 1986 it was decided to launch a major research project on the topic. The project would verify direct and indirect factors which explain the deforestation phenomenon by specifically identified country groups and identify critical factors of forest-based socio-economic development. Profound case studies of a few countries and comparative country analyses will be executed. Refined deforestation scenarios up to the year 2025 and beyond will be produced by country groups, and eventually also by countries. The social costs and benefits of deforestation will be analyzed. Finally policy analyses will focus on formulating policy programs to control deforestation. The project is planned to last five years and the participating institutions are The Finnish Forest Research Institute (Division of Social Economics of Forestry), The University of Helsinki (Department of Archeology) and The Swedish University of Agricultural Sciences (Department of Economics of Natural Resources, Umeå). A network of collaborators is under establishment.

Keywords: Deforestation, forest-based development, developing countries, research plan

CONTENTS

		Page
1.	INTRODUCTION	224
	11. Pilot study findings	224
	12. Problem of deforestation	228
	13. Forest plantations: a solution?	232
2.	PURPOSE OF THE RESEARCH PROJECT	236
3.	METHODS AND MATERIAL	239
	31. Case studies	239
	32. Comparative country analyses	240
	33. Causal and scenario analyses	241
	34. Policy analyses	242
	35. Material and information network	244
4.	RESEARCH PROJECT IMPLEMENTATION	246
REFERENCES		252
ANNEX		257

1. INTRODUCTION

11. Pilot study findings

"Deforestation has been recognized as a serious problem for at least 15 years, but little effective action has been taken to bring it under control. One of the main reasons for inaction has been a general lack of understanding of the processes causing deforestation." (Grainger 1987, p. 6.)

A pilot study was undertaken by The Finnish Forest Research Institute during 1986. Additional financial support was received from The Academy of Finland. The study confirmed the acute need for a major research project in this field.

The pilot study for the investigation revealed a number of initial problems. For example, data concerning tropical deforestation are unreliable and numerous investigations have been carried out. Furthermore, since each of them takes a somewhat specialized approach, making comparisons is difficult. It appears that few investigations if any have related the problem of forest-based socio-economic development concomitantly with the deforestation process.

The deforestation and development analyses (Palo 1987a, b) led to the conclusion that deforestation and forest-based socio-economic development were closely linked. Of the papers of which the writers are acquainted, those by Douglas (1983) and Westoby (1978 & 1985) gave strong support to the concern expressed above (also Univ. of Helsinki 1985). Furthermore, it became evident that forest plantations, which play an important role in forest-based development, are emphasized in the forest policies of many countries. However, plantations do not represent any straightforward remedy to the problem of deforestation (see section 13).

The World Commission on Environment and Development (1987, p. 37) gave also support to this approach by stating the

following: "Environment and development are not separate challenges; they are inexorably linked. Development cannot subsist upon a deteriorating environmental resource base; the environment cannot be protected when growth leaves out of account the costs of environmental destruction. These problems cannot treated separately by fragmented institutions and policies. They are linked in a complex system of cause and effect."

Empirical work by Palo and Mery (1986) demonstrated the clear negative relationship between population pressure and forest coverage under a set of other causal factors, thereby supporting the recent work by Allen & Barnes (1985). These empirical investigations draw attention to the conflict between population growth and the needs for clearing forests for agricultural land and other uses. The complexity of demographic pressures and sustenance of resources has been frequently focused during the last few decades also at a more general level (e.g. Blaxter 1986; Woods 1987).

Palo (1984 & 1987 a) compiled a list of 20 propositions which he considers to be fundamental to the problem of examining deforestation in a socio-economic context. These propositions already form a priori framework for the determination of the domain of the investigation. Deforestation and erosion in the tropical and subtropical regions were depicted as an accelerating process, where population pressure on land plays a strategic and indirect role (Figure 1).

A clear need was revealed for a multidisciplinary approach, in which forest economics is linked to e.g. general development economics and geographical, ecological, demographical, archaeologic-historical, anthropological and political sciences. A similar conclusion has also been derived elsewhere: "Studies need to be interdisciplinary if they are to match the complexity of the tropical rain forest ecosystem and the human impact upon it" (Grainger 1987, p. 14. See also e.g. Odum 1983).

Contacts with some leading experts in tropical deforestation and international organizations were initiated during the pilot study. Professor Palo participated in relevant international congresses in Ljubljana, Yugoslavia and Delhi, India. Professor Per-Olof Johansson from the Royal Agricultural University of Sweden visited the study group. Our team paid a visit to the Forestry Department of FAO. Further relevant international and national organizations will be visited to ensure coordination and access to existing information.

The detailed findings of the pilot study are reported as separate papers of this issue (Palo, M. 1987a, b; Palo, M. & Mery, G. & Salmi, J. 1987; Siiriäinen, A. 1987; Palo, M. 1987b; Mery, G. 1987). In addition to our pilot study, a number of other researchers and international organizations have stressed the acute needs for further research on deforestation and development in developing countries (Grainger 1987; Riihinen, 1986; Riihinen and Simula 1986; Simula 1986; Jarva 1985; Wazeka 1985). The Club of Rome recently devoted one Session of its Helsinki Conference to "global forests", where tropical deforestation with its research requirements were clearly pointed out (Jarva 1986). The 18th World Congress of The International Union of Forest Research Institutes expressed deep concern about the lack of research on this front (IUFRO 1986; Annex 1).

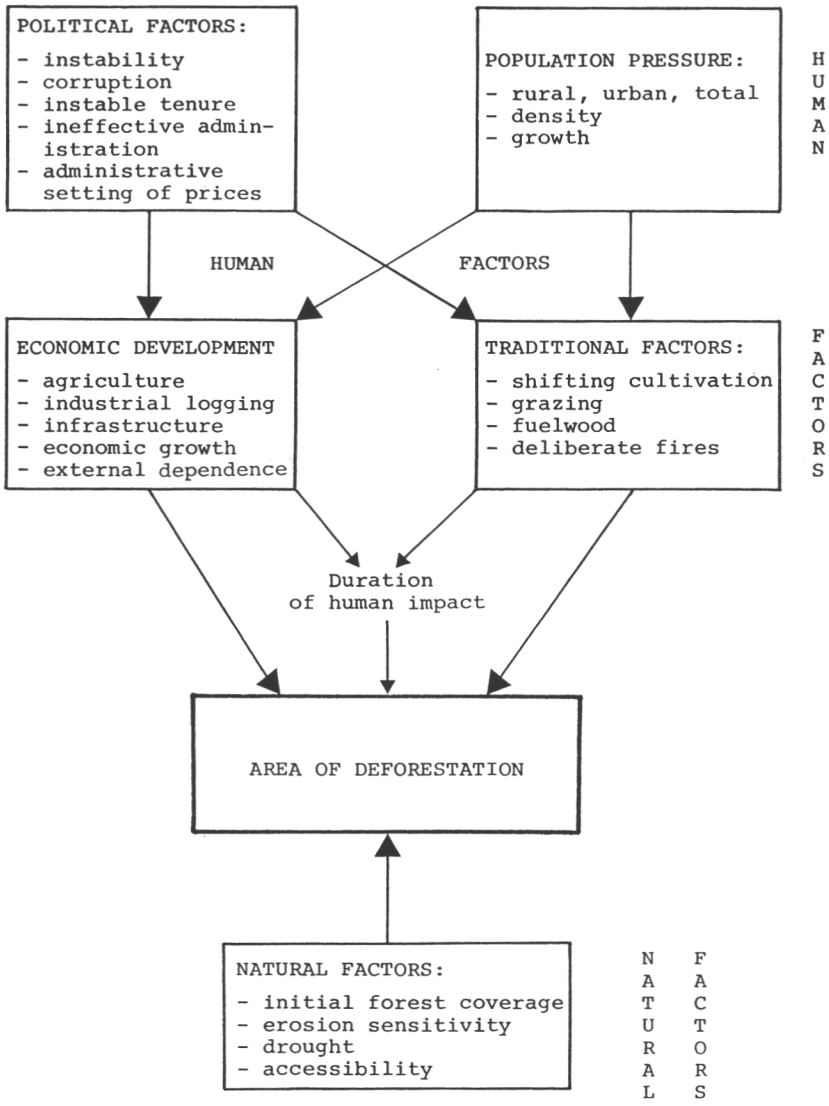


Figure 1. A frame model of accelearating tropical deforestation (Palo 1987a).

12. Problem of deforestation and development

Various studies on the assessment of tropical deforestation have recently been published, each of them supporting widely differing results (Sommer 1976, Persson 1977, Lanly and Clement 1979, Barney 1980, Myers 1980, FAO and UNEP 1981). These studies have used diverse deforestation concepts and different basic data. In spite of these discrepancies, all the above authors agree in stating that the deforestation process is progressing at an alarming rate in most of the developing countries.

In our project we have adopted a definition of deforestation that implicates the elimination of a given forest ecosystem, which is replaced by agricultural cultivations - either permanent or temporary -, pasture lands, human settlements, industrial and infrastructure constructions or, ultimately, by other man-made ecosystem. A similar concept was employed by FAO (Lanly 1982) in the most recent assessment of the forest resources in 76 tropical countries. According to that study, the deforestation of closed and open forests was estimated to have reached 11.3 million hectares annually for the period 1981-85.

The appraisal of the socio-economic consequences generated by deforestation is a complicated one. In addition to the inherent complexity of the deforestation process (Figure 1), balancing its social benefits against its social costs is jeopardized by the fact that they are not equally distributed, either in time or in space (Poore 1976). Moreover, people who might be affected by deforestation may be different from those who benefit from it. Deforestation is, by its basic character, a process where profound market-external costs and benefits are created, therefore, in addition to the existing - often weak or occasionally missing - market mechanisms, effective public control would be essential but is mostly lacking. By adopting an evaluation criterion based not only on the temporary but also on the lasting effects of deforestation on human welfare, the

potential benefits and costs can be determined, although the administrative implementation and control might still remain problematic.

Clearing a large area of tropical forest may provide the following potential benefits:

- It releases new land for temporary or sustainable agricultural cultivation, for grazing, human settlements or for industrial and infrastructure constructions.
- Harvesting may supply wood and timber, fuelwood, fruit, industrial phytochemicals, edible oils, raw materials for medicine production, etc.
- Temporary employment opportunities for people in the harvesting as well as in the processing and wood marketing operations.

However, it is often assumed that deforestation causes more social costs than benefits. Numerous descriptions of negative elements - either local, national, transnational or global in nature - derived from the deforestation consequences have been available since ancient times. For instance, Plato in his "Criteas" gave a detailed description about the serious consequences of deforesting a mountain. (E.g. Poore 1976; Dasgupta 1982; Myers 1984a & 1986.) The following is a summarized list of the potential problems created through deforestation:

- Reduction of genetic resources through depletion and extinction of plant, animal and microbe species is a growing threat. The extinction of species is irretrievable.
- Acute local or national shortages in the wood, timber and fuelwood supply are caused by deforestation in several developing countries. Decline in wood and timber supply deteriorates the future potential for forest-based economic development. Fuelwood scarcity may bring suffering to 2.4 billion people by the year 2000 (FAO 1985b).
- Acute scarcities in supplies of meat from wild animals, of edible fruit and fungi, rattan, bamboo, oils, waxes, gums, resins, spices, balsams, medicines, drugs, dyes,

pharmaceuticals and other non-wood products will be created by deforestation.

- The denudation of the watershed upland forests leads to deep changes in the hydrological regime of the area. It often produces shortages of good-quality water for urban centers, siltation of hydroelectric facilities and reservoirs, lack of regular supply of irrigation water for downstream farmers, and even droughts and flooding during the rainy season.
- Losses of soil productivity are dramatic. A direct effect of losing the protective vegetation cover is soil degradation and erosion. The loss of fertile top soil has been estimated at 6 000 million tons per year (FAO 1979).
- Several diverging opinions haven been expressed concerning the influences of deforestation on the carbon cycle of the biosphere, especially on the carbon dioxide content of the atmosphere, and hence on the world climate at the micro and macro levels. Some researchers believe that the burning of tropical forests constitutes an important source of increasing atmospheric carbon dioxide (Myers 1984a, Woodwell et al. 1983).

Deforestation should be considered primarily as a social and sociological problem (Douglas 1983; Simula 1986). The first human group to suffer the consequences of deforestation is often the indigenous people who live in the forest and get their sustenance from the forest. This phenomenon not only deprives them of their land, but it may also cause sickness, death and extinction.

The rural people or even the citizens who live far away from the deforested area will probably suffer from a diminution of soil productivity, scarcity of fuelwood and other forest and agricultural products which also become more expensive. Also, they are usually affected by adverse environmental effects caused by deforestation, such as flooding, drought or water shortage accompanied by health hazards or even desertification (Myers 1984b; Gorse 1985).

Deforestation and erosion, together with their causes and effects form a strong vicious, often accelerating, circle to accentuate rural and urban depression (Figure 1). The problem of deforestation appears politically hard to solve due to its paradoxical nature: its driving forces lie both in affluence and in poverty. Industrial logging often works as an indirect factor: by constructing new roads and extracting the largest trees it opens up new, previously inaccessible forests to the more direct agents of poverty which again increase the clearing of forest. The export value based on industrial logging of natural and plantation forests in all developing countries amounted to 7-9 billion US dollars annually in 1980-1984 (FAO 1986). Apparently large sums of money are generated also in agricultural exports and other business based on deforested soils. The international and national business interests and national governments mostly form a ruling power elite, often interrelated with corruption.

Poverty in rural areas is one of the key factors in generating deforestation in developing countries. In the early 1980's there were about 1.2 billion fuelwood users who could meet their energy needs only by depleting forests (FAO 1985b). At the same time, it was estimated that 745 million small farmers and 165 million landless peasants were dependent on forests (El Ghonemy 1984). Their immediate subsistence simply depends on cooking with fuelwood, on food production by shifting cultivation or on fodder production by herding their cattle and other animals on woodland ranges. Although they may realize the adverse long-range effects of deforestation, they have no options but to destroy forests or starve (e.g. Spears and Ayensu 1984, Myers 1984b). In the short-range their behaviour is rational and their destructive actions on forests are obligatory for survival. Also, politically their actions have mostly been accepted due to the precarious rural development so far achieved in most developing countries, the prevailing short planning horizon and the economical constraints of those countries.

Some symptomatic problems in forest-based development are inherent in deforestation: scarcities in future timber

supplies, and in external trade in forest products. The share of the export value of the developing countries out of the world total has declined from 18 % to 15 % while the equivalent share in import value has grown from 12 % to 19 % during 1973-1984 (FAO 1986). Accordingly, even the self-sufficiency of the developing countries has been declining. However, the value of forest-products exports by the developing countries has doubled in 1973-1984, while that of the developed countries has grown 2.4 times. A few developing countries, such as Brasil and Malaysia, have penetrated the international markets for processed forest products, but the bulk of them have remained outside the potential benefits of export-led, forest-based development.

13. Forest plantations: a solution ?

About 11.5 million hectares of forest trees were planted by 1980, according to FAO's last survey of 76 tropical countries (Lanly 1982). 75 % of this total planted area was classified as industrial forest plantations, where the main objective is to provide raw material for mechanical wood processing industries, pulp and paper industries and charcoal for industrial uses. The remaining 25 % had been planted for other purposes like fuelwood production for rural communities, watershed protection, agroforestry projects, soil conservation, wildlife preservation, etc.

The major part of industrial plantations form compact and extensive masses of rapidly growing exotic species. The most commonly planted trees have been fast-growing hardwood species (47 %), other hardwood species (27 %) and softwood species (26 %). However, these percentages are actually changing and the proportion of the area planted with pines is increasing.

The yield of these man-made forests depends largely on the site characteristics, species employed and management practices adopted. However, most of these forests are high-yielding ones. For example, the volume increment rates o

Eucalyptus spp. in Brazil may exceed 60 m^3 per hectare per year in plantations established on good sites and managed using appropriate systems (Galvao and do Couto 1983).

Most of these forest plantations are young: 40 % have been planted during the period 1976 - 80 (Lanly 1982). The trend towards an acceleration of the annual rate of plantations is clear. For example, it is estimated that Latin America's industrial plantation areas will have tripled by the year 2000 (McGaughey and Gregersen 1983).

Table 1. Areas of established forest plantations until 1980 (Source: Lanly 1982).

Continent	Total Plantations (million ha)	Indus. plant. as % of total plantations	Annual plant./ closed forest defor. ratio
Tropical America (23 countries)	4.6	88	1 : 10
Tropical Africa (37 countries)	1.8	56	1 : 14
Tropical Asia (16 countries)	5.1	69	1 : 4
Total (76 countries)	11.5	74	1 : 8

The different continents have diverse histories and traditions of plantation activities. According to the available statistics up to the year 1980, we can conclude that the majority of the stands planted in tropical Africa and in tropical Latin America were established after late sixties. In tropical Asia, on the other hand, massive plantation work began even earlier (Lanly 1982).

The annual rate of establishment of new forest plantations by 1980 was 0.4 million ha in tropical America, 0.1 million ha

in tropical Africa and 0.4 million ha in tropical Asia. All forest plantation efforts up until 1980 are small compared to the total deforestation (Table 1). However, it is necessary to bear in mind that reforestation or afforestation activities are already playing an important role in supplying raw material for forest industries, and may also have an additional positive effect in regenerating denuded, previous forest areas.

Consequently, forest plantations constitute a complementary effort to control degradation and destruction of existing forests. The subsequent investment opportunities were pointed out clearly in two recent action plans for tropical forestry (FAO 1985 a; The World Resources Institute 1985). However, they cannot in isolation be considered as a relevant remedial policy to halt deforestation. This point of view is supported by Ross and Donovan (1986): "the problem of deforestation must be recognized to be in most cases distinctly different from the need for reforestation". Our agreement with this asseveration is based on the following facts:

(i) Most forest plantations (74 %) are industrial ones (Table 1), which are intented to supply wood for industrial processing. Such plantations have no direct link with the socio-economical factors that have been identified as the main causal factors of deforestation (Palo 1987 a).

(ii) Forest plantations are spatially highly concentrated, particularly in Asia and Latin America. In the latter continent, Brazil, Chile and Argentina account for approximately 85 % of the total planted area (Mery 1987). India and Indonesia have 77 % of the forest plantations established in tropical Asia. On the other hand, deforestation is a rather wide spread phenomenon that drastically affect most countries in the tropical world.

(iii) An important share of deforestation is actually taking place in remote areas where land is not yet a constraining factor for practicing a subsistence economy. That is in contrast to the fact that most of the industrial plantations are rather close to industrial consumption centers.

(iv) The successful experiences gained in growing high-yielding stands have so far not been counterbalanced by

paying enough attention to some potential environmental risks such as:

- depletion of soil nutrients through extraction of biomass from the plantation sites;
- vulnerability of monocultures to diverse pests and diseases;
- impoverishment of the local genetic plasm available for future natural regeneration of the climax forests in cases where clear-cut forest areas are planted.

The role of forest plantations in the developing countries is widely recognized as a catalyst for industrial development. The simultaneous planning and interactive implementation of plantations and mills have been characteristic in this front. Brazil, with such projects as Jari, Aracruz, Cenibra, Amcel and Riocell, provides positive illustrations in this respect. Our research project will examine in detail, especially in the case study countries, the role of plantations in the more general approach of forest-based socio-economic development as outlined by Palo (1987 b).

However, in spite of our rather critical view on the role of forest plantations in the prevention of deforestation, we agree that under fortunate circumstances they may play an important role. For instance, at the village level, when the dwellers are cooperative, a new fuelwood plantation or a new agro-forestry plantation may save a natural forest area from further deforestation through human or animal pressures. Outside the tropics, China provides an illuminating case of large-scale forest plantations (about 35 mill. ha), although most of them have been created for the rehabilitation of previously deforested areas (FAO 1978, Palo & Mery 1986, p.27).

2. PURPOSE OF THE RESEARCH PROJECT

The research project as a whole should contribute towards increasing our knowledge concerning the forest-based socio-economic development process in general, and about its deforestation constraint in particular. More specifically, the purpose is to enhance the chances of ex ante and ex post evaluation of forest-based development projects in developing countries and of strategy choices. A concomitant aim is to contribute towards increased education and training by facilitating the completion of several theses for graduate and under-graduate students in the case study countries, as well as in Finland, and also by organizing specific training courses. A final aim is to interact with diverse national and international policy-makers and agents of deforestation and development, and to disseminate effectively the research results in order to improve the relevant control mechanisms.

Accordingly, the results expected from this research project comprise the following:

- The verification of direct and indirect factors which explain the deforestation phenomenon by specifically identified country groups.
- The identification of the existence or non-existence of forest-based socio-economic development and of the inherent conditions among the developing countries.
- Quantified alternative scenarios of deforestation perspectives, also by groups of countries.
- Historical analyses of deforestation and development in the selected case study countries will be produced jointly with the University of Helsinki, Department of Archeology. The case studies will comprise historical long-range analyses of deforestation (Siiriäinen 1987) with its causes and consequences, as well as similar analyses of socio-economic development based on forests.
- Cost-benefit analyses of the consequences of deforestation in the case study countries.

- Recommendations for policy aims and means in order to improve the controlling of deforestation and forest-based development.
- The ultimate aim of the project is to create, on the basis of the other results and whenever feasible, country-wise deforestation scenarios up to the year 2025 and beyond.

The Finnish forest industries have, during the few past decades gradually become more internationalized. The Finnish corporations have encountered more competition also from some developing countries in their international marketing (Kiljunen 1986), they have purchased or established mills in other developed countries and some of them have been active in consulting and co-operating in establishing forest plantations or mills in developing countries. Jaakko Pöyry Oy, Ekono Oy and some other consulting companies have expanded their operations into the developing world. Also the development aid of the Finnish Government has increased and is expected to grow rapidly in the future.

Consequently, the potential beneficiaries of the project include developing countries, FINNIDA, Finnish forest industry firms and other relevant national and international bodies. Special emphasis is devoted to the applicability of the study in promoting development and putting brake on deforestation in the developing world.

In order to facilitate analyses of more case study countries, the project will invite further collaborators from other (Scandinavian) countries. The research activity of this project will be specifically liaised with the proposed project "Social costs of tropical deforestation" being carried out by P. Riihinen and M. Simula (1986), as well as with the Club of Rome's present Africa project (e.g. Siiriäinen 1987) and other relevant research (e.g. Deutsches Forstverein 1986; Duinker 1987; Fugalli 1986; Grainger 1987; IIED 1986 a & b; Nilsson 1986). In order to ensure effective liaison, a specific advisory group for this project is being created.

The results anticipated from this research project will contribute to our knowledge, leading to more effective controls designed to check avoidable deforestation and its serious consequences. The results may also assist in the allocation of development aid and business investments within forest sectors of developing countries more effectively and efficiently from the socio-economic development point of view. The results will be transmitted to the relevant national organizations, international agencies and business firms which require quantified data for their project evaluation and decision making.

3. METHODS AND MATERIAL

31. Case studies

A fundamental problem encountered by the team is the apparent paradox concerning the quality and quantity of the accessible empirical data about forest-based development and deforestation in the developing countries (e.g. Palo 1975, 1978, 1980, 1983; Palo & Olojede 1982). Numerous documents, files and other data and information have been accumulated in various quarters as a result of the efforts of national governments, international organizations and donor countries. They are, however, often of dubious quality due to a lack of relevancy, coverage, accuracy etc. Since the most accessible data concern the developing countries as national wholes, these countries constitute suitable entities for further case studies.

The case studies will focus on the long-range environmental, demographic, socio-economic and political development of a country from a perspective of forest-based economic development and deforestation. Innovations in subsistence economies have, through the ages, contributed to both development and deforestation in traditional societies. The identification of the emergence and diffusion through the ages of activities such as pastoralism, cultivating pastoralism, cattle raising, cultivation (agriculture), shifting cultivation, iron production, industrial logging and forest industries, provides a fundamental theme for the case studies (Siiriäinen 1987).

The data and information accumulated on changes in the forest coverage of case study countries will be analyzed. The possibilities of employing the results of remote sensing, forest inventories and vegetational mapping will be studied. The role of forest plantations and other forest-based development projects will also be evaluated (Section 13). A theoretical frame for case studies consits of the provisional theory of tropical deforestation (Palo 1987 a). The social costs and benefits of deforestation will also be described

and analyzed. The provisional theory of forest-based socio-economic development (Palo 1987 b) provides an understanding of the past positive development (if any) and the missing linkages behind any trapped development.

Finland can be used as a reference country from the industrialized world to provide an example of a country where a marked forest-based development has occurred during about one century, and where the previously acute deforestation threat has been avoided. Although the present developing countries encounter quite different international technologies, economies and political environment from those in the past, Finland can still, under the known reservations, stand as a comparative measure. For instance, Williamson (1986) made a parallel historical comparison of Britain and some other European countries with present developing countries in his analysis on industrial development.

During 1987 counterpart research organizations and researchers will be identified in the case study countries. Close cooperation will be established with them later on. Contacts with relevant researchers and institutions in other Scandinavian countries will also be created in 1987 in order to ensure that more case countries will be studied during 1988 - 1991.

32. Comparative country analyses

Social science investigations have traditionally employed country-wise data in their empirical analyses (e.g van Gemert 1986; Williamson 1986; Alapuro, R. et al. Eds. 1985). The application of relative variables (instead of absolute quantities) only has been one way of overcoming the problem of different sized countries. Locational and historical aspects, socio-economic development, natural environment, demographic and political factors all create differences among nations and countries. In the absence of time series of deforestation variables the problem becomes accentuated.

A comparative analysis methodology has been established by political scientists in order to reduce heterogeneity among countries.

The comparative analysis will describe past developments and the present situation through classifications and typologies. The final aim is to find invariancies or common features or generalizations among the countries. The "hard" data can be complemented with "soft" data comprising literature, other documents, observations and interviews unfixed form.

During 1987 a grouping of developing countries by factor, discriminant and residual analyses will be executed. This grouping is aimed at three main goals, i.e. a) to determine the criteria relevant for a final grouping of countries for further deforestation investigations, b) to analyze the common characteristics of the forest sector development, and c) to promote the selection of additional case-study countries during 1988-1991.

The basis for the work is the geographical grouping applied by Palo and Mery (1986). In addition to that, other relevant criteria will also be tested. The residual analysis applied so far has suggested some minor changes in the initial geographical grouping of countries. The pilot grouping analysis of the tropical countries done during the feasibility study of 1986 has demonstrated the viability of the proposed methods. Different country groupings are needed for different purposes of analyses, thus the groups for explanation and scenario models may differ from each other. The results of case studies will be linked with the other countries within the relevant country groups.

33. Causal and scenario analyses

Regression analyses will be continued during 1987 according to experiences gained in the pilot study of 1986 (Palo and Mery 1986; Palo, Mery and Salmi 1987). They will be complemented with econometric applications and further

residual analysis (e.g. the problem of outliers). The various multivariate analyses have some restrictions when analyzing the sort of system shown in Figure 1, with its various feedback loops and accelerating nature. Accordingly, the possibility of applying a system simulation technique will also be considered.

Causal models are needed for the basis of scenario making, and for choosing of effective policy instruments. For example, The Forestry Department of FAO and IIASA (in Austria) have already expressed an interest in our scenarios. The UN population predictions cover all nations and territories, and hence provide a solid support for long-range deforestation scenarios. Unfortunately GNP or other economic variables have not such a wide coverage.

34. Policy analyses

Case studies, comparative country analyses, causal and scenario analyses of this research project all provide a factual basis for policy analyses. Such analyses will be executed only in cases where collaborative parties and cosponsors will appear. The ultimate aim here is to determine relevant ends and means for a policy formulation that would be suitable for immediate implementation and for effective, efficient and fair public control of deforestation and forest-based development. However, the enhancement of public control in this front with diverging vested interests is the most problematic task due to the vicious circle character of the deforestation process (Figure 1).

Policy analyses will be particularly focused on the case study countries. The mutual fitness of ends and different kinds of means appropriate for a deforestation policy formulation in a particular country and situation have to be clarified. Not only effectiveness and economic efficiency of a policy program but also its distributional effects, social and cultural acceptability, as well as its operational and administrative practicality, have to be analysed. In

deforestation and forest-based development issues, such questions as who is gaining, who is paying and how much, where and when, are most essential. Divergences between the incidence of costs and distribution of gains are markedly existing in this front. Therefore various compensating policy measures have to be identified.

One particular problem in policy formulation confronted here is the strong interdisciplinary and intersectoral nature of the problem area (e.g. Riihinen 1986). Although the framework of policy analyses is based on standard procedures of economic and forest policy analyses (e.g. Tinbergen 1966; Clawson 1977; Tikkanen 1987), deforestation policy analyses require a specific approach based on the particular experiences in environmental dispute resolutions (Bacow & Wheeler 1984) and on the experiences gained in investigating complex systems such as the biosphere or the international energy system (Nilsson 1986; Duinker 1987; Toth 1986).

Such an approach will be applied in the form of policy workshops. Workshops will be organized during the course of the research project, if collaborative parties and cosponsors will appear. A policy workshop is a flexibly structured process designed to promote mutual interaction and knowledge between the researchers and policy-makers. A workshop period consists of three phases - preparations, the workshop proper, and evaluation - and can be repeated. Making alternative scenarios and analysing their consequences via the interactive formulation and "testing" of alternative deforestation policies that respond to challenges in the scenarios are at the heart of the policy workshop process.

Policy-makers learn from researchers about the ramifications of alternative policies, and researchers learn from policy-makers about various conceptions of the deforestation problem and the kinds of relevant new information that policy-makers feel they need to cope with. The interactive learning process is assumed to contribute towards better structured views of the problem in the minds of the participants. The workshop process produces also statements on where institutional or

technological or other policy measure changes are needed to better cope with the deforestation problems, and what kind of improvements in monitoring could create early warning systems and thus ease the problem solving.

35. Material and information network

The research project will be based primarily on existing data and other empirical material. No specific field work for information gathering is planned, mainly for financial reasons. The research workers of the project have prior acquaintance with the case study countries. During 1987 counterpart researchers and institutions will be established in the case study countries, which will be of additional assistance in collecting empirical material. Several further visits to relevant international organizations, such as, UNEP, UNESCO, UNCTAD, UNIDO, OECD and IIASA are required to complement the existing data base of the project.

The basic data on forest areas and deforestation will be based on the comprehensive recent assessment (FAO & UNEP 1981, Lanly 1982), which will be up-dated in liaison with the FAO Forestry Department along with their future revisions. The World Bank Development Reports and UN demographic publications provide the basic country-wise data already applied by Palo and Mery (1986) and by Palo, Mery and Salmi (1987), but so far only partially analyzed. A set of 60 variables for 72 countries is already in the computer files of the Finnish Forest Research Institute.

In order to facilitate the documentation of the available information, the creation of a data base for information on forest-based development and deforestation in developing countries will be continued. Another system for an international information network based on the principle of exchanging experiences and visits among researchers will be developed.

The data base will comprise information on published papers, reports etc. dealing with the problem of this study. In addition, it will contain information on e.g. relevant development aid projects in developing countries and research projects related to the present theme. The data base will be expanded to its final form during the duration of the research project program. It will thus provide the various users with a means for systematic screening of existing data. The data base is planned to be managed with a system able to organize, sort, relate and up-date a large collection of information in different related fields. These goals can be achieved using a database relational program. This makes it an easy-operating and user-friendly on-line system.

4. RESEARCH PROJECT IMPLEMENTATION

The Finnish Forest Research Institute (Division of Social Economics of Forestry), The University of Helsinki (Department of Archeology) and The Agricultural University of Sweden (Department of Economics of Natural Resources, Umeå) are the participating institutions which will provide necessary research facilities for the project staff. The project will be led by Professor Matti Palo (The Finnish Forest Research Institute) and Professor Ari Siiriäinen (University of Helsinki). Professor Per Olov Johansson (The Swedish Agricultural University, Umeå) and Dr. Ashley Selby (The Finnish Forest Research Institute) will also collaborate in the Core group.

The project team will be formed by the following researchers:

- Mr. Gerardo Mery: full-time researcher (The Finnish Forest Research Institute) who will primarily study the deforestation process.
- Mr. Jyrki Salmi: full-time researcher (The Academy of Finland) who will primarily analyze the forest-based economic development questions.

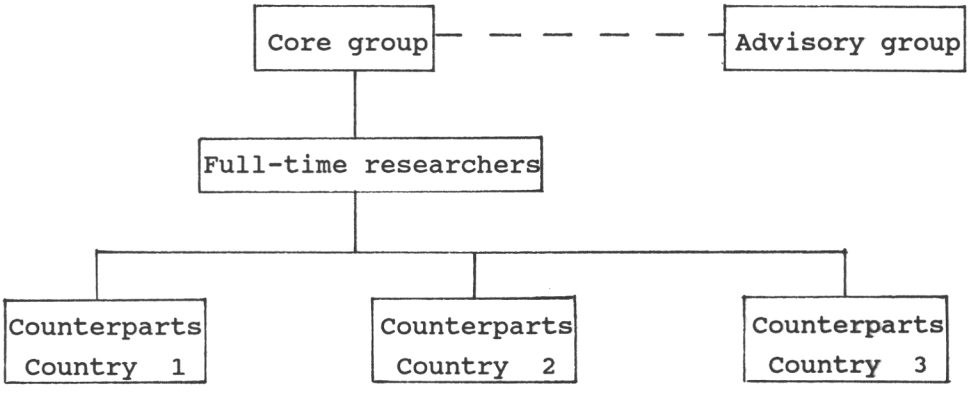


Figure 2. Organizational outline of the research project.

- An assistant to Professor Siiriäinen (The Academy of Finland / The University of Helsinki): full-time researcher whose main activity will be in the field of long-range analysis of man-environment relationships.

The project will have the organization shown in Figure 2.

The first stage of the research project is scheduled to last for three years and the second stage for two years. The research tasks will be accomplished by a minimum of three full-time researchers, led by a Core group and in collaboration with a counterpart group in the case-study countries and liaised by an Advisory group.

During 1987 the project will be focused on a few country case studies. They will be initiated jointly with relevant counterpart organizations and researchers from the case countries. The work will also continue on the provisional theory of tropical deforestation with joint efforts by professor Per-Olov Johansson and by the project team, on the further grouping of countries, on causal analyses of deforestation and the development phenomena by applying the cross-sectional data of 1980 along with factor and regression analyses. Furthermore, improved deforestation scenarios will be created by country groups.

However, priority will be given to the case studies in the near future. At least one country per continent will be studied. Man - forest environment relationships in a long-range perspective will be analyzed according to Siiriäinen (1987). Information about deforestation in each individual country will be gathered, and the peculiarities of this process will be analyzed. Information on the development of forestry and forest industries will be collected and the role played by such forest developments in the country's economy and social relations will be assessed. Finally, a cost-benefit analysis of deforestation will be executed.

The objectives will be pursued in each case country by following a sequence of three phases:

- First phase work will be carried out in Finland as follows:
  - bibliographical review, data collection and expansion of the existing information base on the topics above,
  - analyses of the collected information,
  - establishment of mail communication with researchers and research institutions in the case countries, aiming at creating a counterpart research team.

- Second phase work will be carried out in each case-study country as follows:
  - establishment of the counterpart group and its research schedule,
  - revision of bibliography, data and other information,
  - elaboration of counterpart group's report.

- Third phase work will be done in Finland as follows:
  - editing and checking of collected data,
  - revision of the methods used for the analysis,
  - compilation of the results,
  - writing of the final report,
  - discussion and printing of the final report.

A period of three years (June 1987 - May 1990) is required (by the existing staff to carry out the studies in three different countries, following the schedule of Figure 3. The

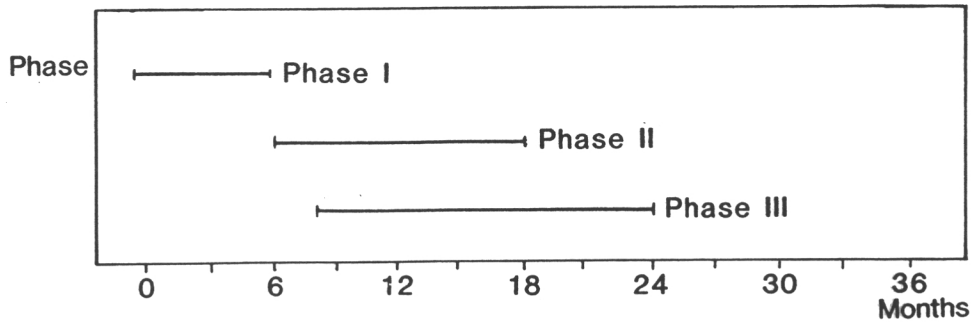


Figure 3. Schedule of the research work performed in every case study country.

selection of potential case-study countries was made using the following criteria: availability of information, availability of cooperative parties, prior acquaintance of the present researchers with these countries, FAO's Forestry Department's (major data supplier) opinions, national importance of deforestation or forest-based development and a past of present aid programs by Finland.

The aim during the first phase is to choose, at the most, one country per continent. Resource availability will dictate the final selection. The candidates for the choice of case study countries are the following:

Latin America:	Chile	Africa:	Kenya
	Peru		Zambia
	Brazil		Tanzania
	Mexico		Ethiopia
			Zaire
			Mozambique
			Nigeria
Asia:	Nepal		Burma
	Malaysia		The Philippines
	Sri Lanka		Indonesia
	India		Thailand

Chile and Finland (as a reference country) were selected as the first two countries to be focused on by case studies beginning in 1987.

The implementation of this research plan will require, first of all, an effective follow up of what has been done so far in this front in the whole world. Possible visits abroad during the first years of the project would contribute not only in data collection, but also in identifying potential cooperative and information network parties.

It is intended that the cooperative parties will comprise such organizations as the FAO Forestry Department, UNEP,

Unesco, ICRAF, international development banks, OECD-Development Centre, WIDER, FINNIDA, and the University of Helsinki. Also other Nordic partners will be welcomed.

The following persons will be invited to join the advisory team: Dr. P. Frhr. v. Fürstenberg (Deutscher Fortsverein, Fed. Rep. of Germany), Dr. Kari Keipi (Inter-American Development Bank), Dr. Kimmo Kiljunen (University of Helsinki, Institute of Development Studies), Dr. Norman Myers (Oxford, England), professor Sten Nilsson (IIASA), professor Risto Seppälä, research director (The Finnish Forest Research Institute), professor Simo Poso (University of Helsinki, Department of Forest Mensuration and Management), professor Päiviö Riihinen and Dr. Markku Simula (University of Helsinki, Department of Social Economics of Forestry) and representatives of FAO, FINNIDA and WIDER.

Policy workshops designed to promote the mutual interaction and exchange of information between the project researcher and relevant policy-makers will be organized both on continental and national bases. Policy workshops for Latin America, Africa and Asia will take place during 1988-1989, and national ones for case study countries during 1989-1991. The implementation of the workshops requires financing and collaboration by some national or international development organizations.

A particular effort will be devoted to an effective dissemination of research results. Major publications and scientific articles focusing on the scientific community will be published primarily in the Communicationes - series of The Finnish Forest Research Institute and in the Scandinavian Journal of Forest Research. Working papers and intensive reports focusing on both scientists and practical foresters, agronomists and other professionals will be published in Tiedonantoja (Reports) - series of The Finnish Forest Research Institute and in Unasylva of FAO. In addition, popular articles addressed to the general public will be distributed in all collaborative countries, and especially in

the case study countries with the help of the counterpart bodies. Also workshops and seminars will be organized.

In the various implementation phases of the present research project specific attention will be paid to liaising and coordinating aspects. Our project is basically sosio-economic and historical by its approach, and primarily utilizes already existing data and information on a country-wise basis. The other ongoing research projects familiar to us (Fugally 1986; Grainger 1987; Riihinen and Simula 1986; Luukkanen 1987; Pietarinen 1987) are either more biologically oriented and/or directed more towards small localities of particular countries. Therefore, on the one hand the efforts by us and by others tend to complement each other, and on the other hand the problem of deforestation and forest-based development is so complex and global that all scientific efforts are kindly welcomed. The last view is parallel to the recent declaration by the International Union of the Forest Research Organizations (Annex 1).

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Annex 1.

I U F R O

18th World Congress

Ljubljana, Yugoslavia 1986

Declaration

Considerations

The very survival and welfare of man depends of the maintenance of trees and forests and the continuation of the products, services and benefits they provide.

The socieconomic and environmental impacts of loss of these resources are not yet fully appreciated by the public, nor completely understood by scientists.

Dramatic losses of forests, with consequent losses of soil and decline of soil productivity, are occurring in tropical countries because of expansion of agriculture, urbanization, overexploitation of forest resources themselves, and increasing demands for fuelwood and other products. Rapidly increasing sizes of human populations, changing conditions in land tenure, and lack of social stability are serious political and cultural issues impeding solutions.

Equally threatening is the increasing damage to temperate forests caused by the polluting effects of various industries, traffic and heating of houses on the air, water, soil and trees themselves, Although scientists have sufficient information to suggest provisional remedies, exact cause and effect relationships are not sufficiently known. The great impact of forest fires should also be considered.

The importance of research in attacking these problems is not fully recognized, and research is often inadequate, poorly targetted, or not applied because of lack of financial and human resources and inadequate mechanisms for transferring results into practical resource management.

Recommendations

Governments and international development agencies, recognizing the socioeconomic importance of trees and forests, should provide the resources for research, development and application of appropriate, sustainable systems of resource management. They should re-examine urgently the social, political and economic issues underlying deforestation and pollution.

Forest services and professional foresters, recognizing the complexity of relations among forests, environments and national socioeconomic welfare, should appreciate the need for relevant research, particularly in tropical deforestation and temperate environmental pollution. Working together with researchers and extension foresters, they should mobilize and speed the transfer of scientific findings to hasten the solution of socioeconomic and environmental forestry problems.

Research and educational institutions, recognizing the limits of research resources, should develop methods of evaluating the benefits of research and of anigning priorities to research topics and should provide adequate training and career rewards for individual researchers. They should ensure that forestry research programmes are directed towards major challenges facing mankind to meet growing needs for food, wood and energy, and to improve man's environment.

IUFRO, recognizing the threats to mankind posed by deforestation and pollution, should seek to expand its special programme for developing countries and to establish a paralel interdisciplinary programme on the causes, effects and integrated management of pollution.

New IUFRO programmes and existing Research Groups, recognizing the over-riding international significance of these two major problems, and working with other research agencies as appropriate, should collect and synthesize existing information, define standardized methods for monitoring, study short-term management measures to keep forests living, initiate long-term research on causes and effects, determine the relevance of knowledge to countries in which the problems are not yet apparent, and inform governments, adminiatrations and the public.

KANSANTALOUDELLISEN METSÄEKONOMIAN TUTKIMUSSUUNTA

Kansantaloudellisen metsäekonomian tutkimussuunnan yleispäämääränä on tutkia metsätalouden ja metsäteollisuuden sekä metsien monikäytön kansantaloudellisia ja sosiaalisia kysymyksiä sekä puun käyttöä ja metsätasetta.

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