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STUDY OF REQUIREMENTS FOR TRAINING IN NATURAL RESOURCES IN LATIN AMERICA AND THE CARIBBEAN

SITUATION AND TRENDS OF RENEWABLE NATURAL RESOURCES OF LATIN AMERICA AND THE CARIBBEAN

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SITUATION AND TRENDS OF RENEWABLE NATURAL RESOURCES OF LATIN AMERICA AND THE CARIBBEAN [1/]

By

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SYMBOLS AND ABBREVIATIONS USED

Cal (cal)	Calorie(s)
Cal/m2	Calories per square meter
Gm3	Cubic gigameter
Gr (gr)	Gram(s)
Gr/m2	Grams per square meter
Gr/m2/year	Grams per square meter per year
GW	Gigawatt
GWh	Gigawatt hour
Ha (ha	Hectare(s)
Persons/km2	Persons per square kilometer
K cal	Kilocalorie
K cal/m2	Kilocalories per square meter
Kg (kg)	Kilogram(s)
Km (km)	Kilometer(s)
Km2	square kilometer
M (m)	meter(s)
Mgr (mgr)	~~Milogram~~ Milligram(s)
Mgr/lt	~~Milograms~~ Milligrams per liter
Mm3	Cubic megameters
Mtm	Megatons
MW	Megawatts
Ppm (ppm)	Parts per million
GDP	Gross Domestic Product
MT (mt)	Metric ton(s)
MT/km2/year	Metric tons per kilometer per year
TWh	Terawatt hour
US$	United States dollars
W	Watt(s)
%	Percent

BID (IDB)	Inter-American Development Bank
BIRF (IBRD)	International Bank for Reconstruction and Development (World Bank)
CATIE	Tropical Agronomic Center for Teaching and Research
CEE (EEC)	European Economic Community
CEPAL (ECLA)	Economic Commission for Latin America
CEPIS	Pan American Center for Sanitary Engineering and Environmental Sciencies
CIP (IPC)	International Potato Center
DECARAF	Chile. The former government department responsible for renewable natural resources
EEUU (USA)	United States of America

FAO	United Nations Food and Agriculture Organization
ICRAF	International Council for Research in Agroforestry
IICA	Inter-American Institute for Agricultural Sciences
INCORA	Colombian Institute for Agrarian Reform
INDERENA	Colombia. Natural Resources Institute
ITC	International Trade Center (UNCTAD)
UICN (IUCN)	International Union for the Conservation of Nature
JUNAC	Board of the Cartagena Agreement
ONU (UN)	United Nations
OEA (OAS)	Organization of American States
OIT (ILO)	International Labor Organization
OLADE	Latin American Energy Organization
OMM (WMO)	World Meterological Organization
OMS (WHO)	World Health Organization
ONERN	Peru. National Office for the Evaluation of Natural Resources
ONUDI (UNIDO)	United Nations Industrial Development Organization
OPS (PAHO)	Pan American Health Organization
PNUMA (UNEP)	United Nations Environmental Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WWF	World Wildlife Fund

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SUMMARY

In 1977 Latin America and the Caribbean had a total population of about 350 million, growing at a rate of 2.8% per year; it is assumed that the rate will decrease to 2.5% in the years ahead. By the year 2000 the population will probably exceed 600 million, with an average density of 30 persons per square kilometer. The highest density will be found in the Caribbean with 195 persons/sq km and the lowest in the Southern Tier with only 14.3 persons/sq km. By that time 75% of the population will be living in cities of over 10,000 inhabitants, and 53% in cities of over 100,000. At present, the population of the continent is on the whole poor with a per capita gross domestic product of US$1,100; however, it is considerably less poor than that of other continents. By the year 2000 per capita GDP is expected to have doubled. The population is appreciably better fed than that of the other countries with developing economies, but even so, an estimated 56% of the children under nine years of age suffer from calorie deficiencies.

The present use of land in Latin America and the Caribbean is distributed as follows: 9% arable land, 26% natural pastures, 49% forests and 16% unused land or land occupied by human infrastructures. In other words, not less than 35% and probably as much as 45% of the continental land area has already suffered the total destruction of its natural ecosystems, or at least their drastic alteration.

The natural quality of soils for agricultural production is in general poor, the proportion being estimated realistically at 8 to 16% of the total area. Many optimistic reports indicate that the potentially arable soils are much more extensive (27 to 32%), but these sources acknowledge that their use without serious deterioration requires the application of an advanced and costly technology and highly favorable socioeconomic and cultural conditions.

Moreover, only 65% of the currently arable land is harvested annually, and the harvests are several times smaller than the potential that could be obtained. This attests to the priority that should be given to increasing productivity vis-a-vis the ~~always~~ hitherto preferred alternative of expanding the agricultural frontier. In the year 2000 it is believed that agriculture will have to cover slightly more than 14% of the continental land mass in order to meet the requirements of the population; in other words, by that time all soils suitable for agriculture theoretically would be in use. However, many of these soils are already being used for an extremely destructive type of stockraising.

Beyond any doubt, stockraising is the human activity with the greatest environmental impact in Latin America and the Caribbean. Distinguished by a very low level of technology, it has already occupied enormous areas at the expense of forests. It is estimated that if the livestock population grows at the trend rate (which coincides with the desired rate), there will be a maximum of 480 million head of cattle (including equines, sheep and goats) in the year 2000. In this case, assuming that stockraising will be intensified so as to maintain 0.69 head/ha rather than 0.58 head/ha as at present, pastures would cover 34% of the continent in the year 2000, or slightly more than that covered by forests. Other projections assume that the livestock population will increase to a lesser extent; in this case the pasture area obviously would be slightly smaller. At the same time, some believe that stockraising already occupies an area much larger than that shown in the statistics.

At present, the expansion of farming and particularly of stockraising takes place essentially through the destruction of natural forests. Irrigation and drainage account for a very insignificant proportion in terms of area. The present area of forests is a highly controversial topic, but is estimated at 991 million hectares, of which 681 million are dense tropical forests,

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81 million dense temperate forests and 229 million sparse woodlands. By the year 2000 the forest area will be reduced to only 673 million hectares, with 524 million in dense tropical forests, 72 million dense temperate forests and only 77 million sparse woodlands, the latter being most favored for the expansion of stockraising. Should this be the case, by the year 2000 forests will cover only 33% of the area studied. But if the estimates are correct as to the true extent of the area used for grazing -- including that shown in the statistics as sparse woodland -- only 20% of the area would remain under forests.

Idle land and other land unsuitable for agriculture would represent 18% of the area in the year 2000. The increase in this category will be due primarily to desertification, highly accelerated erosion by water and wind, salinization and urban and industrial expansion. Part of the dry idle land will be irrigated, and irrigation and drainage will be the only means of recovering significant areas up till the year 2000. These lands will continue to account for the largest part of agricultural production.

Although in absolute terms most of the new arable land will be gained in the Brazilian Amazon region and in other low-lying parts of that basin, a relatively larger proportion will be provided by the upper Amazon, i.e. in the eastern Andes, with catastrophic ecological consequences. A similar situation will occur in Central America where -- as in the rest of the continent -- agricultural expansion is achieved more at the expense of protective forests than of productive ones. The expansion of stockraising will be greater in sparse woodlands and on plains than on lands covered by dense tropical forests. Because of agricultural expansion some natural ecosystems may disappear completely, among them forests of Araucaria in Brazil, Podocarpus in various parts of Latin America, some types of forests in southern Chile, etc.

The loss of land is due primarily to erosion, in particular that caused by water, which in many countries is moderate to severe on most of the land. Desertification already affects 20% of the study area, and is increasing sharply. Also significant are salinization and alkalinization, which degrade excellent agricultural land particularly because of poor management of irrigation water; some 8% of the land of South America has been damaged by these processes.

Also contributing to the loss or deterioration of land are urban expansion, pollution, loss of fertility, climate and natural disasters. The greatly preferred response to these problems is to expand the agricultural frontier rather than to prevent them or correct them by managing soils better. The main way in which agricultural land is expanded is through spontaneous settlement, which usually results in migratory agriculture; this may account for as much as 77% of the annual increment in agricultural land, with disastrous consequences for the environment. Next in importance is irrigation, with expansions that are small and costly but which produce much of the harvests. At present there are 13 million hectares under irrigation, and the total will be about 22 million in the year 2000. More and more, drainage is becoming the most prominent form of land reclamation. The intensification of farming and stockraising, which should be given highest priority, is not proceeding at a sufficient rate owing essentially to the concentration of resources in large-scale irrigation projects. Agrarian reform, which would help intensify the use of land, has been undertaken only in a partial or inadequate fashion in a few countries. Reforestation, which would make it possible to ~~recover~~ reclaim land that has been abandoned because of misuse, has been comparatively neglected; less than 5 million hectares has been reforested to date, and the total may reach 8 million by the year 2000.

It is believed that the best alternative for agricultural production

on land that does not offer optimum conditions for this purpose is "integral rural development." This approach makes it possible to optimize the use of potential for farming, stockraising, forestry, wildlife, fishing, tourism and other activities. Fundamental within this context are watershed management, agro-forestry, the improvement of stockraising and its association with the forest, integrated management of pests and diseases, management of natural forests and other technological combinations which should not neglect reconsideration of the value of native species vis-a-vis exotic ones, plant protein vis-a-vis animal protein, more rational methods of fertilization, and attention to advanced technologies such as microbiological agriculture and genetic engineering, which will play a major part in the next century.

Water is abundant in the area studied, although it is not distributed equally. At present only 3% of the area's water resources and 8% of its hydroelectric potential are being used. Most of the water is consumed by agriculture. Over 80% of the urban population is supplied with potable water, while less than 30% of the rural people have this service; in terms of volume, however, city dwellers have 5 to 15 times more potable water than campesinos. The use of water is expected to increase by 120% between 1977 and 2000, with the largest growth being for industrial purposes. Large-scale projects will continue to be undertaken for the development of water resources, especially for energy. However, supply could be improved greatly through the use of simple and cheap non-conventional technologies, especially for the rural poor and through ~~the~~ simultaneous curtailment of the losses of water that are now suffered in crop fields and in impoundment, storage and distribution works.

The pollution of fresh water and sea water is a serious problem in Latin America and the Caribbean, although the former is not yet as serious as on other continents. But pollution of the sea is already a matter of great

concern in the Caribbean. The characteristics of this problem are not much different from what is found elsewhere in the world; petroleum, mining and metallurgy, pesticides and urban and industrial wastes are the main polluting agents. These problems will tend to worsen significantly in the decades ahead. Large-scale hydroelectric projects, as in other regions, have already caused severe environmental disturbances downstream. And because no consideration is given to management of the collector basin, these works themselves are subject to sedimentation and other costly effects.

The problem of air pollution in Latin America is on the whole similar to that experienced on other continents, although the cities of this region are appreciably less afflicted by pollution than others of the world, except in the case of certain highly industrialized urban centers. But here again the problem will become much worse because of the great industrial expansion foreseen, ~~and~~ the inadequate and unenforced legislation, and ~~because of~~ the limited administrative structure that exists; the same situation prevails with respect to the pollution of ~~the~~ water.

As is well known, the flora plays a preeminent part in the human diet, and this has been and continues to be especially true for Latin America and the Caribbean. The vast tropical lands of this continent are not very suitable for the cultivation of grain, which means that root crops and legumes will have to play a much more significant role than in the past; the present situation, ~~this~~ seems to be a consequence of prejudices brought from Europe. At the same time there is an enormous variety of native species, many of which are equivalent to cereals but which have been sadly neglected despite their ability to grow under extreme ecological conditions and despite their high nutritional value. The feeding of cattle on the basis of hydrolization of wood or similar techniques, or with shrub species or grasses, combined with reforestation, is another promising aspect which is not yet being

given due importance. The extraction of wood from tropical forests remains selective and can be rationalized only through integral development, opening the way to large plants for the chemical processing of wood in addition to the present types of mechanical processing. Medicines, drugs, rubber, resins and ornamental and recreational use are others among the many resources obtainable from flora, which too often are exploited insufficiently or improperly.

The threat of extinction is as great for plants as for animals, or even greater; there is already a long list of flora that have become extinct in some ecosystems. By the year 2000 it is believed that several thousand species will have disappeared from Latin America and the Caribbean, many of them unknown to science. Genetic erosion also will affect a great number of species and varieties of domesticated plants that are used but little, reducing alternatives for genetic improvement. Several studies on the importance of the phytomass of the tropical rain forest confirm the projections made regarding its total use, which can have severe environmental repercussions unless drastic measures are taken in the management of this resource.

The wild fauna is a resource whose importance has been minimized. Nonetheless, it has been shown that over 85% of the animal protein ingested by the rural dwellers of the Amazon and Orinoco regions is obtained from hunting and fishing. Other wildlife products are equally important in the utilization of marginal land, such as vicuña wool in the high semiarid plateaus, crocodile skin in areas with abundant water, etc. Among the most promising species, besides the ones just mentioned, are all those that can attract tourists, hunters, and industry and trade. Their proper use depends on the implementation of management programs, which appear to be technically and economically feasible; but above all, their future hinges upon a resolution of the present conflict between protectionism and conservationism.

Fishing resources are abundant in Latin America, especially in the Southeast Pacific. The estimated potential of the seas adjacent to the continent is about 34 million tons, of which an average of 23% has been utilized, thus leaving a wide margin. However, the improper exploitation of certain ocean fish, such as the anchovy, have significantly diminished ~~the~~ possibilities for the future. The situation of whales is especially bad. The existence of krill in Antarctic waters has opened up a new prospect, since 15 to 50 million tons could be harvested on a sustained-yield basis. Inland fishing contributes only about 170,000 tons, but has been declining even though its potential would be great if the correct measures were taken.

With regard to domesticated fauna, Latin America and the Caribbean use the same species as the rest of the world. Nonetheless, they have a valuable genetic diversity because of the early introduction of these animals from the Iberian peninsula. The most important native domesticated species include the camelids and guinea pigs. The alpaca and the llama, of which there are slightly more than 5 million at present, afford an exceptional opportunity for development in the central region of the high Andes.

The extinction of species, subspecies and breeds of land and aquatic animals, whether domesticated or wild, is a serious and growing problem. Wild animals will disappear mainly because of the invasion and destruction of their ecosystems, and to a lesser extent through hunting of various kinds. Marine and inland species will be affected by pollution and overfishing, and domestic species by ~~near~~ mere neglect. The groups most affected will be invertebrates, especially insects.

With the expansion of human activity that is foreseen, especially stockraising and farming and to a lesser extent forestry, but also because of pollution, tourism and other factors, many unique ecosystems will have been

reduced severely by the year 2000. Among these are the forests of Podocarpus, the forests of southern Chile, the araucaria forests, the mangrove swamps, the coastal hills of Peru and Chile, the Galapagos Islands, the Mato Grosso swamp and a number of others. In this connection, the rate at which national parks and other conservation units have been established during the last ten years has been spectacular, the protected area having expanded by 670% between 1970 and 1980, and now covering 1.63% of the area studied. But this system is imperfect, since seven biogeographical provinces are not protected and a great number have very small percentages of protection. Moreover, 34% of the units are of less than 10,000 ha. The best protected region from any standpoint is the Andean. Still, many units are not managed properly and others are abandoned. Furthermore, the lack of public awareness of these areas may cause the successes to be reversed. In one way or another, it seems likely that the protected area in the year 2000 will be much larger than at present, perhaps as much as double in view of the projects under way.

Latin America and the Caribbean are well endowed with mineral resources, especially copper, bauxite, silver, tin and several others. Through the year 2000 and even after, the area studied will continue to export growing quantities of minerals, which suggests that the adverse environmental effects of this activity will become more and more acute.

The obtaining and use of energy, which is now at a crossroads, will continue to have decisive importance for the environment of Latin America and the Caribbean. Most of the electric energy is obtained from hydroelectric sources (58%), followed closely by thermal energy (41%). In terms of potential, the proportions are 67% for hydroelectric sources and only 14% for petroleum, 7% for natural gas and 6% for coal. It is estimated that the petroleum reserves of the study area could last about 30 more years at the present rate of use. With regard

to total consumption of energy, fuelwood and charcoal account for 31%, bagasse 9%, petroleum 55% and hydroelectric and geothermal sources 5%. Analysis of alternatives for the future shows that non-conventional sources such as solar energy, geothermal energy and the biomass (including all organic residues) and certain others will account for a growing share, which by the year 2000 will be between 11 and 26% of the total energy supply. The biomass therefore will continue to be the principal source, although its relative importance will decline.

Many human activities that affect the environment also have very direct consequences for human and animal health. The best known cases, of which Latin America and the Caribbean have had their share, are ~~the~~ large-scale hydraulic works ~~that~~ which can bring diseases such as malaria, schistosomiasis and others. Road building that facilitates the dispersion of diseases related to settlement and/or wooded areas, such as rabies, can lead to campaigns against the carrier animals which alter important ecological processes.

The situation of native cultures displays its own special dichotomy. Two of the five native neotropical races -- the meso-American and Andean -- which were the great pre-Hispanic cultures continue to have very large populations, retain much of their cultural heritage, and moreover have mingled and/or integrated quite well with their ~~respective~~ fellow-citizens. In contrast, the other three races -- whose social development was limited in the period before the conquest -- were decimated during the colonial era and virtually annihilated after independence. The disappearance of all the pampa-patagonian cultures is virtually a fact; on the other hand, the redskins and particularly the Atlanto-tropical peoples of the Amazon and Orinoco regions have fared somewhat better. Nonetheless, all attempts to preserve their ethnic and cultural features have failed, and there is little hope for escaping the extinction of

numerous other cultures by the year 2000, unless there is a profound change in the present concept of development.

When one analyzes the reasons why the human population of Latin America has living conditions so far below the acceptable level, even though, lacking much land suitable for agriculture it does have other valuable resources, one finds, as always, social injustice. This is the fruit of unjust economic and social relations, of the policies and laws that reflect them, and of the entire impact of this situation on planning, administration, public opinion, education and research.

The conclusion drawn from this entire exercise is that the people of Latin America and the Caribbean hold in their hands the resources needed to ensure a decent and happy future for themselves. This is not a region that in general can be considered rich in conventional terms, and even less so in comparison with some other continents; but neither is it poor, and it has the present advantage of a small human population that enables it to look at the future with confidence if the appropriate measures are taken now. The principal resource, because of the threats that face it, is the soil. There are few soils naturally suitable for ~~fruit~~ food production, and their negligent use therefore has caused irreversible losses. The primary cause of the poor use of soil is stockraising, which moreover has a drastic impact on other resources such as the flora and fauna. The rationalization -- and in particular the intensification -- of stockraising is accordingly a matter of the highest priority. This, like all the other measures needed, calls essentially for an original approach, i.e. technologies that respond to national and local conditions; and humility as well, recognizing that many of the techniques developed in the past continue to be the best provided they are made compatible with scientific progress. For a region such as Latin America and the Caribbean,

where the generation of wealth must perforce result from the integral and integrated utilization of all potential resources -- since few of these are in themselves sufficient -- it is absolutely imperative to bring about a full dialogue and harmonious union of all those responsible for the management of each natural resource.

1. INTRODUCTION

1.1 Background and terms of reference

This report is part of the project "Study of Requirements for Training in Natural Resources in Latin America and the Caribbean" undertaken by the World Wildlife Fund of the United States (WWF-USA) under the technical direction of the School of Natural Resources, University of Michigan, USA, with funding from USAID and the United States National Park Service.

The purpose of that project is to identify the training needs of Latin America and the Caribbean for the inventory, management, development and monitoring of natural resources in accordance with the requirements of environmental protection, concepts of ecological development and the new world economic order.

The purpose of the present study, within the general framework described above, is to "describe the present situation and assess the trends of natural resources in each region for the 1980s and 1990s, in relation to the need for trained personnel in Latin America and the Caribbean." In accordance with the terms of reference, a particular effort has been made to "ascertain the present situation and project the trends in the region, during the coming decades, which will determine the needs for trained personnel in fields related to management of the environment and natural resources." For this purpose, under the terms of reference, emphasis should be given to the present or expected situation regarding: (a) the continuous territorial expansion of agriculture; (b) major changes in population distribution, whether planned or spontaneous; (c) industrialization; (d) the exploitation of renewable and nonrenewable natural resources;

(e) population growth; and (f) development in belts between wilderness regions and already ~~colonized~~ settled areas.

1.2 Overall methodology of the study

As might be expected, the study is based essentially on statistical data available from the agencies of the United Nations system (especially FAO, UNESCO, WHO and ECLA), the Organization of American States (especially IICA) and international financial institutions such as the World Bank and IDB. In addition, a significant amount of official information has been obtained from governments, universities and many private national and international organizations.

Existing projections or estimates of trends through the years 1990 and 2000 have been used insofar as possible, with selection of the most reliable ones. In other cases, projections have been made with the statistical methods usually employed for these purposes.

The strategy adopted to obtain the results indicated in the terms of reference varied in accordance with the information available for each topic and with the nature of the topics. In general, however, it may be summarized as follows: (a) description of the present situation of each renewable natural resource on the basis of quantitative and qualitative information regarding its use; (b) projection of the present situation of each renewable natural resource through the years 1990 and 2000, ~~having regard to~~ considering the most likely developments on the basis of the requirements of the population and the real possibilities of meeting them; (c) analysis of the environmental impact of the present and projected situation, indicating the most affected biogeographical provinces in each region ~~of the hemisphere~~ studied and the problems that are and/or will be most critical; (d) discussion of the concrete possibilities of preventing

or limiting the most adverse environmental effects, taking into account the socioeconomic and political situation of the region or of the countries cited as examples; and (e) indicative conclusions ~~regarding~~ as to the need for training or other measures that can help to avoid the problems identified.

For purposes of the analysis, the area of the study (Latin America and the Caribbean) has been divided into six basic regions (North America, Central America, Caribbean, Andean, Atlantic and Southern Tier). However, because of the availability of data, these regions are sometimes grouped in other ways (North America and Central America, South America, Andean and Atlantic). The grouping of countries in each region is shown in Table 1, among others, which also include associated free states, overseas provinces, colonies and other territories which are not countries per se. Some islands under colonial administration have been grouped together. Although the text frequently refers to vast areas such as the tropical or Amazon regions, some of the information has been systematized on the basis of Udvardy's biogeographical classification (1975), which, for purposes of this study, comprises four ~~kingdoms~~ realms and 56 biogeographical provinces.

The problems are addressed by individual resources, in terms of each of their present and potential uses and other possible indirect effects on them. The study first considers soil, followed by water, air, flora and fauna. The most exhaustive treatment is given to soil, which embraces the aspects of greatest importance here -- agriculture, stockraising and forestry -- and their mounting impact on natural areas. There is also discussion, for each resource and at the end, of the effects of the exploitation of mineral resources and of problems related to energy, urban development and industry. Finally, some

aspects of human health and of native and local cultures are considered.

1.3 Limitations of the study

Obviously, it is presumptious to take up so sweeping and complex a topic for so vast and disparate (a region), in such a ~~disproportionally brief~~ limited period of time, ~~with~~ for a single expert whose capabilities naturally do not embrace so extensive a range of knowledge. Nevertheless, this was the challenge and an effort was made to meet it in the best possible way. Clearly, however, no guarantee can be given that the present study is free of errors and inaccuracies, which means that its findings must be regarded as merely indicative. Moreover, in one way or another it is an analysis of macroprojections.

In addition, the scarcity of statistical data for each country and their varying reliability -- problems which are magnified in the statistical summaries prepared by the international organizations -- lessen the validity of the observations made in this study.

Finally, data could not be obtained from one source or another in countless cases, yet they must be reconciled to yield specific results. In such cases the author has made careful estimates, but their value is inevitably debatable.

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Many institutions and individuals have made it possible for the author to complete this work in so brief a time, making up for gaps in his ~~capabilities~~ expertise and providing information which, because of its great volume, would have required ~~several~~ months of meticulous research.

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2. PHYSICAL AND HUMAN CONTEXT

2.1 Countries, regions and biogeography

To speak of Latin America and the Caribbean is to speak of three continents: North America, South America and Antarctica. Mexico is clearly part of North America, much of its territory lying within the Nearctic subregion; at the same time, Argentina and Chile have extensive territories on the Antarctic continent. At present there are 29 officially independent countries in the area under study, but there are 38 different political units; several have been grouped under the names of British, Netherlands and ~~the~~ United States Antilles. The regional division adopted is arbitrary, although it is based on a certain homogeneity, whether geographical (North America, Central America) or political (Andean). In all cases it has been used totally or partially in the past, with or without variants. Table 1 shows the countries and other political units included in each region.

Excluding Antarctica, the area under study has a total land mass of over 20 million square kilometers. Tropical and subtropical forests occupy much of the land, especially in South America where they cover three fourths of the total area. Mountainous terrain also is extensive, with the Cordillera of the Andes ~~which puts~~ cutting through South America from the extreme south to the north, as well as highlands in Central America and Mexico and many of the Caribbean Islands. Although smaller in extent, desert regions abound in the Southern Tier countries, Peru and Mexico. Prairies are most extensive in Argentina, and naturally predominant in the islands of the Caribbean. Antarctic and subantarctic lands make up much of the territories of Argentina and Chile.

Table 1. Regions, countries and territories: area; population, density and growth; per capita income 3/

Region / Country	Area 2/ (km2)	Population 1/ (000)	Density (Pop/km2)	Population Growth 3/ (%)	Per Capita Income 2/ (US$)
NORTH AMERICA					
Mexico	1,958,201	65,421	33	3.5	991.4
Total/Average	1,958,201	65,421	33		
CENTRAL AMERICA					
Belize	22,965	140 2/	6	3.1 4/	
Costa Rica	50,900	2,111	42	2.6	1,048
El Salvador	21,156	4,524	214	2.6	604
Guatemala	108,889	6,839	63	2.0	898
Honduras	112,088	3,439	31	3.3	514
Nicaragua	148,000	2,559	17	3.5	857
Panama	77,082	1,823	24	3.1	1,271
Total/Average	541,080	21,435	40		
CARIBBEAN					
British Antilles	2,173	357 2/	164	1.0	
Netherlands Antilles	992	240 2/	242	1.7 5/	1,590 4/
US Antilles	345	96 2/	278	1.5	
Bahamas	13,935	220 2/	16	3.9 2/	2,600
Barbados	430	263	611	0.2 2/	1,654
Cuba	114,524	9,718	85	1.6	800
Dominica	751	80 2/	107	1.1 5/	410 4/
Grenada	344	108	313	0.4 2/	440
Guadeloupe	1,780	334 2/	188	1.6 5/	240 4/
Haiti	27,750	5,534	199	1.7	188
Jamaica	10,962	2,102 3/	194	1.7	1,204
Martinique	1,100	346 2/	315	1.5 5/	1,540
Puerto Rico	8,897	3,468 2/	390	1.8	2,472
Dominican Rep.	48,442	5,658	117	2.9	837
St. Lucia	616	120 2/	181	1.6 2/	530 4/
Trinidad and Tobago	5,128	1,200	234	1.0	1,329
Total/Average	238,169	29,844	125		
SOUTH AMERICAN-ANDEAN					
Bolivia	1,098,581	5,285	5	2.7	484
Colombia	1,141,736	25,614	22	2.8	612
Ecuador	270,670	7,543	28	3.4	619
Peru	1,285,216	16,821	13	2.8	889
Venezuela	916,490	13,989	15	3.1	2,083
Total/Average	4,712,693	69,252	15		
ATLANTIC					
Brazil	8,511,965	119,477	14	2.8	1,090
French Guiana	90,000	58 2/	0.6	1.5 e/	
Guyana	214,970	803	4	1.9	538
Paraguay	406,752	2,888	7	2.9	520
Suriname	163,265	461 3/	3	3.2	1,370
Total/Average	9,386,952	123,687	13		
SOUTHERN TIER					
Argentina	2,776,656 b/	26,395	10	1.3	1,720
Chile	624,593 b/	10,732	17	1.9	1,314
Malvinas Islands	12,173	2 2/	0.2	1.0 a/	
Uruguay	176,215	2,886	16	1.2	1,331
Total/Average	3,589,637	40,015	11		

Table 1 continued

SOUTH AMERICA/Average	17,689,282	232,954	11		
LATIN AMERICA AND CARIBBEAN /Average	20,426,732	349,654	17		
ANTARCTICA Argentina Chile	 990,727 c/ 1,250,000 d/				

Notes: (a) Information for 1977 or 1978.

(b) Continental area. Antarctic territories also excluded.

(c) Excluding Malvinas Islands, but including other islands claimed. Land area only.

(d) Much of this area also is claimed by Argentina.

(e) Author's estimates based on personal references.

Sources: (1) ECLA (1978), (2) World Almanac (1950), (3) OAS (1977), (4) World Bank Atlas (1976), (5) UN World Demographic Yearbook (1976).

There are numerous classifications and descriptions ~~on~~ of the ~~various~~ basic ecological units that make up Latin America and the Caribbean, but only one of them has been used extensively, in particular for regional and national development planning. This is the system of classification of life zones or plant formations devised by Holdridge (1978) thirty years ago and utilized primarily by J. Tosi and his disciples in nearly all of tropical America (numerous publications). The innovative feature of the system of life zones compared to previous classification systems is first of all biotemperature, which is a means of expressing the heat factor only in the portion that permits the growth of plants; and second, the logarithmic progression formed by increases in heat and precipitation, which affect vegetation to an appreciable degree. This system, well-founded but very simple in its application and widely used -- including, in the analysis of each zone, pedological variables, the determination of associations and recesses, the succession of plants, atmosphere and water, socioeconomic aspects and development alternatives based on land use planning and productivity -- has unquestionably been the principal contribution made to integrated rural development in the history of Latin America.

For the present study, however, a different system has been used to group the basic ecological units of Latin America and the Caribbean, essentially because it is the one adopted by IUCN in connection with the world system of national parks and other protected areas, which is one of the most important topics of this study. It is the system of classification of biogeographical provinces of the world developed by Udvardy (1975) and based in turn on the work of Dasmann (1973, 1974) and others. In this system the territories of Latin America and the Caribbean belong to the Neotropical Realm (47 biogeographical provinces), the Nearctic Realm (5 biogeographical provinces), the Oceania Realm (1, the province known as Southeastern Polynesian, with the Juan Fernandez islands) and the Antarctic Realm (3, the provinces of Insulantarctica, Marielandia and Maudlandia).

Table 2, which is based on the division by areas adopted in Udvardy's map (op. cit.), gives an idea of the geographical significance of each biogeographical province with respect to each continent and to each region into which Latin America and the Caribbean have been divided. Because of problems related to projections and scales the result is imperfect, but it does indicate the size and importance of each province. As may be seen, the largest provinces in the area studied -- excluding the Antarctic Realm -- are the Amazonian (2,500,000 km2), Brazilian Rain Forest (1,900,000 km2), Campos Cerrados (1,800,000 km2), Madeiran (1,600,000 km2), Gran Chaco (1,100,000 km2), Monte (1,000,000 km2), Caatinga (900,000 km2), Guyanan (800,000 km2), Madrean-Cordilleran (700,000 km2), Patagonian, Southern Andean and Yungas (600,000 km2 each) and La Puna, Argentinian Pampas, Uruguayan Pampas and Chihuahuan (about 400,000 km2 each). The provinces occupying the smallest areas, with less than 100,000 km2, are: Yucatecan (52,000 km2), Californian (28,000 km2), Panamanian (68,000 km2),

Bahamas-Bermudan (14,000 km2), Lesser Antillean (12,000 km2), Equadorian Dry Forest (76,000 km2), Venezuelan Deciduous Forest (43,000 km2), Chilean Araucaria Forest (25,000 km2), and Chilean Sclerophyll (57,000 km2). To these should be added certain biogeographical provinces which are very isolated small islands or lakes, such as the islands of Cocos, Juan Fernandez, Galapagos, Fernando de Noronja, South Trinidade, Revilla Gigedo and others, as well as Lake Titicaca, which have not always been included in Table 2. That table also shows the proportion in which each biogeographical province is represented in the regions; it is significant that in this regard, with few exceptions (Madrean-Cordilleran, Central American, Cuban, Greater Antillean, Amazonian and Monte) none occupies more than 20% of the area. This underscores the ecological diversity found, which is greatest in the Andean region with 20 biogeographical provinces including the Galapagos Islands. The majority of the biogeographical provinces account for 5% or less of the area of their region, attesting to the complex nature of any attempt to preserve them.

Table 2. Biogeographical provinces and their areas in the regions of Latin America and the Caribbean

Region	Biogeographical Province	Code	Area (km2)	% of area of region
NORTH AMERICA	Campechean	8.1	186,225	9.5
	Yucatecan	8.15	51,501	2.6
	Guerreran	8.14	170,363	8.7
	Sinaloan	8.13	162,531	8.2
	Californian	1.7	27,806	1.4
	Sonoran	1.8	178,392	9.1
	Chihuahuan	1.9	364,617	18.6
	Madrean-Cordilleran	1.21	610,371	31.2
	Tamaulipan	1.10	206,395	10.5
Total			1,958,201	100.0
CENTRAL AMERICA	Campechean	8.1	76,809	14.2
	Panamanian	8.2	68,275	12.6
	Central American	8.16	320,893	59.3
	Madrean-Cordilleran	1.21	75,103	13.9
	Cocos Island	8.43	32	-
Total			541,112	100.0
CARIBBEAN	Bahamas-Bermudan	8.38	14,365	6.0
	Cuban	8.39	114,524	48.1
	Greater Antillean	8.40	96,051	40.3
	Lesser Antillean	8.41	12,029	5.1
	Guyanan	8.4	1,200	0.5
Total			238,169	100.0
ANDEAN	Colombian Coastal	8.3	179,554	3.8
	Guyanan	8.4	142,323	3.0
	Amazonian	8.5	1,108,425	23.5
	Madeiran	8.6	140,438	3.0
	Venezuelan Dry Forest	8.17	230,451	4.9
	Venezuelan Deciduous Forest	8.18	42,886	0.9
	Equadorian Dry Forest	8.19	75,874	1.6
	Pacific Desert	8.24	164,002	3.5
	Llanos	8.27	401,993	8.6
	Campos Limpos	8.28	89,541	1.9
	Colombian Montane	8.34	154,105	3.3
	Yungas	8.35	620,662	13.2
	Puna	8.36	372,014	7.9
	Northern Andean	8.33	261,554	5.6
	Southern Andean	8.37	218,669	4.6
	Gran Chaco	8.21	398,223	8.5
	Campos Cerrados	8.30	97,553	2.1
	Monte	8.25	4,713	0.1
	Lake Titicaca	8.47	8,300	0.2
Total			4,712,693	100.0

Table 2 continued

ATLANTIC	Guyanan	8.4	706,726	7.5
	Amazonian	8.5	1,433,327	15.3
	Madeiran	8.6	1,505,948	16.0
	Serra do Mar	8.7	215,955	2.2
	Brazilian Rain Forest	8.8	1,851,858	19.7
	Brazilian Planalto	8.9	240,799	2.5
	Caatinga	8.20	917,329	9.8
	Gran Chaco	8.21	256,665	3.0
	Campos Limpos	8.28	89,822	1.0
	Babacu	8.29	267,554	2.9
	Campos Cerrados	8.30	1,700,681	18.1
	Uruguayan Pampas	8.32	170,088	1.8
Total			9,386,952	100.0
SOUTHERN TIER	Brazilian Rain Forest	8.8	23,372	0.8
	Valdivian Forest	8.10	134,457	3.7
	Chilean Nothofagus	8.11	117,187	3.3
	Gran Chaco	8.21	426,809	11.9
	Chilean Araucaria Forest	8.22	24,671	0.7
	Chilean Sclerophyll	8.23	56,743	1.6
	Pacific Desert	8.24	74,013	2.1
	Monte	8.25	1,030,016	28.7
	Patagonian	8.26	579,770	16.7
	Argentinian Pampas	8.31	444,079	12.3
	Uruguayan Pampas	8.32	256,579	7.2
	Southern Andean	8.37	308,493	10.8
	Puna	8.36	28,448	0.8
Total			3,589,637	100.0

Note: Table based on Udvardy's map. Not precise because of the large scale of the map; figures are merely indicative.

Source: Udvardy (1975).

2.2 Population

Latin America and the Caribbean, with some 350 million inhabitants in 1977, is the least populated region of the world with the exception of Oceania. At the same time, it is the region with the highest natural population growth rate. This population is by no means distributed uniformly, but rather is heavily concentrated in certain regions, such as South America and North America (Mexico), which have 85% of the inhabitants of the area studied. In terms of geographical divisions, however, the most densely populated region is the Caribbean, with about 125 persons/km2, followed by Central America with 40 persons/km2 and North America with 33 persons/km2. The least populated region is the Southern Tier with only 11 persons/km2, followed closely by the Atlantic (13 persons/km2) and Andean regions (15 persons/km2). The political units with the lowest population density are the Malvinas Islands and French Guiana with less than 0.6 persons/km2, while Barbados has 611 persons/km2 and 13 other Caribbean islands have 100 to almost 400 persons/km2. In Central America, population density is very high only in El Salvador (214 persons/km2), and is very low in Belize and Nicaragua. The most heavily populated country is Brazil, with about 120 million inhabitants in 1977; however, its population density of 14 persons/km2 is very close to the average for South America, and slightly lower than the average for Latin America and the Caribbean (17 persons/km2) (Table 1).

Table 3. Population Growth and Density - Projections for 1990 and 2000

Region / Country	Population Growth 1/ 2/			
	1990		2000	
	Population (000)	Density (persons/ km2)	Population (000)	Density (persons/ km2)
NORTH AMERICA				
Mexico	104,201	53.2	132,244	67.5
Total/Average	104,201	53.2	132,244	67.5
CENTRAL AMERICA				
Belize	182(a)	7.9	217(a)	9.5
Costa Rica	3,075	60.4	3,493(a)	68.6
El Salvador	6,484	306.5	8,708	411.6
Guatemala	9,676	88.9	12,739	117.0
Honduras	5,182	46.2	6,978	62.3
Nicaragua	3,778	25.5	5,154	34.8
Panama	2,533	32.9	3,218	41.8
Total/Average	30,910	57.1	40,507	74.9
CARIBBEAN				
British Antilles	400(a)	184.1	436(a)	200.6
Netherlands Antilles	269(a)	271.2	293(a)	295.4
US Antilles	113(a)	327.5	128(a)	371.0
Bahamas	323(a)	23.2	409(a)	29.4
Barbados	269(a)	625.6	275(a)	639.5
Cuba	11,584(a)	101.6	12,717	111.0
Dominica	99(a)	131.8	115(a)	153.1
Grenada	113(a)	328.5	118(a)	343.0
Guadeloupe	354(a)	198.9	371(a)	203.4
Haiti	8,525	307.2	9,860	355.3
Jamaica	2,464	224.8	2,726	248.7
Martinique	367(a)	333.6	384(a)	349.1
Puerto Rico	4,217(a)	474.0	4,841(a)	554.1
Dominican Rep.	7,265	140.0	11,767	242.9
St. Lucia	143(a)	232.1	162(a)	263.0
Trinidad and Tobago	1,503	293.1	1,754	342.0
Total/Average	33,008	159.6	46,356	198.0
SOUTH AMERICA - ANDEAN				
Bolivia	7,974	7.3	9,299	8.5
Colombia	32,008	28.0	42,441	37.2
Ecuador	11,676	43.1	14,596	53.9
Peru	23,323	18.2	29,468	22.9
Venezuela	18,049	19.7	25,705	28.1
Total/Average	93,030	19.7	121,509	26
ATLANTIC				
Brazil	159,974	18.8	212,507	25.0
French Guiana	68(a)	0.8	77(a)	0.9
Guyana	1,080	5.0	1,256	5.8
Paraguay	4,073	10.0	5,274	13.0
Suriname	488	4.2	904	5.5
Total/Average	165,883	17.8	220,018	23.4
SOUTHERN TIER				
Argentina	30,189	10.9	32,861	11.8
Chile	13,553	21.7	14,934	23.9
Malvinas Islands	2(a)	0.2	2(a)	0.2
Uruguay	3,617	20.5	3,448	19.6

Total/Average	47,361	13.2	51,245	14.3
SOUTH AMERICA/Average	306,274	17.3	392,772	22.1
LATIN AMERICA AND CARIBBEAN /Average	479,393	23.5	611,879	30.0

Note: (a) Author's estimates.

The population of Latin America and the Caribbean increased at an average annual rate of 2.8% from 1963 to 1975; it is assumed that the rate will decline to 2.5% between 1980 and 2000. Growth rates vary widely among regions and countries. At present the highest rates are those of Bahamas (3.9%), Mexico (3.5%) and Ecuador (3.4%). The lowest rates are found in the Caribbean and the Southern Tier. The population of the area studied is projected at 479 million in 1990 and 612 million in 2000. Density in the year 2000 will be absolutely critical in the Caribbean, with an average of 195 persons/km2, and high in Central America and North America. The average for South America will be only 22 persons/km2 and the average for all regions is projected at 30 persons/km2 (Table 3).

Table 4 shows the maximum hypothetical growth of the largest Latin American and Caribbean countries in terms of area and population. As may be seen, between the years 2005 and 2015 most of the countries will reach a net reproduction rate of 1, which means that on average, women of child-bearing age bear only enough daughters to replace themselves in the population. This group includes Brazil and Mexico (in 2015), which accounts for 54% of the hypothetical stationary population of the entire area. However, given the age structure of the population, it will not be stationary until many years later, in most cases between 2065 and 2075. A stationary population is one in which the age structure is constant, the birth rate is constant and equal to the death rate, and the growth rate is therefore zero. By that time Latin America and the Caribbean will have a population on the order of 1 billion; in other words, the population projected for the year 2000 will be only 61% of the projected maximum. The world population projected for the year 2000 is 6.05 billion, and the hypothetical stationary population is 9.84 billion (World Bank, 1979).

Immigration into Latin America is very modest at present and does not offset emigration, which is also comparatively insignificant.

The population of Latin America and the Caribbean can already be regarded as predominantly urban, since it is estimated that in 1980 over 63% lives in cities of more than 10,000 inhabitants and 40% in cities of more than 100,000 (Table 5). The trend, calculated by the United Nations (1977), is toward a marked urban concentration; by the year 2000 it is expected that 75% of the population will be living in cities of over 10,000. Nonetheless, there will be noteworthy differences between the more developed countries of the Southern Tier - such as Argentina and Chile where 90% of the population will be residing in cities of over 10,000 persons - and those of the Caribbean, where only 62% will be living in such urban centers (Table 3). There are now countries in the Caribbean, such as Barbados, where the population is predominantly rural, obviously because of the very high population density that characterizes them.

Table 4. Hypothetical stabilization of population growth in selected countries of Latin America

Region / Country	Hypothetical stationary population (millions)	Year in which net reproduction rate of 1 will be reached	Year in which stationary population will be reached
NORTH AMERICA			
Mexico	204	2015	2075
CENTRAL AMERICA			
Costa Rica	5	2005	2065
El Salvador	14	2015	2075
Guatemala	23	2025	2085
Honduras	15	2030	2090
Nicaragua	9	2020	2110
Panama	4	2005	2065
CARIBBEAN			
Cuba			
Haiti	16	2030	2130
Jamaica	3	2005	2065
Dominican Rep.	15	2015	2075
Trinidad and Tobago	2	2005	2065
ANDEAN			
Bolivia	19	2030	2100
Colombia	55	2005	2065
Ecuador	26	2020	2080
Peru	55	2025	2085
Venezuela	40	2010	2070
ATLANTIC			
Brazil	341	2015	2075
Paraguay	9	2015	2070
SOUTHERN TIER			
Argentina	41	2005	2065
Chile	19	2005	2070
Uruguay	4	2005	2065

Note: A net reproduction rate of 1 means that fertility is at replacement level.

Source: World Bank (1979).

Table 5. Projected urban concentration in 1990 and 2000, in cities of over 10,000 and over 100,000 population.

Region	Size of City	1980		1990		2000	
		% urban	% rural	% urban	% rural	% urban	% rural
North America and Central America	> 10,000 pop.	60.2	39.8	66.4	44.7	71.7	28.3
	>100,000 pop.	36.6	63.4	43.7	56.3	50.3	49.7
Caribbean	> 10,000 pop.	50.0	50.0	56.7	43.4	62.2	37.8
	>100,000 pop.	30.0	70.0	35.1	64.9	40.0	60.0
Andean and Atlantic	> 10,000 pop.	63.3	36.7	70.0	30.0	75.2	24.8
	>100,000 pop.	40.1	59.9	48.0	52.0	54.0	46.0
Southern Tier	> 10,000 pop.	83.3	16.7	87.2	12.8	90.4	9.6
	>100,000 pop.	54.8	45.2	61.7	38.3	63.5	36.5
Latin America and Caribbean	> 10,000 pop.	63.7	36.3	69.5	30.5	74.8	25.2
	>100,000 pop.	40.3	59.7	47.1	52.9	52.9	47.1

Source: United Nations (1977).

2.3 Economy and agricultural production

Table 6 presents some economic indicators for Latin America and the Caribbean as estimated by FAO (1979). In order to obtain a picture of world agriculture toward the year 2000, that organization developed two alternative scenarios. The first is merely trend-based, while the second is normative, i.e., intended to show a result which is both "more desirable" and "possible." The annual percentage increase in GDP for the period 1980-2000 falls between 5.6% (trend) and 7.3% (normative), equivalent to a per capita GDP of US$2079 in the first case and US$2983 in the second for the year 2000. Agricultural GDP will increase at an annual rate of 3.6%, but its share of total GDP will fall from 8% in 1990 to 5% in 2000. At the same time, the value of inputs as a percentage of the gross value of production will rise from 28% in 1990 to 30% in 2000.

Table 1 shows the per capita incomes of most of the Latin American and Caribbean countries for 1977 and 1978. As may be seen, they vary considerably among regions and countries. FAO (1979), on the basis of data for 1975, classified these countries in four groups: high-income (per capita GDP over US$700), middle-income (per capita GDP between US$300 and US$700), low-income (per capita GDP of less than US$300) and oil-exporting countries. The first group includes Costa Rica, Panama, Cuba, Dominican Republic, Jamaica, Argentina, Brazil, Chile, Peru, Suriname and Uruguay. The countries in the second group include El Salvador, Guatemala, Nicaragua, Bolivia, Colombia, Guyana and Paraguay. Haiti is in the third or low-income group, and Venezuela, Ecuador, Trinidad and Tobago and Mexico are among the oil-exporters of the fourth group. The same source indicates that in 1975 the share of agriculture in GDP exceeded 30% only in Haiti and Paraguay among the 24 countries studied, while in nine other countries it was

less than 15%. At that time 13 of the countries exported less than 25% of their agricultural production, while the rest exported larger percentages. Only Argentina, Guyana, Suriname and Uruguay exported cereals in 1975. All of the others showed increasing, stable or decreasing ~~decreasing~~ deficits during 1963-75.

Table 6. Aggregate economic indicators for Latin America and the Caribbean, and projections.

		1963 (US$)	1963-75 (annual %)	1975 (US$)	1980-90 (annual %)	1990 (US$)	1990-2000 (annual %)	2000 (US$)	1980-2000 (annual %)
Total GDP	Trend		5.8		5.3		5.4		5.4
	Normative		5.8		6.9		7.7		7.3
Per capita GDP	Trend	765	2.9	1072	2.7	1562	3.0	2079	2.8
	Normative	765	2.9	1072	4.2	1806	5.2	2983	4.7
Agricultural GDP					3.7		3.4		3.6

Note: 1975 US dollars.

Source: FAO (1979).

The United Nations (1972), groups the countries under other criteria and notes that six types of nations can be distinguished in Latin America. Type I comprises Argentina, Chile and Uruguay, which have about 13% of the Latin American population and are characterized by production and per capita income levels far exceeding the average and by a high degree of urbanization. Type II comprises Brazil, Colombia, Mexico, Peru and Venezuela, which have ~~accounts for~~ over 67% of the population of the area studied and are characterized by still moderate levels of per capita income, high rates of economic growth, and urbanization similar to that of the type I countries. These nations have already reached comparatively advanced stages of industrialization and economic diversification. Type III includes most of the smaller countries; their per capita incomes are about the same as those of the Type II countries and their growth rates also are high, although there is less industrialization and economic diversification and the urban percentage of the population is significantly lower. The type IV countries have low per capita product and low economic growth rates, together with limited urbanization. Types III and IV account for 13% of the population. Cuba is classified as Type V, with a rather low growth rate. Type VI includes territories and islands which have a very small part of the population of the subcontinent.

Another important feature of economic development is the declining situation of agriculture vis-à-vis other sectors in terms of employment. For Latin America as a whole, the agricultural labor force increased from about 31 million in 1950 to 38 million in 1975, a growth rate of only 0.8%; the increase in the nonagricultural labor force was 37 million in the same period, representing an annual growth rate of 3.5% (FAO, 1979). But even the modest increase of 7 million in the agricultural labor force during that 25-year period undoubtedly

aggravated unemployment and underemployment in agriculture, and moreover, has reduced the average ~~area of~~ amount of arable land per agricultural worker.

2.4 Food

As FAO correctly points out (1979), trends in the level and distribution of world food consumption have remained generally unchanged since the 1960s. The supply (consumption) of food per person in 1975 was 2,207 calories in 90 developing countries studied, which is equivalent to satisfaction of 96% of nutritional requirements, compared to 93% in 1963. In this ~~regard~~ respect, Latin America is in a better position than other areas, with 2,543 calories per person and supply of 106% of nutritional requirements. Nonetheless, the amount of animal protein in the human diet remained stationary at 11 grams per person per day in the developing countries, while it rose to an average almost five times greater in the developed countries. Furthermore, because of the unequal distribution of food there continue~~d~~ to be undernourished persons in Latin America, estimated to number 41 million in 1974-76 (13% of the total population).

However, when more appropriate parameters are considered, the nutritional situation in Latin America and the Caribbean is seen to be much more tragic. Hammarskjöld (1975), in his report on development and international cooperation for that year, stated that 40% of the undernourished people ~~of~~ in the world are children and that half of the children of the Third World suffer from malnutrition. He noted that half of the children of Latin America had become part of a "subhuman class with diminished faculties" (see Tables 7 and 8), and wondered what kind of people we are preparing for the end of the century.

Table 9 shows the differences among regions. The Southern Tier and Atlantic regions have the best diets, while most of the Caribbean, Central

American and Andean countries have malnourished populations. The countries in the most critical straits (in ascending order of calorie consumption) are Haiti, El Salvador, Ecuador, Bolivia, Dominican Republic, Honduras, Guatemala and Colombia.

Table 7. Children and adults with calorie deficiencies in Latin America and the Caribbean, 1975 (in thousands).

Age Group	With deficiencies		Without deficiencies	Total
	Number	%	Number	Number
0-9 years	51,600	55.5	41,400	93,000
9 years and over	60,400	27.5	159,600	220,000
Total	112,000	35.8	201,000	313,000

Note: Gross percentages.

Source: Selowsky (1978).

Table 8. Protein calories of malnutrition in children under five years (1971-75) in selected countries of Latin America and the Caribbean.

Region / Country	% of malnutrition			Total
	Degree I	Degree II	Degree III	
NORTH AMERICA				
Mexico	41.8	13.2	1.8	56.8
CENTRAL AMERICA				
Costa Rica	43.7	12.2	1.5	57.4
El Salvador	48.5	22.9	3.1	74.5
Guatemala	49.0	26.5	5.9	81.4
Honduras	43.0	27.2	2.3	72.5
Nicaragua	48.8	10.8	1.1	60.7
Panama	4.9	2.2	0.7	7.8
CARIBBEAN				
Barbados	39.0	11.0	1.2	51.2
Haiti	28.9	35.6	17.4	81.9
Jamaica	39.0	9.4	1.4	49.8
Dominican Republic	49.0	23.0	4.0	76.0
ANDEAN				
Bolivia	29.0	10.2	0.7	39.9
Colombia	45.6	19.3	1.7	66.6
Ecuador	28.9	9.6	1.2	39.7
Peru	32.8	10.9	0.8	44.5
Venezuela	35.3	12.2	1.4	48.9
ATLANTIC				
Brazil	48.4	17.2	2.7	68.3
Guyana	43.0	16.0	1.7	60.7
SOUTHERN TIER				
Chile	13.7	3.2	0.9	17.8
Overall average	92.5	16.4	2.5	61.4

Note: Gomez' classification (I - slight, II - moderate, III - severe)

Source: WHO (1976).

Table 9. Apparent daily per capita consumption of calories and proteins in selected countries of Latin America and the Caribbean, 1971-73

Region / Country	Energy consumed (kilocalories)	% of energy requirement[a]	Protein consumed[b] (grams)
NORTH AMERICA			
Mexico	2,657	115	61
CENTRAL AMERICA			
Costa Rica	2,576	114	63
El Salvador	1,916	83	51
Guatemala	2,155	93	58
Honduras	2,102	93	53
Nicaragua	2,467	110	69
Panama	2,580	111	62
CARIBBEAN			
Barbados	2,488	108	75
Cuba	2,515	108	63
Jamaica	2,543	114	67
Haiti	1,793	79	39
Dominican Republic	2,074	92	50
Trinidad and Tobago	2,412	99	65
ANDEAN			
Bolivia	2,032	85	47
Colombia	2,191	94	50
Ecuador	1,948	84	43
Peru	2,380	101	62
Venezuela	2,468	99	62
ATLANTIC			
Brazil	2,757	115	67
Paraguay	2,510	108	70
SOUTHERN TIER			
Argentina	3,222	122	95
Chile	2,781	114	77
Uruguay	3,077	115	98
Overall average	2,570	112	66

Note: (a) Based on minimum requirements estimated by FAO for each country. The minimum average estimated for Latin America and the Caribbean as a whole is 2,320 calories per day.

Source: ECLA (1975).

3. SOIL

3.1 The potential of soils

Few topics in this study are as sharply controversial as that related to the proportion of soils which are suitable for agricultural production. This is due to the essentially relative nature of the concept of the potential of soil for agriculture, which is overwhelmingly dependent on economic criteria. In terms of strictly technical feasibility, any soil can be cultivated if it is managed properly or if the required improvements are made. In fact, soil is not even necessary now that modern systems of hydroponic agriculture are available. Because of the ever more urgent need to increase the supply of food, there is a strong tendency to be optimistic regarding the amount of land still available for agriculture and stockraising in Latin America. The reality seems to contradict this attitude when, as will be seen below, it shows the very low productivity of most of the land now under cultivation, the vast area already "squandered" or abandoned, and the low quality of human life that has been achieved. The optimistic approach, which in general is the most technocratic as well, usually fails to consider the socioeconomic feasibility of meeting the technological demands imposed by its proposals, nor does it seem to assess the environmental implications of its contentions. The pessimistic view, on the other hand, with generally erroneous logic gives excessive importance to the adverse ecological impact of the expansion of agriculture and forestry, and again omits due consideration of social and economic conditions. In this chapter, with the scant information available, an attempt is made to find a middle way between these two divergent schools of thought.

As may be seen in Table 17, it is estimated that in 1977 the area under study had approximately 1,700,000 km2 of arable land, i.e. nearly 9% of the total land area. The present production of this agricultural land yields the socioeconomic results indicated briefly in the preceding chapter. Noteworthy among the optimistic viewpoints regarding the availability of arable land is that of IICA (1976), which states that the potentiable arable area on the mainland of Latin America is 5,421,000 km2; this is more than three times the present arable area and 27% of the total area. IICA concludes from this that "the availability of potential farmland would not be a limiting factor in the expansion of production in Latin America." The source of this statement is basically the Soil Conservation Service of the United States, cited by the OAS (1974). That source, regrouping soil classes I, II and III in class II, gives the information on selected countries presented in Table 10. Its findings are truly surprising, since national and international agencies, using the same system of classification of land by capacity for ~~highest~~ best use, have obtained results three to ten times less than those of the source indicated. Examples are given in Table 11 for selected countries and regions taken at random, on the basis of information available to the ~~office~~ author. With the exception of Paraguay and the western part of Nicaragua -- small and without doubt exceptionally fertile areas in the Latin American context -- none of the countries or regions indicated has more than 10% of its soils in classes I-IV, which are considered to be suitable for intensive agriculture; in all cases the proportion of soils in classes VII and VIII is immense.

Table 10. Existence of additional high-quality land in selected countries with nutritional deficits as an example of the "optimistic" view of certain sources (areas in km2).

Country	Area of Arable land in use 1/	Total potential arable land regrouped in class II 2/	
		Area	% of national territory
Bolivia	31,000	300,310	27
Colombia	51,000	439,730	39
Haiti	3,700	6,450	23
Honduras	5,860	32,670	29
Ecuador	41,000	125,320	46
El Salvador	4,930	13,200	62
Peru	31,000	335,650	26
Venezuela	60,000	406,330	44

Notes: Soil classes I, II and III have been regrouped in class II.

Sources: 1/ FAO.

2/ USDA, cited by OAS (1974).

Table 11. Classification of land by use capacity, selected countries and regions of Latin America

Country	Region	Area (km2)	Soils suitable for intensive agriculture (a) (%)	Soils suitable for permanent crops, cultivated pastures and reforestation(b) (%)	Soils suitable for forestry and to a much lesser extent for pastures (c) (%)	Soils suitable for forest protection or without possible use (d) (%)
Chile (1)	National	756,950	7.2	10.8	15.6	66.4
Peru (2)	"	1,285,210	2.7	13.0	45.6	38.7
Venezuela (3)	"	916,490	10.2	38.6	51.2	
Paraguay (4)	"	406,750	18.0	38.0	34.0	10.0
Colombia (5)	"	1,136,167	7.5	33.8	58.7	
Nicaragua (6)	Pacific	18,555	26.2	9.7	64.1	
Panama (7)	Darien	16,372	6.9	25.7	35.6	29.1
Costa Rica (8)	National	50,800	15.2	37.4	37.0	10.4
El Salvador (8)	"	21,146	15.5	19.1	8.2	57.2
Guatemala (8)	"	108,889	8.8	32.9	29.3	29.0
Honduras (8)	"	111,728	7.8	10.0	55.2	27.0
Nicaragua (8)	"	130,548	3.8	51.8	31.3	13.1
Panama (8)	"	75,900	4.0	21.2	39.3	35.5

Notes: (a) Class II to IV soils (class I is virtually non-existent)
(b) Class V and VI soils
(c) Class VII soils
(d) Class VIII soils

Sources: Based on information from: (1) Contreras (1974), (2) Zamora (1971), (3) Griesbach (1978), (3) Suzaeta (1979), (4) INCORA (1964), (5) OAS (1978), (6) OAS (1978 a), (7) OAS (1978 b), (8) FAO (1968).

The case of Peru provides an excellent illustration of the probable overestimation referred to in the preceding paragraph. That country has only 35,502 km2 of potentially arable land in soil classes I to IV, with the largest proportion in class IV. Even considering the range of classes from I to VI there are only 201,967 km2, which is still 40% less than the area shown for Peru in Table 10. Actually, in Peru the arable land in use represents 2.3% of the national territory and the potentially arable land, including soil class IV, amounts to only 2.7% of the country's total land area (Zamora, 1971).

Initially, even FAO stopped far short of holding a view as optimistic as that described. Table 12 presents information on soil resources and their major limitations in Latin America and the Caribbean (FAO, 1977), taken in general form from the report of the world resources project carried out by FAO/UNESCO (1964). This table shows clearly that even in the case of the favorable alternative only 25% of the land of North America (Mexico), Central America and the Caribbean has no serious limitations for agriculture, and that in South America the proportion is only 15%. In the aggregate, this amounts to 3,300,000 km2, of which 52% is already in use. The amount of land remaining is therefore about 1,500,000 km2, i.e. one half of the area indicated as available by the sources mentioned above. But as may be seen in the table, there are other assessments, also based on the information provided by the FAO/UNESCO study, which are 30 to 55% lower; in this case the estimates made by IICA (1976) on the area of agricultural soils still available are eight times too high. The present author is not in a position to say which of the two alternatives shown in Table 12 is closest to the actual situation. But it is obvious that not even the most responsible international agencies have resisted the temptation to be optimistic.

Proof of the contagious optimism referred to in the foregoing paragraph can be found in a recent document of FAO itself (1979) entitled "Agriculture toward 2000." That report, on the basis of further investigation, finds that Latin America has a potential availability of 6,530,000 km2, of which only 26 to 27% is now in use. This new picture of the situation, which is presented in Table 13, is based on the initial and as yet unpublished results of an ongoing study. Here again, this estimate obviously ~~is based on~~ reflects the view that even though the unexploited land is of lower quality than that now in use, technological advances will make it possible to overcome all the limitations. As we are well aware, this will not be easy.

Table 12. Soil resources of Latin America and the Caribbean and their major limitations (in percentages).

Region	Without serious limitations (c)		Drought (d)		Mineral problems (e)		Shallow-ness (f)		Excessive water (g)		Perma-frost	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
North America, Central America and Caribbean	11.1	25	32.2	32	19.6	16	25.1	17	10.3	10		0
South America	9.1	15	16.8	17	49.1	47	13.1	11	10.2	10		0
World	10.5	11	29.0	28	23.3	23	24.1	22	13.3	10		6

Notes: (a) Estimates made by a consultant contracted by FAO to prepare the report on the Situation of Natural Resources and the Human Environment for Agriculture and Food (FAO, 1977).

(b) Estimates actually published in the FAO report.

(c) Without serious limitations: Chernozems, Greyzems, Phalozems, Luvisols.

(d) Drought: Yermosols, Xerosols, Kastanozems, Solonchaks, Solonetz, Regosols, Arenosols.

(e) Mineral problems: nutritional deficiences or toxicities. Includes Ferralsols, Acrisols, Nitosols, Podzols, Podzoluvisols, Andosols.

(f) Shallowness: Lithosols, Rendzinols, Rankers, Cambisols, (in part).

(g) Excessive water: Fluvisols, Gleysols, Vertisols, Planosols, Nitosols.

Source: Data from the FAO/UNESCO Soil Map (1964) processed by FAO (1977).

Table 13. New estimates of potential arable land in Latin America[a] (areas in millions of hectares).

Total area	Areas with high precipitation		Areas with low precipitation		Problem areas		Flood areas		Deserts (b)		Suitable for irrigation (c) area
	Area	%	Area	%	Area	%	Area	%	Area	%	
653	204	31	30	5	241	37	173	27	15	43	181

Notes: (a) Soil and water classes follow the suitability classification of the FAO regional agroecological study. The four suitability classess -- very suitable, suitable, barely suitable and unsuitable -- correspond to projected yield as a percentage of the maximum attainable under optimum agroclimatic and edaphological conditions; thus, for some barely suitable soils the yield may only be 10% of the optimum level. These are:

Areas with high precipitation.	Areas with precipitation levels permitting a growing period of 120 to 270 days; soil quality very suitable or suitable.
Areas with low precipitation.	Level of precipitation permitting 75 to 120 days of growth; soil quality very suitable, suitable or barely suitable.
Problem areas.	Precipitation level permitting a growth period of over 270 days; soils of all usable qualities in this zone, plus that part of the zone of 120 to 270 days of growth for which the soil is classified as barely suitable.
Natural flood areas.	Lands covered with water during part of the year and lowland rainfed rice fields.
Irrigated areas.	Fully or partly irrigated land.

(b) Desert areas with irrigation.

(c) Area already irrigated (partly or fully) plus areas suitable for irrigation in the future. Included in the previous columns.

Source: FAO (1979).

Table 14. Soils of the Caribbean region (in Km2)

Soils	Mexico, Central America and Antilles	Colombia, Venezuela, Guyana, Suriname and French Guiana	Total
Fluvisols	31,370	124,400	155,770
Gleysols	63,470	219,940	283,410
Regosols	135,540	47,560	183,100
Lithosols	246,600	222,710	469,310
Arenosols	-	43,490	43,490
Rendrinas	135,500	2,510	138,010
Androsols	195,320	33,650	228,970
Vertisols	163,110	37,280	200,390
Kastanozems	360,050	10,380	370,430
Phaiozems	10,860	-	10,860
Cambisols	308,100	144,050	452,150
Luvisols	302,650	56,020	358,670
Podzols	-	10,800	10,800
Planosols	15,250	25,980	41,230
Acrisols	213,070	532,310	745,380
Nitosols	107,900	131,230	239,130
Ferrasols	6,510	672,860	679,370
Histosols	24,920	20,280	45,200
Solonchaks	2,420	14,500	16,920
Solonetz	-	3,150	3,150
Yermosols	246,360	5,410	251,770
Xerosols	149,750	29,030	178,780

Source: FAO/UNESCO Soil map, Vol. III (1975), Vol. IV (1971). In FAO (1979).

In North America, Central America and the Caribbean the most serious limitation is drought (32%), but this applies primarily to Mexico. Next is the shallowness of the soil, followed closely by mineral problems. In South America the most serious limitation is due to mineral problems, and is found essentially in the Amazon and Orinoco regions. Drought also is a very important factor, followed by shallowness. The factor that varies most in the estimates of Table 12 is that of shallowness. Table 13 presents more detailed information on the soils of countries in the Caribbean area, based on the FAO/UNESCO World Soil Map already mentioned.

Since the largest proportion of virgin land is located in the humid tropics of South America, and since many believe that the limiting factors there are easier to overcome than those of arid lands, analysis of the agricultural potential of its soils is a matter of great importance. Unfortunately, the information available for this purpose is very poor and generally even more "extremist" than that for Latin America as a whole. As another example of an "optimistic" evaluation we may mention that of Nelson (1975), presented in Table 15, which indicates that 34% of the soils of the Amazon and Orinoco regions are suitable for cultivation to some extent, and that at least another 32% is suitable for pastures and permanent crops. Oddly enough, these estimates -- which are several times higher than those of the initial FAO assessment for Latin America as a whole as shown in Table 12 -- are based on the very sources used by that organization, which clearly attests to the relative nature of all these analyses. Indeed, a review of the estimates and comments made by Nelson himself (1975) can lead to conclusions very different from his; actually, only the soils which he classifies as alluvial and dry uplands clearly have an

acceptable fertility level, and they represent only 4% of the South American humid tropics. This proportion coincides with what has been found in Amazon countries such as Peru, where 1% of the land is suitable for agriculture in the Amazon lowlands and 3 to 4% when the Amazon highlands are included (Zamora, 1971). In Brazil, the RADAM project -- supplemented by EMBRAPA studies -- showed that 85% of the soils of the Amazon are easily leached latosols, characterized by low fertility, high acidity and shallowness.

Table 15. Soil resources of the humid tropics of South America in terms of their possibilities of use (in millions of hectares).

Country	For Crops						For pastures, permanent crops (f) or forests	Total
	Alluvial (a)	Dry uplands (b)	Low Fertility (c)	Hydromorphic (d)	Marginal or sloping (e)	Total		
Colombia	3.6	1.5	20.2	6.3	0.4	32.0	69.4	101.4
Ecuador	0.1	0.4	4.8	0.6	0.1	6.0	15.3	21.3
Peru	0.1	1.6	17.2	2.7	0.4	22.0	55.1	77.1
Bolivia	0.7	0.6	12.3	10.8	2.2	26.6	52.2	78.8
Argentina	2.7	3.1	5.7	2.3	1.7	15.5	21.7	37.2
Paraguay	0.7	4.2	7.1	2.8	0.7	15.5	25.2	40.7
Brazil	3.2	21.8	174.4	25.4	18.5	243.3	503.4	746.7
Venezuela	0.2	2.3	17.1	5.7	5.0	30.3	24.8	55.1
Total	11.3	35.5	258.8	56.6	29.0	391.2	767.1	1,158.3

Nelson (1975) gives the following notes to his table:

(a) Developed soils with recent deposits located in flood plains or deltas. The characteristics of these soils depend on the material from which they originate.

(b) These soils have a rolling or flat topography, good drainage, no erosion and moderate or high fertility.

(c) These soils are of the dry upland type but have very low natural fertility. If fertilizers and proper agronomic techniques are used an acceptable harvest can be expected.

(d) These soils are located in depressions with very little possibility of drying (draining).

(e) These soils present problems in their use for agriculture because of their shallowness and unsuitable texture (clay or sand). They have some elevation and are susceptible to erosion.

(f) These soils are not suitable for agricultural production because they have one or more of the following adverse characteristics: excessive slope, ~~deficit~~ (inadequate) drainage, high proportion of sand or clay, rocky or stony subsoil.

Source: Nelson (1975).

As the foregoing comments show, the controversy about the agricultural potential of the soils of tropical rain forests is fed by insufficient data and is marked by an excessive divergence of opinions. As already noted, at the optimistic extreme we have the statements that 32% or 27% of Latin America is arable (FAO 1979, IICA 1975), that 23 to 62% of the territory of some countries with nutritional deficits is arable (USDA, cited by OAS, 1974), or that 34% of the Amazon or Orinoco regions are suitable for cultivation (Nelson, 1975). The moderate positions show a rather wide range of judgments, such as that 15% (FAO 1977) or 9.1% (op. cit.) of the soils of Latin America are arable; or that, as shown in Table 11, the countries of South America have 2.7% to a maximum of 10.2% of soils suitable for intensive agriculture. At the pessimistic extreme are found, in general, scientists involved not in the problems of development but in those of environment (in its more limited sense), or the "ecologists." According to these circles of opinion, the soils of the tropical rainforests should continue to have virtually no agricultural use; on the whole, their views are ill-founded and have little validity. For the purposes of this study, the author -- ~~giving~~ attributing greater validity to the type of information contained in Tables 11 and 12 -- has assumed that the soils of North America, Central America and the Caribbean are arable in a proportion varying from 15 to 22%, while in South America this proportion is 7 to 12%; this gives a proportion of 8 to 16% for the entire area studied.

Recalling that the classification of soils by use capacity is based on the degree of difficulty involved in making them agronomically productive without destroying or wasting them, it is obvious that future agricultural expansion in Latin America and the Caribbean will face increasing costs as less

suitable soils are brought into use. If the final estimate in the preceding paragraph is valid, it means that there is already virtually no arable land available in the most conservative case, or that there is an area equal to that now in use in the most favorable case. When this potential has been utilized, agriculture will continue to expand essentially with shallow soils, i.e. those on sloping lands exposed to erosion. Table 12 shows that this type of soil provides the basis for the most favorable alternative. At the same time, soils with mineral problems and a scarcity of water will be brought into use, requiring even greater outlays to overcome their limitations and permit their rational use.

Table 16 gives an example of the relative nature of the classification of soils by their use capacity on the basis of the technologies applied. In the "official Amazon region" of Brazil, with about 6 million square kilometers, only 2.75% of the soils would be good or fair for short or long-cycle crops if ordinary agricultural techniques are used; however, if the natural limitations of the soil are overcome through the use of advanced techniques including fertilization, up to 42% of the land in that region can be considered good. Land that is very poor or unsuitable for agriculture, which at present represents up to 95% of the area, would thereby be reduced to only 31%. Between these two extreme positions there is obviously a whole range of alternatives less ideal than those based on the case of advanced technologies given in the example.

To a considerable degree, the environmental problems related to land use are caused by stockraising; for this economic activity the soil classifiers are on the whole more generous as regards the areas they consider to be suitable,

as may be seen in Table 11. More will be said about this aspect below, since if agricultural expansion takes place chiefly at the expense of land used for stockraising, the adverse effects on the environment will be more tolerable.

Table 16. Use capacity of soils of the Official Amazon Region of Brazil on the basis of primitive (System A) and advanced (System B) agricultural technologies.

	Stratum type	Definition of stratum (classification of soil)	System A		System B		Total System A		Total System B	
			Area	%	Area	%	Area	%	Area	%
CLASS I	Ia	Good for short and long-cycle crops	3,606	0.04	17,426	0.29				
	Ia		14,422	0.24						
	Ib	Good for long cycle crops, fair for short cycle crops.	18,027	0.30	1,698,718	28.27				
	Ib		-		316,669	5.27				
	Ic	Good for short cycle crops, poor for long cycle crops	91,335	1.52	56,484	0.94				
	Ic		37,856	0.63						
	Id	Good for long cycle crops, poor for short cycle crops	-		438,650	7.30				
	Id		-		21,632	0.36	165,246	2.75	1,549,579	42.43
CLASS II	IIa	Fair for short and long cycle crops	40,259	0.67	87,129	1.45				
	IIb		-		198,294	3.30				
	IIb		121,981	2.03	63,094	1.05				
	IIb		-		66,098	1.10				
	IIc	Fair for long cycle crops, poor for short cycle crops	-		79,318	1.32				
	IIc		-		71,506	1.19				
	IIc		-		19,228	0.32				
	IId	Poor for long cycle crops, unsuitable for short cycle crops	-			-				
	IId		-		1,025,120	17.06	162,240	2.70	1,609,787	26.79
CLASS III	IIIa	Poor for both types of crops	2,349,483	39.10	11,417	0.19				
	IIIa		242,159	4.03	104,555	1.74				
	IIIa		753,516	12.54	48,071	0.80				
	IIIa		55,282	0.92	63,094	1.05				
	IIIa		88,932	1.48	91,936	1.53				
	IIIb	Poor for short cycle crops, unsuitable for long cycle crops	601	0.01		-				
	IIIb		277,612	4.62	159,837	2.66				
	IIIc	Poor for long cycle crops, unsuitable for short cycle crops	-		4,807	0.08				

Table 16 continued

CLASS III	IIIc				-	2,404	0.04	3,767,585	62.70	486,121	8.09
CLASS IV	IV		Unsuitable for agriculture	1,553,303	15.85	785,364	13.07				
	IV			35,452	0.59	112,367	1.87				
	IV			286,625	4.77	465,690	7.75				
	IV			38,457	0.64		-	1,913,837	31.85	1,363,421	22.69
				6,008,908	100.0	6,008,908	100.0	6,008,908	100.0	6,008,908	100.0

Less than 20% of the unit is in class I

Less than 20% of the unit is in class II

More than 20% and less than 40% is in the class indicated; the rest is in a lower class.

Less than 20% of the unit corresponds to classes I and II considered.

More than 30% but less than 40% is in the class indicated; less than 20% is in class I and the rest is in a lower class.

Source: Brazil. Soil Use Map (prepared by the author to obtain the figures shown). A substantial margin of inaccuracy is probable.

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3.2 Present use of soils

Table 17 presents information available to FAO on the present use of land in each country of the six regions into which Latin America and the Caribbean ~~has~~ have been divided. For North America the proportion of arable soils currently available is 12% of the land area of the region; pastures cover 39%, forests and other areas populated with woodbearing plants cover 37%, and the remainder (12%) consists of barren and unused land (deserts, snow-covered mountains) or urban areas. In Central America the land now arable ~~also~~ makes up 12% of the region, pastures 19%, forests 53% and other land 15%. In the Caribbean the arable proportion is the largest for the entire area studied (26%), while pastures (23%) and forests (20%) account for the smallest areas; this region also has the highest percentage (31%) of unproductive land and/or urban areas. The Andean region has the smallest proportion of arable land in use (5%); pastures cover only 20% while forests make up 59% of the territory; unusable areas and land used for other purposes amount to 16%. In the Atlantic region the percentage of arable land is 8%, pastures 20%, forests 58% and other classifications almost 15%. Finally, in the Southern Tier arable land represents 12% of the territory, while pastures represent the largest proportion with 46%; forests cover 22% and other categories 20%.

Table 17. Present use of land

Region / Country	Arable land		Cultivated land		Permanent crops		Pastures		Forests and the like		Other	
	Area (km2)	%	Area (km2)	%	Area (km2)	%	Area (km2)	%	Area (km2)	%	Area (km2)	%
NORTH AMERICA												
Mexico	232,200	12.1	151,900	65.5	15,200	6.5	744,990	38.7	707,000	36.8	238,850	12.4
Total/Average	232,200	12.1	151,900	65.5	15,200	6.5	744,900	38.7	707,000	36.8	238,850	12.4
CENTRAL AMERICA												
Belize	510	2.2	408	80.0	190	37.2	210	0.9	10,120	44.3	11,960	52.4
Costa Rica	4,900	9.7	3,631	74.1	2,070	42.2	15,580	30.6	25,000	49.4	5,180	10.2
El Salvador (a)	7,310	35.3	7,340	100.4	2,240	30.5	6,100	29.4	2,630	12.6	4,680	22.6
Guatemala	18,000	16.7	13,920	77.3	3,500	19.4	8,800	8.2	58,000	53.6	23,090	21.4
Honduras	9,150	8.2	7,590	82.9	1,850	20.2	20,000	17.9	71,000	63.5	11,740	10.4
Nicaragua	15,050	12.6	7,450	49.5	1,760	11.6	33,840	28.5	62,820	52,9	7,040	5.9
Panama	5,660	7.5	3,640	64.3	1,150	20.3	11,610	15.3	41,560	54.6	17,160	22.5
Total/Average	60,580	11.9	43,979	74.1	12,760	21.5	96,140	18.9	271,130	53.3	80.850	15.0
CARIBBEAN												
British Antilles	440	20.7	368	80.0	80	19.1	140	6.6	390	18.3	1,160	54.4
Netherlands Antilles	80	8.3	64	80.0	-	-	-	-	-	-	880	91.7
US Antilles	60	17.6	48	80.0	10	16.6	90	26.5	20	5.9	170	50.0
Bahamas	160	1.6	128	80.0	140	87.5	10	0.1	3,240	32.2	6,660	66.1
Barbados	330	76.7	264	80.0			40	9.3			60	14.0
Cuba	31,500	27.5	20,880	66.2	6,700	21.2	27,700	24.0	20,300	18.0	35,020	30.6
Dominica	170	22.6	8,540	5023.5	100	1.1	20	2.7	350	46.7	210	28
Grenada	160	47.1	218	80.0	140	87.5	10	2.9	40	11.8	130	38.2
Guadeloupe	480	27.2	384	80.0	90	18.8	210	11.9	700	39.8	370	21
Haiti	8,700	31.6	10,370	119.2	3,350	32.3	5,200	18.9	2,000	7.2	11,660	42.3
Jamaica	2,650	24.5	1,760	66.4	600	22.6	2,100	19.4	4,920	45.4	1,160	10.7
Martinique	260	24.5	208	800	190	73.0	250	23.6	280	25.4	270	25.5
Puerto Rico	1,590	17.9	1,193	750	620	39.0	3,340	37.7	1,710	19.3	2,220	25.1
Dominican Rep.	12,300	25.4	9,913	80.6	3,500	28.45	14,800	30.6	11,040	22.8	10,240	21.2
St. Lucia	170	27.9	136	80.0	120	70.5	30	4.9	110	18	300	49.2
Trinidad and Tobago	1,570	30.6	943	60.0	870	55.4	110	2.1	2,260	44.1	1,190	23.2
Total/Average	60,620	25.9	55,175	91.2	16,500	27.2	54,030	23.1	47,220	20.2	71,700	30.7

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Table 1 .ontinued

ANDEAN												
Bolivia	33,050	3.0	10,890	32.9	850	2.5	271,000	25.0	562,000	51.8	219,420	20.2
Colombia	35,050	5.3	42,470	77.1	15,700	28.5	175,500	16.9	771,900	74.3	36,250	3.5
Ecuador	50,890	18.4	17,980	35.3	11,000	21.6	22,000	7.9	148,500	53.6	65,450	20
Peru	34,330	2.7	19,860	57.8	3,300	9.6	271,200	21.2	738,000	57.7	236,470	18.4
Venezuela	53,370	6.1	17,650	33.0	5,570	10.4	168,300	19.1	479,700	54.4	180,680	20.4
Total/Average	226,640	5.0	108,850	48.0	36,420	16.0	908,000	19.9	2,700,100	59.2	728,270	15.9
ATLANTIC	(b)											
Brazil	724,889	8.6	458,200	63.2	84,200	11.6	1,660,000	19.6	4,769,472	56.4	1,299,310	15.4
French Guiana	30	0.03					50	0.06	80,010	89.7	9,060	10.2
Guyana	3,790	1.9	2,080	54.8	150	3.9	9,990	5.1	181,900	92.4	1,170	0.5
Paraguay	11,200	2.8	10,720	95.7	1,700	15.1	151,000	38.0	204,000	51.3	31,100	7.8
Suriname	460	0.3	590	128.3	100	16.9	100	0.1	143,000	88.6	17,910	11.0
Total/Average	740,369	7.9	471,590	63.7	86,150	11.6	1,821,140	19.6	5,373,382	57.8	1,358,550	14.6
SOUTHERN TIER												
Argentina	350,000	12.8	277,430	73.2	100,000	28.5	1,435,000	52.4	602,200	22.0	349,490	12.8
Chile	58,280	7.8	20,210	34.6	1,980	3.3	118,000	15.7	206,860	27.7	365,660	48.8
Malvinas Is.							12,000	99.0			170	1.0
Uruguay	19,100	11.0	12,720	66.5	600	3.1	135,500	78.0			19,020	11.0
Total/Average	427,380	11.6	310,360	72.6	102,580	24.0	1,700,500	46.3	809,068	22.0	734,340	20.0
SOUTH AMERICA	1,394,439	7.9	890,800	63.9	225,150	16.1	4,429,620	25.3	8,887,542	50.7	2,821,160	16.1
LATIN AMERICA AND CARIBBEAN	1,747,839	8.5	1,141,854	65.4	269,610	15.4	5,324,780	26.3	9,912,892	49.1	3,211,750	15.9

Notes: Information for 1977.

(a) In El Salvador and Haiti the area planted is larger than the arable area. The difference was used to calculate the percentage of perennial crops.

(b) The cultivated area was estimated on the basis of FAO projections, as was the arable area of Brazil. Where FAO projection figures are not available (FAO, 1978), they have been estimated by the author (e.g. Caribbean Islands).

Sources: The table is based on the FAO Yearbook of Production (FAO 1978), but the column for cultivated land was calculated for 1977 on the basis of data used by FAO for the publication Agriculture toward 2000, as was the arable area for Brazil.

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This first glance at the information once more shows the markedly distinct situation of the Caribbean, whose currently arable area is proportionally two to five times larger than that of any other region, and which moreover has more than twice as much unproductive or urbanized land as the others. Thus, it has a much smaller proportion of forests. There are no great differences among the other regions, except in the proportion of land devoted to stockraising, which is very high in the Southern Tier and in Mexico. Obviously, the regions with the largest proportions of forests are the Andean and the Atlantic, followed closely by Central America. The Andean region has the smallest proportion of currently arable land, with less than half that of any other region except the Atlantic, which also has comparatively little.

The information provided in Table 17 is merely indicative, since a comparison with other sources in FAO itself or in the individual countries reveals noteworthy differences. The case of Brazil merits special mention in this regard because its vast territory (41% of the area studied) means that any variation in the data referring to it will alter the proportions for all of Latin America. According to the FAO Statistical Yearbook, the arable area plus that devoted to permanent crops was 497,200 km2 in 1977. But according to the sources used for the ~~document~~ report Agriculture toward 2000 the area of arable land was 670,249 km2 in 1975 (about 725,000 km2 in 1977). Moreover, according to this latter source the area cultivated was 422,679 km2 in 1975 (about 460,000 km2 in 1977). Brazilian statistics show that in 1977 there were 406,440 km2 of annual crops and 65,333 km2 of perennial crops (471,774 km2 in total). Thus, it appears that the figures given in the FAO Yearbook for

Brazil refer~~ed~~ to the area actually cultivated and not -- as for the great majority of the countries -- to the arable area utilized plus that with immediate or short-term potential use (fallow or tillable without major investments). Accordingly, in Table 17 the author has opted to use the figure in the report Agriculture toward 2000, reducing the area of forests proportionally. The FAO figures for the latter are much too high, as will be demonstrated below. This is due partly to the inclusion of open ~~mountain~~ forest lands, but chiefly to the fact that no statistic recognizes the existence of what is called "wasted land" in this report.

3.2.1. Agriculture

The production of food in Latin America, including fish, increased at an annual rate of 3.5% from 1961 to 1970 and 3.4% from 1970 to 1977. Agricultural production expanded at an annual rate of 2.9% from 1961 to 1970 and 3.0% from 1970 to 1977 (FAO, 1978). Between 1970 and 1977 the countries with the lowest annual growth rates (less than 1.9%) were Barbados, Cuba, Trinidad and Tobago, Uruguay, Peru, Haiti, Jamaica, Honduras, Guyana, Dominican Republic and Chile. The highest rates of expansion (4 to 5%) were registered in Bolivia, Brazil, Paraguay and Nicaragua.

Agricultural production in Latin America has experienced its most spectacular growth since 1968 in the categories of vegetable oils, citrus fruits, apples, tea, jute and other fibers, tobacco and eggs, all of which expanded by over 4% a year. On the other hand, the production of tubers, coffee, cotton, rubber and wool has been declining. The area covered by this study is a very important producer of coffee, bananas and sisal, accounting for more than 50%

of world production in each case. It also contributes a substantial part (27 to 35%) of world production of cacao, sugar and citrus fruits, and slightly over 10% of world production of legumes, vegetable oils, cotton and tobacco. Among Latin America's livestock products only wool exceeds 10% of world production, followed closely by meat (Table 18).

To assess the future expansion of agriculture, it is extremely important to know some of its present characteristics in terms of the intensity with which the available land is used. First of all, as may be seen in Table 17, more than 34% of the arable land with potential for immediate use does not produce annual crops. This situation is most extreme in the Andean region where 52% of the arable land produces no crops; the Atlantic and North American regions also are below the average in this regard. Obviously, the opposite is true in the Caribbean, where virtually all of the arable land is used. In countries such as Dominica, Haiti and El Salvador the area used for agriculture exceeds the area considered as arable.

Table 18. Production of principal agricultural products in Latin America and the Caribbean, 1977.

Product	Production (000 mt)	% of world production	Annual % variation 1968-77
Agricultural products			
Cereals	85,236	5.8	3.6
Tubers	47,052	8.2	- 0.6
Dry legumes	4,759	10.0	0.1
Citrus fruits	13,875	27.0	7.0
Bananas	18,569	51.6	1.1
Apples	1,418	5.1	5.7
Vegetable oils (oil equivalent)	5,316	11.7	8.2
Sugar	26,687	29.3	3.7
Coffee (green)	2,591	60.2	- 0.1
Cacao (grain)	499	35.0	3.7
Tea	46	2.6	6.7
Cotton (fiber)	1,760	12.4	- 0.4
Jute and others	110	2.5	5.6
Sisal	252	52.5	1.2
Tobacco	774	13.7	4.3
Rubber	28	0.1	- 1.5
Livestock products			
Meat	12,867	9.9	2.6
Milk	33,409	7.4	3.7
Eggs	1,922	7.7	4.9
Wool	300	11.6	- 2.0

Source: FAO (1978).

To some extent, the amount of irrigated land is an indicator of the intensity of agriculture. The proportion is highest in North America (33%) and also is high in the Andean region (23%) and the Caribbean (18%). It is lowest in the Atlantic region (3%) and low in Central America and the Southern Tier as well. For the entire area studied, irrigated lands represent only 11% of the area cultivated each year. Furthermore, it can be expected that on average, perennial crops cause significantly less erosion than annual crops. It is interesting to note that 24% of the cultivated land of the continent is occupied by perennial crops; the ~~highest proportion is found~~ proportions are highest in the Andean region (34%) and the Southern Tier (33%), and also ~~is~~ are high in the Caribbean (30%) and Central America (29%).

Taking into account the land classified as arable at the present time, the average per person for Latin America and the Caribbean is 0.5 ha. On the other hand, if only land actually cultivated is considered, the average is a mere 0.34 ha/person. This last figure is of great significance for any analysis, because it shows ~~a~~ the reality and not ~~a~~ the potential, however realizable it may be considered. With regard to individual regions, this figure points up the critical situation of the Andean and Caribbean regions, with only 0.16 and 0.18 ha/person, respectively; this goes far to explain the social situations prevailing in most of the countries involved, and particularly their food problems. It should be noted in passing that North America and Central America are not in a substantially better position; only in the Atlantic region is the situation more tolerable, and only in the Southern Tier is it clearly good with 0.78 ha/person, i.e. nearly five times ~~greater~~ more than in the Andean region which it borders (Table 19).

Table 19. Arable and cultivated area per capita in Latin America and the Caribbean, 1977

Region	Available arable area (ha/person)	Area harvested (ha/person)
North America	0.35	0.23
Central America	0.28	0.21
Caribbean	0.20	0.18
Andean	0.33	0.16
Atlantic	0.60	0.38
Southern Tier	1.07	0.78
South America	0.60	0.38
LATIN AMERICA AND THE CARIBBEAN	0.50	0.34

Sources: Based on data in Tables 17 and 1.

In the five countries of the Andean region, where per capita GDP averaged US$960 in 1976, agricultural GDP per rural dweller was US$445. Even in Venezuela, with a per capita GDP of US$1,705 in that year, agricultural GDP was only US$422 per campesino. In Bolivia agricultural GDP per rural dweller was only US$120. In that region the daily supply of calories and protein has increased only in the last decade, and in the mid-1970s the coverage of requirements was 75% for protein and 87.5% for calories. Even these ~~Nonetheless, the~~ aggregate figures conceal ~~the~~ substantial differences among social groups with different income levels; comparatively small groups are overfed ~~in contrast to~~ while large groups suffer~~ing~~ the effects of undernourishment and malnutrition, the situation often being more critical among rural dwellers than among urban populations (JUNAC, 1976). These countries are importing increasing quantities of wheat and flour, barley, sorghum, maize, rice, oilseeds, oils and fats and dairy products, in an attempt to maintain the nutritional level of their people.

For Latin America as a whole agricultural imports have risen, but in general this increase has remained within reasonable limits. Approximately 40% of the total has consisted of wheat, for which production faces ecological constraints in much of the area. Obviously, it is questionable whether wheat -- which is difficult to produce locally -- should be used to meet the food needs of a region of the world that has the capacity to produce other equivalent foods, but the consumption habits of the population have been molded by more than four centuries of colonization and now seem irreversible.

Latin American agriculture has been modernized to a considerable extent. FAO (1978) notes that the use of fertilizers has increased nearly

20 times over the last 25 years, that the number of tractors has risen sevenfold, and that the area under irrigation has doubled. At the same time, the agricultural labor force has expanded by only 50%, and the area cultivated by 70%. Although the expansion of the area cultivated remains the leading factor determining the increase in production, the annual rate of expansion declined from 2.7% in the 1950s to 1.9% in the present decade. Average yield per hectare increased by 1.2% a year (1.8% if Brazil is excluded) from 1950 to 1974. There has also been a substantial increase in the productivity of labor. Moreover, a subsector of modern commercial agricultural enterprises has emerged. But with all these positive changes, there remain such serious negative aspects as the precarious living conditions of the majority of farmers and the poverty that has continued to spread despite the substantial increase in per capita agricultural GDP. In many countries no less than 26% of the rural labor force is unemployed and underemployment is extensive, resulting in massive migration to urban centers.

Table 20. Situation of agriculture in Latin America and the Caribbean (areas in km2)

Region	Arable land (1)(2)	"Available" arable land (2)(b)	Cultivated land (1)	Fallow land		Cultivated land with rainfed farming	Irrigated land(2)		Land with annual crops	Land with permanent crops (2)	
				Area	%		Area	% of cultivated land		Area	%
NORTH AMERICA	256,879	232,200	151,900	80,300	34.6	101,900	50,000	32.9	136,700	15,200	10.0
CENTRAL AMERICA	51,198	60,580	43,979	15,341	25.9	40,769	3,210	7.3	31,279	12,700	28.9
CARIBBEAN	56,729	60,620	55,175	5,275	8.7	45,105	10,070	18.3	38,675	16,500	29.9
ANDEAN	209,938	226,690	108,850	117,840	52.0	84,350	24,500	22.5	72,430	36,420	33.5
ATLANTIC	744,491	740,369	471,590	268,779	36.3	459,520	12,070	2.6	385,440	86,150	18.3
SOUTHERN TIER	524,625	427,380	310,360	117,020	27.4	281,660	28,700	9.2	207,780	102,580	33.1
SOUTH AMERICA	1,479,054	1,394,439	890,800	503,639	36.1	825,530	65,270	7.3	665,650	225,150	25.3
LATIN AMERICA AND THE CARIBBEAN	1,843,860	1,747,839	1,141,854	604,555	34.6	1,013,304	128,550	11.3	872,244	269,610	23.6

Notes: Information for 1977.

(a) Data from "Agriculture toward 2000" supplemented by the author for other countries (only the smallest).

(b) Data from FAO Production Yearbook and table for Brazil.

Sources: (1) Basic data for Agriculture toward 2000 (FAO, 1979); (2) Production Yearbook (FAO, 1979).

One highly visible feature of the evolution of agriculture in Latin America is the dichotomy between the expansion of the modern subsector and the stagnation of the traditional subsector. By way of illustration, technological progress has been highly concentrated in geographic terms. Brazil and Mexico alone consumed more than two thirds of the fertilizers used, while nearly three fourths of the agricultural tractors were in those two countries and Argentina. However, a very small proportion of the farms in those same countries have adopted new technologies. There is evidence that most of the increase in agricultural production is attributable to the modern subsector. In Mexico 80% of the increase in production during 1950-60 came from less than 4% of the production units, particularly those located in irrigated regions of the North and Northern Pacific (FAO, 1978).

3.2.2. Stockraising

Stockraising in Latin America shows two well-defined historical stages separated ~~marked~~ by the discovery and conquest of the American continent. Prior to those events livestock development was modest and was based essentially on camelids (llama and alpaca), poultry (ducks and turkeys), a rodent (the guinea pig) and the dog. In the Andes region, where most of these animals were raised intensively, they represented an important though not decisive proportion of the protein supply of the great local cultures. Despite the fact that their population was much larger ~~greater~~ than at present, the ecological impact of llamas and alpacas was not great because their low weight, padded feet and feeding habits kept them from being a major factor in the compacting of soils or the degradation of pastures. The second stage began with the massive introduction of bovine cattle, equines, goats, sheep, swine and domesticated poultry (chickens, ducks, geese) and, naturally, dogs and cats. Both equines and ruminants are characterized by their

high weight, horny hooves and costly feeding habits. Except for weight, sheep and goats have the same characteristics. Quickly adopted by the rural people, the populations of all these animals increased tremendously, and over the centuries they came to occupy vast areas of the new continent, with a marked adverse effect on its landscape but on the whole without ~~offsetting~~ compensatory benefits for its people.

Stockraising currently occupies not less than 26% of the territory of Latin America and the Caribbean. The largest pasture areas are in Mexico, Argentina and Uruguay, and the proportions are also ~~very~~ substantial in Costa Rica, El Salvador, Nicaragua, Bahamas, Cuba, Martinique, Dominican Republic, Puerto Rico, Bolivia, Peru, Brazil, Paraguay and the Malvinas Islands. All of these countries devote more than 20% of their territory to grazing; in some, such as those of the Southern Tier (except Chile) the proportion is over 50%, reaching 77% in Uruguay and 99% in the Malvinas Islands.

In a recent study, Romanini (1978) states that in tropical America the system of extensive stockraising without fertilization of pastures is dominant, and that when attempts are made to fertilize them the results are ~~unfavorable~~ poor because the large biomass produced cannot be properly utilized by livestock during wet periods. In some cases there is lignification of fodder or overgrazing because of the lack of available biomass during the dry period. In recent decades the transformation of tropical forests into pastures has accelerated rapidly with the opening of roads and the availability of large investments for the meat industry. Romanini adds that the risks are great because extensive stockraising uses very little labor (one herdsman can manage 100 ha of pastures in the extensive system), and moreover, the tropical pastures of humid zones are not stable ecosystems that can produce indefinitely.

Table 61 shows the livestock population of Latin America and its projections. For 1977 the livestock population of this part of the world was estimated at 22,553,000 horses, 6,623,000 mules, 8,029,000 donkeys, 267,558,000 bovines, 288,000 buffalo, 111,434,000 sheep, 28,843,000 goats and 72,822,000 swine. In that year the estimated pasture area was 5,324,780 km2 (Table 17), giving a density of about 0.58 livestock units/ha, excluding swine from the calculation.

Furthermore, it is assumed that the central and southern Andes regions have a population of domesticated camelids (llamas and alpacas) of about 5 million, distributed as shown in Table 21, and that they use 5 to 6 million hectares of high Andean pastures (plateaus) for mixed grazing with livestock species that have been introduced. As will be seen below, these species represent one of the major development alternatives for the Andean uplands.

Table 21. Estimated population of domestic camelids in the Andes (000s of head)

Country	Alpacas	Llamas
Argentina	10	50
Bolivia	300	2,000
Chile	70	100
Peru	2,000	900
Total	2,380	3,050

Note: Information estimated for 1980.

Sources: A. Pumayala (National Agrarian University, personal communication), A. Brack (Project Vicuña, personal communication).

3.2.3 Forestry

The largest proportion of the land is shown as under forest, but this type of use, unlike the ~~previous types~~ others, does not necessarily imply the drastic alteration of natural ecosystems; moreover, it embraces a vast area of ecosystems in a virgin or nearly virgin state. The use of land for forestry obviously includes reforestation with exotic or native species, in pure or mixed stands. Consequently, the analysis of forestry is more complex than that of the other types of use, involving the dual use of land for conventional purposes, i.e. for production, in this case wood and other products -- and/or nonconventional purposes -- i.e. for the production of services to man which are tangible but more difficult to evaluate and less universally ~~accepted~~ acknowledged. In addition, forest lands are classified to include lands held in reserve for future agricultural or forestry uses, which in the meantime are being exploited as mentioned above.

The statistics, which are far from perfect for ~~agricultural use~~ farming and poor ~~with regard to use for~~ as regards stockraising, are absolutely chaotic when it comes to the various types of forestry use. In addition to understandable intrinsic factors, they are affected systematically by the vagueness of the concept "arable or potentially arable land," which nearly always increases at the expense of forested lands. Furthermore, ~~agriculture~~ farming and stockraising have a byproduct which is not quantified separately in the statistics, and which in this report has been denoted as "wasted lands." These are always attributed to the forestry sector, making statistical measurement even more difficult.

According to Table 17, ~~the~~ forests and similar areas, including in this category "lands with natural or planted trees, whether or not productive"

and "land on which forests have been cut but which will be repopulated with trees in the foreseeable future" (FAO, 1978), amount to almost 10 million square kilometers or 50% of the entire region of Latin America and the Caribbean. According to the same source, the most heavily forested regions are the Andean (59%), Atlantic (58%) and Central America (53%). The poorest in terms of forest area are the Caribbean (20%), the Southern Tier (22%) and North America (37%).

Table 22. Area of tropical forest in Latin America and the Caribbean, according to different sources and alternatives (in millions of hectares)

Region	Climax	1958	1960-1968	1970	1975	1980	1990	2000	Loss 1980/2000	% of Loss
NORTH AMERICA				61.3(2)	60.4(2)	60 (8) 59.5(2)				
CENTRAL AMERICA		29.6(3)		24.6(2)	22.9(2) 17.6(6)	22.5(8) 12.5(6) 21.2(2)	55.8(2)	46.8(2)	18.1(8)	27.9(8)
CARIBBEAN				3.7(2)	3.0(2)	3(8) 2.8(2) 4.1(5)	4(3)	3.8(3)	0.3(2)	
ANDEAN				191.6(2)	183.6(2)	190(8) 176.7(2)	580(2)	548(2)	64.1(3)	10.5(2)
ATLANTIC				391.2(2)	392.9(2)	374.5(8) 375.3(2)				
NORTH AND CENTRAL AMERICA AND THE CARIBBEAN	53(1)	73.5(3)	52(4)?	89.6(2)	34(1) 86.3(2)	83.5(2) 69(5)				
ANDEAN AND ATLANTIC	750(1)	865.7(3)	769(4)?	582.8(2)	472(1) 566.5(2)	522(2) 612.1(5)				
LATIN AMERICA AND THE CARIBBEAN	803(1)	939.2(3)	821(4)	672.4(2)	788(6)? 506(2) 652.8(2)	641.2(7) 635.5(2) 681.1(5) 660.(8)		562(6)? 552(2)?	83.5(2)	13.1(2)

Notes: (1) Includes only rain forests, and their "climax" corresponds to present conditions; (2) Includes humid and dry tropical forests, but excludes Paraguay. Non-tropical forests are included in the cases of Mexico and Brazil; (3) Includes non-tropical forests in the cases of Mexico and Brazil; (4) Includes forests and other areas with trees. The data seem to refer to the 1960s.

?: Doubtful data, obtained indirectly (other authors) from the source cited.

Sources: (1) Sommer (1976), (2) Lanly and Clement (1979), (3) FAO World Forest Inventory (1960), (4) FAO-UNEP Report (FAO, 1975), (5) Lanly and Gillis (1980), (6) UNEP (1980), (7) Leyton (1980), (8) FAO (1980).

These figures have always been regarded as exaggerated by specialists. Several studies have been made for purposes of ~~their~~ comparison, among which two successive approximations, referring to the tropical region of Latin America and prepared under the FAO/UNEP project on Evaluation of tropical forest resources by Lanly and Clement (1979) and Lanly and Gillis (1980), are of particular value because they are based on the most reliable field observations that could be obtained. For obvious reasons, the data presented below are taken essentially from the Lanly and Gillis report (1980), which is a revised and refined version of the earlier ~~report~~ paper.

According to Lanly and Gillis (1980), there are 6,810,500 km2 of dense forest resources in the regions that have been denoted here as North and Central America, Caribbean, Andean and Atlantic. They exclude only the Southern Tier, which will be treated separately. As may be seen in Table 22, which summarizes most of the existing studies on the availability of tropical forest resources in Latin America, the data vary greatly except in the case of the official statistics already mentioned; the different figures are shown together. Thus, in contrast to the sources used for the Production Yearbook (FAO, 1978), which show 9,103,832 km2 of forests in 1977 (and probably somewhat less in 1980, based on the trends indicated in those sources), all other studies give substantially lower figures. Among the latter, that of Sommer (1976) estimates the smallest area, but this is mainly because he included only tropical rain forests while Lanly and Clement (1980) and Leyton (1980), drawing upon earlier studies, include both humid and dry tropical forests. Other differences between the two studies directed by J.P. Lanly are due, for example, to the exclusion of Paraguay in the first; as indicated by the author, however,

the 7% difference (increase) in the second report can be explained essentially by the availability of new data ~~on~~ for Bolivia and Brazil, which show that both countries have areas larger than what is usually accepted. In any case, the report of Lanly and Gillis (1980) is provisional. For instance, it does not include data on Puerto Rico and some other Caribbean islands.

~~Nonetheless~~ Moreover, the overall data presented by Lanly and Gillis (1980) refer solely to "dense forests," and the authors exclude from that category all mixed formations of leaf-bearing trees and grasses, as well as the different "facies" of the Brazilian cerrado, the many types of treed savannas with or without palm trees, and the Chaco jungle. This being the case, the report is fully consistent with current FAO statistics referring to both dense and open forests. Actually, if we add to the 6,810,500 km2 of dense forests indicated by those authors only the Brazilian cerrado and the caatinga (about 2,500,000 km2), we will have nearly reached the figure shown in the FAO statistics, which are greatly exceeded if the Chaco and treed savannas are added. Obviously, what happens is that these open forests are shown largely as natural pastures. Nevertheless, many difficult questions remain, as will be seen in due course.

According to the same source (Table 23), the tropical forests consist essentially of latifoliates (96%) and to a much lesser extent of conifers (4%), concentrated in North America, Central America and the Caribbean (94%). It is well known that the tropical conifer forests of South America consist of Araucaria (in Brazil) and Podocarpus (in various regions), while in the rest of the area they consist of various species of Pinus.

Table 23. Tropical forest resources (dense forests) in Latin America and the Caribbean, 1980

Region	Latifoliates		Conifers		Total area km2
	Area (km2)	%	Area (km2)	%	
North and Central America	430,550	66	218,050	34	648,600
Caribbean (a)	33,500	82	7,550	18	41,050
Andean and Atlantic	6,106,950	98	13,900	2	6,120,850
LATIN AMERICA AND CARIBBEAN	6,571,000	96	239,500	13	6,810,500

Note: (a) Belize is included in the Caribbean.

Source: Based on Lanly and Gillis (1980).

Table 24. Dense tropical forests according to their use for productive or protective purposes in Latin America and the Caribbean, 1980

Region	Productive				Protective	
	Exploited		Unaltered			
	Area (km2)	%	Area (km2)	%	Area (km2)	%
North and Central America	221,600	35	164,800	25	262,200	40
Caribbean (a)	26,000	63	2,800	7	12,250	30
Andean and Atlantic	397,150	6	4,505,650	74	1,218,050	20
LATIN AMERICA AND CARIBBEAN	644,750	9	4,673,250	69	1,492,500	22

Note: (a) Belize is included in the Caribbean.

Source: Based on Lanly and Gillis (1980).

On the basis of their type of utilization, the dense tropical forests have been grouped in productive and protective categories. Table 24 shows that 78% of the dense forests of Latin America and the Caribbean are suitable for productive purposes. ~~On~~ Of these, the majority have already been exploited in North and Central America (57%) and in the Caribbean (90%), while in South America the majority (92%) have remained unaltered. It should be noted that the term "unaltered" refers to the exploitation of forests for wood and not to the exploitation of non-woodbearing forest products, which cover vast areas as in the case of rubber (Hevea), rosewood (Aniba roseadora) and Brazil nuts (Bertholletia excelsa), to cite only three species. Even so, the figures given for South America seem rather conservative. Table 24 also shows the proportions of protective forests, which are high in North America and particularly in Central America and the Caribbean, and low in South America. In the latter region the proportion of protective forests obviously is much ~~greater~~ higher in the Andean countries, where it reaches 40%, than on the Brazilian plains, which are comparatively immune to erosion.

Lanly and Gillis (1980) have also estimated the area of dense forest exploited annually. Table 25 shows an average for the area exploited annually in each region, broken down by latifoliates and conifers. As may be seen, about 3 million hectares are utilized each year, generally on a very selective basis, i.e., with extraction of 5 to 20 m3/ha. Part of the wood production comes from felled trees recovered prior to clearing for agricultural purposes; in addition, it is obvious that a significant proportion of the forests exploited each year were worked one or more times in the past. The annual rate of utilization is 4 to 5 times higher for conifers than for latifoliates, and is especially high for South American conifers.

Table 25. Area of dense tropical forest exploited annually (1976-80).

Region	Latifoliates		Conifers		Total	
	Area (km2)	Rate of utilization (%)	Area (km2)	Rate of utilization (%)	Area (km2)	Rate of utilization (%)
North and Central America	2,400	0.6	2,300	1.1	4,700	0.7
Caribbean(a)	200	0.6	100	1.3	300	0.7
Andean and Atlantic	21,850	0.4	2,000	14.4	23,850	0.4
Latin America and the Caribbean	24,450	0.4	4,400	1.8	28,850	0.4

Notes: (a) Belize is included in the Caribbean area.

(b) Part of the areas exploited annually was worked previously.

(c) Annual rate of utilization or % of forest exploited each year.

Source: Lanly and Gillis (1980).

The extent of deforestation is a much more important phenomenon than the extraction of forest products. The authors cited have also studied this aspect, and their findings are shown in Table 26 and 27. They estimate annual deforestation or clearing at over 4 million hectares. The distribution of this impact is 75% in productive forests and the remainder in protective forests; on average, the situation in this regard is more serious in Central America and the Caribbean than in Latin America as a whole, although it is critical in the Andean countries. Moreover, although broadleaf forests are affected much more in absolute terms, ~~the~~ conifer forests are affected much more adversely in absolute terms. The average rate of deforestation of conifers is more than twice that of latifoliates.

The causes of deforestation have been classified in two groups: the type which the authors call ~~nomadic~~ migratory agriculture with fallow land, which accounts for 34% of the annual deforestation; and the advance of settlement, which is responsible for 66%.

Theoretically, the first of these phenomena permits some recovery of the forest cover, at least temporarily and until it is overtaken by the second, which eliminates any possibility in this regard. The authors also point out that ligneous formations resulting from prior agricultural use (medicinal plants in Mexico, stands of Cecropia, young secondary forests, etc.) and representing stages of reconstitution of the forest account for 6% of the dense forest area not affected by agriculture. This proportion is much higher for conifer forests (42%) than for leaf-bearing trees (5%), and much higher in Central America (45%) than in South America (2%).

Table 26. Average annual deforestation (1976-80) in dense tropical forests of Latin America and the Caribbean (areas in km2)

Region	Productive forests		Protective forests		Latifoliates		Conifers		Total	
	Area	% (b) / Rate of deforestation (c)	Area	% (b) / Rate of deforestation (c)	Area	Rate of deforestation (c)	Area	Rate of deforestation (c)	Area	Rate of deforest-ation (c)
North and Central America	6,100	67 / 1.6	2,950	33 / 1.1	7,200	1.7	1,850	0.8	9,050	1.4
Caribbean(a)	100	67 / 0.4	50	33 / 0.4	100	0.3	50	0.7	150	0.4
Andean and Atlantic	24,850	77 / 0.6	7,200	23 / 0.6	30,550	0.5	1,500	11	32,050	0.5
Latin America and the Caribbean	31,050	75 / 0.6	10,200	25 / 0.7	37,850	0.6	3,400	1.4	41,250	0.6

Notes: (a) Belize is included in the Caribbean.

(b) The percentages refer to the area of dense forests in each region.

(c) The annual rate of deforestation or % deforested each year.

Source: Based on Lanly and Gillis (1980).

Table 27. Annual deforestation by causes (areas in km2)

Region	Nomadic agriculture with fallow land		Advance of settlement	
	Area	%	Area	%
North and Central America	3,650	40	5,400	60
Caribbean (a)	100	50	100	50
Andean and Atlantic	10,100	32	21,950	68
Latin America and the Caribbean	13,850	34	27,450	66

Note: (a) Belize is included in the Caribbean.

Source: Lanly and Gillis (1980).

The situation of the natural forests of the Southern Tier -- the only region not included in the Lanly and Gillis study (1980) and others cited above, all of which refer to the tropics -- is shown in Table 17. Argentina and Chile are seen to have more than 800,000 km2 of forests, making up 22% of the total area of those two countries.

In the tropical zone of Latin America and the Caribbean approximately 5 million hectares will have been reforested by the end of 1980. Table 28 shows some characteristics of this type of forest land use. The Atlantic and Andean regions (essentially Brazil) have more than 84% of the reforested area; on the whole, this consists equally of industrial plantings and other types, notably for protective purposes or for charcoal, fruits and ornamental trees. It is significant that over 50% of the plantings have been made in the last five years, evidencing a marked increase in the rate of planting not only in Brazil but in several other countries as well. Despite these efforts, as Lanly and Gillis (1980) correctly note, the total area reforested to date hardly exceeds the area deforested in a single year.

Reforestation in the Southern Tier, especially in Chile, is an aspect of great national importance. Some 650,000 hectares had been planted in that country through 1979, chiefly with Pinus radiata (90%) and to a lesser extent with eucalyptus and other species. About 550,000 hectares have been planted in Argentina (Table 28).

Table 28. Area of forest plantings estimated through the end of 1980 in tropical countries of Latin America and the Caribbean (in km2).

	North and Central America	Caribbean (a)	Andean and Atlantic	Total
Industrial	1,020	2,080	22,800	25,900
Latifoliates	490	1,140	8,570	10,200
Prior to 1976	180	910	4,980	6,070
1976 to 1980	310	230	3,590	4,130
Conifers	530	940	14,230	15,700
Prior to 1976	210	530	8,260	9,000
1976 to 1980	320	400	5,980	6,700
Other plantings	4,810	130	19,510	24,450
Total plantings	5,830	2,210	42,310	50,350

Note: (a) Belize is included in the Caribbean.

Source: Based on Lanly and Gillis (1980).

Table 29. Forest plantings in Latin America and the Caribbean (in km2).

Region / Country	Area (1)	% of plantings in region	% of plantings in area covered by the study
NORTH AMERICA			
Mexico	400	100	-
Total	400	100	-
CENTRAL AMERICA			
Costa Rica	2	10	-
Honduras	1 (3)	5	-
Nicaragua	17	85	-
Total	20	100	-
CARIBBEAN			
Cuba	1,402(2)	99	3
Jamaica	16	1	-
Dominican Rep.			
Total	1,418	100	3
ANDEAN			
Bolivia	350 (3)	11	-
Colombia	808	25	2
Ecuador	270	8	-
Peru	1,120	34	2
Venezuela	740	22	2
Total	3,288	100	7
ATLANTIC			
Brazil	30,000	100	64
Suriname	100	-	-
Total	30,100	100	64
SOUTHERN TIER			
Argentina	5,500	45	12
Chile	6,500	53	14
Uruguay	200 (3)	2	-
Total	12,200	100	26
SOUTH AMERICA	45,488		96
LATIN AMERICA AND THE CARIBBEAN	47,826		

Note: Most of the data referred to 1977 and a small number to 1976.

Sources: 1. World Wood, July 1979. 2. Cuba, INDAF (1976)
3. Author's estimate.

The majority of the wood production of Latin America and the Caribbean (about 252 million m3 per year from 1974 to 1976) consists of ~~firewood~~ fuelwood (76%), and the rest ~~is~~ wood for processing. Of the 59 million m3 of wood destined for processing, 47 million m3 were consumed annually in the form of logs, net trade (imports - exports) still being negligible in world terms (FAO , 1979). For 1977, exports of sawn lumber were estimated at 1,822,000 m3, while imports totaled 1,868,000 m3; 67% of this trade is in conifers. With regard to pulp and paper, despite the substantial increase in production the region has shown a mounting deficit; exports clearly exceed imports only in the category of boards. In the aggregate, however, Latin America and the Caribbean still show a substantial deficit in the balance of trade of forest products because of the shortfall in pulp and paper (FAO, 1979).

Per capita consumption of sawn lumber is very low: 0.07 m3/person in 1977, or less than half of average world consumption, although there are significant differences among countries. For example, per capita consumption is 0.34 m3 in Costa Rica but 0.003 m3 in Haiti, 0.11 m3 in Brazil and Ecuador and 0.02 m3 in Argentina. Consumption of pulp and paper is heavily concentrated in Brazil, Mexico and Argentina, which consumed 70% of the pulp and 68% of the paper in 1977. In that year, average per capita consumption of paper was 22 kg, again one half of the world average. Venezuela has the highest per capita consumption with 50 kg.

At the world level, the net wood harvest estimated for the year 2000 will be nearly 2.5 times that of 1975, including production from natural and cultivated forests. For Latin America, projections of consumption of industrial wood products indicate that it will rise from 20 million cubic meters in 1980 to 48 million in 2000. Similarly, ~~construction~~ consumption of wooden panels will rise

from 3 million cubic meters to 8 million between 1980 and 2000, while that of paper will increase from 9 million cubic meters to 26 million. To meet this demand, the annual extraction of industrial wood must increase from 59 million cubic meters in 1974-76 to 175 million in the year 2000. During the same period the felling of trees for ~~firewood~~ fuelwood will increase from 193 million cubic meters to 450 million per year (FAO, 1979).

3.2.4. Other uses of land and unused land

The "other" column in Table 17 shows the area and percentage of soils ~~for~~ in each country and region which are not being used for agricultural, stockraising or forestry purposes. According to the FAO Production Yearbook, on which this information is based, the term "other land" refers to unused but potentially productive land, building areas, idle lands, parks, ornamental gardens, highways, roads, uncultivated land any other land not included in the other categories. Although the table does not so indicate, it is understood that this category also includes certain inland bodies of water, marshes and other wetlands, snow-covered areas, land permanently covered with ice, deserts, rocky areas, etc. As may be readily seen this category embraces many aspects that it would be interesting to consider separately, but such an undertaking would be very difficult.

This type of land represents 16% of the area of Latin America and the Caribbean. In the Caribbean ~~this~~ the percentage is twice the average, and in the Southern Tier it is well above the average. In the Caribbean this is due to the high degree of urbanization (the consequence of high population density) and to the existence of bare rock and/or other barren areas. In the Southern Tier it is due to the existence of large arid zones and frozen and/or rocky regions.

The abundant and recent information now available for Bolivia (Brockmann 1978) provides some examples of the characteristics of lands classified as "other" in Table 17. Table 30 shows the situation of land use in Bolivia, while Table 31 provides details on idle lands; in that country, such lands -- together with wet and submerged areas, bodies of water, land covered by snow and permanent ice and unspecified types -- make up this category of soils.

Table 30. Total area of categories and present use of land in Bolivia (in km2).

Category	Area	Percentage
Land with pastures and/or shrubs	338,307	30.81
Land with forests	564,684	51.40
Cultivated land	28,794	2.62
Wet and/or submerged land (a)	24,201	2.20
Bodies of water (a)	14,197	1.29
Idle land (a)	126,101	11.47
Snow and permanent ice (a)	2,148	0.20
Unspecified uses (a)	149	0.01
Total	1,098,581	100.00

Note: (a) "Other land" in ~~the~~ table ___ .

Source: Brockmann (1978).

Table 31. Uncultivated areas in Bolivia (in km2)

Category	Area	Percentage
Upland uncultivated areas		
Salt deposits	10,574	8.4
Saline soils	10,824	8.6
Sand deposits	4,908	3.9
Sand deposits and saline soils	5,082	4.0
Rocky outcroppings	39,709	31.5
Rocky outcroppings and pastures and/or shrubs	53,272	42.2
Rocky outcroppings and sand deposits	1,135	1.0
Lowland uncultivated areas		
Salt deposits	25	
Saline soils	82	
Sand deposits	344	0.4
Sand deposits and pastures and/or shrubs	156	
Total	126,101	100.00

Source: Brockmann (1978).

The example of Bolivia also is interesting because it permits still another comparison of the international statistics with the actual situation revealed by exhaustive and up-to-date study. According to FAO (1978), "other lands" represented 20.2% of the area of Bolivia in 1977, while according to the Brockmann study (1978), in that year only 15.2% of the national territory fell within that category.

For the region as a whole (see Tables 39 and 64), the majority of the "other lands" consists of desert, which may account for as much as 66%. Rocky outcroppings account for another important proportion, especially in the Cordillera of the Andes, the Caribbean islands, the Sierra Madre and certain other mountainous regions. On the other hand, wet or submerged lands and bodies of water predominate on the extensive medium-low or low-lying lands of much of the area studied.

It appears that no estimates have been made regarding areas occupied by urban, highway, industrial or other infrastructures in Latin America and the Caribbean. In the developed countries, however, annual losses during the period 1960-70 ranged from 0.08% in the United States to as much as 1.23% in Belgium. Cumulative losses between 1978 and the year 2000 are projected at 2% for the United States and 24% for Belgium, although the weighted average for 14 industrialized countries is only 2.5% for that period. In the context of the study it is unlikely that the annual rates will be as high, but their impact may be greater in terms of the limited amount of arable land available, which is most affected by urban development.

3.3 Loss of land

There has been a massive loss of land in Latin America and the Caribbean, and there are indications that this loss greatly exceeds the gains achieved through irrigation, clearing, recovery of saline soils or floodlands and other measures taken to maintain or expand the agricultural frontier. By far the leading cause of soil loss is erosion by water, but also important are desertification, salinization, erosion by wind, economic erosion, loss of natural fertility, contamination of the soil, and obviously droughts and natural disasters.

3.3.1. Erosion by water

Erosion by water evidently reaches its maximum on mountainous terrain. Both there and in lowland areas it is essentially the result of human activity. In any case, annual crops cause erosion several times greater than that which occurs with perennial crops, the ideal condition being natural climax vegetation. When clean-cutting is practiced in upland areas, or when crops are planted on steep slopes -- to mention only two examples -- erosion occurs at a rapid rate. Other critical factors are the characteristics of the soil and of rainfall, which need not be high to cause erosion.

No regional studies of this fundamental aspect have been found. Consequently, the information refers to individual countries and is not always recent or comparable; however, it does give an idea of what has been happening. In North America (Mexico), the Directorate General of Soil and Water Conservation reported in 1950 that of 145.5 million hectares surveyed, over 90 million were being destroyed by moderate erosion and particularly by accelerated erosion, while 12 million hectares had virtually lost their topsoil, as may be seen in Table 32. Bearing in mind, moreover, that Mexico is a mountainous country and that 50 to

60% of its arable land is devoted to maize crops, one can easily see that the problems of erosion require priority attention.

Table 32. Erosion in selected areas of Mexico (in ha.)

Degree of erosion	Area	%
Soils without erosion (forests of wood-bearing species).	14,277,286	9.8
Soils with incipient erosion (humid lands, forests of non-woodbearing species and areas with fruit trees or permanent crops).	26,046,149	17.9
Soils with moderate erosion (irrigated areas and flat pasture lands).	30,518,890	21.0
Soils with accelerated erosion (pastures on slopes, dry farming areas and fallow lands).	63,077,812	43.3
Completely eroded soils (uncultivated and unproductive land).	11,596,806	8.0
TOTAL	145,516,943	100

Source: Mexico. Secretariat of Agriculture (1950), based on the 1950 Agricultural, Livestock and Forestry Census.

In Central America the countries with significant erosion are El Salvador, where it is estimated that 100% of the land has suffered slight to moderate erosion; Guatemala and Honduras, where the problem also is serious in all upland areas, but where it is nonetheless reported that the banana plantations of the lowlands have been little affected; Costa Rica, where in general the problem of erosion is less acute than in Mexico or in El Salvador; and Puerto Rico, where erosion also is confined to upland areas (Lal, 1977).

In the Caribbean erosion by water is especially severe since rainfall is high, there are strong winds, primary vegetation is sparse, many islands are mountainous with steep slopes, much of the soil is ~~high~~ highly susceptible to erosion, and agricultural techniques are usually deficient. It has been reported (Ahmad, 1977) that Trinidad and Tobago has suffered significant erosion in some areas, and that a large part of those islands -- especially Tobago -- is susceptible to erosion. In Haiti the problem is worse than anywhere else in the Caribbean, with bedrock exposed on more than 50% of the area in many places. It is also critical in St. Lucia, St. Vincent, Montserrat and Jamaica. On the other hand, and for various reasons, erosion is less of a problem in the Dominican Republic, Cuba, Grenada, Barbados, Dominica and Antigua.

A very recent study in Colombia (Colombia. INDERENA, 1977) found that 75% of the land was affected by erosion in one way or another, and that 31% had undergone massive displacement. In general, this study seems to underestimate the actual problem, since the authors find that only 1.9% of the land had been affected by severe to very severe erosion -- chiefly in the Guajira peninsula -- while another 1.2% had been affected by moderate to severe erosion (Table 33). Still, this means that 8.3% of the agricultural land had been damaged by moderate to very severe erosion. According to other sources (Conservation Foundation, FAO, 1954), annual soil losses in Colombia were as high as 426 million metric tons, 80% of which was due to clean-cutting. In 1948 it was estimated that of Colombia's 30 million hectares of Andean lands, 23% was bare rock, 5% was severely eroded and 25% would be lost to agriculture by 1970.

Table 33. Erosion in Colombia (in km2)

Type and degree of erosion	Partial Area	Total Area (group)	% of National Area
Areas without appreciable erosion		282,000	24.8
Areas affected primarily by surface water erosion		586,000	51.4
- Very slight to slight	415,000		36.4
- Slight to moderate	146,000		12.8
- Moderate to severe	7,000		0.6
- Severe to very severe	18,000		1.6
Areas affected primarily by massive displacement		268,000	23.5
- Very slight to slight	28,000		2.5
- Slight to moderate	233,000		20.4
- Moderate to severe	7,000		0.6
Areas affected primarily by wind erosion		3,000	0.3
- Severe to very severe	3,000		
Total		1,139,000	100.0

Source: Colombia. INDERENA (1977).

Erosion by water affects at least 30% of the territory of Peru, in the Andean region of that country, both on the arid slopes of the west and on the very humid slopes of the east, to which migratory agriculture is now moving. Low (1967) and more recently ONERN (1979) have assessed and/or mapped erosion in that country. Table 34 reproduces the information provided by Low (1967); it is confirmed by Gamarra (1945), who found that the rivers of the narrow coastal strip of Peru alone were carrying off 632 million m3 of sediment each year, which is equivalent to ~~the~~ a loss of topsoil ~~on~~ from 316,000 ha per year. Similar statements have been made by Tosi (1960) and others.

Table 34. Potential erosion in the Andean region of Peru.

Extent of erosion (MT/km2/year)	Area (km2)	% of total area
0 - 1000	216,040	16.9
1000 - 1500	670,620	52.4
1500 - 2000	215,544	16.8
2000 - 3000	95,400	7.4
3000 - 4000	34,580	2.7
4000 - 5000	31,700	2.5
5000 - 7000	16,120	1.3

Source: Low (1967), based on Fournier's formula.

The magnitude of erosion in Ecuador is similar to that in Peru. In Venezuela this problem is very serious in the Andean region, where most of the cultivated land has been affected by moderate to severe ~~region~~ erosion, but it is also reaching major proportions in lowland areas because of the lack of cohesion of soils, the high degree of erosion caused by the prevailing type of rainfall, the low infiltration rate of the soil, and exposure of

the soil to rainfall because of the intensive agriculture carried on there (Pla, 1977).

In Chile not less than 25% of the national territory was already affected to some extent by erosion in 1957 (Chile. DECARAF, 1957); this would be equivalent to nearly two-thirds of the country's agricultural area at that time. The situation has worsened since then; an OAS/IDB-Chile study (cited by Chile. Ministry of Education, 1974) indicated that from Valparaíso to Cautín, in a belt of about 50 to 60 km from the coast, almost 60% of the soil had been destroyed by erosion, i.e. 285,530 km2 of 484,065 km2.

Little information seems to exist on erosion in the Amazon region. Holeman (1968) notes that the Amazon river, with a basin of 5,776,000 km2, has an average annual suspended load of 363 million metric tons, equivalent to 63 metric tons per km2. This is a very small load in comparison with such rivers as the Yellow or Ganges, but is much greater than that of the Nile, for example. A better idea of the extent of erosion in the Amazon basin is given by the increase in the frequency of flooding in low areas, and by the ~~increasing~~ growing extent of this phenomenon as well as the ever greater constraints being placed on river navigation. It must be recalled, however, that this damage occurs chiefly in the upper Amazon region, i.e. on the eastern slopes of the Andes, where intensive and chaotic migratory agriculture is practiced.

Table 35. Erosion in Chile (in km2)

Type of erosion	Area	% of agricultural area	% of national area
Slight or no erosion	53,600	17.4	7.2
Predominantly slight erosion	94,250	30.5	12.7
Moderate erosion	8,250	2.7	1.1
Moderate to severe erosion	32,600	10.5	4.4
Total	188,700	61.1	25.4

Source: Chile. DECARAF (1957).

In much of the state of São Paulo, Brazil, soils are susceptible to erosion because of the rolling terrain. In the cerrados erosion is severe only when there is overgrazing or uncontrolled burning. Poorly managed coffee plantations also cause erosion. There are alarming data on the erosion that occurs in the Amazon region whenever large-scale agricultural development is undertaken (Lal, 1977). Marquez et al (1961) have studied the erosion of certain soils in São Paulo under different types of crops, obtaining data that clearly show the advantages of perennial crops over annual crops and over pastures as well, in avoiding losses of soil (see Table 36).

Table 36. Effect of the type of soil on erosion under different crops (MT/ha/year)

Crop	Bauru-sandy	Red soil	Batu Catu-sandy
Annual	21.1	9.5	21.5
Perennial	1.0	0.6	1.0
Pastures	1.2	2.7	1.2

Source: Marques et al (1961).

Table 37 presents the evidence gathered by Elgueta and Jirkal (1952) on the decreased productivity of soils in eight localities of Chile during three decades of subjection to erosion by water. Some of these places have virtually ceased to produce and the farms have been all but abandoned.

Table 37. Wheat yield in hundreds of kilograms per hectare in eight eroded localities of Chile.

Year	Cauquenes	Chanco	Quirihue	Florida	Mulchen	Traiguén	Imperial	Collip.
1911-17	8.7	9.7	7.7	11.2	10.3	11.3	12.0	13.4
1918-24	8.6	7.2	-	-	9.9	11.1	12.6	9.9
1925-31	8.0	6.8	7.1	7.3	8.0	10.1	10.5	8.8
1932-39	5.9	4.7	4.8	6.7	7.0	10.2	9.9	7.2

Source: Elgueta and Jirkal (1952).

Another major problem associated with erosion by water is the accumulation of sediments in reservoirs and waterways and the frequent obstruction of irrigation canals. The cost of removing sediments, dredging of waterways, purification of water supplies and rebuilding of irrigation systems is very high.

3.3.2 Desertification

Desertification is a typical problem of areas bordering hot sandy deserts and of all regions that lose their protective cover of vegetation through overgrazing, excess salinity or alkality, or agriculture in unsuitable places, among other causes. Obviously, the vulnerability of an ecosystem to desertification is determined above all by its climate, but also by the characteristics of terrain, soil and vegetation. Table 38 shows the areas of the Americas that are in danger of desertification, classified as subject to very high, high or moderate risk, according to the probable rate of desertification without a change in present conditions; this classification is based on the United Nations World Desertification Map. As may be seen, present and potential desertification affects about 20% of the hemisphere, reaching its maximum in Chile, Argentina, Mexico and Peru (see Table 39).

Table 38. Area affected and likely to be affected by desertification in the Americas (in thousands of km2)

Region	Existing extreme desert	Degree of danger of desertification			Total	% of total land area
		Very high	High	Moderate		
North America and Central America (a)	33	163	1,313	2,854	4,363	19
South America	200	414	1,261	1,602	3,478	20
Total	233	577	2,574	4,456	7,841	20

Note: (a) In this case North America includes the United States and Canada.

Source: World Desertification Map (UN/FAO, UNESCO, WMO, 1977).

It is estimated that about 68 million people live in dry regions of the Americas; of this number 50% live in cities, 43% are engaged in agriculture, and 7% in stockraising (UN, 1977).

There are different types of deserts (hot, cold, rocky, sandy) but all are characterized by deficiencies in rainfall so severe that they can be cultivated or used for stockraising only ~~through~~ with special measures, particularly irrigation. The fight against desertification is all the more urgent because it is a dynamic process which accelerates and expands by itself. In a short time rehabilitation becomes an ever slower and more costly undertaking and degradation quickly reaches a threshold beyond which it is irreversible from a practical and economic standpoint. But even excluding very cold arid lands and extreme deserts -- which do not undergo

subsequent degradation -- there is a large area of dry land which is potentially productive but threatened. It must also be kept in mind that desertification has consequences that go beyond the areas directly affected, as when the dust it creates travels great distances (UN, 1977).

The most important deserts in the area studied are the internationally known ones such as the Mexican, Peruvian, Atacama and Patagonia ~~mountain~~ in - Forest deserts. There is another large arid zone in the Brazilian Northeast, but it is not as dry as the deserts just mentioned.

Table 39. Arid and semi-arid lands in Latin America (in km2)

Region / Country	Arid Area (km2)	% of country or region	Semi-arid area (km2)	% of country or region
NORTH AMERICA				
Mexico	493,136	25	295,882	15
Total	493,136	25	295,882	15
ANDEAN				
Bolivia	164,786	15	109,857	10
Ecuador		0	14,178	5
Peru	257,042	20		0
Venezuela		0	45,602	5
Total	421,828	9	169,637	4
ATLANTIC				
Brazil	85,118	1	507,920	6
Paraguay			20,337	5
Total	85,118	1	528,257	6
SOUTHERN TIER (a)				
Argentina	833,066	30	833,066	30
Chile	302,779	40	37,848	5
Total	1,135,845	32	870,914	24
SOUTH AMERICA	1,642,791	9	1,568,808	9
LATIN AMERICA AND THE CARIBBEAN	2,135,927	11	1,864,690	9

Notes: Percentages refer to the land area of each country or region.
(a) Excluding Antarctic territories.

Source: Based on Arid Lands Newsletter (Paylore and Greenwell, 1979).

3.3.3 Salinization and Alkalinization

The accumulation of salts to the point at which there is a harmful effect on soil productivity and crop yields is known as salinization. Alkalinization is caused by high saturation of the soil with sodium. Salinization is determined primarily by the aridity of the climate, geomorphology, topography, hydrology, the physical properties of soils and, obviously, by agricultural practices.

On the basis of the World Soil Map (op. cit.) it has been determined that 19,650 km2 (0.7%) of Central America and Mexico are affected by salts, and that 1,291,630 km2 (7.6%) of South America is so affected.

Peru is one of the countries most severely affected by this problem. On the coast alone, 1,024 km2 (13.5%) is subject to minor problems of drainage and/or salinity, 194 km2 (2.5%) is affected by moderate to severe problems of salinity, and 1,355 km2 (17.5%) is subject to moderate to severe problems of salinity as well as drainage. In total, 34% of the agricultural soils of that region -- the most fertile in Peru -- is jeopardized by problems of salinity, mostly associated with poor drainage (Peru. Dirección General de Aguas, 1976). It has been stated, moreover, that the rate of salinization matches or exceeds the rate of gain of land through massive and costly irrigation works.

3.3.4 Economic erosion

Economic erosion is defined as the loss of soil due to the installation of infrastructures required by man and occupying the soil or preventing its use in one way or another. Urban development is the leading cause of this type of erosion, followed by construction of roads and other transportation facilities.

There are no studies showing the extent of this type of soil loss in Latin America, but given the rapid rate of urban and industrial development it is undoubtably appreciable.

It is significant that all of the cities founded since the Spanish conquest of America are located on the most fertile lands of valleys. Even in countries as lacking in arable land as Peru -- where good soil has been obtained by means of ~~developed through~~ irrigation throughout history -- the cities located in the central parts of valleys have expanded to the point that in many of those valleys the arable land will disappear completely within a few decades. Table 40 shows the situation in the Rimac valley where the city of Lima is located. It is surprising to find that in pre-Hispanic times the urban areas of the Andean region were carefully located on untilled land bordering valleys but never in them, where only temples were allowed.

Table 40. Rate of urban expansion in the Rimac valley, Peru (in hectares)

Year	Cultivated area	Urban area	Total area	Urban area as % of total area
1920	23,067	3,266	32,243	9.8
1965	26,788	5,445		16.8
1969	23,334	8,899		27.6
1970	21,432	10,801		33.5
1975	12,445	19,798		61.4
1977	9,898	22,345	32,243	69.3

Source: Peru, Directorate General of Water~~s~~ and Soils (1979).

3.3.5 Erosion by wind

In Latin America erosion by wind is appreciably less severe than erosion by water or economic erosion. Nonetheless, it is a serious problem in some countries, including the most arid ones such as Chile, Peru and Mexico. In Chile and Peru wind erosion also takes the form of coastal dunes. These are formed by the sediments carried by rivers to the sea and returned to the land by tides, ocean currents and winds, gradually covering vast productive areas. There are also inland dunes, which are very extensive in northern Peru and many parts of Chile. Elizalde (1970) states that in 1900 F. Albert estimated that the central region of Chile had 2,442 km2 of dunes, and that for the country as a whole the total ~~could~~ might be as much as 6,000 km2. Later, it was shown that in the area between Aconcagua and Chiloé alone there were 1,310 km2 of dunes, more than half of which were of the coastal type. However, the province of Chile most affected by wind erosion is southern Magallanes, where the land is highly exposed to very strong winds and moreover has been subjected to excessive grazing.

In Peru wind erosion is severe on the entire coast and on the western slopes of the Andes, but is most spectacular in the northern departments of Piura and Lambayeque where sediments transported by air and dunes invade crop fields and fill up irrigation canals, ditches and drainage channels, in addition to destroying cities such as Sechura and damaging the engines of the jet aircraft that operate in the area. In Colombia wind erosion is severe on about 3,000 km2.

3.3.6 Loss of fertility

When the soil is not replenished with nutrients to maintain fertility it suffers a gradual deterioration, especially in wet climates where this process is aggravated by leaching and the exhaustion of nutrients from the soil, which is already poor in nutrients in those regions. In South America 47% of the soils are subject to what has been called mineral resistance.

The practices of fallowing and migratory agriculture are intended to alleviate this problem. In the first case rotation periods are comparatively short and are often aimed at preventing damage to plants such as that caused by nematodes. In the second case, which is most frequent in the humid tropics, ideal fallow periods are very long -- 10 to 25 years depending on soil conditions -- but as the population increases these periods are shortened to the point that they do not permit recovery of the soil, which suffers a drastic chemical degradation.

The other alternative is obviously fertilization. World production of chemical fertilizers rose from 54 million tons to 98 million tons (N, P, K) in the decade between 1966-67 and 1976-77. It has been estimated that 56% of the total increase in crop yields in the developing countries during that period ~~is~~ was attributable to fertilizers. In Latin America fertilizer consumption rose from 1.4 million to 4.4 million tons between 1965 and 1975; it is estimated at 5.4 million tons for 1980 and is expected to reach 18.6 million tons in the year 2000. In other words, the rate of increase between 1980 and 2000, projected at 6.4% per year, would be about one half of the rate registered between 1965 and 1975 (FAO 1978, 1979). As will be seen below, organic fertilizers also are of great importance.

In general, however, fertilization as now practiced does not restore what is taken from the soil in the form of plant nutrients, and there is a general and progressive decapitalization which will have serious consequences in the medium term.

3.3.7 Contamination

Contamination of the soil also causes its degradation and eventual loss. The principal source of contamination is the water with which the soil is irrigated, and the second is air carrying harmful substances which are deposited in the soil. These sources of soil contamination will be discussed in connection with water and air resources. However, there is another, more direct type of soil contamination through excessive or inadequate fertilization, the use of pesticides and the organic residues of intensive stockraising.

Two of these three elements of soil contamination -- fertilizers and organic residues from stockraising -- are not yet of great significance in Latin America and the Caribbean. Consumption of fertilizers (including chemical agents) in these regions is several times less than their consumption in the developed countries. For example, from 1970 to 1974 Latin America consumed a total of 13.7 million metric tons of chemical fertilizers, while 73.6 million tons were applied in Western Europe and 68.8 million metric tons in the United States and Canada in the same period. Nevertheless, it is known that there are significant local abuses in the use of fertilizers owing to the lack of knowledge of soil management techniques.

The improper application of pesticides and herbicides is another serious problem with regard to soil, although it is highly localized within the area studied. This practice has its main impact on living organisms

in the soil, but can poison it for long periods.

3.3.8 Climate and natural disasters

Climate has a decisive effect on man which is manifested to a great extent through agriculture. For this reason, there is need to study and attempt to predict its evolution in the years ahead. Unfortunately, so little is known about climate that any attempt at prediction is risky, especially in view of the increasing role played by human activity in interaction with natural phenomena.

As part of a study on the world environment in the 21st century, now being conducted by the United States Government, the probabilities of climatic changes have been analyzed. Up to five climatic alternatives or scenarios have been developed: extensive global cooling, moderate global cooling, moderate global warming, extensive global warming and continuation of the conditions that have prevailed for the last 30 years. For purposes of this study only three climatic scenarios have been ~~used~~ considered. The first assumes that there will be no change. The second assumes that world temperatures will rise by 1°C, in which case ~~the~~ warming will ~~take place~~ occur chiefly in the polar regions and highest middle latitudes, with very little change in the tropics; annual precipitation in this case will increase by 5 to 10% and variability will decrease each year. The third scenario assumes that world temperatures will decrease 0.5°C and that maximum cooling will occur in the high and middle latitudes, with virtually no change in the tropics; rainfall will decrease and variability will increase both monthly and yearly. In this case storms and the accompanying precipitation will affect the Equator, improving conditions in the higher latitudes of the great deserts and worsening them in the Equator.

The main natural disasters that have affected agriculture up to the present are droughts, floods, hurricanes and typhoons. Droughts are a critical factor in large areas of the Andean region, the Southern Tier and North America. Floods are most severe in the lowlands of the Amazon and La Plata river basins, while hurricanes and typhoons are most damaging in the Caribbean and Central American regions and on the Atlantic coast of Mexico.

Hurricanes and typhoons -- also known as tropical cyclones -- are severe tropical storms characterized by unusually high winds which cause immense direct damange by the wind itself, pressure and rain, and indirect damage ~~caused by~~ due to high waves and subsequent flooding. Each year 15% of the tropical cyclones occur in the Caribbean. Soils and agricultural activity in general, as well as coastal lands, are severely damaged by tidal waves; these are series of colossal ocean waves created by submarine earthquakes exceeding 6.5 on the Richter scale and by coastal landslides or volcanic eruptions. There were no fewer than 22 major tidal waves in the region between 1530 and 1969 (UNEP/CEPAL, 1979).

3.4 Land gains

This section discusses all conventional ways in which land is "gained" or the agricultural frontier is expanded; these include activities undertaken, controlled or encouraged by governments as well as those without government support, whether tolerated, ignored or -- in some cases -- opposed. The first group includes, in order of magnitude of lands incorporated, settlement, irrigation and drainage. The intensification of agriculture and stockraising should also be considered in this category. In the second group, migratory or nomadic agriculture is by far the most important. From a social

standpoint, mention should also be made of agrarian reform, which in many cases contributes to an effective "gain" of land.

3.4.1 Settlement

In this report settlement is understood to mean the expansion of agriculture into new lands not requiring an irrigation infrastructure. It may be undertaken, directed or merely encouraged by the State. It is assumed that in all three cases the government has made the necessary studies so that the process will be rational, in particular by ascertaining the capacity of the soil and issuing regulations on the size of farms and the nature of the farming or stockraising activities to be carried out. In State settlements the government assumes responsibility for the development of infrastructures, in addition to providing the usual facilities (credits, inputs, product marketing, etc.). In directed settlements the government effort is usually limited to the preparation of a development plan and provision of transportation infrastructures, as well as credit and other facilities. In the last case the settler is free to occupy the land that he wants, receiving only credit assistance and official authorization in the form of a title of ownership.

Countless settlement programs have been undertaken in the humid tropics of Latin America. It is unfortunate that comparatively few have been successful, and that ultimately most of them have contributed to the loss of soils and deterioration of the environment (since they have led to migratory agriculture) as well as to the creation of socio-economic conditions of extreme poverty. In contrast, nearly all of the successes have been achieved by spontaneous settlers with minimum government intervention. These include many of the settlements devoted to perennial agriculture of the industrial type, such as sugarcane, oil palm, coffee, tea, cacao, bananas and citrus fruits, etc. On the other hand, settlements devoted to annual crops (the most suitable sources

of carbohydrates and proteins) have usually met with limited success; the same can be said with regard to stockraising. Moreover, annual crops often merely precede the planting of pastures.

On the whole, the reason for the lack of success of settlements in the humid tropics has been the failure to consider ecological conditions; such an awareness would have permitted the development of appropriate technologies. Dourojeanni (1976) reports that in an ambitious government settlement program in the middle valley of the Huallaga river (Peru), where studies recommended that 59% of the land be devoted to agriculture, 70% was devoted to stockraising instead. One unfortunate result of this decision was that within a few years over 50% of the campesinos abandoned the land and infrastructures to avoid payment of a debt that could not be covered with their low yields. In that same settlement thousands of hectares of rich forest were burned without use of the wood, and the settlers were obliged later to purchase wood for their houses and fences at a high cost from distant suppliers. Incredibly, the program did not provide for the most minimal forest exploitation. In the same area, Sanchez et al (1974) showed that the mechanized clearing advocated by the government was not only costly but resulted in rice, cassava, maize, sorghum, bean and fodder harvests 50 to 70% lower than those obtained with traditional clearing, because of compacting, poor distribution of ash and the carrying off of part of the rich topsoil to lower-lying areas to level the land. Obviously, in this failure as in others, a part was played by such administrative factors as the lack of qualified technicians, failure to carry out infrastructure and service programs, deficient marketing, etc.

The example discussed briefly above has been duplicated with some variants in all countries of tropical America. Unfortunately, it is impossible to offer comparative data on successes and failures. The quality of the soil, so variable in the humid tropics, has been the determining factor in most of the successful cases; it is therefore a matter of concern that part of the scarce good land available is now being used for stockraising, with the problems that this will pose for its future conversion to farming. In Peru, another major failure was the massive Le Tourneau stockraising project in the fertile lower-middle valley of the Pachitea river. It should be noted that virtually no extensive stockraising project in the Peruvian Amazon has proved economically profitable. On the other hand, every one of the few attempts to intensify or establish breeding has had encouraging results. As noted by Dasmann et al (1973), the management of pastures in the humid tropics entails problems of animal nutrition. Forage plants with high nutritional value can grow on recently deforested lands where the soil has been enriched by ash or the organic matter of the original forest. However, this nutritional value is not maintained. Most forest soils are not capable of producing fodder with high protein value, even though they can produce enormous quantities of cellulose, starch and lignin. They must therefore be fertilized, but this is not easy.

Brazil is unquestionably the country in which the most settlement has taken place. It has based its programs of national integration on the building of roads. From 7,063 km of paved roads and a total of 736,033 vehicles of all types in 1957, it had an estimated 84,000 km of paved roads and more than 5 million vehicles in 1975. In northern Brazil, which includes the country's entire Amazon region, there were only 1,520 km of roads (262 km paved) at the beginning the 1960s. By 1974 the federal highway network comprised 8,600 km, with 2,000 km of paved roads. The purposes of the Trans-Amazon highway are: (a) to integrate

the northeast Amazon region with the central-south region of the country; (b) to colonize the region through the exploitation of lands most suitable for agriculture and stockraising; (c) to facilitate the exploration and economic development of the resources in its area of influence; and (d) to link and complement river navigation systems so as to provide access to upland areas and permit their rational development (Resende, 1973).

The success of these roads is expressed in terms such as those used in the case of the Belem-Brasilia highway: the population (excluding the cities of Belem, Anápolis and Brasilia), which was 100,000 in 1960, had reached 2 million by 1970; where there were only 10 towns in 1960 there were 120 in 1970; where there were no cattle in 1960 there were 5 million head in 1970; and where there were only subsistence crops in 1960 there were intensively-grown crops of maize, beans, rice and cotton in 1970 (Resende, 1973). This approach is similar to the one taken in Peru with the Jungle Fringe Highway, and in many other countries as well. Everything depends on the color of the glass through which one looks.

Settlement is not an exclusive feature of the humid tropics. In the Paraguayan Chaco, for example, although the ecosystem is extremely arid, attempts are being made to settle vast areas using wells for people and cattle, while farming continues to be based on the low rainfall. The settlements already established in the more humid areas are prosperous, but as Perfumo (1979) correctly notes, this has been achieved through a precarious equilibrium with existing forests. The expansion of agriculture and stockraising, ignoring ecological constraints, will upset this balance and the entire region will inexorably be transformed into a desert.

3.4.2 Irrigation

Irrigation is a means of settling the most arid lands. It requires extremely large investments but the control of water for irrigation permits crop yields which make such investments economically and socially advantageous. However, not all soils are suitable for irrigation; those which are not include soils with very low water retention capacity or very low permeability, those which have very high salinity or alkalinity, those with a high water table, those which are very rocky or stony, steeply sloping lands and those excessively susceptible to erosion. Irrigation is possible with surface water or by tapping the water table. In either case the objective may be to regulate irrigation or to bring new lands under cultivation; frequently both purposes are sought at the same time. When irrigation is regulated more crops can be harvested each year, which is a way of expanding the agricultural area.

Table 20 summarizes the information available on the area irrigated within each region into which Latin America and the Caribbean have been subdivided, as discussed in the pertinent section. Table 41 amplifies that information, also showing the expansion of the irrigated area during the decade 1967-77 and the situation of each country with regard to area irrigated. The Caribbean made the greatest effort in irrigation during that period, followed by Central America and Mexico; those three regions had rates of expansion of over 50%. Next are the Atlantic and Southern Tier regions, followed by the Andean region, which brought the smallest area under irrigation during that decade (expansion of less than 16%). In absolute terms, Mexico (39%), followed by Argentina, Chile and Peru (9-12% each) and Brazil (8%), accounted for the greatest part of irrigation in Latin America.

Table 41. Irrigation in Latin America and the Caribbean

Region / Country	Irrigated area in 1967 (km2)	Irrigated area in 1977 (km2)	Increase in irrigated area		% of irrigated area
			area (km2)	%	
NORTH AMERICA					
Mexico	33,000	50,000	17,000	51.5	38.9
Total	33,000	50,000	17,000	51.5	38.9
CENTRAL AMERICA					
Belize		20	20		
Costa Rica	260	260			0.2
El Salvador	200	500	300	150.0	0.4
Guatemala	480	640	160	33.3	0.5
Honduras	660	800	140	21.2	0.6
Nicaragua	250	740	490	196.0	0.6
Panama	180	250	70	38.9	0.2
Total	2,030	3,210	1,180	58.1	2.5
CARIBBEAN					
Cuba	3,800	7,000	3,200	84.2	5.4
Guadeloupe	20	10	- 10	-50.0	
Haiti	460	700	240	52.2	0.5
Jamaica	240	320	80	33.3	0.2
Martinique	10	30	20	200.0	
Puerto Rico	390	390			0.3
Dominican Rep.	1,200	1,400	200	16.7	1.1
St. Lucia	10	10			
St. Vincent	10	10			
Trinidad and Tobago	110	200	90	81.8	0.2
Total	6,250	10,070	3,820	61.1	7.8
ANDEAN					
Bolivia	800	1,200	400	50.0	0.9
Colombia	2,400	2,900	500	20.8	2.3
Equador	4,630	5,100	470	10.2	4.0
Peru	10,700	11,800	1,100	30.3	9.2
Venezuela	2,650	3,500	850	32.1	2.7
Total	21,180	24,500	3,320	15.7	19.1
ATLANTIC					
Brazil	6,800	10,000	3,200	47.1	7.8
Guyana	1,090	1,220	130	11.9	1.0
Paraguay	400	550	150	37.5	0.4
Suriname	200	300	100	50.0	0.2
Total	8,490	12,070	3,580	42.2	9.4

Table 41 continued

SOUTHERN TIER					
Argentina	11,800	15,100	3,300	28.0	11.7
Chile	11,200	13,000	1,800	16.1	10.1
Uruguay	420	600	180	42.9	0.5
Total	23,420	28,700	5,280	22.5	22.3
SOUTH AMERICA	53,090	65,270	12,180	22.9	50.8
Grand Total	94,370	128,550	34,180	36.2	100

Source: FAO (1978).

In terms of cultivated area of the country, Peru has the largest proportion (40%) of irrigated land in Latin American and the Caribbean. It is followed by Chile (22%), Mexico (18%), Jamaica (15%), Guyana and Cuba (14%), Dominican Republic (13%), Trinidad and Tobago (12%) and Costa Rica (11%). All of the other countries have proportions of about 5%, with the exception of Haiti (8%). Tables 42 and 43 present data on potentially irrigable areas and on areas to be irrigated in the short and medium term in selected Latin American countries, as reported by IICA in 1976 (Merea, 1977).

Table 42. Potentially irrigable areas in selected Latin American countries (in km2)

Country	Potentially irrigable areas	Potential areas as % of irrigated areas
Bolivia	6,000	546
Chile	13,000 (a)	105
El Salvador	2,500	596
Guatemala	4,500	750
Haiti	1,100	157
Honduras	2,500	563
Mexico	80,000	160
Panama	2,724	900
Peru	17,330	155
Venezuela	7,270	309

Note: (a) Including 8,000 km2 of irrigation improvements. Information for 1976 and/or 1977.

Source: IICA -- Merea (1977).

Table 43. New areas to be irrigated in selected countries of Latin America in the short and medium term (in km2)

Country	Area covered by programs under way (a)	% increase with respect to irrigated area
Brazil	3,670	61
Colombia	900	33
Costa Rica	1,000	151
Chile	920	7
El Salvador	1,528	584
Honduras	767	173
Panama	728	241
Peru	2,247	20

Note: (a) Medium term defined as up to 30 years, and at different stages of study, financing and execution. Information for 1976 and/or 1977.

Source: IICA -- Merea (1977)

Despite the fact that Argentina has the largest irrigated area in South America, it represents only 5.8% of the cultivated area of that country, which incidentally has a comparatively low intensity of cultivation inasmuch as double-cropping is impossible in many irrigated areas, partly because of harsh winter weather. Even this small irrigated area accounts for 20% of the value of agricultural production. Irrigation is essential for the provinces of Jujuy, Alta, Tucuman, Santiago del Estero, La Rioja, Catamarca, Mendoza, San Juan, Córdova, San Luis, Neuquen, Río Negro, southern La Pampa, southwestern Buenos Aires, Chubut and Santa Cruz. Available surface water is estimated at 3,900 m3/sec., and it has been calculated that irrigation of about 3.5 million hectares -- less than 5% of the potentially arable land -- would be technically feasible. Table 44 shows the concrete medium-term possibilities of increasing the irrigated area of Argentina, indicating a potential of 564,300 ha.

Table 44. Tentative estimate of potentially irrigable areas in Argentina (1976)

Action	Area (ha)
Consolidation	83,000
Exercise of irrigation rights	120,000
Recovery of saline soils	29,300
New large-scale projects	67,000
Full use of existing irrigation systems	236,000
Other (underground water, etc.)	30,000
Total	564,300

Source: IDB, Appraisal of Irrigation Projects (unpublished).

It is also very important to mention the potential of Brazil, where irrigation has had little development and is concentrated in the south, being used almost entirely (90%) for rice growing. Moreover, because there is no permanent irrigation, two thirds of this land is worked in rotation with forage crops. Irrigation in Brazil is most feasible in three well-defined areas: 900,000 km2 located primarily in the Northeast, excluding only the São Francisco river basin; 640,000 km2 in the São Francisco river basin, with an annual availability of about 100,000 million cubic meters; and 900,000 km2 in the Southeastern region. In the first of those three areas, adding the lands currently under irrigation in the Southeast, there are dams with a storage capacity of 12,000 million cubic meters; however, because of their unsuitable location in terms of the land to be irrigated, they are greatly underutilized. In the medium term, projects now under way will bring about 176,000 ha under irrigation in the first two regions mentioned. These projects were to be combined with rural settlement programs in order to establish farmers now engaged in nomadic agriculture, especially in the Northeast.

Peru has the largest percentage of irrigated land in South America. Its 800,000 hectares of irrigated land on the coast, 310,000 hectares in the Sierra, and a small irrigated area in the Ceja de Selva, represent 40% of the cultivated area of the country. There are many irrigation projects on the Peruvian coast, some in operation, some under construction and some with final studies, covering over 600,000 ha between regulation and/or incorporation of new lands. The most important from the standpoint of area gained is the Olmos Project in the North, which will incorporate up to 150,000 ha of true wilderness.

The general assessment made by IICA (Merea, 1977) and the examples noted -- which are only a few of those that could be cited -- demonstrate that in general the technical possibilities of expanding irrigation with surface water are quite substantial. Added to this, as in the above-mentioned case of Argentina, is the fact that one or more of the following situations is present in all countries: present storage capacity not fully utilized, existence of irrigation engineering systems but no assurance or availability of water when required, major hydraulic works and irrigation infrastructure which have not been completed on farms or lack secondary distribution networks and -- the essential element -- adequate water management.

FAO (1977) estimated the goals that should be achieved by 1990 in Latin America and the Caribbean with respect to the improvement of existing irrigation systems; the incorporation of new areas under irrigation; construction of new drainage systems; and the investments required for these purposes at 1975 prices. Tables 45 and 46 present data on the first two aspects, showing that 4.7 million hectares of irrigated land should be improved; irrigation should be established on 3.1 million new hectares; and 19.2 million hectares should be drained. An additional 32,670 million m3 of water is required

annually, which would involve an investment of US$10.084 billion at 1975 prices. Because of inflation the amount required may have doubled by now, which makes financing a critical limiting factor. In Latin America it is not unusual to find irrigation systems under construction with costs that well exceed US$4,000 per hectare, and drainage works with costs exceeding US$1,000. Nonetheless, it is estimated that by the year 2000 some 22 million hectares will be under irrigation (FAO, 1979).

Moreover, significant resources are available in the form of underground aquifers which are ignored or underutilized in some areas and which in others are overexploited, with serious consequences.

This chapter has not considered the adverse impact of irrigation works. Without going fully into this matter, it is useful to mention two highly important aspects: the virtually total neglect of the management of watersheds and the accelerated salinization of the low areas of valleys or irrigated lands. Both of these conditions, which are pathetically visible in nearly all irrigated regions of Latin America, lead to a gradual reduction in the cultivated area which has been gained at such cost. In Peru, for example, it has been noted that the rapid erosion of watersheds serving the main irrigated areas causes irrigation canals to fill up in periods several times less than normal; moreover, it is estimated that the rate of salinization is faster than that of irrigation.

Table 45. Projection of areas to be irrigated by 1990 through improvements and the incorporation of new areas (in km2)

Region	1975	1990		
	Irrigated area	Improvement of irrigation		Irrigated area to be incorporated (a)
		Minor improvements	Major improvements	
NORTH AMERICA AND CENTRAL AMERICA	52,550	8,000	8,000	10,000
CARIBBEAN	9,080	1,620	1,620	2,400
SOUTH AMERICA	52,640	13,870	13,870	18,610
Total	114,270	23,490	23,490	31,010

Note: (a) Including drainage systems.

Source: Merea (1977), based on the FAO document Water for Agriculture (1977).

Table 46. Projection of area requiring drainage by 1990, with or without irrigation.

Region	1975	1990	
	With and without irrigation	Areas to be drained	
		With irrigation	Without irrigation
NORTH AMERICA AND CENTRAL AMERICA	81,600	2,110	41,540
CARIBBEAN	12,000	770	3,110
SOUTH AMERICA	372,250	17,300	127,620
Total	465,850	20,180	172,270

Source: Merea (1977), based on the FAO document Water for Agriculture (1977).

3.4.3 Drainage

Drainage makes it possible to solve all or part of the problems of salinization, and obviously those of flooding as well. As already noted, salinization very often accompanies irrigation; it is estimated that 50% of the irrigated lands of the world have been adversely affected by salinization, alkalinization and flooding, to the point where much of this land has had to be abandoned. A great deal of attention is now being given to the recovery of these lands, as may be seen in Table 47 which summarizes the present situation (1975) regarding drainage and the objectives for 1990, comparing these with the area equipped for irrigation in 1975 and its projections for 1990 for Latin America as a whole.

Table 47. Irrigation and drainage in Latin America in 1975 and projections for 1990 (in km2)

Irrigation		Drainage	
Area equipped in 1975	117,490	Area equipped in 1975	465,850
New areas to be irrigated by 1990	31,010	Improvements to be made by 1990	192,450
Improvements in existing irrigation systems by 1990	46,980	- irrigated lands	20,180
- Minor	23,490	- unirrigated lands	172,270
- Major	23,490		

Source: United Nations Conference on Water, Water for Agriculture (1977).

3.4.4 Migratory agriculture

During the last half century migratory agriculture has been the leading factor in the expansion of farmland in Latin America. As already discussed, this activity can be confused with settlement since one can lead to the other and at some point in the process one of the following takes place: agriculture

and stockraising are stablized, although not necessarily with acceptable productivity; or land is abandoned in such a state of deterioration that its recovery is almost impossible from an economic standpoint.

Watters (1971), among others, has made valuable contributions to the knowledge of problems of migratory or itinerant agriculture in Latin America. That author (1975) points out that the term "migratory agriculture" embraces a wide range of agricultural practices which predominate in the humid tropics but are not exclusive to those regions. The terms "clear and plant," "nomadic agriculture," "itinerant agriculture," "conuco," "milpa," and "spontaneous settlement," by which such forms of agricultural activity are known in the various regions of the area studied, refer to forms of agriculture which are perfectly rational and adapted to ecological conditions, as well as those which are damaging to the environment. In general, however, migratory agriculture is characterized by the use of unsophisticated tools, the cutting and burning of forests and the alternation of short cropping periods (two to four years) and long fallow periods (20 years or more). Actually, it can be defined as an agricultural system based on field rotation much more than on crop rotation.

Migratory agriculture can also be classified in two main types according to its intrinsic nature. The first type, known as stable, maintains an appropriate balance among cultivated, fallow and untouched lands; the latter can remain in that state and can be used for hunting or the harvesting of wood-bearing or other forest products. In this case the farmers carry out a land management plan as rational as any modern plan of forest development. Although this practice is followed by primitive peoples the concept is completely up to date for the use of soils of low natural fertility in areas with abundant land available. The second type is known as unstable, and involves at least

two factors absent in the other case: the high and increasing density of the rural population, and the fact that this population is not native and lacks knowledge of local conditions, bringing in agricultural techniques from other areas. The result is the overrunning of the land and the migration of agriculture on very broad, continuous fronts. The fallow period is greatly shortened, and eventually the land is completely abandoned by its first occupants and later taken over by new migrants, who find an even more wretched life if that is possible. After a certain time the land is virtually abandoned. As already noted, if these soils are fair or good the population is stablized.

It is important to have an idea of the extent of migratory agriculture in relation to other types of expansion of the agricultural frontier. Lanly and Gillis (1979) note that more than 40,000 km2 of tropical forests (Tables 26 and 27) are cut and burned each year (1976-80) because of migratory agricultu with fallow land and the advance of settlement, which in this case often means the same thing (stable and unstable migratory agriculture). At the same time, it is known that the amount of arable land increased at an average rate of 17,000 km2/year between 1972 and 1977 (FAO, 1978), and that there was an average annual increase of about 3,900 km2 of irrigated land during the same period. While acknowledging that the enormous disparity between the area of tropical forests leveled each year by migratory agriculture and the arable area gained annually in the entire hemisphere is due to the abandonment of land or its conversion to pastures, it must nonetheless be noted that as much as 77% of the new land incorporated each year in Latin America may be due to migratory agriculture and/or settlement.

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This rough figure seems to be confirmed by an imposing volume of national reports on areas cleared during given periods of time (in the country as a whole or in certain regions), as shown in Table 62.

3.4.5 Intensification of agriculture and stockraising

As already noted, agricultural productivity has risen appreciably in Latin America and the Caribbean. Nonetheless, it is still far from acceptable and even farther from the potential of each crop in relation to the available soils. Three options are available for increasing yields. The first can be adopted when there is an actual possibility of improving the environment so as to obtain optimum growth of varieties with high potential yield. In this case high-cost inputs must be used, permitting spectacular improvements in yield. The second option is to bring about moderate increases in yields, giving less preference to purchased inputs. Use is made of crop varieties with low potential yield but better adapted to local conditions. The third option calls for a minimum set of inputs tailored to the local environment, which are applied specifically to areas where natural conditions impose a comparatively low limit on yields. The purpose of this strategy is to bring about a very modest increase in yields while increasing the reliability or stability of production (FAO, 1979).

As a rule, governments find it preferable or more feasible to opt for expansion of the agricultural frontier rather than making better use of already cultivated land. There are many and sound reasons for this. Nonetheless, the mounting obstacles to the expansion of arable areas are forcing a change in this trend; this may be seen in Table 48, which was prepared by FAO (1978) to show the new trend and project it to the years 1990 and 2000.

Table 48. Arable land, harvested area and cropping intensities (millions of hectares)

Year	Arable area			Harvested area			Cropping intensity		
	Irrig-ated	Rain-fed	Total	Irrig-ated	Rain-fed	Total	Irrig-ated	Rain-fed	Total
1980	14	177	191	12	107	119	86	60	62
1990	18	220	238	16	138	154	90	63	65
2000	22	268	290	21	172	193	94	64	66

Source: Agriculture: Toward 2000 (FAO, 1979).

Despite the concrete possibilities of increasing the intensity of cultivation, as shown in Table 48, FAO does not believe that the gains in this regard will be substantial in Latin America and the Caribbean, where the increase is much lower than that estimated for the developing countries in general (77% to 85% in the next 20 years). The reason is that this region still has arable land in reserve and that the massive Brazilian program for expansion of the agricultural frontier -- which has a very strong influence on the figures for the hemisphere -- is essentially one of rainfed farming of the very extensive type.

The case of cereals, to which half of the cultivated area of the world is devoted, is a relevant indicator of the low intensity of cropping in Latin America. The average world yield was 1,840 kg/ha in 1975. That of the European Community countries was 3,800 kg/ha, that of the United States 3,500 kg/ha, and that of Latin America only 1,800 kg/ha -- lower than the world average and less than half the yield of the developed countries. Table 49 shows some maximum present yields of selected crops in Peru compared to the potential yields obtained experimentally. Although the estimate is ambitious, it is impressive to see that producing even 50% of the potential yield of those crops would be equivalent to a doubling of the country's arable land and would practically eliminate the pressure on natural forests.

Table 49. Potential yields and maximum annual yields of selected crops in Peru, 1974 (kilograms/hectare)

Crop	Potential experimental yield	Present maximum yield	% of potential
Rice	16,000	4,500	28
Sweet potatoes	45,000	12,200	37
Maize	18,000	1,600	9
Peanuts	7,500	1,500	20
Potatoes	40,000	6,215	16
Wheat	8,300	950	11
Cassava	48,000	12,200	25

Source: Peru. Ministry of Agriculture.

FAO (1979) has estimated that by the year 2000 Latin America and the Caribbean could achieve substantial increases in the yields of certain annual crops, as shown in Table 50. An increase in yields of permanent crops would be more difficult to achieve during that period.

Another aspect worth taking into account is the great potential for increasing production through the techniques of greenhouse and hydroponic farming. The advantages of greenhouse cultivation include increased production and earlier maturity, reduction of the incidence of pests and diseases, and the possibility of producing throughout the year and therefore out of season. In addition to these benefits, hydroponic farming permits a maximum saving of water and spectacular production increases on the order of 10 to 15 times the best yields imaginable under field conditions, since four or five times more plants can be grown per square meter. There has been very little development of either technique within the area studied. Argentina and Chile produce flowers and vegetables in greenhouses, and hydroponic techniques are employed to a limited extent in Cuba, Chile, Mexico and a few other countries. The main obstacles to their more widespread use are the extremely high cost of installation and the highly skilled personnel required. But they are economically profitable ~~possible~~.

Table 50. Yield levels of selected annual crops in Latin America and the Caribbean (tons/hectare)

Crop	Year	Yield	Crop	Year	Yield
Wheat	1975	1,370	Sugarcane	1975	51,930
	1990	1,730		1990	60,250
	2000	2,050		2000	67,110
Rice, paddy	1975	1,860	Soybeans	1975	1,710
	1990	2,110		1990	1,850
	2000	2,320		2000	2,080
Maize	1975	1,560	Groundnuts	1975	1,180
	1990	1,860		1990	1,290
	2000	2,150		2000	1,430
Barley	1975	1,200	Pulses	1975	590
	1990	1,440		1990	640
	2000	1,680		2000	710

Source: Agriculture Toward 2000 (FAO, 1979).

Stockraising is the activity which occupies the largest proportion (75%) of the lands from which natural ecosystems have been radically eliminated, i.e. those devoted to farming, stockraising, reforestation and urban, industrial and road development.

As Table 61 shows, the intensity of stockraising was generally very low in all of Latin America and the Caribbean in 1977, with only 0.58 livestock units per hectare (including bovines, equines, goats and sheep). Stockraising could be classified as relatively intensive only in the Caribbean (2.11 head/ha) and Central America (1.33 head/ha), with minimum intensity in the Southern Tier (0.49 head/ha).

Although three head/ha are easily maintained on many well-managed farms -- especially in Central America, the Caribbean and the humid Argentine pampas and some regions of Brazil and Mexico, among the rather infrequent cases -- on the great majority of farms carrying capacity is far below the already low average for the study area even when the soils are substantially equivalent. When the soils are of lower quality or have been degraded by centuries of excessive or uncontrolled grazing, carrying capacity declines to ~~the level of~~ 1/2 head of native sheep per hectare as in the Central Andes or 1 head of bovine cattle per 17 hectares as on the Venezuelan plains. Shaner (1980) emphasizes this, noting that in the humid tropics the usual requirement is one hectare per head, but as soil fertility and the nutritional value of fodder declines as much as seven hectares per head is required. Since the majority of the tropical areas are subject to dry seasons, the cattle lose weight. Thus, it takes four to six years to reach a reasonable carcass weight of 400 to 450 kg, and requires extensive areas so that the livestock can be

moved to new pastures. Because there are virtually no slaughterhouses in production areas, the cattle are brought for slaughter having lost weight. Moreover, in such regions livestock are seriously affected by epidemiological problems, among which rabies, hoof-and-mouth disease and leptospirosis are only the worst. Acute problems also are caused by toxic weeds.

Extensive or even very extensive pasturing is not bad per se since it can be rational in keeping production costs low and not damaging soils or forage crops. But the latter is not always the case, and what is worse, this type of land use does not allow for the fact that alternative uses such as farming, reforestation, intensive stockraising and even the management of natural forests can be much more profitable in economic and social terms. Extensive stockraising is the result more of habit than of reasoning, and ultimately has the greatest impact among all human activities on natural ecosystems and on the land in general.

Meat production in the Latin American countries has grown tremendously since the mid-1950s. The main incentive has been to supply the markets of the United States, western Europe and Japan. In tropical America meat production has doubled over the last 20 years, while in Chile and Argentina it has increased by only 29% and 36%, respectively, and has decreased by 0.1% in Uruguay since 1960. Despite the striking increase in meat production in the tropical Latin American countries, per capita meat consumption fell by 13.5% between 1960 and 1974, ~~despite a~~ even with a population increase of only 2.9%. Per capita consumption fell by over 40% in Costa Rica and Paraguay, and by 19% to 38% in Colombia, Mexico and El Salvador. This is not surprising when it is observed that meat exports have increased by 448% in the region during the last 20 years (Shane, 1980).

The impact of extensive stockraising on natural areas is well illustrated by the following case. Venezuela has about 30 million hectares developed north of the Orinoco. More than 4 million hectares of this area is devoted to farming. Of the rest, 3 million hectares are devoted to intensive stockraising and 23 million hectares to extensive stockraising (Griesbach, 1978). These figures are very different from those published by the United Nations, which shows only about 17 million hectares of pastureland in that country (Table 17), attesting once more to the relative value of the UN statistics. A study published by the Ministry of the Environment and ~~Jewable~~ Renewable Natural Resources of that country (1978), projecting food needs through the year 2000 and calculating the requirements for stockraising land in the absence of technological improvements, states that 79 million hectares would be required; if moderate technological improvements are made and the human population increases more slowly, 65 million hectares would be required. To meet even the requirements of the second alternative would mean leaving no forest north of the Orinoco and beginning the destruction of those to the south (FAO, 1978).

The evidence shows that the trend toward the expansion of pastureland in tropical Latin America will continue. Virtually all of the countries plan to expand pasturelands as the basis for an increase in livestock production and are being spurred in this direction by foreign capital interested in supplying the markets already mentioned. The World Bank and the Inter-American Development Bank are not opposed to this policy. To the contrary, the World Bank has encouraged it with massive loans and only recently, like the IDB, has begun to give preference to smaller-scale stockraising operations which presumably are of the more intensive type.

An attempt has been made in Table 61 to project the most probable course of the intensification of stockraising. In Latin America and the Caribbean intensity could increase from 0.58 head/ha to 0.71 in 1990 and 0.81 in 2000, if the statistical data that were used to project the increase in the livestock population and the expansion of the pasture area are sufficiently accurate. Although some doubts may arise, as shown by the Venezuelan example mentioned above, the improvement in carrying capacity is reasonable and possible despite the greatly expanded use of technology that it will require.

FAO (1979) points out that livestock production techniques will have to change even more drastically than farming techniques if the demand of the future is to be met, since livestock production must increase more rapidly than farm production. This will ~~demand~~ require changes in the composition of herds, the organization of production and its relationships with agricultural production and the technologies employed. The contribution of genetic improvement~~s~~ will be especially important for swine and poultry raising and for dairy farming. Although production will continue to be based primarily on pasture lands and agricultural byproducts, more use will have to be made of forage grains and concentrates. Tables 51 and 52 present some indicators projected by FAO (1979) in its study Agriculture Toward 2000 with respect to Latin American stockraising. It should be recalled that these projections are normative, i.e. they are the most "desirable" results.

Table 51. Structure of cattle and buffalo meat production in Latin America and the Caribbean, 1980-2000

	1980	2000
Animals (000 millions)	292	482
Off-take (%)	14.6	18.3
Carcass weight (kg/animal)	191	209
Production (000 tons)	8,132	18,417
Growth rate 1980-2000 (% per annum)		
- Number of animals		2.5
- Production		4.2

Note: Normative projections

Source: FAO (1979), Agriculture Toward 2000

Table 52. Changes in the volume and structure of meat and milk production in Latin America and the Caribbean, 1975-2000

	1975	2000
Red beef and mutton meat production (millions of tons)	7.7	19.3
Pork and poultry meat production (millions of tons)	3.8	11.7
White meat as share of the total (%)	33	38
Milk from cows and buffaloes (millions of tons)	29.8	84.1
Other milk (millions of tons)	0.06	0.18

Note: Normative projections

Source: FAO (1979), Agriculture: Toward 2000.

Notwithstanding what has been stated in the two preceding paragraphs, which assume a significant intensification of stockraising, it remains unlikely that while the livestock population would be growing by 56% between 1977 and 2000 the pasture area would expand by only 12% during the same period (Table 61). The trend toward expansion of the pasture area was calculated on the basis of statistics obtained by FAO from the countries themselves, which are known to be unreliable. However, they are basically the only data available.

3.4.6 Rehabilitation

Soils degraded by abusive agricultural practices can be restored by various methods whose cost, while nearly always high, is nonetheless justified in many cases. Besides drainage, which was discussed in a separate section, land rehabilitation includes many chemical and/or physical processes which return the lost fertility to the soil. The impact of these techniques on the gain of land is particularly difficult to assess, and in any event -- with the exception of drainage, already mentioned -- does not seem to be very significant in Latin America.

3.4.7 Reforestation

Reforestation is another way of gaining land provided there is no prior clearing of natural forests to carry it out. As a matter of fact, this is usually not the case; rather, the lands used for agriculture are unsuitable, or often abandoned by farmers and stockraisers because of inadequate use. Under these circumstances, afo forestation and reforestation appear not only as economically and socially profitable alternatives, but as means of restoring soils for a new period of agricultural use, especially with conifers, which

are true soil builders. All of the well-known ecological benefits should also be kept in mind. To date reforestation has been negligible in Latin America and the Caribbean, as may be seen in Table 29. The trends calculated by FAO (1978) indicate that industrial plantations could cover slightly more than 8 million hectares in the year 2000, with 4.5 million hectares of broad-leaved species and 3.5 million hectares of conifers. Of this total, it is estimated that 69% would be high-yield and the rest low-yield. There would also be plantings for protection, fruit-growing and/or ~~firewood~~ fuelwood in proportions similar to the present ones.

3.4.8 Agrarian Reform

On the whole, land ownership in Latin America is highly concentrated. Table 53 shows the values of the Gini index (which relates the percentages of land area in farms to percentages of the number of landowners) for 17 Latin American countries. Most of these have indexes above 0.80 and an average of 0.86, evidencing a higher concentration than in other parts of the world. This situation causes mounting social pressures in the form of a demand for land through agrarian reform, which is defined here simply as the redistribution of rights to land from the large landowners or latifundistas to those who work it. Thus, it is not surprising that the countries in which agrarian reform has already taken place were precisely those that had Gini indexes approaching or exceeding 0.90, as was the case in Mexico, Bolivia, Chile, Venezuela and Peru. The agrarian reform in Cuba (Gini index only 0.74) responded to a different set of conditions (Eckstein et al, 1978). Table 54 shows the same situation, in a different form, for Bolivia, Peru and Venezuela prior to the agrarian reforms, manifesting the extreme polarization of land tenure.

Table 53. Gini index of concentration of land ownership in 54 countries, various years.

Range of index values	Latin American countries	Other non-industrial countries	Industrial countries (a)
0.80 or higher	12	3	2
0.70 to 0.79	5	4	4
0.60 to 0.69	0	7	4
0.50 to 0.59	0	4	3
0.40 to 0.49	0	3	3
Total	17	21	16

Index values and years for Latin American countries

Country	Year	Index	Country	Year	Index
Mexico	1930	0.96	Brazil	1950	0.84
Bolivia	1950	0.94	El Salvador	1950	0.83
Chile	1936	0.94	Uruguay	1950	0.82
Venezuela	1956	0.91	Dominican Rep.	1950	0.79
Peru	1950	0.88	Cuba	1945	0.79
Guatemala	1950	0.86	Honduras	1952	0.76
Ecuador	1950	0.86	Nicaragua	1950	0.76
Colombia	1960	0.86	Panama	1961	0.74
Argentina	1952	0.86			

Note: (a) Industrial countries are defined as those with less than 30% of their labor force in agriculture.

Sources: Huntington (1968); Eckstein et al (1978).

Table 54. Structure of agricultural land ownership prior to the agrarian reforms in Bolivia, Peru and Venezuela

Size of farm (ha)	Bolivia		Peru		Venezuela	
	% of number of land-owners	% of national agricultural area	% of number of land-owners	% of national agricultural area	% of number of land-owners	% of national agricultural area
Less than 5	60	0.2	83	6	54	1.3
5 - 100	26	1.4	16	10	41	7
100 - 1000	7	6	1	14	4	13
over 1000	6	92	0.2	69	1.5	79

Source: Eckstein et al (1978).

Although some of the large estates are worked intensively and have yields commensurate with what would be expected given the quality of their soils, most of them are worked partially with little mechanization, or through forms of indirect management, which do not allow productivity matching their potential. There is much evidence of this; Eckstein et al (1978) present statistics on Bolivia for 1950 which show a close correlation between potato production and size of holding, with the largest harvests (over 2,500 kg/ha) obtained on farms of less than 5 ha, and the smallest harvests (less than 1,500 kg/ha) on those of over 1,000 ha. The study of agrarian reforms shows that they have to raise productivity in every case where the holding was a traditional hacienda. The result in terms of productivity for those which were mechanized farms is less obvious, but there is no evidence that productivity is lower after the reform. In summary, there is every indication that agrarian reform is a useful tool for rural development and the increase of production and productivity, and it is likely that the processes now under way will be intensified in the years ahead.

Obviously, rural poverty cannot be overcome through agrarian reform alone. It should be recalled that in 1969 17% of the rural population of Latin America had an annual per capita income of less than US$50, and that 25% earned less than US$75. Taking as the parameter an income less than one third of the average national per capita income -- i.e. less than US$50 -- 38% of the rural population would ~~be included~~ classified as poor (World Bank, 1975). Furthermore, countries like Peru which have carried out profound agrarian reforms are well aware that they do not necessarily solve the problem of the landless campesinos.

ILO (1972) showed the following percentages of landless workers with respect to the agricultural labor force: Costa Rica (53%), Dominican Republic (25%), Honduras (27%), Jamaica (41%), Mexico (49%), Nicaragua (43%), Argentina (51%), Chile (66%), Colombia (42%), Ecuador (39%), Peru (30%), Uruguay (59%), Brazil (26%) and Venezuela (33%).

3.5 "New" alternatives for agricultural production

This section summarizes the principal alternatives available to increase agricultural production and productivity without causing further damage to the environment or while limiting the present deterioration. In many cases these alternatives entail only a much more intensive use of resources that are now being exploited, which would actually increase the impact of man on them, although in some cases it may be possible to avoid such effects on virgin areas. It should also be noted that more intensive use -- although it does involve a greater artificiality of means of production -- is not "anti-ecological" per se, as contended by too many amateur "ecologists". On the other hand, many of the alternatives discussed below are not really new; some are essentially traditional. But little use is made of them because the European colonizers ~~have~~ proscribed them in favor of their own techniques and species, which are largely responsible for the catastrophic environmental situation of the Third World. Finally, some alternatives have been developed during the last 50 years, and although they are in general use in the advanced countries they are not yet being applied in Latin America. The first group of alternatives mentioned (those involving advanced technology) includes genetic engineering, microbiological agriculture and the forest as a direct source of food for man and livestock. The second or basically traditional group

includes agroforestry, native vs. exotic species and vegetable vs. animal protein. The third group includes watershed management, management of pests and diseases, and others. These alternatives will be considered without any special order or ranking.

3.5.1 Integral and integrated rural development

~~The~~ This term embodies the essence of the set of development alternatives available in the rural sector to achieve the possible and sustainable optimum quality of human life. Before addressing this aspect, it need only be added that integral and integrated rural development is nothing more than the application of common sense or logic so as to integrate the human needs of today and tomorrow with the potential of nature and with that of other human groups. The reason for the failure to apply common sense is basically ambition, which leads to social injustice and is, deep down, solely responsible for the human condition.

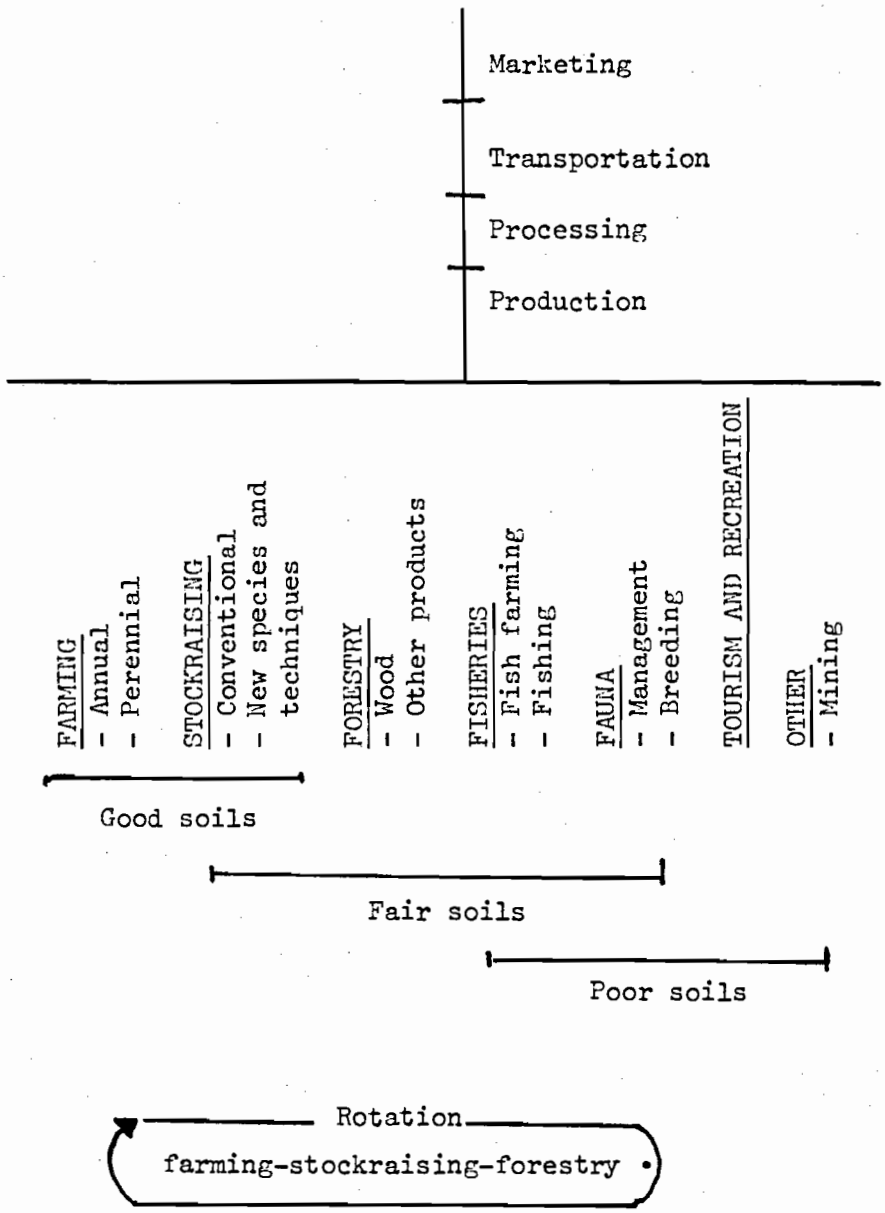
The expression of rural development is rural settlement, which should be based on socio-economic units defined by the integral and integrated nature of ~~its~~ production systems, aimed at maximizing the social, economic and ecological return. Rural settlements obviously gear their production techniques to the environment. They may be relatively simple and homogeneous when conditions are appropriate, for example when the land is fertile and there is a mild climate and abundant water, or very complex when they are established in areas subject to severe constraints, for example in the Amazon region or in other tropical rain forests. The settlements of greatest interest for purposes of the present study are those in the latter group, i.e. settlements in marginal or quasi-marginal areas, for it is there that the impact of poorly planned human activities is most damaging.

In such situations, more than in any other, rural settlements should provide for the simultaneous and well-considered utilization of the following resources: soils suitable for agriculture (annual and perennial crops, stockraising), soils suitable for forestry (reforestation and management of natural forests), forests (wood, non-wood forest products and multiple use in general), wild flora and fauna (subsistence, commercial and sport hunting as well as the use of medicinal and other plants), fishery resources (fishing, fish farming), natural landscapes (tourism, recreation), and finally, minerals and other resources if present. In other words, taking into account the level of economic or biological productivity, they must make the fullest possible use of each productive element of the ecosystem, wasting nothing, to achieve an overall productivity level comparable to that of more favorable ecosystems. This condition, which seems elementary, is rarely met in settlements in the humid tropics, for example, where absolute priority is given to speculation over anything else, contrary to what is indicated by the suitability of the soils. Thus there are farming settlements, stockraising settlements, and sometimes settlements with both activities; but there are hardly any agricultural-forestry settlements and these are never combined with the use of other natural resources. Moreover, farming, stockraising and forestry methods are totally conventional. This situation occurs even in desert ecosystems where the campesinos either raise goats or work precarious small farms, but almost never engage in commercial forest extraction. In such places this activity is carried on by others, and neither they nor the government combine it with reforestation, beekeeping, recreation or tourism, etc. It is true that the local populace usually knows of such integration and puts it into practice, and that the settlers also learn it after a few generations if any possibility of integration remains; but in

such cases they never rise above subeconomic levels of subsistence and contribute little to the economy despite the existence of markets (Dourojeanni, 1976, 1979).

In rural settlements, then, there should be integration of agriculture, forestry, fishing and hunting with processing, at least at the level of primary transformation and with transport and marketing, as one means of ending the inequitable relationship between countryside and city and assuring the benefits of ~~the~~ a greater return for ~~the~~ farmers or rural workers. The minimum requirement for this is the prior preparation of studies for land classification and often for the evaluation of forest or other resources. One of the fundamental techniques ensuring success is the rotation of land between agricultural and forestry uses (Table 55).

Table 55. Ideal integration of activities in ~~the~~ rural settlements located in marginal or quasi-marginal areas.



Source: Dourojeanni (1976, 1979).

The following is a straightforward discussion of three examples of integral rural development programs now under way in Peru which illustrate the ideas expressed above. They involve very different ecological conditions: deserts, high mountains and tropical jungle. The first (project Piura) is on the northern coast, where the forests were destroyed by cutting for ~~firewood~~ fuelwood and charcoal and more recently for parquet as well. Simultaneously, the presence of extensive stockraising, especially that of goats, prevented any natural regeneration. Today only 1.95% of the forests are still productive in that department. The most serious consequence besides the lack of wood and cattle feed is desertification. Dunes are advancing over the valleys, so difficult to irrigate, and into populated areas with severe economic consequences. In 1974 a total ban on forestry was declared in that region. While the ban was not fully obeyed -- nor was it expected to be, given the difficulty of enforcement -- a reforestation project based on the carob tree (Prosopis chilensis) was conceived to provide work for the unemployed. Planting was begun in a very dry area and now covers more than 1,000 hectares. The carob was selected because of its adaptation to the lack of water and because it yields fruit suitable for human and animal food, leaves for livestock feed and wood for various uses. The planting was a total success. With the passage of time hay and other forage crops, especially Leucaena, began to be grown among the carob trees to provide feed for cattle, especially mutton sheep. Later, ~~stables~~ staples (beans, maize) were planted to take advantage of the seasonal rains, and the scheme was completed with beekeeping, for which the carob flowers are especially well suited. The workers in the project, nearly all landless campesinos from the surrounding area, were sceptical at the outset but became interested in the system as they began to understand it; today they are the beneficiaries of seasonal agriculture and beekeeping. Provisional data suggest that a campesino family can live

decently with 25 hectares under this system, and that it can greatly improve its situation, for example by also planting forest species for other uses and fruit trees, and by installing windmills. There are now plans to develop the scheme on 25,000 ha and it is believed that in total, not less than 100,000 ha could be recovered in this way and at very low cost, especially in comparison with the cost of an irrigated hectare. Moreover, the adjacent valleys are protected from wind erosion (Valdivia and Cueto, 1979).

The second case (Cajamarca project) is in an area which, like other parts of the Andes, is characterized by severe erosion of the hillsides, which show deep gouges. They lack forest or scrub vegetation and the grass is very sparse. The springs are dry. The campesinos use part of the land for seasonal agriculture followed by long rotation periods, and the rest for very extensive stockraising. Poverty is extreme in this region. In 1965 a program was initiated for the recovery of hillsides based on a strict classification of land making it possible to separate lands suitable for forestry from those that should be used for farming, stockraising or protection. The process began with the improvement of pastures so that livestock could be concentrated, releasing land suitable for forestry which was planted with pine and eucalyptus. These plantations will be the base for the economic development of the region, producing wood for processing and supplying the nearby pulp and paper industry. Today some 4,000 ha have been planted with the help of government loans or food grants. The campesinos, who own the land, receive wages or food, and the harvest is exclusively theirs after repayment of the loan and the modest interest charged. In addition, crafts centers (ceramics and other products) have been developed to afford employment until the plantation goes into production. After a few years the water will begin to flow again in the springs,

and ~~even more with~~ this will be helped by the installation of drainage systems. The water collected is stored in small dams for delivery to the villages and lower slopes of the mountains, where the project includes the construction of terraces on which intensive agriculture with irrigation can be practiced. Thus, the system not only generates substantial forest production but also increases agricultural production, and allows towns to be established where there were only scattered huts. All of this can be complemented with recreational hunting in the forests, the breeding of trout, and tourism; later, industries will be established to increase the value added of production. A feasibility study has now been completed for a first stage of 60,000 ha of forest plantings for industrial purposes in Cajamarca, and the government is seeking international financing for this purpose.

The third case (Von Humboldt project) is under way in the Amazon region, as part of a large-scale industrial forest development project in a national forest near the city of Pucallpa, for which technical cooperation was received from FAO. An agro-forestry program has been under way in this region since 1976. It is hoped thereby to address the constant problem of invasion of the forest by campesinos settled along the roads and navigable rivers, with the continuous sharp conflicts that were created. In agreement with the campesinos, ~~the~~ National Forest officials permitted the clearing and burning of previously exploited forests and the cultivation of any crops that could be raised. Beginning in the second year, the forest authorities turned over young plants of suitable species which the campesinos were obliged to plant and care for. In other words, crop rotation is made compatible with rotation under the forest management plan, ensuring a symbiosis between campesino and forest. This scheme has been complemented by study of the possibility of introducing fast-

growing plants (Cecropia, Ochroma, Guazuma) on abandoned land to supply a nearby paper mill. Further analyses are being made to confirm the advisability of establishing ecotones to increase the productivity of smaller wild fauna, the integration of stockraising with forest management and the consumption of hydrolized wood and green forest fodder, selection of native fruits, etc. The program is taking on its greatest importance now that the state has opened this and other national forests to private enterprise, which means that the possibilities of conflict between campesinos and forest developers will increase significantly.

The three examples discussed above are not the only ones in Peru, and much less in the hemisphere as a whole. For example, Colombia has developed a model for its Orinoco region which it has been applying in the "Las Gaviotas" project, comprising four phases: establishment of an integrated services unit; construction of new plants for the processing of renewable natural products which do not affect the plantings (fruit and leaves, oils and extracted fibers, etc.), in addition well adapted stockraising and farming, animal rearing pens and fish farms, tourism, handicrafts, etc.; construction of the core human settlement; and settling of campesino families of Andean origin (Lugari, 1976). The new concepts of appropriate technology will find their maximum expression in rural settlements of this kind.

These aspects of rural development have been addressed at the theoretical level by a large number of individuals and institutions, and there is an adequate conceptual framework for further action in the field (IUCN 1975, Poore 1976, Dasmann et al 1973, IICA 1974). But the concepts are seldom applied by governments or by international organizations providing development assistance or lending institutions.

The prevailing situation as regards rural development has many well-known causes, but here we wish to stress others which are less universally accepted and which experience shows to be fundamental. The first is the total lack of interdisciplinary dialogue, understanding and even good will. The governments and many international agencies, among their departments and within each of them, operate in watertight compartments attempting to impose their contribution to the general welfare as though it were the only important factor in all cases. In agricultural development agencies the problem takes on comic aspects when the offices responsible for farming, stockraising and forestry engage in disputes about jurisdiction over areas and budgets, certainly ignoring the welfare of the rural people which obviously requires concerted action. Second, when there is a higher-level decision to harmonize action and integral rural development is mentioned, this is usually entrusted to departments much more concerned with socio-economic and political problems than with the realities of ecology and productivity; they ignore these completely, causing another type of imbalance seen in so many agrarian reform and settlement processes. Furthermore, settlement programs can also suffer from excesses of pure engineering, being based on abstract designs of communication routes, services, population centers and "poles of development".

The World Conference on Agrarian Reform and Rural Development, held in Rome in 1979, declared that the diversification of rural economic activities -- including the integrated development of farming and stockraising, fisheries, aquaculture and forest development -- is essential for broad-based rural development. There was found to be a need for the design and implementation of policies and programs affecting agrarian and rural systems with the full understanding and participation of all rural dwellers, including young people, and of their own organizations at all levels. This declaration seems to mark

the beginning of a change in attitude.

3.5.2 Management of watersheds

A hydrographic basin or watershed receives water from the atmosphere, retains it for a variable time during which it can be beneficial or prejudicial to man and his works, and then returns it to the atmosphere and carries it to the ocean. The functioning of a watershed is determined by a variety of factors which should be studied and understood before a program is drawn up for its management. These factors include the shape and dimensions of the watershed, the topography and slope of the land, soils and geology, the volume and type of precipitation and characteristics of storms, uses of land and types and condition of forest coverage. Some of these factors can be altered or regulated by man to modify or influence the direction, velocity or volume of the movement of water within the basin. The deliberate manipulation of these factors to bring about the desired functioning of watersheds is known as watershed management (Bay, 1971).

Thus, watershed management should contribute to rural development by ensuring the quality and timely availability of water, and at the same time should limit or prevent the loss of soils due to erosion by water. Many definitions of watershed management have been broadened to the point that they resemble the concept of rural development; this, it should be noted, also is beginning to occur with agro-forestry. In reality, however, rural development based on rural settlements is the objective to which both watershed management and agro-forestry contribute. The confusion arises from the fact that the watershed management itself is impossible without some order in the rural development of the area affected. Agro-forestry can make a significant contribution, but it is essentially a technological package more suitable for some cases than

others. In any event, the two most important direct lines of action of watershed management are biological methods (among which coverage with agricultural, forest, scrub and pasture plants is decisive) and artificial methods (which include engineering works of highly variable dimensions and kinds, ranging from terracing and leveling to dams and torrent control infrastructures.

This question is of obvious importance in a region where the terrain is generally rugged and where human populations have preferred to settle in mountainous areas whose natural vegetation has been destroyed or in adjacent desert or semi-desert areas that are dependent on the water produced within them. Nevertheless, watershed management is probably the most forgotten aspect of agronomy in all of Latin America and the Caribbean. Although it is discussed in nearly all the countries, few of them have government departments specifically responsible for promoting it and concrete action in the field is rare. One such exception is the management of the watershed of the Piedras Blancas river, which has supplied water to the city of Medellín, Colombia since the beginning of the century. The watershed was declared to be a municipal forest in 1918, when work began to be done with noteworthy results. Latin America has seen no other experiments of such importance with regard to the impact of forests on soil and water conservation. On the other hand, Venezuela has been making a considerable effort in watershed management based on the adaptation of farming to the Andean slopes, with terracing, the use of contour lines, diversion canals, hillside ditches, collector canals, absorption channels, stablization of slopes, stone walls, interior drainage systems, dikes and tanks, as well as strip farming, coverage crops, pastures and forest and fruit tree plantings. This work has already covered not less than 22,000 ha under the Directorate of Watershed Management. As Peña (1978) points out,

however, the high watersheds that present problems in Venezuela cover only 25 million hectares, of which 4 million are in the Andes.

3.5.3 Native species vs. exotic species

The introduction of this topic into the study is in no way intended to set up any type of discrimination among species which are native or foreign to a given country or region. All plants and animals that can provide benefits should be tested and used in accordance with the results. Many species have thrived much more outside their natural distribution area, as in the case of hevea (Hevea brasiliensis), a South American species which has been developed particularly in tropical Asia, or the eucalyptus (especially Eucalyptus globulus), which is more commonly cultivated in Latin America than Australia. In this regard, Latin America is one of the regions in which the most plants have been domesticated, including such important ones as the potato, maize, sugarcane, pineapple, beans, avocado, peanuts, cotton, cacao and cassava. These are among the many that have adapted outside the neotropical environment as well as or better than within it. Similarly, many foreign food plants have been introduced successfully, including rice, barley, wheat, stone fruit, citrus fruits, bananas, etc.

But this ebb and flow of species has not been motivated solely by a desire to improve human welfare. Much to the contrary, it has taken place largely as a colonial imperative, initially in an attempt to reproduce the conditions of the conquering countries in the conquered regions. Because of this, and later through the social mechanisms of domination, the population, caught up in a system of castes and classes, increasingly rejected the local foods that were not accepted by the conquerors, which were left to be consumed by the most humble people. Thus, in Peru -- which was the most important colonial center of South America -- maize has been nearly eradicated from the consumption habits

of much of the population, especially urban dwellers, in favor of wheat; meat from domestic camelids was displaced by beef and mutton in the same way. Unfortunately, the ecological conditions of the land do not allow the new habits to be served. A similar situation has occurred in the case of rice, which is produced at great ecological cost in the coastal deserts. On the other hand, the introduction of bovines and wheat has been a panacea for Argentina because they fit in well with its natural potential. In later periods the imposition of certain types of crops, especially those for processing, was a result of international or national domination. Thus there has been extensive development -- often on the only good soil -- of export crops such as cotton, bananas and sugarcane, while most of the national population is underfed.

During these processes a very large number of plant species that had already been or were being domesticated have been bypassed, scorned and even maligned. Many of these species have an extraordinary potential for adaptation to specific ecological conditions, because of their high productivity under such conditions and frequently because of their exceptional nutritional value (Table 56). In the Andean region alone these crops are counted in the dozens, and in Latin America as a whole they probably reach 100. Vavilov (1951) pointed out that the area of Peru, Ecuador and Bolivia is one of the major places of origin of cultivated plants, with 45 original species. In addition to the better known species of this region, which have already been mentioned, Leon (1965) lists some others of great importance such as tubers and corms: ulluco (Ullucus tuberosus), oca (Oxalis tuberosa), mashua (Tropaeolum tuberosum), and achira (Canna edulis); roots: maca (Lepidium meyenii), jumaca (Pachyrrhizus ahipa), arracha (Arracacia xanthorrhiza) and yacon (Polymnia sonchifolia);

grains: cañihua (Chenopodium pallidicaule), quinoa (Chenopodium quinoa), Inca wheat (Amaranthus caudatus), tarhui (Lupinus mutabilis) and a large number of fruits and vegetables, notably various amonaceae, juglandaceae, mimosaceae, papilionaceae, pasifloraceae, caricaceae, solanaceae and sapotaceae.

Table 56. Chemical analysis of cañihua (1) and quinua (2) in comparison with other cereals (percentages)

Composition	Cañihua	Quinua	Wheat	Barley	Oats	Maize	Rice
Moisture	10.90	8.87	12.84	12.90	12.99	10.96	12.15
Ash	3.70	2.92	2.40	3.33	3.68	2.16	1.56
Proteins	15.23	14.80	11.57	9.93	9.82	9.97	7.09
Fat	8.04	2.50	3.45	3.86	4.29	5.21	2.83
Fiber	3.85	3.28	5.96	2.50	6.32	1.50	1.82
Carbohydrates	58.58	67.53	63.70	67.48	63.80	71.38	78.75
Phosphorus (P_2O_5)(3)	0.37	0.40	0.19	0.22	0.35	0.28	0.12
Calcium (Ca 0) (3)	0.65	0.16	0.04	0.08	0.16	0.04	0.06

Notes: (1) Chenopodium pallidicaule

(2) Chenopodium quinoa

(3) In the ash.

Sources: Department of Nutrition, Peru, Ministry of Public Health and Social Welfare.

The warm areas of Latin America and the Caribbean have numerous other cultivated food plants which are likewise unappreciated and forgotten and once again consumed by very few people. These include taro (Xanthosoma sagitifolium), chaya (Cnidoscolus sp.), naranjilla (Solanum quitoense) and others. A report of the National Academy of Sciences (1975) deals with this subject.

Along the same lines, a noteworthy case is that of the cultivation of African oil palm (Elaeis guianensis) in Colombia, Ecuadro, Peru and Brazil, among other countries. In the first three at least, this is being done to help overcome the distressing deficit in oils and fats. The countries have undertaken vast and very costly planting projects (100,000 ha in Peru by the year 2000), without even considering the possibility of utilizing the dense Mauritia palm trees which cover several million hectares in each country. Although the Mauritia can now produce much less oil per hectare than the domesticated and improved African palm, it nonetheless has the advantage of existing in abundance and in readily accessible places, besides yielding an oil of optimum quality and possibly fibers and other products (Salazar, 1967). The cost of planting only 6 to 10 ha of Elaeis probably would have paid for the studies necessary to make the rational exploitation of millions of hectares of Mauritia feasible. This situation, regrettably so common, is the fruit of resistance to change on the part of traditional agronomists, who cannot conceive of beginning to domesticate new species and/or oppose having forest plants produce food. Another obvious factor is the economic interests which are behind the sale of technologies and genetic material, often with international technical and financial cooperation. On the other hand, private investors or the state -- poorly advised or advised by traditionalist professionals -- prefer not to take risks in operations which are presented to them as uncertain even though this

is not necessarily the case.

Economic forces undoubtedly are responsible for such other incomprehensible situations as abandonment of the cultivation of plants that yield excellent natural pesticides. In particular, these include the neotropical cube (Lonchocarpus nicou, L. urucu) and similar species, such as Derris elliptica and the chrysanthemum (the latter two of Asian origin) among many others. Rotenone was produced and exported in great quantities outside the Amazon region, and the same was true of pyrethrin; but the clandestine propaganda carried on against them by the manufacturers of synthetic pesticides drastically reduced ~~the~~ interest in producing and applying them. A slow change is now under way because of the worldwide desire to use pesticides that minimize the risk to the environment and to man. Rotenone, pyrethrin, sabadilla and nicotine -- among the main species ~~that~~ but only a few of what may be scores ~~of others~~ in the Amazon region alone -- are degradable or nonpersistent insecticides, of low ~~toxity~~ toxicity to mammals, manageable without risk, efficient, and moreover suitable for use in combination with a wide range of other products (Wille et al 1937, ITC, 1976).

To conclude this section, the author wishes only to emphasize the fact that Latin American and Caribbean agriculture in the decades ahead has much to gain and nothing to lose by giving renewed importance to species, subspecies, varieties and breeds of cultivated plants and domesticated animals that have been pushed aside during the course of history for social or economic reasons. In this connection, a greater role should be given to native species vis-a-vis exotic species, and distorted or ill-formed consumption habits should be changed if necessary. The return from these efforts can be highly important for the human diet.

3.5.4 Vegetable protein vs. animal protein

Up to the present, it has been considered desirable to achieve an equilibrium between the supply of vegetable and animal protein in the human diet, in which animal protein was given a very important role. Nonetheless, there is a definite trend toward a change in this attitude in the light of new evidence on the future availability of food, the comparative efficiency of plants and animals in producing it, the costs of production and the real need for animal protein for human health, among other factors. The results seem to indicate that in future mankind will have to eat an increasing amount of food of plant origin.

The most convincing argument is the second of those mentioned above. With our knowledge of trophic structure and ecological pyramids -- whether of numbers, biomass or energy -- it is evident that omnivorous man would gain by obtaining his food directly from producers (plants) instead of primary or secondary consumers as when he consumes meat. In this connection, Table 57 presents Odum's (1971) classical example showing the efficiency that would result if man (the child) were to take the place of the herbivores that supply his food (the calf). Such a change would permit a drastic reduction in the area required to feed mankind. It should be recalled in this regard that despite the considerable deficiency in meat production in relation to demand within the study area, forage crops occupy 4.7 times the present agricultural area harvested. Moreover, a substantial part of that area also is used to produce food for animals, in whose raising even primary consumers are used, as in the case of fishmeal. It is impossible to ~~content~~ believe that the entire human

population can consume the 120 to 130 kg of meat consumed annually by the people of the United States; furthermore, this is totally unnecessary since a proper diet requires only 30 to 35 grams per day, including dairy products. The habit of eating meat -- especially red meats -- seems to be atavistic and to some extent a symbol of power. As recently noted by a high French official in agriculture, it is the animals of the developed countries that are starving the Third World; because of their great number and their genetic selection for high production, they now compete directly with humans for cereals, protein foods and oilseeds (Le Point, July 1979).

Table 57. Hypothetical example showing (in simplified form) the loss of energy and reduction of biomass and numbers in the three types of pyramidal representations of trophic links

Species	Trophic role	Number (individuals)	Biomass (kg)	Energy (calories)
Alfalfa	Producer	2×10^7	8,211	1.49×10^7
Calf	Primary consumer	4.5	1,035	1.19×10^6
Child	Secondary consumer	1	48	8.3×10^3

Note: Based on an area of 4 hectares and a one-year period.

Source: Adapted from Odum (1971).

The response to this state of affairs is a gradual and partial replacement of meat in the diet by meat substitutes obtained directly from the biomass, i.e. purified vegetable protein (isolated or concentrated) offered as an imitation of meat, including fibrous matter ~~similar to~~ with the appearance of meat, and with its taste and smell. "Soybean meat" is a prototype but there are already other products made from sunflowers, peas and -- in the near future -- colza. It is assumed that by 1985-90 vegetable protein will begin to play a significant role, although milk protein also is likely to compete with that of plants in the gradual displacement of meat.

In this connection, a new look is being taken at the role of beans, peas and similar legumes, which for centuries have been regarded as second-class foods or "for the poor", forgetting that they were the basis of the diet of the great pre-Hispanic American cultures. These legumes offer an impressive set of advantages over other food: their high protein content, their capacity to fertilize themselves with nitrogen through efficient symbiotic processes, ~~their~~ the tolerance ~~of~~ by certain species ~~for~~ of drought, ~~coal~~ cold and other extreme conditions, their resistance to pests, their excellent qualities for storage, the speed of their growth and their good taste. Species such as the tarhui (Lupinus mutabilis) grow under frigid conditions in acid soils and contain 50% protein; others such as the lima bean prosper in the infertile soils of the Amazon region, while many Mexican species grow in areas of extreme aridity. The Green Revolution promoted cereals, often at the expense of local beans, without taking into account that cereals require costly fertilization, are two or three times poorer in protein and are not as resistant either to drought or to pests. Moreover, many beans can produce oil. As in another case

discussed above, if only a fraction of the investment in the study, improvement and promotion of wheat and rice cultivation had been expended on these legumes, there probably would be less hunger on the earth.

We should also mention the limited development of horticulture in all of Latin America and the small part played by green foods in the daily diet. This is another aspect that should be given priority in the decades ahead.

3.5.5 Agro-forestry

Combe and Budowski (1978) define agro-forestry as the set of land management techniques involving the combination of forest trees with crops or stockraising, or both. The combination can take place simultaneously or be spread over time and space. Its purpose is to optimize production per unit of area, following the principle of continuous management. Bene et al (1977) and King (1979) define it as a system of sustained management of land which increases its production, combining crops (including arboreal crops) with forest plants or animals, simultaneously or sequentially, on the same unit of land, applying techniques that are compatible with the culture of the local population. Agro-forestry includes agro-silviculture, forest-pasture systems, agro-forest-pasture systems, and systems of multipurpose production (King, 1980).

Actually, as King (1980) points out, agro-forestry is applied to some extent in no less than 100 developing countries, including virtually all those of Latin America and the Caribbean. Some of the leading examples in this hemisphere are the coffee and cacao plantations shaded by legumes (*Inga*, *Erythrina*, *Albizzia*) and/or timber-yielding species (*Cordia alliodora* and *Cedrela odorata*, among others); forage crops in combination with trees providing food, fuel

(Artocarpus, Psidium) or wood (Eucalyptus deglupta, Cedrela, Cordia alliodora); grazing in ~~producing~~ production forests (Pinus radiata, P. caribaea, Eucalyptus); wind breaks (Cupressus, Eucalyptus, Casuarina, Cassia); forest plantations for stockraising (Leucaena, Prosopischilensis, P. tamarugo); and fruit trees planted in fields of annual or perennial crops (Bertholletia excelsa, Bactris gasipaes, Cocos nucifera, Anacardium occidentale, Tamarindus indica). Combe and Budowski (1978) present a large body of systematic data in this regard, and King (1980) cites some 200 arboreal and cultivated species which are planted in combination in various places.

What can be said with certainty is that with few exceptions these practices have always been looked at askance by modern agronomy in Lation America and have been relegated to marginal rural areas. It is also a fact that these techniques are not always applied in the most desirable way. Today, however, attempts are being made to reactivate them, improve them and propagate their use on all soils having natural limitations that require more careful and complex management than that practiced on better soils. In this connection, Peruvian legislation has recently recognized the principle of agriculture-forestry rotation in the Amazon region of that country, which had been considered as abandonment of the land and was grounds for expropriation under the agrarian reform. Still, an enormous amount remains to be done; it is worth the effort because agro-forestry not only increases production -- which is obviously important -- but also justifies and demands a higher intensity of labor. Moreover, as the original condition of the forest is restored, it also ensures better protection of soils against the effects of erosion and other forms of degradation. In addition, there is evidence that in many cases the combination of well spaced trees and crops, even when the trees are large and give shade, does not diminish and can even increase crop

production; likewise, thinning is always possible, especially because competition is extreme during the first years. Agro-forestry is therefore a perfect answer to the eternal problem that makes campesinos oppose reforestation: the long period without significant income. Furthermore, Nair (1979) has demonstrated clearly that most of the reforestation programs do not take full advantage of the nutrients, water and energy available during the initial stages of plant growth, a period well suited to intercropping.

Many agro-forestry projects are under way at the present time. The Center for Research and Teaching in Tropical Agriculture (CATIE) in Turrialba, Costa Rica, is the Latin American institution moving ahead most steadily in this area. The OAS program IICA-Tropics should also be mentioned. At the international level there is even an International Council for Research in Agro-forestry (ICRAF), devoted exclusively to this work. At the country level the most important projects in experimental agro-forestry, monitoring and promotion include those of agriculture-swineraising-forestry in the Ecuadorian Amazon region (Bishop, 1979); the agro-forestry programs in Bajo Calima, Colombia (Leguizama, 1979); those of Costa Rica in the La Suiza watershed (Beer et al, 1979); those of Brazil in Jari (Briscoe, 1979); those of Suriname (Vega, 1979); those in Chetumal, Mexico (Chavelas, 1979); and many others. Still, the efforts that are being made in both the international and national spheres remain disproportionately small in relation to the prospects afforded by this rediscovered option.

3.5.6 The forest and the feeding of livestock

Up to the present the development of stockraising and that of forestry in Latin America have essentially been in conflict. Although historically the forest has suffered the consequences of the expansion of forage crops for stockraising, it can now be predicted that this trend will cease, as the scarcity of forest products makes them economically competitive. The situation in

New Zealand is a good example. Nonetheless, a turnaround of the magnitude experienced there cannot be expected in Latin America before the year 2000, and by then the impact of deforestation will perhaps be irreparable in terms of ~~the~~ destruction of the environment.

Curiously, the livestock of greatest value to mankind -- i.e., species having a polygastric ~~digestio~~ digestive system -- are precisely those which also have the greatest likelihood of being integrated into ecosystems characterized by the formation of large volumes of cellulose: forests. In a manner of speaking, bovine cattle, sheep and goats are potentially enormous termites that can obtain the essential elements of life from wood. Obviously, there is a missing link in the trophic chain between forest and livestock, but its insertion is technologically and economically feasible. The more difficult task is to overcome the habit of feeding livestock with the comparatively small biomass produced by natural pastures or even by cultivated forage crops.

The problem of making wood digestible has been virtually solved, either through steam processes or through hydrolysis; equipment for this is available on the market in Canada and the United States. Furthermore, during the two World Wars industrial plants used hydrolysis to convert wood into edible sugars and produced yeast from these sugars to obtain food rich in protein~~s~~ for humans and animals. Nonetheless, the hydrolytic process is still costly and thus is not competitive with the conventional processing of sugarcane and soybeans, although minor improvements in transformation processes could make it so. A promising solution for lowering their cost could be the use of biodigestion by organisms. Through the steam process the digestibility <u>in vitro</u> of the wood increases to a level comparable with that of medium or even higher-grade hay.

The material produced, easily converted into powder or granules, can be incorporated in normal diets and is accepted by the animals. Bender and Bowden (1969), among others, mention these possibilities, noting that in their experiments with different species they have succeeded in increasing the digestibility of the aspen (Populus tremuloides) by much more than 50% through steam treatment. Although their results with conifers have been less encouraging, they found that the utilization of carbohydrates contained in waste wood and unused trees offers a possibility of applying additional amounts of solar energy to met human needs. While this aspect has not yet been completely resolved, especially with tropical species, considerable progress has been made.

Procedures that are now economically feasible supply carbohydrates to the diet in the form of sugars and starches, but with very little protein. They also provide bulk. They must therefore be supplemented with the missing elements or ~~must therefore~~ be considered as part of the diet. The main problems hindering the more generalized application of such procedures lie in the different behavior of soft and hard woods and of conifers and broad-leaf species, and in the toxicogenic or toxic substances that may be present. Thus, arduous though rewarding study is required for each of these many species. The low-cost methods for eliminating lignin represent a major field of research to improve digestibility.

Apart from what has already been said, the integration of stockraising and forestry can be achieved in other ways, as demonstrated by the project in Peru with Prosopis chilensis and the one in Chile with P. tamarugo, as well as others such as the use of Leucaena leucocephala to provide leaves and fruits for livestock feed. In addition to these species, fodder-bearing trees such as Artocarpus, Acacia, Erithrina, etc. may be mentioned.

3.5.7 Toward better stockraising

Stockraising, more than other human activities, is resistant to change. Nevertheless, in addition to the potential for feeding livestock with by-products of forest exploitation or with unused forest species (as discussed in the preceding section) and for combining stockraising with farming and forestry (as also discussed above), there are other possibilities for its intensification and improvement which have been largely neglected in Latin America. Taking into account that at present only one unit of livestock is raised on each 1.7 ha in Latin America and the Caribbean, the first objective should be to attain an average of 1 unit per hectare by the year 2000. Should this goal be achieved the pasture area in that year would be 30% less than the projections of the present situation considered most likely, and extensive stockraising would moreover be made substantially more profitable. Besides what has already been said and what is commonly accepted with regard to the management and improvement of pastures, there are other possibilities for ecosystems which cover large areas and where the raising of beef cattle is now most extensive.

One of these original and promising approaches to livestock development has been developed in the State of Apure on the Venezuelan plains. The grasslands of that region are periodically subjected to heavy flooding caused by the high seasonal precipitation and by the damming of natural channels or drains because of the rise in the water level in the rivers. Following the rainy season the grasslands are drained and remain very dry for a large part of the year. Under these conditions it takes an average of 10 ha to maintain one head of cattle. To solve the problem of flooding, in 1967 various alternatives were considered, such as the draining of channels or the construction of dikes. The latter proved

to be the best and most economical course of action because it was feasible to build very low dikes joining lines of natural banks in lowlands and pools, on a perpendicular to the maximum slope and between channels. This was the origin of the Apure Modules, a network of low dikes which limit the effects of flooding but at the same time form artificial pools that ~~can~~ retain the water until the next rains. The natural vegetation adapted well to the changes, with excellent growth of many highly palatable species which remain green throughout the year. Moreover, by opening the gates it is possible to regulate the water level so as to benefit the vegetation, which cannot survive indefinitely under water. Also, the stored water can be used for irrigation, while the banks of the dikes are ideal for traditional farming. Under these circumstances stockraising has been reorganized on the basis of 4,000-ha plots; the initial goal is to maintain 1 head per 2 hectares, but an average of 1 per hectare can easily be maintained if simple improvements are made, and more than 3 with fertilization and rotation. The steers reach 400 kg in 2-1/2 years, whereas they normally required 4 years to reach that weight in the past. In addition to these benefits, the permanent presence of water has had a spectacular impact on the wild fauna, which has proliferated beyond anything that was expected. There are all kinds of birds together with turtles and crocodiles in the wettest areas, while capivaras, deer, peccaries and many other herbivores and carnivores occupy the rest of the region. It is certainly possible to manage this fauna as a complement to stockraising. To date 225,000 ha have been improved, with about 30,000 now in full operation. The first phase of the project covers one million hectares (Ambiente, 1978).

Needless to say, not everything is perfect in this project, the main problem -- apart from administrative and operational factors that need not be considered here -- seems to be the differing quality of the soils and their highly variable behavior ~~in~~ under the new hydrological conditions. It is feared that salinization will occur and that undesirable plant species will proliferate. Moreover, under certain conditions grazing and trampling have already caused "bare spots" (compacted and eroded areas). There is also fear of the reappearance of malaria because conditions are so favorable to the breeding of mosquitos and because birds carrying malarial parasites are present. Still, all of these problems can be solved and in no way support the hardly constructive criticism leveled against the project by some "ecologists", ignoring that its success will make it possible to greatly reduce the pressure of stockraising on natural areas.

A similar idea was developed on a purely experimental basis in the Puno uplands of southern Peru, at an elevation of over 4,000 meters. It was observed that the animals of all kinds living around the lakes and pools obtain most of their food from them, particularly the "llachu" (Elodea, Potamogeton, Miriophyllum) or succulent and nutritious floating vegetation, together with several species of reeds (Scirpus, Heleocharis). Plans were therefore made to use water from the streams to inundate part of the nearly flat, semi-arid open areas covered with degraded hard grasses by means of small dikes, and to plant the species mentioned in the water, providing the cattle with a combination of land and water grazing through appropriate rotation. In areas where this is possible the carrying capacity can be increased several times.

Since average production in Brazil is about 35 kg live weight of cattle/ha/year, whereas in developed countries 400 kg/ha/year is produced,

more intensive production methods have been introduced in that country. These, which include the "Voisin" method, are based on more or less prolonged periods of rest which eliminate all losses of energy resulting from the search for food. Stabling obviously requires greater initial investments and the organization of food production and harvesting, but the data show that it permits increases of up to 1,000 kg of live weight/ha/year (Pinheiro, 1974). In the upper Amazon region of Peru some settlers maintain up to 5 head of livestock/ha with the same techniques, and produce all of the necessary food on the farm itself, which is devoted primarily to coffee growing.

3.5.8 Fertilization in the future

Agriculture evolved slowly but productively for millenia, until mineral fertilizers were introduced widely in the middle of the last century. In particular, the nitrate of South America has been a decisive factor in the great leap in agricultural yields. Agricultural machinery was greatly improved during that period, although farming continued to depend on animal traction for a long time. Only 40 years ago a second revolution occurred. In this case, yields per hectare doubled and tripled thanks to motorized mechanization, synthetic fertilizers, pesticides, certified seeds and plants, etc. As is well known, however, such industrialized agriculture is not found everywhere and coexists with the subsistence type.

Until 1973 a state of "energy euphoria" prevailed. This continued despite the warnings that were given, and mankind must now face the stark fact that the boom is over without knowing what path to follow in the future. Actually, "modern" agriculture is notably and increasingly inefficient in the use of energy. In the United States, while 5.3 calories of scarce energy were required to produce 1 calorie in the form of food in 1940, this already low efficiency

decreased further to 7.7 calories to produce 1 in 1970. Thus, there is a striking waste of energy in agriculture, which nonetheless is far less than what occurs in other activities. "Modern" agriculture, which is a primary or producing activity in ecological terms, has become an activity which consumes more than it produces. On the other hand, energy analyses of "primitive" agriculture have shown clearly that for each calorie invested it produces 5 to 50 food calories. This paradoxical situation has its socio-economic explanations and justifications, but in any case it cannot be sustained, and there is an imperative need for a progressive return to more efficient use of the ecosystem, associated with the optimum utilization of the capital that it represents. What has been done in the People's Republic of China in the area of integral rural development demonstrates that the solution is within the reach of human knowledge (Bonnier, 1979).

In this context the problem of fertilization takes on crucial importance. Here again legumes and other families of plants that are capable of fixing atmospheric nitrogen will play a dominant role. Legumes can fix up to 350 kg/ha/year of nitrogen, which is equivalent to tranforming air into more than two tons of protein; moreover, the developed countries discharge in the sea, as waste, an amount of organic nitrogen greater than that contained in the fertilizers that they purchase and apply. Also substantial are the losses due to the non-utilization of crop residues which are burned and completely lost.

The fixation of nitrogen by nodular-root legumes, through their symbiosis with Rhizobium bacteria, is bound to be a key element of fertilization in the future. In temperate zones, clover and sea grass fix the equivalent of 250 to 400 kg/ha of nitrogen per year, and in the tropics various legumes and

herbaceous mixtures fix 200 to 250 kg/ha of nitrogen per year, ~~while~~ and much more in some cases (FAO, 1977). When this advantage is combined with those already mentioned regarding the nutritional value of legumes to humans, a nearly ideal solution is offered. Inoculation with Rhizobium bacteria can improve nodulation or permit it where it does not exist in a specific Rhizobium. The latter occurs with Lotonius, Desmodum and Centrosema, as well as with soybeans, which in the absence of their specific variety consume nitrogen from the soil. The science of genetics makes it possible to increase symbiotic efficiency. Moreover, it is now well known that the fixation of nitrogen from the air is not exclusive to legumes, and occurs in other families and with different symbionts. Such is the case of Casuarina, an arboreal species in symbiosis with actinomycetes which enable it to fix 60 kg of nitrogen/ha/year in Senegal. Many other symbioses of this type have been discovered in tropical rain forests, partly explaining the apparent fertility of their soils.

Blue-green algae play a similar role. It has been found that algae associated with aquatic ferns (Azolla) in ricefields provide more nitrogen than the root system of the plant, which fixes about 0.05 kg/ha/day. Recent studies show that rice can absorb an average of 60 kg/ha of nitrogen, in addition to that provided by fertilizers (FAO, 1977).

With regard to discarded residues, FAO (1977) estimated that in 1971 the developing countries had 113 million tons of plant nutrients in the form of organic residues, i.e. about eight times the amount of mineral fertilizers used by those countries. The plant nutrients contained in human, animal, agricultural and urban organic residues in that year included 41.7 million tons of nitrogen, 14.5 million tons of P_2O_5 and 35 million tons of K_2O. However, it is not equally easy to use them in all cases, owing particularly to health hazards and the danger of pollution, although these are by no means insurmountable problems.

It should be noted that the use of dung, compost and night soil as plant nutrients can be combined with the production of biogas (methane). The process reduces the loss of organic matter by decomposition and curtails losses of nitrogen while producing gas for cooking and other uses.

3.5.9 Microbiological agriculture

Micro-organisms, through oxidation and fermentation, have contributed to the human diet since prehistoric times. Some examples are bread, beer, wine, vinegar, cheese and butter, as well as many others. This use of micro-organisms is based on their capacity to break down starches and other polysaccharides, by means of the enzymes that they hydrolize, into simpler sugars such glucose; others break down proteins into peptides or amino acids. The near future will see what might be called the "domestication" of microbes and their enzymes. The latter, which have been used in free form in solution, are being insolubilized or immobilized, i.e., fixed or encapsulated in plastic supports. Their activity is thereby multiplied and they are made reusable, permitting their use over long periods. The economic manufacture of food sugar rich in fructose from cornstarch, for example, has been feasible for years; only the fear of adverse socio-economic consequences is hindering its massive application. The same thing will be done with wood in the near future, simply by duplicating the activity of the catalytic base of the enzymes. Moreover, taking into account the role of nitrogenase -- which enables nitrogen-fixing bacteria and algae to contribute between 50 and 100 million tons of this element to the earth each year, one can see the importance of creating an artificial catalyst that duplicates the function of nitrogenase to replace the costly process of industrial fixation now in use.

Proteins and vitamins can be produced from petroleum. Theoretically, one ton of paraffin can yield one ton of yeast with 50% protein. If half of

the world consumption of petroleum were used to grow yeast 7.5 million tons of protein could be obtained, sufficient to cover the protein deficit projected for the year 2000.

The main characteristics of protein production through micro-organisms are the rapid speed of production, due to the short period between generations; the small area required for production; and the independence of the process from climatic conditions. One disadvantage of plant protein vis-à-vis animal protein is its lower lysine content; however, thanks to a method of biosynthesis developed in Japan, large quantities of lysine can be produced to fill the gap.

3.5.10 Genetic engineering and other possibilities

A number of novel alternatives for the production of food and other substances are still being tested in the laboratory or have recently been proven feasible. Some of the most important ones are genetic engineering, the management of microbes and enzymes already discussed, the synthesis of enzyme-emitting molecules, controlled fermentation reactions and the harnessing of basic reactions of photosynthesis. The potential of these new techniques is immense and they will certainly be at the heart of the agricultural and industrial revolution that will take place by the end of the century. They will probably be the dominant factor in the agriculture of the future. But as already observed in the industrial agriculture of the advanced countries, the existence of a technology does not ensure its equal availability to all; for the rest of the century at least, its applications will be minimal in Latin America and the Caribbean.

Microbiological genetics has made extraordinary advances in the last 20 years which now point to the possibility of altering genotypes through what is known as genetic engineering, i.e. the production of new genes and the

modification of germs so as to ultimately create life itself. Bacteria have been the basis of this research, the recent results of which include the replication of interferon.

3.5.11 Integrated management of pests and diseases

The spectacular development of traditional chemical control -- i.e., that using conventional pesticides -- and the magnitude of its adverse effects have led to the development in the last two decades of new approaches aimed at minimizing environmental destruction and increasing the efficiency of pest control. Some manifestations of this search for more ecological solutions are the renewed emphasis on the possibilities afforded by biological control, the study of selective pesticides or those which are not toxic to forms of ~~live~~ life that are not being controlled and of methods of application that reduce risks, physical or chemical sterilization programs, and renewed attention to control through cultivation or forest management.

At the same time, there has been evidence of the advantages of associating certain pest control techniques and thereby enhancing the relative benefits of each. Much progress has been made in the combination of biological control with chemical control, for example through application of pesticides prior to the release of parasites in order to increase their impact on the host population, or through the joint application of certain insecticides and bacteria. In many cases the timing of treatment has been taken into account in the application of such combinations, so that it will be done when natural enemies are insignificant in number or vulnerable; careful selection has been made of the pesticides least injurious to beneficial fauna, and parts of the crops have been left untreated to maintain reserves of natural enemies.

Although there has been a tendency for some time to refer to this combination of biological and chemical control as integrated control, more recently a much broader connotation has been given to the latter term. Integrated control is now defined as the management of populations of insects and other animals so as to maintain the damage they can cause below economically supportable limits. Integrated control is not confined to direct interference in the development of pest populations; rather, considering the ecosystem in all its breadth and complexity, it attempts to act upon populations of all species that play a significant role in the natural balance. The strategy of this form of control is to maximize natural control forces by using other tactics, with a minimum of disturbance, and only when there is a threat of economic loss which justifies such use. It therefore harmonizes the wide range of possibilities afforded by the different control methods. Of fundamental importance among these are biological and cultivation control, which -- within certain limits -- make it possible to regulate the population of harmful insects through the trophic linkage.

The following are some basic conditions and characteristics of integrated control: (a) its application requires a thorough knowledge of the ecosystem permitting at least the identification and quantification of the factors which have greatest impact on the evolution of populations of actual and potential pests. These factors include not only the number of natural enemies and other pests, but also climate, soil, cultivation and management techniques, and the condition of the plants to be protected and other host plants; (b) in integrated control the suppresion of pests is clearly intended to maintain their populations at subeconomic levels. One of the problems is to determine those

levels, since the maintenance of the pest ensures that its natural enemies will remain, reducing the likelihood of outbreaks; and (c) while insecticides are an important element of integrated control, they are considered in their true status as poisons extraneous to the environment, ~~in which they destroy~~ destroying not only plagues but also beneficial fauna, besides creating resistance among insects, phytotoxicity and pollution of the environment.

The integrated control of pests has been applied successfully in Peru, in the coastal valleys surrounded by deserts, since the 1950s, chiefly but not only in the growing of cotton and citrus fruits. It has also been applied in Nicaragua, also in cotton growing, and in other countries as well. At present there is a renewed interest in this approach which permits some optimism, although its application is being carefully monitored and severely restrained by the economic interests of the large pesticide industry.

The reasonably near future will see the application of such new chemical methods as hormones and the like, systemic insecticides with controlled release, repellents and substances that block the feeding of pests, chemical sterilizers, pheromones and other chemical agents that can be used to capture insects or disturb their orientation, and attractants. These are some of the methods that are now being studied with a view to elimination of the contaminating effects of conventional pesticides. There has also been development of genetic control methods, which offer further possibilities of avoiding the damage caused by pests without introducing additional dangers to the survival of mankind. All of these new and promising methods should nonetheless be applied within the context of integrated control.

3.5.12 Management of tropical forests

Few subjects are as controversial as this. ~~In some circles,~~ the management of tropical rain forests is regarded by some as impossible in economic terms. To others it is just as feasible as the management of temperate natural forests, taking the differences into account. Neither of the two positions has any solid ~~definitive~~ basis, especially in Latin America, because there has never been a managed tropical forest anywhere in the hemisphere, not even for experimental or pilot purposes. The first serious action in this regard began in the last decade, and its results are therefore not conclusive; nonetheless, some significant indicators are available as will be seen below. Obviously, the absence of managed forests whose results could be evaluated in no way proves that such management is not feasible. The reasons for this situation are well known, including the apparently inexhaustible abundance of resources, and above all the pre-capitalist approach of extraction-marketing which has predominanted among forest developers. The apparent or real technical difficulties inherent in the management of such forests has not been a factor; it has simply been rejected de facto on the basis of immediate economic considerations.

The economic feasibility of the management of tropical rain forests should be analyzed in terms of the length of forest rotation. Taking into account the still vast areas of natural forest available, it is impossible to understand the desire for very short rotations which are justified rather when land is scarce. The natural forests of temperate regions are managed with rotations of 50-100 years or more, depending on latitude. What then is the purpose of rotations of less than 50 years in the tropics? This is important because the degree of intervention, within the range of possibilities from purely natural regeneration to complete substitution with a cultivated tract, depends essentially on how long one is willing to wait and ultimately on costs as well. If selective extraction

(15 to 25 m2/ha) is the only method followed, it is likely that on returning to the tract one will find a forest with an equivalent volume in cubic feet but with a different composition. But of what importance is that? For a variety of reasons, it is impossible to predict which woods will be preferred at that time; rather, the important factor will be the biomass. If the method selected is natural regeneration, ~~whether~~ or not stimulated, the rotation does not necessarily have to be a long one; because of its non-age-specific character, the natural forest will produce mature trees that can be harvested over time. The equilibrium point is given by the economically usable volume. But if more artificial methods are used -- such as strip reforestation on bare land, -- supplemental plantings with ~~of the various~~ existing types, or reforestation after total clear cutting -- it is obvious that the large initial investment and maintenance costs will require a shorter rotation. These are merely two of the alternatives available, to be applied according to the circumstances, but there is no reason ~~grounds~~ for denying a priori that they are feasible.

The problem changes somewhat when one takes into account the alternative forms of management for the new uses of the forest, such as production of raw material for the chemical industry, in which all species of any age are usable, permitting extraction by clear cutting. In this case, however, natural regeneration also is possible through the use of strategically distributed seeded strips of appropriate size; still, it is obvious that reforestation has great potential since it can produce biomass under conditions competitive with nature.

Although there is no conclusive experience in the hemisphere, as noted above, there have been some recent major initiatives. Some of these are the Ticoporo Forest Reserve in Venezuela, the Von Humboldt National Forest in Peru and the Tapajoz National Forest in Brazil; there has also been a great deal of experience with such programs in Suriname, Puerto Rico and elsewhere ~~other countries~~.

In Ticoporo, nine years after the beginning of forestry operations by concessionary companies which are implementing management plans supervised by the government and processing the raw material extracted, the results have been highly promising: the implementation and continuous refinement of a plan for management of the forest and preservation of its less tangible values; reforestation of various types, chiefly enrichment and supplementation with native and exotic species; building of permanent infrastructures, mainly roads; introduction of new species on the market; maximization of industrial efficiency through the use of residues. The Ticoporo experience is being duplicated in the Von Humboldt National Forest, with excellent forest inventories, technical and economic feasibility studies and a management plan, which will serve the private and para-state industries that have already been established. In the Tapajoz National Forest the aspect of rational use under the principle of sustained production with minimum environmental damage was carefully analyzed, and its technical and economic feasibility was demonstrated at the theoretical level.

In addition, experience has been acquired in reforestation with native and exotic tropical species in almost all of the countries, but particularly in Costa Rica, Suriname, Puerto Rico and Brazil; furthermore, the principle of rational management has been embodied in the legislation of all the Latin American countries. Thus, the groundwork has now been laid for moving from concept to reality, which is expected to mark the great change in tropical forestry during the next two decades.

Another key aspect is the already demonstrated possibility of developing fast-growing timber trees such as Cecropia, Ochroma, Guazuma and others on fallow lands during agricultural or stockraising rotations. The wood produced will be used, as at present, to manufacture pulp for paper and other purposes in the chemical processing industries.

3.6 Trends in soil use

This section summarizes what has been discussed earlier and presents some general conclusions on the scenarios that are likely to prevail in 1990 and particularly in the year 2000 in Latin America and the Caribbean regarding the use of soils, in order to give an idea of the extent and characteristics of the territorial expansion of human activities. Four alternatives have been developed for this purpose, in relation to their impact on natural areas and on the basis of statistical data, criteria and assumptions which are different and unfortunately not always properly comparable.

The first, alternative I, is shown in Table 58. It is based directly and entirely on FAO production statistics (various years) and on their strictly trend-based projection. The second, alternative II (Table 59), is based partly on the same statistics but with all adjustments made for the preparation of Table 17, i.e. the substitution, in the arable land column, of data referring to Brazil by the FAO (1979) data for that country, which seemed to be more reliable for the reasons given in connection with Table 17. Furthermore, in this case a normative projection has been used for the arable land column, also calculated by FAO (1979). The difference in areas resulting from this adjustment was taken, as is logical, from the forests column, reducing the forest area proportionally; in addition, the projections of the other lands column were corrected slightly.

Both of the alternatives mentioned actually constitute working hypotheses for the projections made in the third alternative (III), which takes other factors into account as well, especially aspects of stockraising and its impact on natural forests. This third alternative is intended to embody the

results of the most probable balance between lands gained and lost. Reference also will be made to a fourth and last alternative (IV) based on various data which reflect a much more pessimistic vision of the future as regards both the impact on wild areas and the food production capacity of the area studied.

The four alternatives will be discussed and evaluated through a review of each of the three principal forms of lands use -- agriculture, stockraising and forestry -- and also in terms of unused or "other" land.

Table 58. Strictly trend-based projection of land use in the years 1990 and 2000 in Latin America and the Caribbean (in millions of ha)

Region	Year	Arable land and land suitable for permant crops		Pastures		Forests and the like		Other land	
		Area	%	Area	%	Area	%	Area	%
NORTH AMERICA	2000	22	11.5	74	38.5	54	28.1	42	21.9
	1990	23	12.0	74	38.5	61	31.8	34	17.7
	1977	23	12.0	74	38.5	71	37.0	24	12.5
CENTRAL AMERICA	2000	7	13.7	11	21.6	26	51.0	7	13.7
	1990	7	13.7	10	19.6	26	51.0	8	15.7
	1977	6	11.8	10	19.6	27	52.9	8	15.7
CARIBBEAN	2000	9	39.1	7	30.4	5	21.7	2	8.7
	1990	8	34.8	6	26.1	5	21.7	4	17.3
	1977	6	26.1	5	21.7	5	21.7	7	30.4
ANDEAN	2000	32	7.0	93	20.4	259	56.8	72	15.8
	1990	28	6.1	92	20.1	264	58.0	82	15.8
	1977	23	5.0	90	19.7	270	59.2	73	16.0
ATLANTIC	2000	59	6.4	242	26.0	537	57.8	94	9.8
	1990	52	5.6	217	23.3	551	59.2	110	11.8
	1977	42	4.5	182	19.6	570	61.3	136	14.6
SOUTHERN TIER	2000	58	16.2	168	46.9	70	19.6	62	17.3
	1990	52	14.4	169	46.8	73	20.2	67	18.6
	1977	43	11.8	170	46.8	77	21.2	73	20.1
SOUTH AMERICA	2000	149	8.5	504	28.9	866	49.7	225	12.9
	1990	131	7.5	478	27.4	888	50.9	249	14.2
	1977	108	6.2	242	25.3	917	52.4	282	16.1
LATIN AMERICA AND THE CARIBBEAN	2000	188	9.3	596	29.6	951	47.3	276	13.7
	1990	168	8.3	569	28.3	980	48.7	296	14.7
	1977	143	7.1	532	26.4	1,019	50.6	321	15.9

Note: The projections are entirely trend-based.

Source: FAO Production Yearbook (1978) only, which explains the differences observed for 1977 in various categories with respect to Table 17, where the figures were adjusted in the light of apparently more precise information.

Table 59. Projection of land use in 1990 and 2000 in Latin America and the Caribbean, based on statistical trends corrected in a first approximation (in millions of ha).

Region	Year	Arable land (1)		Pastures		Forests and the like (a)		Other (2)	
		Area	%	Area	%	Area	%	Area	%
NORTH AMERICA	2000	28	14.5	76	39.4	47	24.3	42	21.8
	1990	27	14.0	75	39.0	57	29.5	34	17.6
	1977	23	12.0	74	38.5	71	37.0	24	12.5
CENTRAL AMERICA	2000	7	13.5	11	21.1	27	52.0	7	13.5
	1990	6	11.8	10	19.6	27	53.0	8	15.7
	1977	6	11.8	10	19.6	27	53.0	8	15.7
CARIBBEAN	2000	6	26.1	7	30.4	5	21.7	5(b)	21.7
	1990	6	26.1	6	26.1	5	21.7	6(b)	26.1
	1977	6	26.1	5	21.7	5	21.7	7	30.4
ANDEAN	2000	31	6.8	93	20.4	260	57.0	72	15.8
	1990	25	5.5	92	20.2	267	58.5	72	15.8
	1977	23	5.0	91	20.0	270	59.0	73	16.0
ATLANTIC	2000	155	16.7	242	26.0	441	47.5	91	9.8
	1990	114	12.3	217	23.4	488	52.5	110	11.9
	1977	74	8.0	182	19.6	538	58.0	134	14.4
SOUTHERN TIER	2000	65	17.7	168	45.8	72	19.6	62	16.9
	1990	59	16.0	169	46.0	73	19.8	67	18.2
	1977	43	11.7	170	46.3	81	22.1	73	19.9
SOUTH AMERICA	2000	250	14.3	504	28.7	774	44.2	225	12.8
	1990	198	11.3	478	27.3	828	47.2	249	14.2
	1977	139	7.9	443	25.3	889	50.7	282	16.1
LATIN AMERICA AND THE CARIBBEAN	2000	291	14.4	596	29.5	854	42.3	279	13.8
	1990	237	11.7	569	28.1	916	45.3	297	14.7
	1977	175	8.7	532	26.3	991	49.1	321	15.9

Notes: (1) The projection of arable land is normative, taking various factors into account. It was made by FAO and completed by the author for the missing countries (see Table 60).

(2) The projections of pastures and "other" are strictly trend-based, and have be made by the author.

(a) The area of forests and the like has been estimated by the author by difference.

(b) The obviously excessive decreasing trend in "other" land in the Caribbean has been corrected.

Sources: (1) Statistical data for the document Agriculture: Toward 2000 (FAO, 1979), (Table 60).

(2) Trend projections based on the FAO Statistical Yearbook (Table 58).

3.6.1 Agriculture

It is less difficult to estimate the growth of agriculture than to visualize what will happen in the case of pastures or forests. The reason is essentially that the statistics for agriculture are much more precise. This explains why there is a narrower range of variation between the projections that underlie the four alternatives mentioned above. The area of arable land in the year 2000, for the area studied as a whole, will be in the range of 188 million hectares (alternative I), 291 million hectares (alternatives II and III) and 165 million hectares (alternative IV). The great difference between alternatives II and III on the one hand, and alternatives I and IV on the other, is obvious and is due to the fact that the former refer to arable land which is not necessarily cultivated (but is suitable for cultivation) while the latter refer primarily (though not exclusively) to harvested land. For harvested land in the year 2000, alternatives I and II show 192 million hectares. But from the standpoint of the present study, it is of more interest to know the amount of land prepared for agriculture -- whether in use or fallow -- than the area actually harvested.

The most probable projection, used for alternatives II and III with regard to the development of agriculture, was made by FAO (1979) for its study on agriculture toward the year 2000 and is shown in Table 60. As already noted, this projection is normative and refers to a situation that, while better than the one based on the trend, can be achieved. According to this projection, the area of arable land in Latin America and the Caribbean will increase from 191 million hectares in 1980 to 235 million in 1990 and 290 in the year 2000. The slight differences between the arable land areas given in Table 60 and Table 59 are due to the fact that the latter include~~s~~ areas in certain countries

of Central America and the Caribbean which were not shown in the FAO study mentioned. Between 1980 and 2000 this increase will represent an expansion of 52% in the arable land area. The largest increases naturally will occur in South America, and particularly in the Atlantic region where an expansion of 93% -- i.e., more than double the arable land in 1977 -- is expected during that period. Next in order of magnitude are the Andean region with 43% and the Southern Tier with 21%. As expected, the Caribbean will have very little expansion, only 10%, but the percentage for Central America is very high (29%). Mexico will have the smallest increase with only 9%.

Table 60 also shows the areas that probably will be harvested in 1990 and 2000. Although it is believed that a larger percentage of the arable land can be harvested, the difference is not significant in view of the comparatively low cropping intensities foreseen in the Atlantic and Andean regions. The overall proportion of land devoted to permanent crops will increase only from 15% to 17% between 1977 and 2000, and that of irrigated land will remain unchanged despite the substantial expansion of the irrigated area in absolute terms.

Should these projections be borne out, 14.4% of the land of Latin America and the Caribbean will be devoted to agriculture. In the event that agriculture does not expand as hoped to meet the demand for food in the year 2000, the impact will be less on natural areas and will affect between 8.2% and 9.3% (probably somewhat more) of the area studied. In the most favorable case the ratio of arable land per capita would be 0.48 ha/person and the harvested area 0.32 ha/person. In the worst case it would be only 0.28 ha/person. In either alternative the man/land ratio will worsen with respect to the present

situation, but this is a universal trend which will be offset by higher productivity; moreover, the situation of Latin America is no worse than that of other continents.

Table 60. Projection of area of harvested and arable land, 1990 and 2000 (in km2)

Region / Country	1980		1990				2000			
	Harvested area	Arable area	Harvested area	Arable area	Increase in arable area over 1980	% increase in arable area	Harvested area	Arable area	Increase in arable area over 1980	% increase in arable area
NORTH AMERICA										
Mexico	155,884	255,714	179,929	265,405	9,691	3.8	207,213	279,390	23,676	9.3
Total	155,884	255,714	179,929	265,405	9,601	3.8	207,213	279,390	23,676	9.3
CENTRAL AMERICA										
El Salvador	7,579	6,170	9,191	7,101	1,612	21.3	10,647	7,826	3,068	40.5
Guatamala	14,197	17,725	17,071	19,726	2,001	11.3	20,222	21,750	4,025	22.7
Honduras	7,780	8,553	9,667	10,254	1,701	19.9	12,000	12,296	3,743	43.8
Nicaragua	7,627	8,280	8,943	9,471	1,191	14.4	10,429	10,804	2,524	30.5
Panama	3,716	5,461	4,796	6,580	1,119	20.5	5,488	7,049	1,588	29.1
Total	40,899	46,189	49,668	53,132	6,943	15.0	58,786	59,725	13,536	29.3
CARIBBEAN										
Cuba	21,215	30,468	24,546	32,323	1,855	6.1	26,569	32,455	1,987	6.5
Haiti	10,368	8,513	12,185	9,750	1,817	17.5	13,789	10,741	3,421	33.0
Jamaica	1,717	2,262	2,344	2,745	483	21.4	2,503	2,646	384	16.7
Dominican Rep.	8,825	9,872	10,200	10,036	164	1.7	11,849	10,448	3,024	34.3
Trinidad and Tobago	933	1,247	1,291	1,495	248	19.9	1,453	1,486	239	19.2
Total	43,058	52,362	50,566	56,349	3,937	7.6	56,163	57,776	5,414	10.3
ANDEAN										
Bolivia	11,490	33,419	14,903	36,442	3,023	9.0	19,107	40,618	7,199	21.3
Colombia	44,366	58,765	57,781	58,765	0	0	73,370	91,389	32,624	55.5
Ecuador	18,925	42,375	24,673	51,425	9,050	21.4	31,467	61,987	19,612	46.3
Peru	20,432	32,619	25,351	38,153	5,534	17.0	31,082	44,130	11,511	35.3
Venezuela	18,616	48,054	26,404	61,362	13,308	17.7	32,699	70,296	22,242	46.3
Total	113,829	215,232	149,112	246,147	30,915	14.4	187,305	388,420	93,188	43.3

Table 3 continued

ATLANTIC										
Brazil	493,711	785,528	703,744	1,121,892	336,364	42.8	947,528	1,518,052	732,524	3.3
Guyana	2,099	3,615	2,629	3,615	0	0	2,942	4,973	1,358	37.6
Paraguay	11,591	13,367	16,207	17,906	4,539	34.0	21,468	22,781	9,414	70.4
Suriname	630	493	881	687	251	39.8	1,135	890	585	80.2
Total	508,031	803,003	728,491	1,144,100	341,097	42.5	973,073	1,546,696	743,693	92.6
SOUTHERN TIER										
Argentina	288,756	460,314	389,333	507,724	47,410	10.3	394,921	562,141	101,827	22.1
Chile	20,583	54,040	25,787	59,718	5,678	10.5	28,833	60,238	6,198	11.5
Uruguay	12,993	19,500	14,999	21,871	2,871	12.2	17,556	24,495	4,995	15.6
Total	322,332	533,854	800,119	589,313	55,459	10.4	441,310	646,874	113,020	21.2
SOUTH AMERICA	944,192	1,552,089	1,252,722	1,979,560	427,271	27.5	1,602,188	2,601,990	949,901	61.2
LATIN AMERICA AND THE CARIBBEAN	1,184,033	1,906,354	1,532,885	2,354,446	448,092	23.5	1,924,350	2,898,881	992,527	52.1

Note: When the area of harvested land is greater than that of arable land the percentage increase is calculated on the basis of the latter.

Source: Statistical data used for preparation of the report Agriculture Toward 2000, FAO (1979).

3.6.2 Stockraising

To estimate the future impact of stockraising on land areas it is necessary to take into account both the projections of pasture area and the projections of livestock population; thus, special consideration must be given to projections of carrying capacity. Table 61 shows the strictly trend-based projections of pasture land, bovine cattle (with equines, goats and sheep converted to bovine units) and the ~~consequent~~ resulting carrying capacity for each region of Latin America and the Caribbean. The results for the year 2000 indicate a population of 480 million head on an area of 596 million hectares of pastures. These data ~~determine~~ give a carrying capacity of 0.81 head per hectare. Because it is trend-based, this projection is similar to that of alternative I and -- as explained above -- to that of alternative II as well.

The increase in the livestock population has been the subject of several studies. Foremost among these is the study conducted by FAO (1979) on the situation of agriculture in the year 2000. FAO's normative projections (those which are both desirable and feasible) indicate a population of 482 million head of cows and buffaloes (Table 51); to this should be added, after conversion, the increase in equines, sheep and goats, giving a total slightly exceeding one half billion units. Although the normative projection is slightly higher than the trend-based one, the two are essentially similar. However, other studies give much lower figures for the year 2000, for example 368 million head of beef cattle and 168 million head of sheep and goats (United States, personal communication) or 345 million head of bovines and 239 million head of sheep and goats (Fitzhugh et al, 1978).

Table 61. Projection of the livestock population and required pasture area in Latin America and the Caribbean, 1990 and 2000 (thousands of head, thousands of hectares and head/hectare)

Region	1977			1990			2000		
	Livestock population	Pasture area	Carrying capacity	Livestock population	Pasture area	Carrying capacity	Livestock population	Pasture area	Carrying capacity
NORTH AMERICA	39,290	74,499	0.53	49,275	75,000	0.66	57,081	75,500	0.76
CENTRAL AMERICA	12,751	9,614	1.33	18,077	10,305	1.75	22,246	10,802	2.06
CARIBBEAN	11,387	5,403	2.11	12,810	6,175	2.07	13,933	6,695	2.08
ANDEAN	53,745	90,800	0.59	76,418	92,155	0.83	94,185	93,258	1.01
ATLANTIC	106,301	182,114	0.58	139,413	217,063	0.64	165,527	242,486	0.68
SOUTHERN TIER	83,556	170,050	0.49	107,745	168,915	0.63	127,302	168,079	0.76
SOUTH AMERICA	243,602	442,964	0.55	323,576	478,133	0.68	387,014	503,823	0.77
LATIN AMERICA AND THE CARIBBEAN	307,030	532,480	0.58	403,738	569,613	0.71	480,274	595,820	0.81

Note: Trend-based projections of livestock population and area of permanent pastures, based on information for 1969-78 and 1961-77, respectively. Equines, sheep and goats have been converted to bovine units by applying the factors 1.5 (equines) and 10.0 (sheep and goats).

Source: FAO Statistical Yearbook (1978).

The main problem in the development of alternative III lies in predicting the most probable carrying capacity in the years 1990 and 2000. On one hand, as noted in the section on the intensification of agriculture and stockraising, while it is theoretically possible to increase carrying capacity from 0.58 to 0.81 head/ha or more in the next 20 years, it by no means seems likely that the livestock population will increase by 56% during that period while the pasture area expands by only 12%. This is because of the social and technological conditions prevailing in stockraising, the low quality of the natural pastures in use and their present and future degradation owing to poor management, and the present tendency to favor extensive stockraising for meat. On the basis of these factors and certain others -- such as past trends in carrying capacity and the fact that the largest increases in livestock population will occur in South America where the available space is still great - it has been estimated that the most probable carrying capacity in the year 2000 will be 0.69 head/ha. This estimate seems to be further confirmed by the fact that FAO (1979) considers the normative trend to be an increase of 30.5% in cultivated pastures in Latin America, which would thereby expand from 12.6 million hectares in 1980 to 18.8 million hectares in the year 2000. This is precisely the expansion of pastures (natural and cultivated) that would be necessary to maintain 0.69 head/ha in the year 2000.

If we assume as most probable the trend-based and normative projections of the livestock population of Latin America and the Caribbean, which put it at about one half billion head in the year 2000, there would then be an area of 695 million hectares (trend-based projection) to 736 million hectares (normative projection) devoted to pastures. If, on the contrary, the livestock population

should be that indicated by other sources, the area of pastures will fall between 540 and 563 million hectares -- i.e., even less than the pasture area estimated by the trend-based projection and practically the same area as at present, which is not realistic. For these reasons, alternative III takes the results of a combination of the trend-based growth of the livestock population with the carrying capacity determined in the preceding paragraph. This implies that 695 million hectares, or 34% of the land area of Latin America and the Caribbean, will be devoted to stockraising.

In the case of alternative IV, the estimate of pastures in the year 2000 has been obtained by difference with respect to the remaining forest area as indicated by certain sources. Actually, substantial doubt remains as to the statements made earlier about carrying capacity and the area actually occupied by stockraising, which may be vastly greater than the figures given above, taken from the available statistics. It seems to be an exaggeration to speak of 0.58 head/ha -- i.e., one head per 1.7 ha -- as the Latin American and Caribbean average when one considers the situation of stockraising in vast areas such as northern Mexico, the Venezuelan and Colombian plains, the Andes, the dry coastal forests of Ecuador and Peru, the Brazilian caatinga and cerrado, the Gran Chaco, the dry Argentine pampas and Patagonia. All of these are subjected to grazing with an intensity of use far below the average indicated. In other words, much of the land shown as forests and the like actually is devoted chiefly to grazing. These are some of the lands that in another section were called "wasted lands" because their use for stockraising is marginal and destructive of other potential owing to its irrationality. It is likely that more than 60% of the open forest area of Latin America is grazed to a great extent by cows and goats, which results in a very wide and undetermined livestock-forest interface that no statistics can reveal. In any case, the consequence is

very low indexes of carrying capacity for impoverished and/or nomadic herdsmen, and sometimes on large estates as well, with native animals having very low yields. Another portion of the grazed land is classified statistically as "other land." As indicated in an FAO report (1978), despite the fact that the data show 23% of the land area as occupied by permanent pastures for the world as a whole, it can be assumed that nearly half of the land area of the world is used for grazing and forage.

3.6.3. Forests

The strictly trend-based alternative I shown in Table 58 indicates 951 million hectares of forests and similar areas in the year 2000, which would mean a minimum reduction with respect to the base year 1977. As already explained, this is a very unlikely alternative and is the result of an excessively elastic definition of forests which includes vast areas devoted to very extensive grazing or virtually abandoned because of their advanced state of degradation. For this reason, in alternative II the area of forests has been estimated by difference since the other forms of land use increase essentially at their expense. According to this alternative about 854 million hectares would remain in the year 2000 (Table 59), including dense tropical forests, dense temperate forests and open forest and treed grasslands. This would mean a decrease of 14% with respect to 1977, or an average annual decrease of 0.6%.

Nevertheless, if we assume as correct the estimate made regarding the expansion of pastures, and that they actually will cover 695 million hectares in the year 2000, and consider other adjustments made in the figures for "other lands", we find that only about 673 million hectares of forests would remain, which would represent a loss of 30% or an average annual decrease of 1.3%. This is

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the option taken in alternative III. Comparing that alternative with the results of the Lanly and Gillis study (1980), we find that according to those authors 681 million hectares of dense tropical forests would remain in 1980, after decreasing by slightly more than 4 million hectares per year between 1976 and 1980 (0.6% per year). The authors point out that during 1980-85 the destruction of dense forests is expected to increase slightly (+ 5%) in relation to the previous period, especially in Central America. Applying to the Lanly and Gillis (1980) figure an average rate of reduction of forests of 1% per year for the entire period 1980-2000, which does not seem excessive, by the end of that period 524 million hectares of dense forests would remain. ~~If it is assumed~~ Assuming at the same time that ~~the~~ dense temperate forests are being reduced at an average annual rate of 0.5%, they ~~would~~ will decline from 81 million hectares in 1977 to 72 million hectares in 2000. Finally, open forest or treed savannas would still cover 77 million hectares and would have been reduced at an annual rate of 2.9%, i.e. more than double that of the dense tropical forests.

To be sure, there are much more pessimistic projections than the one given in the preceding paragraph. A recent projection developed in the United States for a study on the world situation of resources in the year 2000 indicates that Latin America ~~would~~ will have only 329 million hectares of dense forests in that year. To reach that figure it starts with the existence of 550 million hectares of dense forests in 1978, i.e. 20% less than the figure given by Lanly and Clement (1980) for 1980, and fails to take into account the dense temperate forests of the Southern Tier. The reduction of the forest in that case would be 40%, equivalent to an annual decrease of 1.8% in the area of dense forests (alternative IV).

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There is ample reason to consider the successive evaluations of Lanly and Clement (1979) and Lanly and Gillis (1980) as the most precise since, as already noted, they are based on field work and on new technical information. However, to check them with regard to the rate of deforestation indicated, they have been compared with other more reliable and recent data as shown in Table 62, such as those of FAO (1979), Malleux (1975) and some of the sources cited by FAO (1976) excluding ~~with the exception of~~ those referring to Mexico and the Andean Pact. The result is about 3.5 million hectares per year, which fully confirms the figure given by Lanly and Gillis (1980) for 1980.

Table 62. Various reports on the destruction of forests for agriculture (chiefly migratory farming) in the Latin American and Caribbean countries, showing the great disparities in the available data.

Period / Country	Region	Period	Area (km2)	Annual average (km2)	Source
Up to 1950					
Mexico		1930-50	20,000	100	Watters (1971)
Cuba		1902-59	44,000	772	Cuba, INDAF (1976)
Argentina		50 years	400,000	8,000	FAO (1976)
Brazil	Southern region	1775-1975	1,150,000	5,750	"
Colombia		25 years	75,000	3,000	"
Brazil		up to 1977	2,937,000		Thibau (1977)
1950-70					
Venezuela		1950-75	13,000	510	Veillon (1976)
Mexico		1958-73	436,440?	31,170?	FAO (1976)
Central America		1958-73	8,130	580	"
CARICOM		1958-73	5,850	420	"
Other Caribbean		1958-73	2,140	150	"
Andean Pact (a)		1958-73	213,150	15,230	"
Brazil		1958-73	213,500	15,250	"
S.E. South America		1958-73	36,500	2,600	"
Colombia		1966-76	183,000	18,300	Myers (1980)
Peru		40 years	50,000	1,250	
1970-80					
Peru		1975		1,500	Malleux (1975)
Mexico		1975-80		4,000	FAO (1979)
Colombia		"		8,000	"
Venezuela		"		2,500	"
Panama	Azuero Peninsula	"		920	"
Ecuador		1970-75	500	100	FAO (1976)
Brazil				1,000	Muthoo (1977)

Notes: (a) Including Chile.

? The figures for Mexico (1958-73) seem too high.

Sources: As indicated.

The area of open forests is difficult to estimate because in many cases it is incorrectly taken to include shrub grasslands and scrub formations which other authors classify as grazing areas. The figures for mid-1977 or the end of that year range ~~from only~~ as little as 152 million hectares (estimates made in the United States on the basis of Persson 1974, personal communication) ~~and~~ or 180 million hectares (FAO 1979) to as much as 234 million hectares of treed grasslands and 170 million hectares of scrub (FAO 1976) or -- according to calculations made by the author from the trend-based projections of Table 59 -- about 299 million hectares. Obviously, it is probable that the lowest estimates refer only to treed areas and exclude formations of fuelwood shrubs, but in this case it would be useful to know whether or not these last areas have been added to that of natural pastures.

A probably substantial though undetermined proportion of the lands used for agriculture, especially in the humid tropical regions, returns to forest when left fallow as part of a long rotation or when abandoned for one reason or another. Such secondary forests, particularly those that grow on lands abandoned because of abusive practices, may be of limited future value and their indiscriminate inclusion in the category of forests (probably as dense forests in some cases) alters the actual situation regarding forests from the standpoint of production as well as that of protective value.

Another important aspect with regard to forests is the possible future action of man which, while not necessarily destructive or damaging, can alter their ecosystems to a significant degree. In this connection, Lanly and Gillis (1980) state that in the period 1976-80 about 3 million hectares have been brought into use each year; this represents an annual average of

0.4% of the area of dense tropical forests. FAO (1979) has projected the future consumption of industrial wood products in Latin America which -- depending on the product -- will double or triple; moreover, this region will account for a large share of the international trade in forest products. On the basis of these forecasts, FAO estimates that by the year 2000 a minimum of about 625 million cubic meters of wood will be cut annually, of which 450 million cubic meters will be for fuelwood and 175 million for industrial wood. Assuming that the average rate of extraction will be 20 m3/ha at that time, this could mean that about 31 million hectares would affected by such cutting each year, i.e. ten times the area now being worked annually in dense tropical forests. But this calculation is simplistic since in principle only industrial wood is extracted from dense forests, fuelwood being a byproduct of such extraction. In this case it is likely that -- assuming an average extraction of 25 m3/ha -- about 7 million hectares of dense forest is worked each year. Fuelwood is taken above all from open forests, but in this case it is probable that not more than 5 m3/ha is obtained, which means that an even larger area would be affected.

3.6.4 Other land

According to the trend-based projections, the area of "other" or unusable land will decrease from 321 to 276 million hectares between 1977 and 2000. But this trend for Latin America and the Caribbean is not shared by North America (Mexico), where the area of "other land" is projected to increase from 24 to 42 million hectares in the same period (Table 58), probably because of the expansion of deserts and erosion (alternatives I and II).

In 1977 deserts represented 214 million of the 321 million hectares of "other land." The forecasts indicate that at least 20% of this expansion will come from what today is semi-desert. In this case there will be 232 million hectares of desert in 1990 and 252 million hectares in 2000. Adopting the trend-based values indicated above, this would mean that -- even excluding the approximately 9 million hectares of irrigated land recovered from the desert -- there would be a decrease in the areas of bare rock, permafrost, salt deposits, marshland and other untilled land, and that the proportion of land used for urban, industrial or road construction purposes would also decrease. This is obviously absurd, demonstrating once more the scant value of the statistics. This is seen all the more clearly if we add to the foregoing the impact of intensive erosion in the hemisphere, which is greatly increasing the area of soils with rock outcroppings. For all these reasons, and taking drainage programs into account, the most that can be accepted is that the area of "other" non-desert land will not increase significantly but by no means will decrease. In this case there will be about 360 million hectares in this category in the year 2000 (alternative III).

For alternative IV a larger proportion has been assigned to lands lost or wasted because of abusive agricultural or forestry practices, and land affected by human infrastructures. The overall increase assumed for this category of land in alternative IV is 1% per year, which is moderate, giving an estimate of about 395 million hectares for the year 2000.

3.7 The most probable alternatives and their environmental implications

Table 63 summarizes the four alternatives explained in the preceding section with regard to the future use of land for Latin America and the Caribbean

as a whole. For the reasons stated, alternatives III and IV (especially III) are regarded as most probable. Actually, the fundamental difference between these two alternatives is the placement of grazed forest lands in the category of pastures in alternative IV and not in that of forests as in III. In addition, the most "pessimistic" alternative (IV) also assumes an excessively limited expansion of arable land which is not very probable. In other words, assuming that agriculture will expand by about 200 million hectares (the likely minimum), the area of pastures in alternative IV will be about 1,013 million hectares in the year 2000, i.e. 50% of the area of the entire region.

Table 63. Summary of alternatives (I, II, III, IV) ~~regarding~~ for land use in Latin America and the Caribbean in 1990 and 2000 (in millions of hectares and %)

Alternative		1977				1990				2000			
		Arable	Pastures	Forests and the like	Other	Arable	Pastures	Forests and the like	Other	Arable	Pastures	Forests and the like	Other
I	Area	143	532	1,019	321	168	569	980	296	188	596	951	276
	%	7.1	26.4	50.6	15.9	8.3	28.3	48.7	14.7	9.3	29.6	47.3	13.7
II	Area	175	532	991	321	238	569	915	297	291	596	854	279
	%	8.7	26.3	49.1	15.9	11.8	28.2	45.3	14.7	14.4	29.5	42.3	13.8
III	Area	175	532	991	321	238	640	801	340	291	695	673	360
	%	8.7	26.3	49.1	15.9	11.8	31.7	39.7	16.8	14.4	34.4	33.3	17.8
IV	Area									165	1,048	411	395
	%									8.2	51.9	20.3	19.6

Notes: Alternative I is a strictly trend-based projection from uncorrected data.
Alternative II is a combined of trend-based and normative projections from corrected statistics.
Alternative III is identical to II, with adjustments in pastures and other land.
Alternative IV is based on projections relating essentially to agriculture, forests and other land, with pastures calculated by difference.

Sources: Tables 58 and 59 and the discussion in section 3.6.

The picture of land use in the year 2000 will therefore be substantially different from what it is at present or what it was in 1977, the base year. By the end of the century it is expected that not less than 49% of the land area of Latin America will be devoted to farming and stockraising, which will have drastically altered the natural ecosystems; however, it is possible that this effect will be felt on as much as 60%. To both of these estimates must be added the lands, included in the category of "other," which will have been made sterile because of the effect of human infrastructures or because they will have reached an extreme degree of deterioration, as well as cultivated or heavily worked forests. It can therefore be said with justification that the countries of Latin America and the Caribbean as a whole will begin the 21st century with 60 to 70% of their territory in conditions essentially determined by man. Of the remainder, 51 to 65% will be natural forests and 35 to 49% other natural areas such as arid, rocky and humid lands or land covered by permanent ice or snow, which do not support ~~living~~ life. But virtually all of the natural forests and other areas will have been affected to a lesser extent than the forests in other categories, remaining in their natural though not pristine condition, which will be limited to conservation areas and to a very few scattered units.

Should the situation in the year 2000 be that of alternative III -- which is regarded as most likely -- the area studied will have 14.4% of its land devoted to agriculture and 34.4% to stockraising, followed closely by forests which by that time would cover 33.3% of the area, and finally 17.8% classified as "other land." These figures are broken down in Table 64, which shows that 66% of the arable land will be harvested each year while the rest will be fallow, and that 92% of the land will be rainfed and 8% will be irrigated. Dense tropical forests will account for 78% of all forests, while dense temperate

forests and open forests will each cover 11% of the forest area. Finally, deserts will cover 70% of the "other land" with the remainder covered by rock, ice, marshes and other natural limiting factors, or occupied by housing and other structures.

Table 64. Breakdown of alternative III for the future use of land in Latin America and the Caribbean, considered as most probable (in millions of hectares)

Year	Arable land				Pastures	Forests and the like			Other land		
	Harvested	Fallow	Rainfed	Irrigated		Dense tropical	Dense temperate	Open	Arid	Rock, ice, marshes, etc.	Urban
2000	193	98	269	22	695	524	72	77	251	109	
1990	153	84	219	18	640	592	77	132	232	108	
1977	118	57	162	13	532	681	81	229	214	107	

Source: Table 64 and various tables and discussions in previous sections.

Among regions, the situation obviously will be more drastic in the Caribbean than elsewhere, but will not have changed much more than in North America and the Southern Tier. Although the area used for agriculture and especially for stockraising in the latter region is enormous and proportionately larger than in the Caribbean, a less significant alteration of ecosystems is foreseen because of their comparatively less fragile condition. Lands in the Andean and Atlantic regions will be less affected by human activity than in the others, while Central America -- despite its small size -- will have a situation different from that of the three most altered regions.

In this process of expansion of human activity many of the natural ecosystems represented by relatively small areas will disappear completely and will be replaced by anthropic ecosystems, i.e. crop fields, pastures or forest plantings. This process will be more intensive where soil quality is higher or the land is more accessible. Most of this agricultural expansion will take place at the expense of tropical rainforests. Stockraising also will expand partly into areas now occupied by tropical rainforests, and to a great extent at the expense of dry open or dense forests. As already indicated, many protective forests -- especially those so classified because of their steep slopes -- are and will continue to be ~~occupied by~~ used for farming and stockraising.

4. WATER

4.1 Potential

Latin America and the Caribbean have significant water resources, far exceeding those available on other continents. Their average annual precipitation of 1,500 mm is 50% more than the average world precipitation of 970 mm, and they account for 31% of the surface runoff to all oceans of the world. Nonetheless, the distribution of rainfall is not uniform and extremely dry areas are found next to excessively wet areas. The seasonal distribution and the annual variation of rainfall also are irregular, with successive wet periods and droughts in vast areas.

The watersheds of the Atlantic and the Caribbean are the largest (84% of the region). They contain the longest and most abundant rivers, with the largest part of their basins located in tropical climates, covered by dense vegetation and with gradients of less than 0.5%. They have extensive flood plains and areas with limited drainage. The Pacific slope~~s~~ account~~s~~ for 11% of the area of the region studied. It has small basins, usually with steep slopes and nearly bare of vegetation. River flows are subject to sharp seasonal fluctuations, and moreover transport massive volumes of sediments. Finally, 5% of the total area of Latin America lacks a direct outlet to the sea. Tables 65 and 66 present data on the area of the principal watersheds, their average precipitation and the average flow at the outlet.

Table 65. National and international watersheds and average precipitation by region and country in Latin America and the Caribbean.

Region / Country / Watershed	National Watersheds (000 km2)	International watersheds (000 km2)	Area by watersheds (000 km2)	Average precipitation (mm)
NORTH AMERICA				
Mexico	1,536	437		780
Caribbean			716	1,070
Pacific			837	650
Landlocked			370	390
Total	1,536	437	1,973	
CENTRAL AMERICA				
Belize	11	12	23	
Costa Rica	36	15		
Caribbean			24	
Pacific			27	
El Salvador	8	13	21	1,820
Guatemala	30	79		2,030
Caribbean			86	2,000
Pacific			23	2,130
Honduras	86	26		1,710
Caribbean			92	1,780
Pacific			20	1,380
Nicaragua	82	48		2,140
Caribbean			117	2,210
Pacific			13	1,520
Panama	73	4		3,094
Caribbean			24	3,745
Pacific			53	2,819
Total	326	197	523	
CARIBBEAN				
Bahamas	11.4			
Barbados	0.4			
Cuba	114			1,400
Haiti	21	7		1,380
Jamaica	11			1,980
Dominican Rep.	46	3		1,390
Trinidad and Tobago	5			1,260
Total	208.8	10	218.8	
ANDEAN				
Bolivia	63	1,036		1,250
Plata			230	840
Amazon			71?	1,380
Landlocked			150	220

Table 65 continued

Colombia	456	683		2,400
Orinoco			331	2,160
Amazon			330	2,840
Magdalena			234	1,730
Pacific			73	4,970
Caribbean			116	2,690
Ecuador	116	168		2,000
Amazon			150	2,310
Pacific			134	1,640
Peru	271	1,014		1,690
Pacific			277	200
Amazon			962	2,180
Landlocked			56	720
Venezuela	166	746		1,960
Orinoco			630	2,110
Atlantic			43	1,360
Amazon			43	3,320
Caribbean			191	1,330
Total	1,072	3,647	4,719	
ATLANTIC				
Brazil	3,222	5,290		1,790
Amazon			3,841	2,510
North Atlantic			1,826	1,090
São Francisco			629	1,020
South Atlantic			796	1,580
Plata			1,420	1,200
Guyana	45	170	215	2,560
Paraguay		407		1,020
Paranà			53	1,530
Paraguay			354	940
Suriname	65	98	163	2,420
Total	3,332	5,965	9,297	
SOUTHERN TIER				
Argentina	1,809	968		600
Plata			918	810
Atlantic			1,051	320
Pacific			87	918
Landlocked			771	410
Chile	677	80		1,030
North of Copiapó			282	40
Copiapó-Aconcagua			92	230
Aconcagua-Bió-Bió			113	920
South of Bió-Bió			268	2,390
Uruguay	7	180		1,190
Atlantic			65	970
Plata			122	1,020
Total	2,493	1,228	3,721	

Table 65 continued

SOUTH AMERICA	6,897	10,840	17,727	
LATIN AMERICA AND THE CARIBBEAN	8,967.8	11,484	20,451.8	

Note: The table excludes small Antarctic territories of several countries for which no information is available.

Source: CEPAL, based on national reports prepared for the United Nations Water Conference from the Economic Bulletin for Latin America (Vol. III) and other sources (CEPAL, 1977).

Table 66. Hydrological characteristics of the principal watersheds of Latin America and the Caribbean.

Region / Watershed	Country(ies)	Area (000 km2)	Average flow at outlet (m3/sec.)
NORTH AMERICA AND CENTRAL AMERICA			
Usumacinta-Grijalva	Guatemala/Mexico	131	3,300
Bravo	Mexico	238	150
Lerma-Santiago	"	127	364
Balsas	"	110	387
Panuco	"	74	600
Yaqui	"	50	110
Papalcapan	"	47	1,300
San Juan	Costa Rica/Nicaragua	39	1,614
Fuerte	Mexico	34	150
Coco	Honduras/Nicaragua	27	951
Patuca	Honduras	26	825
Ulua	"	23	526
Coatzacoalcos	Mexico	20	600
Grande de Motagalpa	Nicaragua	20	763
Lempa	Guatemala/Honduras/El Salvador	17	380
Motagua	Guatemala/Honduras	16	252
CARIBBEAN			
Artibonito	Haiti/Dominican Rep.	9	240
Cauto	Cuba	9	150
Yaque del Norte	Dominican Rep.	8	140
SOUTH AMERICA			
Amazon	Brazil/Colombia/Ecuador/Peru/Venezuela/Bolivia/Guyana	6,059	180,000
Rata	Brazil/Bolivia/Argentina/Paraguay/Uruguay	3,092	22,000
Orinoco	Colombia/Venezuela	982	33,000
Tocantino	Brazil	864	17,000
S. Francisco	Brazil	631	3,900
Parnaiba	"	352	4,800
Magdalena	Colombia	284	6,000
Essequibo	Venezuela/Guyana	155	5,000
Negro	Argentina	122	1,050
Pendare	Brazil	94	1,100
Doce	"	85	1,000
Courantyne	Guyana/Suriname	79	2,300
Maroni	Suriname/French Guiana	69	2,500
Jequitinhonha	Brazil	70	450
Jaguaribe	"	70	600
Paraguacu	"	60	650
Paraiba do Sul	"	56	900
Contas	"	55	510
Parinha	"	44	300
Itapicuru	"	37	350
Atrato	Colombia	36	2,700

Table 66 continued

Guayas	Ecuador	35	1,500
Boker	Chile	33	1,500
Olapoque	Brazil/French Guiana	31	1,000
Catatumbo	Colombia/Venezuela	31	350

Source: CEPAL, based on various sources (CEPAL, 1977).

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Underground water also is abundant in Latin America but has been studied and developed to only a limited extent.

Some 55% of the region studied consists of watersheds shared by two or more countries, which account for 71% of the total surface water resources. International watersheds provide 75% of the total flow in South America and 24% in Mexico and Central America. The only international watershed in the Caribbean islands produces 17% of the total runoff of the island of Hispaniola. Several international treaties regulate the use of this type of watershed (CEPAL, 1977).

4.2 Present use of water

At present, only 3% of the water resources and only 8% of the hydroelectric potential available in this part of the world are being utilized. Moreover, only about 13 million hectares are irrigated -- 7.4% of the cultivated area -- although 25% requires irrigation to a greater or lesser extent. Despite this relative abundance of water, the concentration of requirements in many places is so great that it exceeds the demand, as in the case of numerous urban and industrial areas. A similar situation prevails in the case of hydroelectric power production: the most economical resources have already been developed, and it is now necessary to make use of increasingly distant sources (CEPAL, 1977).

About 80% of the population of Latin America lives in places where the annual precipitation is between 500 and 2000 mm. In theory, then, water should not be a limiting factor for the majority of the population. The remaining 20% is divided in equal parts between those living in wetter and dryer areas. The problem of supply obviously arises for the latter, a total of about 30 million ~~periods~~ persons, but it must also be pointed out that more than 90 million rural dwellers have no access to minimum quantities of potable water (CEPAL, 1977).

Of the total water utilized in Latin America and the Caribbean, the largest proportion is consumed in irrigation, followed by hydroelectric power generation, although the two uses can be and usually are combined. Excluding hydroelectric power, as much as 80% is used for irrigation. 8% is consumed in the form of potable water and the rest for industrial and other uses.

4.2.1 Agriculture

The general problems of irrigation and drainage have already been discussed in the sections of this report referring to agriculture as a form of land use. It has been seen that despite the overall abundance of water, there is need in many areas to use irrigation as a means of filling the gap left by the lack or irregularity of precipitation. The areas in which irrigation has traditionally been used are the Andean region of Argentina, the central valley and transversal valleys of Chile, the Peruvian coastal region, northwestern Mexico and some parts of central and southern Brazil, which together represent about 75% of the irrigated area of Latin America.

Because of the importance of irrigation works, they have been promoted on their own merits and without regard to the comparative advantages of other ways of increasing production. As a result, many proposed projects have been called into question and emphasis is being placed on better utilization of existing works. In any case, it is believed that there are still many good projects offering a high return which should be developed in the near future in areas where irrigation has been customary. These works could easily double the area irrigated at present.

It has been reported that Mexico used about 31 billion cubic meters of water for irrigation in 1976, and that South America used about 35 billion cubic meters in the same year (United Nations, 1977). Other sources indicate

that just eight Latin America countries (Argentina, Chile, Cuba, El Salvador, Jamaica, Mexico, Nicaragua, Panama and Venezuela) used 94.7 billion m3 for irrigation in 1975 (CEPAL, 1977). Total current consumption of water for irrigation in the area studied can be put at about 120 billion cubic meters.

4.2.2 Domestic and urban uses

In 1974, 79% of the urban population of Latin America and the Caribbean had access to potable water and sewerage. In 1961 these services had existed for only 58% of the urban population. On the other hand, a mere 26% of rural dwellers had such facilities in 1974. Some countries -- including Barbados, Costa Rica, Nicaragua, Panama, Suriname and Trinidad and Tobago -- provide service for 100% of their urban population, but others -- such as Bolivia, Haiti and Paraguay -- are far below the average. As for the rural population, only Barbados supplies 100%, followed closely by Trinidad and Tobago. Several countries -- including Bolivia, Cuba, Ecuador, Haiti and Paraguay -- provide potable water for much less than 10% of their rural population (PAHO, 1975).

Table 67 presents data on per capita consumption of potable water in 1970 in several countries of Latin America and the Caribbean, comparing consumption in that year with future consumption, and also comparing urban and rural consumption. The latter comparison underscores the acute disparity between the two sectors, with city dwellers receiving 5 to 15 times more water than the rural population.

Table 67. Per capita use of potable water in Latin America and the Caribbean.

Region / Country	Present consumption (liters/day)				Future consumption (liters/day)			
	Urban			Rural	Urban			Rural
	Residential connections		Public connections		Residential connections		Public connections	
	Min.	Max.	Average	Average	Min.	Max.	Average	Average
NORTH AMERICA								
Mexico	100	350	35	150	100	350	35	150
Average	100	350	35	150	100	350	35	150
CENTRAL AMERICA								
Costa Rica	175	275	-	135	200	300	-	200
El Salvador	17	295	40	60	130	400	40	80
Guatemala	150	150	-	25	200	200	-	60
Honduras	20	270	-	93	160	270	-	113
Nicaragua	130	220	50	113	240	300	50	123
Panama	190	300	-	60	210	340	-	75
Average	114	252	45	84	190	302	45	109
CARIBBEAN								
Barbados	230	1,730	46	467	135	570	46	353
Haiti	150	200	30	-	175	225	30	30
Jamaica	320	390	58	170	340	570	68	248
Dominican Rep.	320	375	75	113	130	340	75	113
Average	255	674	52	250	195	426	55	186
ANDEAN								
Bolivia	60	150	18	80	150	250	-	115
Colombia	113	275	-	120	115	300	-	115
Ecuador	140	200	-	105	-	-	-	-
Peru	90	400	28	90	150	300	40	350
Venezuela	200	300	-	225	400	600	-	175
Average	121	265	23	124	204	363	40	189
ATLANTIC								
Brazil	80	500	30	48	100	500	40	48
Guyana	270	360	-	203	450	550	-	455
Paraguay	160	350	20	150	160	350	20	150
Average	170	403	25	134	237	467	30	218

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Table 67 continued

SOUTHERN TIER								
Argentina	300	600	-	150	250	350	-	150
Chile	180	400	15	100	250	500	-	100
Uruguay	120	250	-	140	126	262	-	148
Average	200	417	15	130	209	371	-	133
SOUTH AMERICA	164	362	23	130	217	400	35	180
LATIN AMERICA AND THE CARIBBEAN	158	379	39	134	199	370	43	157

Note: 1970 estimates.

Source: van der Leeden (1975), with original data from WHO (1973).

The utilization of potable water in 1975 was estimated at 9.1 billion cubic meters for the eight countries mentioned above (CEPAL, 1977) and 3 billion cubic meters for Mexico, 11 billion for South America and 5 billion for Brazil (United Nations, 1977). It was estimated in 1977 that Mexico and Chile used 75 and 26 billion cubic meters of water, respectively, for this purpose.

4.2.3 Hydroelectric power

This is the form of water use that is expanding most rapidly in the region, and moreover is making many multipurpose water development projects economically feasible. The key aspects of this use are that it returns the water at a lower elevation and usually alters its condition. There are several cases in Latin America where requirements for irrigation downstream from a hydroelectric plant have made it necessary to build another reservoir, so that the energy generation system would be compatible with the subsequent use of the water for irrigation. Hydroelectric power generation increased at an average annual rate of about 9% during the 1960s.

There is every indication that, particularly because of the world energy crisis, the tendency to increase this type of water use will continue, and at a much greater pace. Now that the most economical sources and those nearest to consumption centers have been developed, we have entered the phase of large interconnections and the incorporation of massive concentrations of capacity. Brazil has the largest projects of this kind, including joint undertakings with Paraguay and Argentina. According to estimates, the installed capacity of hydroelectric plants in Latin America may increase from 27,700 MW in 1974 to about 57,200 MW in 1980 if current plans are implemented (CEPAL, 1977).

This matter will be discussed in greater detail in connection with energy in Latin America and the Caribbean.

4.2.4 Industry

Industry has been connected to public water and sewerage systems when its needs have been comparatively small, frequently having the option of self-supply by means of wells or surface water impoundment. Large steel mills, paper and cellulose plants, petrochemical plants, sugar mills, coffee processing plants and slaughterhouses are some of the industries that have sought locations where they have direct access to sources of abundant water, sometimes far from cities. Underground water is the most common source for the large industries. In many countries water consumption for industrial purposes (including thermal energy) is expected to increase by ~~some~~ about 350% toward the end of the century.

4.2.5 River transportation

~~The use of~~ River transport is highly important on the large rivers of Latin America, and particularly in the systems of the Plata, Amazon, Orinoco and Magdalena-Cauca. Except where it serves mining operations as in Venezuela, and in the case of the Panama Canal (which uses a significant volume of fresh water), river transportation of freight and passengers has in general stagnated during the last decade, but is likely to take on renewed importance because of the energy crisis.

4.2.6 Recreation

The use of rivers and lakes for recreation has been comparatively limited in the entire study region, with the exception of Argentina, Chile, Brazil, Guatemala and Mexico, possibly because most of the population of Latin America has been concentrated in coastal areas with easy access to ocean beaches. Little attention has been given to recreation among ~~and~~ the objectives of large-scale

water projects in the past because the demand has been confined to small groups. However, this attitude has been changing drastically during the last five years as incomes have risen.

4.2.7 Mining

Mining and the related processes of concentration and refining have been located near deposits, usually in upland areas, and this form of water use often entails strong competition with other uses in areas where the resource is scarce. For example, in the Loa river basin in northern Chile, where the average annual flow is about 2.5 m3/second, the requirements of the large Chuquicamata mine and the nitrate works of Maria Elena and Pedro de Valdivia compete with the demand of the cities of Antofagasta and Tocopilla and with the requirement for irrigation of about 3,000 ha. Similar examples can be found in other parts of Chile, in Bolivia and Peru, and elsewhere. In Peru the Marcona iron mine near Nazca installed a water desalination plant to supply the population.

4.3 Future use of water

In Latin America and the Caribbean as a whole the near future will not see a significant change in the availability of water, which will continue to be abundant overall and more than sufficient for the development projected. This is true even though its use will increase by as much as 120% between 1975 and 2000; industrial consumption will increase by 320%, while the use of water for irrigation will increase by 70%. For the countries considered in Table 68, total use projected for the year 2000 will represent only about 10% of the amount available (CEPAL, 1977). On the other hand, it is estimated that the worldwide availability of water, which is about 10 times the demand at present, will be only 3.5 times projected demand in the year 2000 (United States, personal communication referring to data for the Global 2000 study).

Table 68. Use of water in the year 2000, by purpose, in selected countries of Latin America and the Caribbean (in billions of cubic meters per year).

Country	Total use		Irrigation	Potable water	Other uses	Hydroelectric power
	1975	2000				
Argentina	27.7	50.0	23.5	4.6	21.9	
Cuba	8.1	18.9(a)	15.4	1.6	1.1	
Chile	16.8	28.8	25.5	2.0	1.3	82.6
El Salvador	1.0	4.1(a)	3.3	0.8	-	8.0
Jamaica	0.3	.4	.4	-	-	
Mexico	54.2	109.5	69.0	9.9	30.6	254.8
Nicaragua	1.9	10.4	3.2	0.4	0.5	6.3
Panama	4.0	9.5(a)	4.4	0.3	4.8(b)	13.2
Venezuela	4.1	23.0	16.8	5.7	0.4	
Total	118.1	253.8	161.4	25.4	60.6	

Notes: Total use refers to consumption.

(a) Projection for 1990.

(b) Including navigation in the Panama Canal.

Source: CEPAL, 1977.

But this abundant overall supply of water ~~fails to indicate~~ conceals the severe shortages that will affect certain areas in many countries, and within them a number of major cities (such as Lima), as well as extensive agricultural areas of Chile, Peru, Brazil, Mexico and other countries. An enormous amount of water is consumed in industrial processes. For example, 3.5 kiloliters of water are required to produce one ton of cement, 4.5 kiloliters for one ton of iron ore, 5 kiloliters for one ton of coal, 17 kiloliters for one ton of coke, 20 kiloliters for one ton of steel and as much as 220 to 380 kiloliters for one ton of paper. Thus, the great industrial expansion foreseen in the area studied will have ~~a~~ an equally great ~~an~~ impact on the future demand for water.

4.3.1 Conventional technologies for increasing the supply of water

Large or small hydraulic engineering works are the most conventional means of increasing the supply of water. Latin America and the Caribbean have undertaken major water projects making it possible to irrigate 13 million hectares, obtain water for cities and industrial plants, and obviously generate hydroelectric energy. Often two or more of these objectives are combined.

Table 69 lists the largest dams in Latin America, most of which are in Brazil and Mexico. The rate of construction of hydraulic works is continuing to increase, as shown by the fact that 9% of the total lending operations of the World Bank in Latin America and the Caribbean, at June 30, 1979, were for irrigation and water regulation (4%) and potable water supply and sewerage (5%). This excludes hydraulic works in other categories, especially electricity which accounts for 27% of the Bank's lending operations.

Table 69. Largest dams in Latin America.

Dam	River	Country(ies)	Volume (millions of m3)
Ilha Soltera	Paraná	Brazil	34,206
Três Marías	São Francisco	"	22,000
Chocón	Limay	Argentina	
Yacyretá (1)	Paraná	Paraguay/Argentina	21,000
Furnas	Grande	Brazil	20,000
Itaipú (1)	Paraná	Paraguay/Brazil	19,000
Corpus (1)	"	Paraguay/Argentina	
Guri	Caroní	Venezuela	17,700
Raudales-Malpaso	Grijalva	Mexico	12,322
Infiernillo	Balsas	"	12,000
La Amistad	Bravo	Mexico/United States	6,980
Marimbundo	Grande	Brazil	6,395
Pte. Alemán	Rio Tonto	Mexico	6,167
Gatún	Chagres	Panama	5,441
Falcón	Bravo	Mexico/United States	5,050
Salto Grande	Uruguay	Argentina/Uruguay	5,000
Lázaro Cardenas	Nasas	Mexico	4,024
El Novillo (1)	Yaqui	Mexico	2,928
Guárico	Guárico	Venezuela	1,840
Alvaro Obregón	Yaqui	Mexico	1,776
Poechos	Chira	Peru	1,000

Note: (1) Under construction.

Sources: Various.

The largest projects under way include Itaipú and Yacyretá on the Paraná river, which are essentially hydroelectric developments and are being undertaken by the governments of Paraguay and Brazil (itaipú) and Paraguay and Argentina (Yacyretá), as well as the Corpus project shared by Argentina and Uruguay. There are many projects in each country.

Another non-consuming use of water, and one which has been given a new lease on life, is river transportation. It is bound to see significant expansion, especially in countries such as Paraguay and Panama, which for different but equally important reasons are involved in its development. Other major regions for such expansion are the Amazon, from Pucallpa and Iquitos in Peru through Manaos to Belem, Pará; on the Paraná-Rio de La Plata, Upper Paraná, Lower and Middle Magdalena and the Orinoco from Ciudad Bolivar, to mention only a few examples. Costa Rica has already made a substantial effort in canals for shipping.

4.3.2 Promising technologies for increasing water supply

There are numerous techniques for impounding water which do not require infrastructures of the traditional type. Many of these are simple and cheap and have been used for centuries and even millenia; however, as often happens, they have been displaced by more spectacular methods such as damming. Others are truly novel and costly but also promising. They include the collection of rainwater on hillsides by means of ditches dug by hand, which carry the water to ponds. The results of this method can be surprising, all the more if the collection area is properly modified by chemical treatment or cover. Agriculture using irrigation by runoff is another of these simple techniques allowing sufficient rainwater to be collected to produce a crop. Hillsides can be subdivided and the water collected brought to selected planting areas, where it is impounded. The same principle is applied in "microcatchments" for even a single plant, for

example. Such "microcatchments" have been developed only in certain parts of Mexico.

Irrigation with salt water is another concrete possibility, since some crops are quite tolerant ~~to~~ of concentrations of 1,000 to 2,000 mgr/l of dissolved solids, while others can tolerate up to 3,000 to 5,000 mgr/l, for example cotton, barley, wheat, sugar beets, various forage plants, pomegranate, olives, dates, pistachios, etc. Salt water is abundant in many deserts and even in many surface areas, in estuaries, tidal lagoons, landlocked lakes and irrigation drainage canals. In Peru significant use is being made of salt water on the coastal deserts, chiefly with irrigation drainage canals. The recycling of urban wastewater for agricultural purposes, after treatment, is becoming increasingly important. This technique is already being used in Mexico city (with very little treatment) and on the coast of Peru where reforestation is carried out with water previously treated in oxidation wells. Other countries with desert areas, such as Brazil and Chile, also are using this technique, which nevertheless is still expensive.

Wells dug by hand, an ancient technique, are regaining popularity thanks to new materials, designs and equipment. Their use in Latin America is still widespread in some countries (e.g. Paraguay) and it is possible that they will again take on a larger importance. There are other wells such as the "qanat~~s~~" (canal) which is essentially a horizontal tunnel enclosed in a river bed, ~~which~~ ~~brings~~ bringing underground water to the surface without pumps or equipment. Likewise, there are horizontal wells which become improved springs.

Other alternatives for the future, feasible only for the desert and semi-desert regions of Latin America, include the desalination of seawater or salt water. However, this technology is still too expensive and poses other

difficulties such as disposal of the large quantities of hot brine and pumping of the water to its point of consumption. Nonetheless, it is already being used in Argentina, Mexico and Peru. Distillation by means of solar radiation is another concrete possibility; it was used in the Atacama desert in 1872, in a plant to desalinate water for animals used in the nitrate mines, and seems to have operated for 30 years. At present solar distillation is being used in some small communities in the Caribbean. Another alternative is the "mining" of underground water, which is being developed in Mexico through the use of deep wells. The use of remote sensors to detect surface or underground water in arid zones is still another important possibility which is now being explored. It is also possible to increase rainfall by seeding clouds with hypercooled water, ice, frozen carbon dioxide, or silver iodide, causing condensation and rain. There is even speculation about the identification of icebergs of suitable size, location and other characteristics, which could be towed from Antarctica to the Chilean or Peruvian deserts. In Chile an attempt has been made to fuse glaciers in order to increase the flow of rivers. Finally, mention should be made of the possibilities afforded by the catchment of water from fog and dew; the first of these techniques has already been used in the coastal hills of Peru and Chile.

4.3.3 Technologies for conserving water

Reservoirs and canals are subject to heavy losses by evaporation. For this reason, increasing efforts have been made to reduce evaporation either by applying liquid chemical substances, wax or solid blocks of ~~sodium~~ floating material, or by storing the water in reserve wells of sand or gravel. Equally important are losses due to the permeability of canals and reservoirs, caused by calcium and other elements. Chemical treatments, still expensive but effective, exist to correct these problems. In order to reduce evaporation from the soil surface,

which accounts for 1/5 to 1/4 of the water loss in cultivation, use is being made of plant residue, gravel or volcanic ash, paper and plastic, latex, asphalt, oils and other chemical products which also can help to stabilize dunes. Irrigation by dripping and sprinkling and similar methods also are very important and are being applied in Latin America. About 200,000 ha are being irrigated by aspersion in Cuba and 70,000 ha in Peru. Control of seepage in sandy soil is a critical problem, one measure being the installation of continuous sheets or barriers of impermeable material about 60 cm below the surface, with breaks a certain distance apart for drainage. Plant transpiration can account for as much as 99% of the water absorbed by the roots, and up to 94,000 liters of water per hectare per day in a crop at full growth. Methods therefore have been sought to reduce it, using substances which close the stomata, form a film on the foliage or close the leaves; by removing unproductive leaves with defoliants, reducing the movement of air above the plants, and recycling the transpired moisture; and by genetic crossbreeding with varieties that transpire less. Another obviously important means of saving irrigation water is the selection of suitable crops and varieties, as well as their most appropriate management. Finally, mention should be made of techniques of farming in controlled environments, already discussed (greenhouses and hydroponic cultivation), which offer great possibilities. In Puerto Peñasco, Mexico, the University of Sonora has ~~important~~ a major station for the study of these possible techniques (National Academy of Sciences, 1974).

4.4 Present and future problems of the environment

4.4.1 Pollution of fresh water

According to WHO, water is contaminated or polluted when its composition or state is altered in such a way that it no longer meets the conditions which define that composition or state or when it is no longer suitable for the type of use that would have been made of it in its natural state. The definition includes

alterations in the physical, chemical and biological properties of water. The pollution of continental waters in Latin America and the Caribbean is on the whole much less severe than on the continents of the developed or overpopulated countries; locally, however, it can be quite critical and undoubtedly is increasing at a faster rate than in other parts of the world because of the lack of awareness of the situation, as reflected in legislation which is both inadequate and virtually ignored.

pollution of fresh water may be caused by urban, industrial, mining or agricultural activities. Obviously, pollution also is caused by natural factors, but at present they are the least important sources. Pollutants actually consist of several hundred substances which act individually or in chemical combinations. They can be grouped into organic substances, the most important of which are amino acids, fatty acids, esters, anionic detergents, amides, etc.; and inorganic substances, such as numerous salts dissolved in the form of ions, chiefly sodium, manganese, calcium, potassium, chloride, nitrates, fluorides, bicarbonates, phosphates and sulfates. These substances can overtax the capacity of water to purify itself by bacterial action, causing life to disappear completely by asphyxiation.

The impact of pollution is greater in rivers with a low volume of flow than in the larger rivers, but even some of the latter are now severely affected in Latin America; two examples are the La Plata river between Argentina and Uruguay and the Mantaro river in Peru. In Chile, the most polluted water courses are the Mapocho river, the Marga-Marga estuary in Viña del Mar and the Apestado river in Linares, all of which have moderate flow volumes; the same thing is occuring in Peru and in many other countries. Three rivers have been reported to be affected in Bolivia, 21 rivers in Chile, and 13 rivers and 4 lagoons in Peru (Convenio Hipólito Unanue, 1974). Lakes and lagoons are much more

susceptible to pollution than rivers; the situation of Lake Valencia in Venezuela, Lake Junín in Peru and Lake Ipacaraí in Paraguay is critical, to mention only a few examples. In general, however, the potable water consumed in most of the large cities of the area studied, such as Mexico city, is still of good quality.

Mining activities are among the most important sources of pollution of inland water in Latin America, followed closely by urban and industrial activities -- which are difficult to separate because they occur in the same place -- and finally, agricultural activities. Pollution by mining is extreme in nearly all of the Andean countries, but especially in Peru and Chile. One of the most important rivers in the Andes region, the Mantaro ~~river~~ in Peru, is heavily polluted by the processes of 14 lead, zinc and silver concentrators and foundries located on its banks, which have destroyed its fauna and impaired its direct use for agriculture. Also in Peru, the city of Lima is obliged to transfer water from the Mantaro river to the streams that provide its water supply; it is necessary to dredge Lake Junín, from which the Mantaro rises, in order to remove the mineral residue accumulated over several decades. In Chile the Lluta river basin and the La Ligua and Cabildo rivers are polluted by tailings of the Azufrera and Minas de Cobre companies (Convenio Hipólito Unanue, 1974).

The discovery of major petroleum deposits in the central part of the Amazon basin, in the Andes foothills of Bolivia, Peru and Ecuador, has already caused a substantial increase in the pollution of rivers near the places where the oil is extracted and transported by pipelines and ships. This poses a very serious potential danger to the ~~fishing~~ fishery resources and wildlife of the Amazon river and its tributaries, which are vulnerable in case of an accident.

Pollution by urban and industrial activities is caused by wastewater from the two sources. The volume of waste from daily life is constantly increasing,

reaching as much as 600 liters per person per day in the cities of developed countries; this means about 50 kg of solid dry matter per person per year. Although there are more than 400 urban wastewater treatment plants in Latin America, many of them operate inefficiently or not at all. The Dominican Republic is an exception. The main industrial wastes are those of the petrochemical, chemical and cellulose industries. In addition to contaminating water, sewerage destroys the oxygen in the water; detergents and hydrocarbons reduce ~~the~~ its self-purification capacity ~~of the water~~, and when they are combined there is a synergetic effect as the hydrocarbon is emulsified by action of the detergent. The many chemical substances of industrial origin have a wide variety of unforeseeable effects when they combine in water; moreover, virtually all of them are poisonous in large quantities. Industry also causes thermal pollution in many cases, and nuclear energy plants cause radioactive pollution with its resulting mutations. There is also a large amount of mechanical pollution caused by construction in the beds of watercourses or in their basins, which result in erosion and the production of sediment. Still another type of pollution is caused by plastic containers and other non-biodegradable materials.

Pollution from agriculture is and will continue to be caused mainly by the use of fertilizers and pesticides, by the sediments carried in erosion by water, and by salts washed out in the process of irrigation. Trends in the use of fertilizers and pesticides, in the erosion of arable land and other soils, and in irrigation and therefore salinization, point to a sharp increase during the next two decades, as already discussed. The pollution of water by agricultural activities will increase greatly, although it is unlikely to be as severe as in the developed countries. Chlorinated pesticides, which are still used in Latin America, play a key role in water pollution but are giving way to others, such as phosphates and carbamates. Fertilizers can cause excessive growth of

phytoplankton and aquatic vegetation, with severe effects on the availability of oxygen, in addition to the more rapid accumulation of sediments.

Applications of pesticides, especially those used in forests, seriously affect fish, shellfish, mollusks and other aquatic animals. Chemical products can fall into watercourses or be carried away by them through rainfall and natural drainage, with the result that pesticides of high residual potency are concentrated in inland waters, and ultimately in the seas and oceans. Moreover, it is now known that aquatic fauna are generally much more vulnerable to pesticides than terrestrial fauna. For example, certain fish are killed by DDT doses of 112 to 123 grams per hectare; in other species, the majority suffer high mortality with applications of over 1.1 kilograms per hectare (George, 1963). Trout are more resistant than other species, being affected directly by applications of 2.8 kilograms of DDT per hectare. The direct cause of mortality in fish is the toxicity of the product to them, and the indirect cause is its toxicity to the other organisms on which they feed. These organisms are even more susceptible than fish, and applications of 1.1 kilograms per hectare destroy a large proportion; the survival of the fish depends on their ability to consume other food.

As in the case of land vertebrates, each insecticide has a different effect on each species of fish or other aquatic fauna. DDT is highly toxic to these species, but other chlorides are even more harmful. On the other hand, Sevin is not toxic to fish, but unfortunately causes drastic reductions in their food supply. The formulation used is of critical importance. For example, DDT is much more toxic to fish when applied in emulsions than when applied as an oily solution. This is probably due to the capacity of the emulsion to mix with water, and ultimately to come in close contact with swimming animals (Graham and Knight, 1965).

The pollution of water by insecticides can even affect land species such as the eagle. A 1962 survey of the eagle population in the United States, where it is in danger of extinction, showed that there was a severe lack of reproduction in all coastal regions that were treated frequently for mosquito control. The reason is that eagles -- which in such environments feed largely on dead or dying fish -- were inhibited in their reproduction by the DDT residues accumulated through feeding on contaminated fish (George, 1963). Animals at the end of complex trophic chains are particularly vulnerable to residues which are concentrated gradually ~~from~~ from the numerous organisms that form the base of the pyramid to the few carrion-eaters or predators that form its peak. George (1963) cites another highly illustrative example. Three applications of TDE -- at 0.14 parts per million in 1949 and 0.02 parts in 1954 and 1957 -- took a heavy toll of grebes after the last application; 1600 parts per million of TDE were found, i.e. a concentration 80,000 times greater. One fish, the last in a food chain like the grebe, contained 2500 parts per million of TDE, a concentration 125,000 times greater. Among fish, the ~~more~~ most affected were ~~the~~ bottom-dwelling detritivores and/or carnivores, some of which were harmed significantly less because of certain habits and morphological and physiological characteristics. Other fish, hatching seven to nine months after the last application, contained 22 to 25 parts per million of TDE; as late as 1962, five years after the last application, more than one young in a grebe nest was found to have residues in ~~their~~ its fat which still totalled up to 656 parts per million. At that time two species of fish still had 253 and 379 parts per million of TDE in their fat.

4.4.2 Pollution of the sea

Sooner or later the sea receives all of the wastes or pollutants that have been evacuated on land or in inland watercourses, in addition to those that it receives directly. These include household wastewater, pesticides (chlorinated,

phosphated, carbonates, herbicides, mercury and metal-based compounds and polychlorinated biphenyl compounds), inorganic residues (acids and alkalis, nitrites and ammonia, cyanide, sulfite, titanium dioxide, mercury, lead, copper, zinc, chrome, cadmium, arsenic), radioactive materials, petroleum and dispersants, organic petrochemical and chemical substances (aromatic and aliphatic solvents, phenols, intermediaries and byproducts of plastics, amines, polycyclical aromatics), organic residues (pulp, paper waste), military waste, heat, detergents, solid objects, detritus from dredging and inert residues. Most of these pollutants cause serious harm to living resources and to human health, in addition to impairing maritime operations and diminishing natural beauty (Shinn, 1976).

Of all marine pollutants, petroleum and hydrocarbons have received the most worldwide attention because they are regarded as most destructive to aquatic life, particularly because of their persistence and their abundance up to the present. As a pollutant, petroleum enters the marine environment by natural submarine filtration and the natural decaying of marine plants and animal life. However, its main form of entry is through such human activities as coastal transportation, oil well drilling on coasts (in Venezuela, Mexico, Peru and several other countries), from oil tankers or other wrecked or damaged ships, and by ~~voluntary~~ deliberate discharges from ships that pump their cargo out and ballast their tanks with sea water. It has been estimated that human activities put nearly 5 million tons of petroleum into the oceans each year (Table 70). Actually, that is close to the amount that enters the sea naturally, but unlike the latter, discharges caused by man are concentrated along shipping routes or in specific coastal areas, causing severe damage which is well known. The capacity of marine organisms to concentrate toxic substances ~~in themselves~~ in quantities ranging from a few hundred to several million times the concentration in the environment is an aggravating factor. Petroleum has a large biological demand

for oxygen, and therefore is dangerous to surface marine life. Because petroleum substances are usually dissociated by bacterial activity, their permanence depends on the viability and efficacy of bacterial action, which itself depends on such other factors as temperature. Bacterial oxidation below 10°C is very slow; it has been found that petroleum spilled in arctic regions can remain for up to 50 years (Shinn, 1976).

Table 70. Petroleum entering the marine environment each year because of human activity.

Source	Tons per year	Percentage
Petroleum used by motors and industries	3,300,000	67.2
Tankers (normal operation)	530,000	10.7
Other ships (bilge; excluding sports vessels)	500,000	10.1
Refineries, petrochemical plants	300,000	6.0
Accidents of tankers and other ships	100,000	2.0
Other accidents	100,000	2.0
Production on coasts (normal operation)	100,000	2.0
Total	4,930,000	100.0

Source: Shinn (1976), based on the United States Environmental Protection Agency.

Pollution of the sea by petroleum is severe in extensive coastal areas of Venezuela, but especially in Lake Maracaibo, on the Atlantic coast of Mexico, on the northern coast of Peru, on the coasts of Trinidad and Tobago, on the southern coast of Argentina, in the Strait of Magellan, and in general, wherever ~~everywhere that~~ petroleum is extracted on the continental shelf ~~shelves~~. It also is significant in and around ~~the~~ large ports. South America is outside ~~away from~~ the most important oil shipping routes, the main ~~most important~~ one being that connecting Venezuela with Brazil and Argentina. On the other hand, there is a heavily travelled petroleum route between Venezuela and the United States and this, together with Mexican and Caribbean exports plus petroleum coming from the Middle East to the United States, makes the Caribbean sea and the North Atlantic as far as ~~to~~ Bermuda a region of dense traffic and high potential risk which will increase substantially up till the year 2000. It should be recalled that tankers and other ships deliberately or unintentionally (including accidents) discharge more than 50% of the petroleum emitted directly into the world's waters.

Radioactivity reaches the marine environment through natural environmental radiation, fallout from tests of nuclear weapons, direct voluntary and involuntary emissions from nuclear fission plants, elimination of their wastes, and ship reactors. Radiation levels in the environment of the ocean surface have ~~has~~ decreased since 1964 when tests of atomic weapons in the atmosphere and underwater were discontinued. In the future, wastes and emissions of nuclear energy plants will be the main source of radioactive pollution. If the demand for energy of this type continues to grow at its present rate, it will have doubled by the year 2000; given the present and foreseeable efficiency of fission, it will be necessary to dispose of ~~eliminate~~ 1,000 to 5,000 tons of waste products each year (Shinn, 1976). Since there will also be new fuel reprocessing plants, which now produce more

than 99% of the radionuclides that enter the environment, much more serious problems can be expected in the future. It is known that some marine species -- especially the lower forms in trophic chains -- have the capacity to concentrate hundreds, thousands and tens of thousands of times certain radioactive elements; it can therefore be assumed that commercial fish and man will ingest concentrated isotopes. Moreover, the genetic effects of radiation must be considered. However, these risks are not for the immediate future, much less so in Latin America, which is comparatively unaffected by ~~these~~ such problems at the present time. For example, studies of the specific activity of Zn 65 and Mn 54, the only significant radionuclides found in the Peruvian anchovy in 1964 (i.e., when tests of nuclear weapons were still being conducted in the atmosphere and in the water), showed radioactivity levels far below those at which there is any possibility of danger to man (Avila, 1971).

Large quantities of pesticides applied on land enter the sea. Among these, organic chlorinated compounds such as DDT, BHC, aldrin, dieldrin, endrin and others have been in use for 30 years, and still others for 20 years. These products are very persistent, and moreover are heavily concentrated in fatty tissues. It has been found that oysters, for example, can increase small concentrations of DDT up to 70,000 times in one month. Phosphates also play a major role, seriously affecting fish by inhibiting the production of cholinesterase, an enzyme of the nervous system; however, because of its instability it affects them only in estuaries. Carbamates and other new pesticides affect aquatic life, but the continuous development and production of new active substances severely curtail these effects.

Heavy metals form highly stable water-soluble salts. Many are extremely toxic to the marine organisms that accumulate and concentrate them. The most dangerous is mercury which, concentrated in shellfish, has already caused the death of humans who had eaten them. Lead also has reached significant levels,

as have copper, zinc, chrome and cadmium.

Household wastes usually are discharged into the sea intentionally and have two main effects. The first is excessive fertilization, which produces the well known multiplication of phytoplankton, also called "red tide" or water sickness, killing fish over vast areas. While these phenomena do occur normally, their frequency has increased with the discharge into the sea of urban wastes which increase the concentration of phosphates, nitrates and other nutrients. The second effect is poisoning, and obviously the presence of a bacterial and virotic load which can propagate disease; furthermore, solid waste diminishes the recreational and scenic value of beaches and coastal seabeds. This type of pollution, while not widespread, is already common in Latin America and the Caribbean and is tending to increase sharply.

4.4.3 Effects of hydraulic works

While it is obvious that hydraulic works are on the whole necessary and beneficial, one must not underestimate their environmental consequences, which can be very serious and often are avoidable. These include the flooding of farmland, forests, historical and archeological sites, mineral deposits and infrastructures; the creation of habitats which may be favorable to the propagation of vectors of such diseases as malaria and schistosomiasis; the alteration of river systems, halting the biologically enriching effect of flooding, among other consequences; the interruption of reproductive migrations of fish; the deterioration in water quality, salinization of the soil and elevation of the water table, etc.

The most dramatic example of this is the Aswan dam on the Nile river, which has caused the displacement of 100,000 persons; the flooding of highly valued archeological sites, many of whose monuments were saved at great cost;

the impoverishment of the soil and of sardine fisheries because of the disappearance of the sediments carried by floods; waves and tides that now erode the delta, important for farming, which formerly occurred farther inland; salinization and elevation of the water table in the most fertile region of Egypt, which now must be corrected; schistosomiasis has been propagated rapidly in irrigation canals because of the habitat that its host snail finds there now, and because of a lack of adequate sanitary conditions; finally, the water hyacinth has spread through all the canals, acting as a host for these snails and interfering with the water flow.

Latin America and the Caribbean are already familiar with problems of this kind. Some irrigation projects, coupled with poor management of irrigation water, have caused losses by salinization and elevation of the water table on areas equal to what has been gained through irrigation of the upper basin. The total deforestation of areas distant from or within the irrigation systems themselves has caused wind erosion of such magnitude that the systems and drainage canals are congested and unused. In some reservoirs exotic fish have been introduced heedlessly, scattering throughout watersheds with drastic consequences for native species. Works such as those planned on the Iguazú river can affect unique sights such as falls and national parks, as already seen in Saltos del Guairá National Park in Paraguay, submerged under the waters of the Itaipú reservoir. It is now feared that the gigantic works under way in the Paraná river basin will cause the spread of diseases, in addition to their impact on vast areas of natural pastures whose productivity seems to depend on periodic flooding. The latter also occurs with irrigation projects which, as in the case of the Puyango-Tumbes project between Peru and Ecuador, are located on waterways on which fertile marshes depend.

For a few years now there has been interest and specific action to predict and take into account environmental variables in the development of hydraulic projects in Latin America. Some examples are the Guri model, based on the project of the same name on the Caroní river in Venezuela, where a rainfall-vegetation-soil-river model was developed to predict runoff and erosion in a tropical basin with very little information (Rabinovich, 1977). A more complete model is the one devised for integrated planning and studies to determine environmental quality and the development of watersheds, based on the case study of the Bermejo river in Argentina (OEA, 1978). There are other cases, such as that of the project for transfer of water from the Mantaro river to the Rimac basin in Peru, where exhaustive studies are being made of the impact on the environment, including the effects of a dike on the aerial and aquatic fauna of a lake that was declared a national reserve years ago. Thus, there is every indication that future hydraulic projects will be undertaken with a greater awareness of their environmental consequences, and with precautionary measures that are economically feasible in terms of the comparative cost of their adverse effects and the solutions found.

4.4.4 Other environmental effects on water

The quality and quantity of water are ~~strongly~~ heavily affected by the state of conservation of watersheds. As noted in the section on watershed management, these basins are sadly neglected in Latin America and the Caribbean. Surprisingly, however, ~~the~~ large-scale hydraulic projects -- even those developed on rivers with small basins -- are undertaken with no consideration of what happens upstream from the dam; this has catastrophic effects on the economic life of the project and its operating costs. The blame may be placed in part on the countries themselves, which prefer not to increase the amount of their investment, and consequently

their indebtedness, in planning and carrying out the management of the watershed. To a large extent, however, it is also attributable to the international agencies providing economic and financial assistance, which do nothing to encourage good management. The situation is all the more absurd since irrigation and hydroelectric projects benefit those living in valleys, who as a rule are already better off; while in the upper parts of the watershed, where most of the water is generated, one usually finds the poorest inhabitants of the country.

Some changes are being made slowly in this regard. The plan for multiple use of the lake Yojoa basin in Honduras (Honduras. Proyecto Interinstitucional, 1978), the above-mentioned project in the basin of the Bermejo river in Argentina (OEA, 1978), and a detailed study of the environmental requirements for success of the Arenal and Corobicí projects in Costa Rica (Tosi, 1979), are a few examples of this changing attitude. But the studies often remain on the shelf because the government agencies responsible for projects are not willing to assume the higher costs. This happens, for example, when there is need to expropriate land in order to establish protective forests. The problem could be solved in part if, as their new policies indicate, the international banks such as the World Bank and the Inter-American Development Bank apply the sensible criteria that they have developed (World Bank 1979, IDB 1979).

One very special case is that of the Panama Canal, whose operation requires large volumes of fresh water that is available only from a rather small watershed subjected to intensive destruction of forests and highly erosive agricultural uses. The continuation of shipping in the Canal requires urgent corrective measures in the basin.

Another important aspect related to water is the "acid rain" that falls in many places but sooner or later enters watercourses and the sea. World forecasts indicate that the production of nitrogen and sulfur oxides -- the principal causes of acid rain -- will continue to rise because of the increased use of coal and petroleum-based fuels. Locally, the acidification of precipitation has reached incredible levels (ph 2.4) and has already had harmful effects in some European lake fisheries. As yet, very little is known about the global environmental consequences of acid rain, and much less in Latin America, but they seem to warrant attention.

5. AIR

Air, like water, is a natural resource, and it must be kept in mind that the air is merely a thin layer of the earth's atmosphere called the troposphere, and is in contact with the soil. This layer is about 15 km thick at the equator and only 9 km over the poles. The troposphere is divided into two layers delimited by the tropopause at a height of about 3 km. The layer closest to the earth is affected by geographic factors; atmospheric moisture and impurities are concentrated in the upper part. The circulation of masses of air from the troposphere determines climates and their variations. Above the troposphere is the stratosphere where gases are distributed according to their density; the first layer (ozone) serves as a screen and absorbs most ultraviolet radiation.

5.1 Importance of air as a natural resource

Oxygen is indispensable for the respiration of plants and animals. Nearly 19/20 of the oxygen on earth is not in the air, but is contained primarily in carbonates, certain organic substances and ferrous and ferric oxides. Apparently, there is a balance or a near balance between the oxygen produced and that consumed by the combination of human activities and the phenomena of photosynthesis and respiration. The fear has been expressed that the oxygen reserves in the air are declining, but there is no evidence in this regard; rather, it would seem that the reserves of molecular oxygen in the atmosphere and in the oceans will not be threatened by human activity in the foreseeable future. As a matter of fact, the measurements made since 1910 have shown a constant proportion of oxygen in the air, equal to 20.946%, despite the tremendous increase in human activity.

Through the action of photosynthesis, carbon dioxide gas (CO_2) is closely linked to oxygen. This gas, whether in the air or dissolved in water, is the principal reserve of carbon that can be used for the development of organic matter. Highly reliable observations have shown that the CO_2 content of the troposphere rose from 290 ppm at the beginning of the century to 321 ppm in 1970 and 332 ppm in 1976 (Siegenthaler and Oeschger, 1978). This phenomenon, as will be seen below, has been linked to the increase in human activity.

Nitrogen, which makes up 78% of the air, is as necessary to life as oxygen and carbon dioxide gas. Unlike those elements, however, nitrogen cannot be used directly by most living beings, but must first be fixed ~~previously by~~ by specific organisms or by natural or artificial chemical processes. Some estimates (Delwiche, 1970) indicate that the supply of nitrogen from processes of biological fixation may total about 92 million tons per year for the entire biosphere, and that losses due to denitrification can be put at 83 million tons. The remainder, about 9 million tons, is fixed in the soil, rivers, lakes and oceans. The approximate amount of fixation of nitrogen by the different mechanisms is known, and it is estimated that electrochemical and photochemical processes fix 4 to 10 metric tons of nitrous or nitric nitrogen per hectare per year, soil bacteria about 25 kg, and bacteria in the roots of legumes about 150 to 400 kg.

In summary, then, life depends on air through oxygen for respiration, and on oxygen as well as carbon dioxide gas and nitrogen for the formation of organic matter. Through the ozone, oxygen also makes life possible and protects it, as do other components of the atmosphere and the atmosphere as a whole, in terms of the temperature that the sun could generate if the atmosphere did not exist. Finally, mention should be made of the role of the air in the

transmission of sound and the determination of climate.

5.2 Environmental problems resulting from the use of air

5.2.1 Pollution

Air pollution may be defined as the presence of one or more extraneous substances or a major variation in the proportions of its components, which can have harmful or noxious effects, taking into account the state of scientific knowledge. The polluting agents or extraneous substances that cause pollution are gases and solids which are concentrated in suspension in the atmosphere. The sources of pollution are industrial processes, motor vehicles, household and domestic combustion and nuclear explosions; to these should be added sonic pollution or noise.

In many parts of the world, motorized land, air and water transportation is primarily responsible for pollution of the air. It is estimated that in the United States 60% of the total weight of pollutants emitted in the atmosphere comes from this source. The main polluting substances of this kind are carbon monoxide, lead, nitrogen oxide and solid particles. Industry also is a major ~~an important~~ factor, emitting a wide variety of polluting substances into the atmosphere. Household and industrial combustion --including the burning of rubbish, heating, etc. -- also is important, especially when these activities use solid fuels (coal) which produce smoke, dust and sulphurous oxide. Among the nearly 200 air pollutants that have been identified, the most important are sulfur dioxide, carbon dioxide and monoxide, nitrogen oxides, gaseous hydrocarbons released through incomplete combustion of liquid hydrocarbons, lead, fluorides and iron oxides.

Air pollution is most severe in cities and industrial areas. In such places pollutants are generated in large volumes and are concentrated and magnified by heat inversion. Sulfur dioxide is one of the most frequent pollutants found in cities. It is produced by the burning of coal or mineral oils used in industry and in heating. These substances can contain up to 5% sulfur, which is released in the atmosphere as SO_2, and can be transformed into SO_3 and ~~lead to~~ cause the formation of sulphuric acid in aerosol. The smog in many cities of the world, including Latin America, contains this substance. CO_2 is generated by the combustion of organic compounds. Carbon monoxide, hydrocarbons and nitrogen oxides are contained in the exhaust gases of combustion engines, chiefly automobiles. The most toxic are the nitrogen oxides. Lead also can be emitted by motor vehicles. Fluorine, silicates and iron oxides are produced in various industrial processes. Dust is another significant pollutant, entering the lungs in large amounts. Among the diseases associated with air pollution the most important are bronchopulmonary diseases such as asthma, emphysema and bronchitis, and cancer. But air pollution also affects plants, animals and infrastructures and other works of man, including the cultural heritage.

On the whole, air pollution is not as serious in Latin America and the Caribbean as on other continents because of its vast area and small population. But as in the case of water pollution, there are serious local problems that can sometimes reach critical dimensions, especially in mining areas and in a number of large industrial cities.

Pollution of the air by mining activities, and particularly metallurgy, is substantial in the Andean countries and in some others as well. In Bolivia the cities of Oruro and Viacha are severely affected, Oruro by smoke and gas from

mineral and metal foundries using obsolete processes, and Viacha by particulate substances emitted by cement plants. In Peru the situation of La Oroya is poignant: it has one of the country's largest smelters, which exposes the population and the surrounding countryside to high concentrations of particles in suspension and precipitated dust, as well as sulphurous anhydride, lead and arsenic. Similar problems are caused in Chimbote by a steel plant, in Mantaro and Ilo by copper, lead and zinc smelters, and in Condorcocha and Yura by the operation of cement plants. In Chile the main sources of pollution are the El Teniente mines and the smelters at Ventana, Chagres and Paipote, all of which emit sulphurous anhydride (Convenio Hipólito Unanue, 1974). And at this very moment the installation of a major zinc refinery in the suburbs of Lima is being discussed.

The Pan-American Center for Sanitary Engineering and Environmental Sciences (CEPIS) of the Pan-American Health Organization (PAHO) has joined with interested countries to establish a Pan-American network for the sampling of air pollution (REDPANAIRE). The purpose is to develop programs for the control of atmospheric pollution in urban areas of over one-half million population, and in other areas where such programs are needed. As part of this project, 87 cities of Latin America and the Caribbean have been identified as suitable for the initiation of such programs, either because they have more than one-half million inhabitants or very close to that number or because they face current or potential problems of air pollution. The latter category includes 34 cities. From 1967 to 1974 the REDPANAIRE system provided for the measurement of settleable dust, dust in suspension and sulphurous anhydride. The initial results for 29 cities in 14 countries indicate that 75.4% of the samples of settled dust, 22.9% of the samples of dust in suspension and 28.2% of the samples of sulphurous anhydride

exceeded the limits determined by the system.

Table 71 shows the distribution of general averages for each pollutant according to the number and percentage of stations at which measurements were one half, one, or more times the reference levels. It can be seen that the excesses are found primarily in settleable dust. Only 3.7% of the stations showed a general average of less than one half the reference level. In contrast, 77.8% of the total number showed averages above the reference level, while 11.1% exceeded that value by more than five times. In other words, the situation with regard to this pollutant is serious. As for dust in suspension, only 18.5% of the stations had measurements above the reference level; nevertheless, the situation cannot be considered satisfactory. Sulphurous anhydride was at or above the reference level at 25.8 of the stations, ~~which attests to~~ evidencing a major problem (CEPIS, 1976).

Table 71. Distribution of general averages of pollutants (settleable dust, dust in suspension and sulphurous anhydride) according to the number and percentage of stations located in cities of Latin America and the Caribbean whose measurements fall between specific multiplies of the respective reference levels.

Reference levels	Settleable dust		Dust in suspension		Sulphurous anhydride	
	No. of stations	%	No. of stations	%	No. of stations	%
<0.5	3	3.7	45	48.9	55	59.1
0.5 - 1	15	18.5	30	32.6	14	15.1
1.1 - 2	26	32.1	15	16.3	22	32.7
2.1 - 3	15	18.5	2	2.2	2	2.1
3.1 - 4	8	9.9				
4.1 - 5	5	6.2				
5.1 - 10	8	9.9				
>10	1	1.2				
Total	81	100.0	92	100.0	93	100.0

Notes: The reference levels are 100 ugr/m3 annual average for dust in suspension and 70 urg/m3 annual average for sulphurous anhydride. The reference level for settleable dust is 0.5 mg/cm2/month.

Source: CEPIS (1976).

According to CEPIS (1976), the cities most affected by settleable dust are Curitiba, Barranquilla, São Paulo, Guatemala City, Porto Alegre, Rosario, Córdova, Medellín, México City, Belo Horizonte, Buenos Aires, Montevideo and Bogota. In all of these, more than 80% of the samples exceeded 0.5 times the reference value. The cities where more than 25% of the daily samples exceed 100 ugr/m3 of dust in suspension -- the amount proposed as the reference level -- are San Salvador, Rosario, Buenos Aires, Montevideo, São Paulo, Havana, Mexico City, Santiago, Rio de Janeiro and Mendoza. Finally, the cities in which more than 20% of the daily samples exceed the value proposed as the reference level for sulphurous anhydride (70 ugr/m3) are São Paulo, México City, Santiago, Rosario, Havana, Montevideo and Rio de Janeiro (CEPIS, 1976).

The combination of the foregoing parameters shows that the most polluted cities are São Paulo, Rosario, Mexico City, Montevideo, Santiago, Buenos Aires, Havana, San Salvador, Rio de Janeiro, Córdova and Mendoza. Those least affected by the pollutants studied are Kingston, Holguín, Lima, Maracaibo and Santiago, Cuba (CEPIS, 1976).

Automobile traffic is a major pollutant. It has been found that each 1,000 gallons of gasoline consumed release an average 1,365 kg of carbon monoxide, 136 kg of hydrocarbons, 45 kg of sulfur compounds, 0.9 kg of ammonia and 0.14 gr of solids formed by lead, zinc, carbon and metallic oxides (State of California, Department of Public Health). Since it is also known that each vehicle travels about 1500 km per year, consuming about 800 gallons of fuel, it is easy to visualize the tremendous impact of the nearly 19 million vehicles that already existed around 1975 in Latin America and the Caribbean (Table 72). Moreover, these vehicles are concentrated largely in cities, and the majority have poorly regulated engines and use low-octane fuel. Despite the substantial increase in

the price of fuel, most private owners continue to use their vehicles individually and without restraint. Urban traffic in Latin America is chaotic, signals are not usually synchronized and technical inspections of vehicles, if any, are on the whole a mere formality. All of this aggravates the effects of vehicle use on the air, and the situation will not improve with the recent shift toward the use of diesel engines even in private vehicles.

Radioactive pollution of the air is not very serious in Latin America. On the other hand, noise pollution in cities is significant, mainly because of the failure to obey municipal ordinances.

Table 72. Land transportation vehicles in operation in Latin America and the Caribbean, excluding two-wheeled vehicles (in thousands).

Region	Automobiles	Trucks and buses
NORTH AMERICA	2,682.0	1,077.6
CENTRAL AMERICA	312.9	184.9
CARIBBEAN	1,098.9	242.9
ANDEAN	1,794.8	725.9
ATLANTIC	5,989.5	1,114.9
SOUTHERN TIER	2,434.8	1,147.5
SOUTH AMERICA	10,219.1	2,988.3
LATIN AMERICA AND THE CARIBBEAN	14,321.9	4,493.7

Note: The data refer[redacted] to years between 1974 and 1977, depending on the country.

Source: World Almanac (1980).

5.2.2 Problems of carbon dioxide and the ozone

The increase in carbon dioxide in the atmosphere is of growing concern because of the possibility that it may have a "greenhouse" effect, allowing solar radiation to enter but intercepting part of the heat radiated from the surface of the earth into space and returning it earthward.

CO_2 increases in the atmosphere for reasons that are not completely explained; however, an important role is known to be played by the use of fossil fuels, deforestation and the oxidation of carbon fixed in vegetation and in the humus, as well as by the rate of deforestation and destruction of the natural vegetation. Other factors are the pollution of seas which affects phytoplankton, especially diatoms, reducing the proportion of CO_2 recovered by these creatures, as well as the reduction in the capacity of the surface of seas -- which already have high concentrations of CO_2 -- to continue accumulating that element. These factors will be even more important in the future; it is estimated that CO_2 will reach about 400 ppm in the year 2000, and that by the early 21st century the concentration of this gas may be 4 to 8 times greater than at present (Siegenthaler and Oeschger, 1978).

The Geophysics Study Committee of the National Academy of Science of the United States (1977), through the models that it has developed, states that even a doubling of the volume of CO_2 in the atmosphere could raise the average temperature of the lower part of the atmosphere by 2 to 3°C in the middle latitudes, and could cause an increase of 7% in average world precipitation. The increase in temperature would be much greater in the polar regions. The study concludes that the rise in temperature forecast for the period 2150-2200 may mean an increase of over 6°C in the average world temperature of the air.

The ozone layer has two important and interrelated effects: it

absorbs ultraviolet light and thereby protects terrestrial life from the harmful impact of such radiation; it heats the stratosphere by the same process, causing a temperature inversion. This latter affect captures the pollutants emitted by human activities, which in turn can affect the ozone layer. The pollutants believed to be most dangerous to the ozone layer are ~~the~~ fluorocarbons used in pressurized containers, nitrogenized fertilizers and flights of aircraft in the stratosphere, especially supersonic airplanes. All of these effects will continue to increase, and it has been stated that a significant percentage of the ozone may be lost in the next 50 years, which would have grave consequences for the climate and for the health of ~~man~~ humans, animals and plants.

6. FLORA

The Flora, as a natural resource, has already been discussed to some extent in the chapters on agriculture, stockraising and forestry and in connection with soil. Some of its aspects also will be considered in relation to natural and anthropic ecosystems. The present chapter addresses other topics related to the present and future use of wild and domesticated flora and to its conservation in general.

6.1 General aspects

According to the most reliable estimates, there are no less than 375,000 species of plants. The most numerous are the dicotyledoneae with about 200,000 species, followed by monocotyledoneae (50,000), fungi (40,000), brown algae (15,000), mosses (14,000), golden algae and lycopodia (11,000 species each), ferns (10,000), hepaticae and the like (8,000), green algae (6,500) and red algae (3,500). The classes with the smallest number of species are the psylophytes (3 species), equisetineae (25), photobacteria and chemobacteria (50 species each) and cicadidae (65). Latin America and the Caribbean have a large percentage of the world flora described, and the ~~highest~~ largest percentage of the flora that has not been described. There is also a significant percentage of endemisms in this part of the world.

The flora of Latin America and the Caribbean can be grouped roughly into types corresponding to tropical rain forests, semideciduous forests, savannas, prairies, tundras, dry uplands, dry scrublands, wet uplands, semideserts and deserts and glaciers. But when narrower definitions are used, it is found for example that a single country, Peru, has up to 84 zones of natural life that can be characterized botanically and by other parameters

(Peru. ONERN, 1976). This is only one indicator of the extraordinary botanical diversity of the area studied.

It is well known that plants act as a medium for the exchange of gases, and that through their physical properties they are essential for maintaining the balance of oxygen and carbon dioxide in the atmosphere and for moderating the influence of climatic agents. By fixing solar energy through photosynthesis, green plants are the base of any trophic chain, providing all of the food that they require.

It is estimated that in the tropical regions of the world alone there are about 30,000 plants useful to mankind. Of these, at least 1,650 have highly nutritious leaves. Another 1500 species have anti-cancer properties (UNEP, 1980).

6.2 Present use of flora

6.2.1 Human diet

It is generally known that the human diet in Latin America is based essentially on agricultural production, i.e. on plants whose domestication was begun millenia ago, both in the neotropical region and in other continents of the world. Among cereals, those produced and consumed in greatest quantity are wheat and maize, followed by rice and barley. Among tubers, manioc or cassava occupies first place, followed by potatoes. The most common among the great diversity of fruits are citruses and bananas. The vegetable oils in widest use are those of the soybean and cottonseed. Sugar is produced primarily from sugarcane. In the paragraphs below some comments will be made on aspects selected because of their particular interest, with no attempt to be exhaustive.

A major possibility for many regions in which the expansion of cereal growing is limited by natural conditions is the cultivation of tropical root

plants, frequently neglected despite their merits. These include manioc or cassava (Manihot esculenta), potatoes, sweet potatoes (Ipomoea batatas), yams (Dioscorea spp) and taro and related species (Xanthosoma spp, Colocasia spp). In 1975 tropical America produced more than 50 million tons of these roots; ~~manioc~~ cassava accounted for 73%, followed by potatoes (17%) and sweet potatoes (8%). ~~Manioc~~ Cassava is a major source of calories for some 300 million persons throughout the world, including the poor rural dwellers of Brazil. It is also among the most efficient in converting solar energy into carbohydrates (Table 73); moreover, it is quite resistant to pests and diseases, requires few inputs and adapts to a wide range of conditions, especially acid soils of low fertility. Although tropical roots are comparatively poorer than cereals in protein as well as in thiamine and iron, they are excellent sources of calcium, and -- in the case of sweet potatoes -- very rich in vitamin A (Goering, 1979). These crops also have great potential as cattle feed and for industrial purposes, including the production of starch, sugars, ethyl alcohol and monocellular protein. The possibility of producing alcohol to replace 20% of the gasoline consumed by automobilies in 1990 is prompting the extensive planting of ~~manioc~~ cassava in Brazil.

Table 73. Maximum harvests recorded for certain crops.

Crop	Harvest (MT/ha/year)	Energy accumulation (Kcal/ha/day)
Cassava ~~Manioc~~	71	250
Maize	20	200
Potato	65	180
Rice	26	176
Sorghum	16 - 18	140 -158
Wheat	12	110
Banana	39	80

Source: Vries et al (1976).

In Peru, CIP is investigating the possibility of introducing potato farming in tropical or subtropical areas of countries such as Brazil, Mexico and Peru (Thompson et al, 1976). Obviously, this type of initiative calls for some caution since it should be compared with alternatives such as combining the above-mentioned advantages of legumes with those of ~~manioc~~ cassava. A full study of the sweet potato, clearly demonstrating its potential, has been published recently by Folquer (1978).

Many plants used in the diet are not domesticated, and as many others not even cultivated. Their contribution to the overall diet of a given country or that of the continent obviously ~~are~~ is quite modest; on the other hand, they can be of great local importance, and moreover, often represent wasted opportunities to use land with extreme conditions for conventional crops. Noteworthy among the tropical plants of this kind are the pejibaye or pijuayo (Guilielma gasipaes), a palm tree with highly valued and nutritious fruit, found almost everywhere in tropical America; the chestnut or Brazil nut (Bertholletia excelsa), whose seeds command a high price in the world market; the various types of palmettos or hearts of palm, among which are several species ~~of~~ with rapid growth and/or which sprout again, thus making the still latent risk of extinction of species avoidable; the chaya (Cnidoscolus chayamansa), found from Mexico to Costa Rica, whose leaves and shoots are nutritious and are eaten like vegetables; and the inchi (Caryodendron orinocence) of Ecuador, Peru, Bolivia and Colombia, which produces 300 to 800 kg of fruits containing 41% oil and 20% protein (Martinez, 1979). Also of interest are Rollinia mucosa, Eugenia stipitata, Pouteria caimito, Myrciaria paraense, Astrocaryum spp., Oenocarpus multicaulis, Theobroma grandiflorum, T. speciosum, Inga spp, Annona muricata, Genipa americana, Lucuma abovata, Campomanesia lineatifolia, Parinaium pachyphyllum, Eugenia malaccensis, Spondias lutea, S. dulcis,

Pourama cecropiaefolia, Matisia cordata and Poraqueiba paraensis, among many others and in addition to those mentioned elsewhere in this study.

The dry or temperate regions of Latin America also have many food plants that are virtually neglected, including a large number associated with forests. Those of the dry regions include the indian fig, the agave and the Prosopis, whose pods are used in the human diet in the form of various beverages. In the more temperate regions are found the two species of Araucaria (whose seeds have a high food value), Arecastrum romanzoffianum, Celtis spinosa, Copernicia spp, Cercidium australe, Jubaea spectabilis, Lithraea molleoides, Zizyphus mistol, etc. Fungi also are abundant and potentially much more usable than at present. Among those already consumed in Argentina are Boletus luteus and B. granulatis, Lactarius deliciosus, Lycopendrom perlatum, Pholiota spectabilis, Laccaria laccata, Tricholoma albo-brunneum and T. nudum (Yacubson, 1978).

In general, fungi are little used in Latin America where they are not part of food habits; this is true even of long-domesticated species such as mushrooms, which are eaten only by the upper classes. Algae have been used to a somewhat greater extent among many coastal populations, although here again consumption is not significant. A freshwater alga of the genus Spirulina was widely used in Mexico before the conquest. It is still harvested today, but is used mainly as chicken feed.

6.2.2 Animal feed

As discussed earlier, stockraising in Latin America and the Caribbean is based essentially on natural pastures in regions classified ecologically as prairies, savannas, tundras, dry scrublands, dry uplands, wet uplands and semideserts. In addition, native pastures often are used when forests are

open to stockraising. Most of the areas used for grazing have natural species of grasses or fodder of high quality, but the proportion of these in association has frequently declined drastically, with the least palatable species now predominating. This is merely one more characteristic of a situation that is reaching the level of a worldwide disaster, and is due to the backwardness of stockraising based primarily on the availability of extensive areas.

Somewhat as in the case of watersheds, the management of pastures in Latin America is a rather neglected branch of agronomy. This is reflected both in the small number of specialists available and in the absence of legal provisions and administrative bodies for the promotion of rational pasture management and use.

As discussed in the sections on stockraising, in the future this activity will depend more on non-conventional forage crops than at present. One of the plants mentioned, the Leucaena (especially L. leucocephala), is especially promising in that it offers a highly nutritious food as well as fuelwood, industrial wood and very rich organic fertilizer; moreover, as a legume it does not require nitrogenized fertilizer and is useful for erosion control on hillsides, as a windbreak, for shade and even as a firebreak. Another species, originating in Africa, is Acacia senegal, well known as a producer of gum arabic. It is of great value as a forage crop, and [redacted] produces rubber and tannin in addition to fuelwood and charcoal.

6.2.3 Clothing

Plant fibers have played a basic part in the clothing of man since the earliest times, gradually replacing hides and skins and later, to some extent, wool. From pounded bark to cotton thread, and including jute, sisal,

linen, ramie, hemp and many others, plants have served the most diverse cultures of every age for making apparel and other items of daily use, as well as tools for hunting, fishing and other basic activities such as sailing. Synthetic fibers have diminished the role of many plant fibers, but even the synthetic fibers of the future will again be made from plants.

6.2.4 Wood and cellulose

The flora has been an important source of materials for housing and the main element for making the items that man requires for his daily life. It is used in such diverse products as weapons, plows, carts and ships of all kinds. Wood from trees and ~~scrubs is~~ shrubs was the principal material used in the past and continues to be absolutely essential at present, and there is no indication that its consumption will decrease, although its relative importance has declined. On the other hand, ~~as~~ in the form of cellulose its importance is increasing day by day.

The exploitation of natural forests is still the main source of wood and cellulose in Latin America. In several countries, however, the contribution of cultivated forests is increasing greatly, as in Chile, Brazil and Argentina. Even in countries with little reforestation such as Peru, it accounted for 17% of national production of sawn lumber between 1968 and 1977.

The natural tropical forests of Latin America have an estimated 3,000 to 4,000 timber-yielding species. Fewer than 50% of these are known botanically in each country, and fewer than 10% from the standpoint of their physical-mechanical and chemical properties. In this case diversity is an impediment to the utilization of tropical woods, whose possible uses are unknown and can be ascertained only through costly studies. Moreover, each species

of already known commercial interest seldom has more than 1 to 8 trees per 10 ha., greatly raising the costs of extraction or making it virtually impossible to meet orders, except by means of wood grading systems and complex collection centers. Another adverse characteristic of these forests is the low total volume of wood per hectare, averaging 100 m3, of which the usable volume is estimated at 15 to 25 m3/ha, and a maximum of 45 m3/ha based on the traditional forms of wood use, excluding pulp manufacture. Furthermore, 60% of the tropical woods do not float, sharply increasing the costs of transportation to sawmills. These problems, which are far from being the only ones, largely explain the present limited ~~by~~ but destructive exploitation of these forests.

Actually, the extraction of trees from natural forests in Latin America has always been selective, generally involving soft and semi-soft wood species that for one reason or another had already penetrated the market and had become part of consumer habits. The classical cases are those of the cedar (Cedrela spp.) and caoba (Swietenia spp.), which for decades have ~~alone~~ accounted for much more than 50% of the production of practically any tropical country or region. When these species have been exhausted in the most accessible sites -- alongside rivers, streams and roads -- there has begun a gradual exploitation of others which are used not only for sawing but also in sheets. Among these are species of Ceiba, Virola, Cedrelinga, Amburana, Sclerolobium, Yrianthera, Cordia, Juglans, Carapa, Andiroba and others, but they have never represented a large proportion of the species available, and moreover have always been concentrated, in a given area, among only 4 or 5 species. And so, selective exploitation continues. Aside from its impact on the composition of the flora, it has other -- and perhaps more serious -- consequences. These

include its high costs, which are understandable since the present rate of extraction averages a little over 3 m3/ha in most of the forestry operations of the humid tropics; and the enormous areas covered by such operations, where they have their greatest effect on the higher fauna from which they derive additional economic benefits.

The selectivity of forest extraction also has focused, as might be expected, on species that grow in pure or relatively unmixed stands, such as Araucaria, Podocarpus and Pinus -- sought especially for the ductility of their wood and their straight trunks, among other advantages -- and broad-leaf trees such as the quebracho (Schinopsis, Aspidosperma), and guayacán (Tabebuia). . In these cases the volumes extracted per unit of area have been much greater.

The challenge of the future ~~for~~ in the exploitation of natural forests will be ensure ~~is~~ to ~~achieve a~~ more comprehensive extraction which will have a greater impact on the environment in areas where it takes place, but ~~which~~ will be greatly concentrated. This question has already been discussed and will be referred to again below.

The remaining forest production comes and will increasingly come from cultivated forests. It is interesting to observe that this production is based chiefly on exotic species, in particular ~~the~~ eucalyptus (Eucaliptus globulus in the Andean region and several species in the Atlantic region), pines (Pinus radiata in the Southern Tier and P. caribaea and others in the Atlantic, Andean and Central American regions), poplars (Southern Tier), cypresses (Andean region), Gmelina arborea (tropics of America), etc. On the whole, plantings with native species have had little success. Those of Cedrela and Swietenia, with few exceptions such as in Suriname, have failed

because of the lepidopteran shoot borer Hypsipyla grandella. For one reason or another none has prospered except perhaps Araucaria brasiliensis, which covered about 60,000 ha in Brazil in 1976 (Muthoo, 1977). This situation gives rise to much criticism from "ecologists," which is often justified with respect to species in the tropics, especially humid areas. But it has no scientific, economic or social validity for many other regions such as the Andean, where pines and eucalyptus are overwhelmingly preferable to native species, with their slow growth, extremely hard wood and twisted trunks. The "erosive" effects of the eucalyptus that have been cited cannot compare with the effects of denuded soil.

The need for fiberboard and particle board, and especially for pulp and paper, has brought a number of important changes in the prospects for the exploitation of natural tropical forests. The physical-mechanical properties of each species are less important for these purposes, which means that much greater volumes can be extracted. There are numerous projects for the manufacture of pulp and paper with tropical woods, with only a few technical details to be worked out. In the meantime, 25% of the paper consumed in Latin America and the Caribbean is made from sugar bagasse and the rest from wood of conifers and broad-leafed species, some imported but the great majority cultivated locally. To meet the raw material requirements of this industry, great potential is foreseen in pioneer trees planted on abandoned or fallow agricultural land. The most common species of this type include Cecropia, Guazuma, Ochroma and Triplaris, among others, all heliophytes and very fast-growing. This group also includes some Cordia, Ocotea, Rollina, Protium, Virola, Simarouba and others that could serve other purposes as well.

Bamboos also are plants of great usefulness but largely unexploited in Latin America and the Caribbean. Among their main uses are many identical to those of wood, i.e. for various types of construction and as pulp for paper (Guadua angustifolia, already used in Ecuador, Peru and Colombia for housing construction, among other purposes), as well as for fodder (Chusquea, throughout the Americas), basketmaking (Arundo donax from Mexico to South America) and other purposes (Bambusa, Arundinaria, Dendrocalamus, etc.). The advantage of bamboo is that it can produce enormous volumes in very little time, while its root system can be suitable for river bank protection and erosion control. Its shoots are generally edible (Vela, 1976).

6.2.5 Energy

Before the use of coal, hydroelectric power and petroleum became widespread, vegetation was the main source of energy, together with human and animal power and wind and water. Even today, the flora -- essentially in the form of fuelwood and charcoal -- is an important source of energy; in the case of Latin America and the Caribbean it accounts for an estimated 20% of total energy consumption. Worldwide, 82% of the wood consumed by the developing countries is fuelwood (FAO, 1977). But the vegetation also helps to generate energy for man in other forms, as through the alcohol obtained from such crops as sugarcane, ~~manioc~~ cassava, etc., ~~and~~ in the form of agricultural residues, including the sugar bagasse burned in mills, and by producing biogas. The topic of energy produced and producible by plant biomass is discussed below in the context of the energy problem.

6.2.6 Medicines and drugs

Several thousand plants have been known on the different continents throughout history for their medicinal properties and as drugs for diverse

purposes. Modern science has greatly neglected this knowledge, and much of it has been lost; even so, plants are ~~pillows~~ pillars of the present-day pharmacopeia. Latin America and the Caribbean have contributed a great deal to the body of world knowledge in this field, although this is the continent where ~~even more~~ the most remains to be discovered or to be transferred from the knowledge of the so-called "primitive" peoples to that of modern society. Regrettably, genetic erosion affects many medicinal plants more severely than food or wood-bearing plants, which are often much better known and more conspicuous.

The curare and the quina are two of the most famous medicinal plants of the Americas. The first is still common even though it is being exploited to the point of exhaustion; the second, however, has become rare. Incredibly, the quina or cinchona is not cultivated in its country of origin, as is ~~the case~~ true of virtually all plants of medicinal interest in this part of the world. A recent world list of medicinal plants showed that 40 of the 90 registered exist only in wild state and that another 20, although cultivated, also are harvested in nature (UNIDO, 1978).

One of the plants that has been domesticated for thousands of years on the Atlantic slopes of the central Andes is the coca (Erythroxylon coca), a ~~scrub~~ shrub whose genus includes a number of species -- some wood-bearing -- ~~whose~~ the leaves of which were used as a stimulant by the local population. Cocaine, extracted chemically from its leaves, was not known as such. In 1964 only 16,360 ha of coca were registered in all of Peru. When the massive use of this drug began in the United States in the early 1970s, the area planted with coca increased to about 40,000 ha, although official statistics are not available. It is likely that there are not less than 20,000 ha in Bolivia at present.

Aside from the catastrophic implications of the trade of this drug for human health and the public welfare, it has drastic ecological consequences; because of the present methods of its cultivation, on steep slopes with high rainfall, and with the practice of keeping the soil free of grass, a high degree of erosion results. Paradoxically, because of the great profitability of this crop -- which is illegal in most places although tolerated openly -- it receives most of the fertilizers, pesticides and other agricultural inputs in the areas where it is grown. The problem for its peaceful limitation lies in finding crops that would be economically competitive with coca on the poor-quality land that it occupies, which in the final analysis is impossible. Even the best soils of that part of the upper Amazon cannot produce anything with an equal return. Obviously, there are other ways of curtailing this crop.

In other countries of the Americas, particularly Colombia and Mexico, large areas are devoted to the cultivation of drugs consumed illegally in the United States and other developed countries. Coffee and tea are legal stimulants produced in Latin America, both of great importance; others are mate (Ilex paraguayensis) in Argentina and Paraguay and guaraná (Paullinia cupana) in Brazil.

6.2.7 Rubber, resin, oil, tannin and others

The plants that produce substances useful to man in Latin America, in addition to those already mentioned, are very numerous. Noteworthy are the hevea (Hevea brasiliensis), in both its cultivated and wild forms; leche caspi (Couma macrocarpa), the balata tree (Manilkara bidentata), the oje (Ficus antihelmintica), the rosewood (Aniba roseadora), the divi-divi (Caesalpinia tinctorea) the jojoba (Simmondsia chinensis), the annattó tree (Bixa orellana), the carnauba

palm (Copernicia cerifera), the candelilla (Euphorbia antisyphilitica) and the guayule (Parthenium argentatun) ~~and~~ among others.

The rubber tree is an excellent example of what has happened and is still happening with some species that are exploited in their natural state. Originating in the Amazon region, it was exploited intensively and to exhaustion for several decades, causing ~~the bloodiest episodes of~~ the bloody subjugation of jungle tribes, which were used as virtual slave labor or simply annihilated so that the rubber could be taken from their land. Fortunes were amassed at the cost of these people and of the resource, which, though not wiped out, has lost all of its value because of its present scarcity. All attempts to cultivate it in its original area have failed because of diseases and other factors. Today, when natural rubber is again taking on great importance, Asia and Africa have the best prospects. In 1977 Asia produced 3,074,000 MT, Africa 174,000 MT and the Americas only 4,000 MT (FAO, 1978).

One of the species with some potential is the jojoba, a wild bramble of semiarid areas, of the Sonora desert in northern Mexico, whose seeds produce an exceptionally clear liquid that competes with whale oil and is replacing it. Moreover, it hydrogenates well to form a solid wax which is substituted for other waxes. It is easy to produce about 2,250 kg/ha of dry seed, equivalent to 900 kg/ha of oil, but profitable exploitation would require about 2,500 kg/ha of oil, which seems feasible. Under these conditions, ~~the~~ demand would justify cultivation of about 10,000 ha of jojoba (Walters et al, 1979).

The perfume industry has developed on the basis of plants whose flowers continue to provide raw material for present products and inspiration for new ones.

6.2.8 Ornamental plants

The appreciable development of flower-growing and of ornamental gardens, which include plants as diverse as trees and cactuses, is another aspect which is highly important but officially little known and uncontrolled in Latin America. Flowers are ~~production is~~ being exported increasingly to Europe and the United States, given the lower production costs and the excellent environmental conditions of much of the area studied. Something similar is occurring with ornamental plants, but in this case -- for example with certain orchids and cactuses -- part of the production is of purely wild origin. Thus, the survival of certain rare and therefore greatly sought-after species is threatened.

6.2.9 Recreation

Vegetation, especially natural and forest plants, has taken on an irreplaceable role for man in his recreational activities, and no less for his concept of natural beauty.

6.3 Genetic erosion or extinction

On the whole, plants are more susceptible to extinction than animals. Moreover, the extinction of certain plants would have considerably more serious implications for mankind than that of any animal, since human well-being, through the diet, is more associated with plants. It is sufficient to visualize the consequences of losing the little-used or wild genetic material carried in such vital domesticated plants as wheat, rice, sugarcane or maize. This would make it necessary to face, without that material, the constant adaptation of natural enemies, pests and diseases, to the variety cultivated; or even worse, to be obliged to cultivate them under new environmental conditions or to cope

with drastic changes in the climatic conditions of the future. The example mentioned now applies to a large number of cultivated plants, and obviously to very many wild plants whose uses are still undiscovered. Nonetheless, the magnitude of the problem of extinction of plant species is scarcely known, and despite a few isolated warnings, little or nothing has been done.

Threats to the flora arise from a wide variety of situations. Obviously, there is a natural elimination which until a few centuries ago was perforce the main cause of genetic erosion. At present the basic cause is human activity, directly and indirectly. The direct causes include expansion of the agricultural and stockraising frontier, especially the latter; collection, which embraces all forms including forest extraction and urban and industrial expansion. The indirect causes include pollution of the soil, water and air; the application of pesticides and fertilizers to crops, which can have a killing effect on wild plants or can change the original conditions of the soil; the dissemination of animals and plants from one habitat to another; the intentional or unintentional drainage of naturally wet lands, salinization and elevation of the water table, etc. Lucas and Synge (1978) group these threats into those which are independent of species, including those mentioned above as well as others such as overgrazing, fire, construction of dams, changes in forest and pasture management techniques, tourism, highways and mining; and those dependent on species, such as the lack of pollinating agents and collaborators in germination; pests and diseases, especially those that are introduced; critically low populations, collection for botanical and ornamental purposes, selective forestry operations and traditional rural uses.

The impact of all these threats varies from one place to another, and as always it is greater wherever there are natural endemisms: islands, isolated valleys and the like. But the drastic reduction in the area of so many natural ecosystems has made them "islands of natural life," with problems equivalent to those of true islands. The coastal hills of Peru and Chile are an appalling example of this.

The IUCN, through the Committee on Endangered Plants of its Survival Commission, has estimated that no fewer than 25,000 species of plants may already be dangerously rare or seriously threatened (Lucas and Synge, 1978). That organization has begun to develop a highly detailed action plan which includes a variety of aspects in Latin America and the Caribbean, such as the gathering of information, promotion of adequate legislation, better correlation of systems of conservation units with the need to protect the flora, involvement of botanical gardens and better utilization of the Convention on International Trade of Endangered Species. Among its priorities are islands, tropical rainforests, arid zones and humid and coastal regions. Extensive information on the situation in Latin America and the Caribbean has been published by Prance and Elias (1977).

One very peculiar and important aspect of genetic erosion is that already mentioned with regard to domesticated species. The desire for standardization and the frantic search for high-yield varieties have bypassed a very large number of varieties that have other virtues, essential to deal with changing situations, through programs of crossbreeding. The fight against pests and diseases offers abundant examples of crossbreedings of highly productive but susceptible varieties with others that are highly resistant.

The loss of genetic diversity in crops is striking. For example, the wheat production of Canada is based on only four varieties, 72% of the potatoes of the United States also come from four varieties, and all Brazilian coffee trees come from a single plant (Allen, 1980). Meanwhile, crossbred, cultivated or wild varieties are lost or disappear. Populer (1979) states that there are still 557 varieties of pears in the Belgian collections, but that in 1920 a single collection had 1600 varieties of that species. As the author points out, the maintenance of official genetic collections is not sufficient and under these conditions countless varieties are lost by accident or other causes; moreover, what Belgium had in varieties of pears exists nowhere else in the world. He adds that the situation of apples is much worse.

Another report estimates that by 1991 three-fourths of the varieties of plants consumed in Europe will be extinct. These problems are aggravated by inadequate legislation which, in seeking genetic purity, bans the trade and use of non-patented or unlicensed seeds (Sierra Club International Report, March 24, 1980).

Latin America and the Caribbean are not unfamiliar with this type of problem. However, rural poverty -- which is an impediment to the introduction of new technologies -- still permits the maintenance of a wide genetic diversity of ~~the~~ plants cultivated, which often are relatives or varieties of those used in intensive or industrial agriculture. A recent discovery, perennial maize (Zea diploperennis) in Mexico, underscores the importance of this question in opening the door to ~~a~~ less erosive and less costly maize ~~crop~~ cultivation based on an already rare species.

According to Gomez Pompa et al (1972), there is reason to assume that because ~~in view~~ of the inability of the rain forest to regenerate itself under present land use conditions, species are being exposed to massive extinction. This assertion coincides fully with that of other specialists in those regions, who predict the loss of tens of thousands of animal and plant species in those ecosystems before the year 2000.

6.4 Outlook

The role of plants in human welfare will increase in the coming decades, and especially in the next century. Food of plant origin will replace that of animal origin in ever greater proportions. But the role of plants will be even more significant in many other areas, including energy, with a movement toward what may be called the optimized exploitation of photosynthesis.

6.4.1 The Phytomass

The phytomass or plant biomass and its generation and regeneration will no longer be theoretical concepts but will be manipulated by the agronomy of the future, which will come much nearer to techniques of chemical transformation than is seen in the agroindustry of the present. This is logical, especially in view of the nearly insurmountable problems posed in the exploitation of the richest and most productive ecosystems that exist -- such as the tropical rain forests -- within the prevailing economic and political context. Should that change, which also is possible, the door may be opened wider to a "small is beautiful" approach, which in the meantime will continue to be an alternative followed in part. On the other hand, it should not be assumed a priori that ~~a~~ more intensive and "artificial" development must have an adverse environmental impact, since this depends on how it is done. The fact is that the primary productivity of the vegetation justifies new models.

Lieth (1972) estimated the net primary production of the entire world as 155.2 x 10^9 MT of dry matter per year, of which 100.2 x 10^9 MT represents land productivity and 55 x 10^9 MT that of the oceans. The estimates for the annual fixing of energy are 686.9 x 10^{18} cal/year for the world, of which 426.1 x 10^{18} cal/year come from the land surface and 260.8 x 10^{18} cal/year from the oceans. Tropical forests are by far the plant formations with greatest productivity and capacity for energy fixation. Other types of forests also are very important, and for the world as a whole, forests account for two-thirds of the annual primary land productivity. In the oceans, only ~~coralifferous~~ estuaries and coral reefs have productivity comparable to that of tropical and sub-tropical forests, but their total contribution is small because of their limited area. Industrial agriculture also has a high productivity, but only 50 to 60% of that of the tropical rain forests; next are temperate rain forests and certain marine zones. The high seas and deserts have the lowest productivity (0.1 - 0.5 gr/m^2/day), while that of semiarid herbaceous formations, rainfed farming areas and upland forests is slightly higher (0.5 - 3 gr/m^2/day).

Table 74 shows the findings of Salas (1978) and those of other authors whose work he summarizes, with regard to measurements of plant biomass in certain parts of Latin America and the Caribbean, all located in tropical forests. Table 75, taken from Klinge et al (1975), shows the phytomass (in fresh matter) of a rain forest near Manaus. Table 76 complements this information with data on dead organic matter (in dry matter) for the same place.

Table 74. Values of plant biomass (MT/ha of dry matter) for selected tropical forests of Latin America and the Caribbean.

Location	Type	Phytomass/ area	Author
Puerto Rico	Low mountain forest	198 (1)	Ovington and Olson (1970)
"	Low mountain forest	311	Odum et al (1970)
Panama	Lowland forest	363 (1)	Golley et al (1969)
Brazil	Rain forest	380	Klinge (1972)
Colombia	Rain forest	325	Salas (1973)
"	Rain forest	185	"
"	Primary rain forest	326 (1)	Salas (1978)
"	Primary rain forest	182 (1)	"
"	Primary rain forest	185 (1)	"
"	Secondary forest 16 years	203 (1)	"
"	Secondary forest 5 years	68 (1)	"
"	Secondary forest 2 years	19 (1)	"

Note: (1) Without roots.

Source: Salas (1978).

Table 75. Phytomass (fresh matter) of a rain forest in the Central Amazon region.

	Tons/hectares		%
Leaves:			
Dicotyledoneous trees over 1.5 m.	14.1		1.9
Palm trees over 1.5 m.	3.4		0.5
Total over 1.5 m.	17.5	17.5	2.4
Palm trees over 1.5 m.	0.6	0.6	0.1
Total leaves of dicotyledoneous and palm trees	18.1	18.1	2.5
Branches and twigs			
Dicotyledoneous trees over 1.5 m.	202.2		27.5
Plants less than 1.5 m.	0.2		
Total branches and twigs	202.4	202.4	27.5
Trunks			
Dicotyledoneous trees over 1.5 m.	465.5		63.3
Palm trees over 1.5 m.	2.1		0.3
Total over 1.5 m	467.6	467.6	63.6
Plants less than 1.5 m.	0.6	0.6	0.1
Total trunks	468.2	468.2	63.7
Other plants (total phytomass)			
Vines	46.0		6.3
Epiphytes	0.1		-
Parasites	0.1		-
Total other plants	46.2	46.2	6.3
Total area phytomass		743.9	100.0
Roots			
Thin roots	49.0		
Other roots	206.0		
Total roots	255.0	255.0	
Total phytomass		989.9	

Source: Klinge et al (1975).

Table 76. Dead organic matter (dry matter) of a rain forest of the Central Amazon region.

Portion	Range	Average	%
	Tons per hectare		
Standing dead wood		7.6	2.7
(25 individuals/0.2 ha)			
Dead wood from the debris layer		18.2	6.5
Trunks (10 individuals/0.2 ha)	12.5		
Branches	5.7		
Fine debris		7.2	2.5
Leaves	4.0		
Wood	3.0		
Fruits, flowers	0.2		
Organic matter from the soil		250.0	88.3
Total dead matter		283.0	100.0

Source: Klinge et al (1975).

6.4.2 Harvesting and utilization of the phytomass

Because of their large area and the characteristics mentioned in the preceding section and elsewhere, the tropical rain forests of South America will be given gradually increasing attention, the first consequences of which will already be visible in the year 2000. Their development will focus on the following products: pulp and paper, plastic fibers and synthetic rubbers (Goldstein, 1975), ethanol and phenols, food for cattle and later for humans, plasticized wood and probably much more. Some of these uses of the biomass have already been discussed, and others will be mentioned in connection with the energy problem. The importance of the topic has already generated a number of meetings at which significant progress has been reported in the more intensive utilization of the forest biomass in the traditional wood industry, especially the use made of branches, leaves and stumps (FAO/ECE, 1976), which is a first step toward the great revolution that lies ahead.

One of the technologies at hand of great interest is the use of wood fiber in wood-plastic copolymers, which would solve the problem of its dimensional instability in the presence of changes in humidity and its vulnerability to xylophagous insects and fungi; moreover, such use can be made of any wood. Grafts of plastic material have been made on wood in such a way that the wood fibers are coated with a film so fine that its pores are not obstructed. Thus, the resulting product is neither wood nor plastic. Grafting with polystyrene has produced a low-cost thermolabile material with mechanical properties superior to plastic. As a matter of fact, with two parts by weight of wood and one part by weight of styrene, the elasticity modulus of polystyrene rises from 29,607 to over 70,000 kg/cm2 (Antoine, 1976).

The case described is merely one example of many new possibilities that modern physics, especially chemistry, are creating for the more intensive use of vegetation.

7. FAUNA

This chapter presents an analysis of the problems of wild land or jungle fauna, marine and continental hydrobiological resources and native and exotic domesticated or semi-domesticated fauna. Some aspects common to these three groups of animals, such as genetic erosion, are considered ~~only once~~ jointly. As for prospects, special attention is given to some of the problems that will be most significant in the future.

7.1 Availability and characteristics of fauna resources

The known fauna of the world include about 1,500 amphibians, 5,000 mammals, 6,000 reptiles, 8,600 birds, 20,000 fish, 232,000 invertebrates (excluding insects) and 650,000 to 900,000 insects. Each year new species and subspecies are described, especially insects, which already account for 70 to 80% of the animal species known. In 1900 300,000 species of insects were known, and since then an average of 6,000 to 7,000 have been identified each year. The actual total of insect species is difficult to state with accuracy, but the estimates range from 2,500,000 to as many as 10 million. The most abundant insects are the coleoptera, which alone account~~s~~ for 40% of the known species and which far outnumber the next most numerous species, the lepidoptera and hymenoptera (Sabrosky, 1952). The situation of the taxonomic groups of vertebrates is substantially different, since it is likely that more than 90% of the species are already known (although the percentage may be lower for fish). Among mammals, rodents are the most numerous group with 44% of the species, followed by the chiroptera.

In general, the neotropical fauna is least known in the world, especially its invertebrates, of which perhaps as many as 80% have not been described. This is truly regrettable since many species will become

extinct without even having been known to science; it is all the worse because endemism is very strong. Even in the case of birds and animals it is known that as many as 85% and 82% of these species, respectively, are endemic.

The fauna of land vertebrates of the continent is characterized by its relatively low average weight (the largest animal, the tapir, weighs only 300 kg), generating an insignificant animal biomass, estimated at about 20 to 30 kg/ha in the Amazon region. The rest of the land animal biomass in that region ~~comes from~~ consists of invertebrates and represents slightly over 200 kg/ha, ~~consisting~~ comprising primarily ~~of~~ soil mites and collembola and termites and ants (Fittkau and Kling, 1973). Obviously, ecosystems such as the Mato Grosso swamp or the humid pampas, among others, have a much larger vertebrate biomass in their natural condition, but even so they have less than the African savannas, to cite one example. On the other hand, because of their irregular terrain, Latin America and the Caribbean have an exceptional diversity of fauna, particularly birds and insects. For example, Colombia and Peru each have nearly 1700 species of identified birds.

7.2 Present use of wild fauna

7.2.1 Supply of protein

Hunting as a source of protein is still very important in the diet of the rural population in the forest regions of Latin America. On the other hand, it has lost importance in agricultural areas and is insignificant in urban areas, except those located in forest regions or in the case of recreation for the very rich (Dourojeanni, 1978).

Studies and surveys made from 1965 to 1977 in different parts of the Peruvian Amazon region have shown that rural dwellers obtain 85% of their animal protein from hunting and fishing. An initial study in the Pachitea river valley, which is poor in fish and sparsely populated, demonstrated that

the campesinos consumed as much as 460 gr of fresh game per person per day (Pierret and Dourojeanni, 1966). Another study on an extensive area of the Ucayali river valley found that the inhabitants consumed 51.9 gr/day/person of game meat and 135.6 gr/day/person of fish; the rest of their daily consumption was supplied by domesticated poultry and swine, but in small proportions (Pierret and Dourojeanni, 1967). Still another survey made in a rural town near the city of Iquitos yielded similar results, with a daily contribution of 75.8 gr/person (Rios et al, 1973). The city of Iquitos itself has an active, though illegal, market for game meat. The total production of game meat in the Peruvian Amazon region was estimated at over 1,300 MT in 1977. That figure does not include invertebrates, which account for 3 to 6% of the animal protein consumed (see Table 77).

Table 77. Consumption of game meat and other sources of animal protein in the Peruvian Amazon region (in grams of fresh meat per person per day).

Source	Average daily consumption per person		
	Pucallpa to Nauta (Ucayali river) (1)	Tournavista to Puerto Inca (Pachitea river) (2)	In Jenaro Herrera (Ucayali river) (3)
Fish	135.6		158.3
Game meat	52.0	460.0	75.8
Domesticated poultry	22.1		25.7
Swine	12.0		10.2
Beef cattle	-		-
Total	221.7	460.0	270.0

Notes: Beef is consumed only on important occasions and its contribution is insignificant.

Fresh fish is equivalent in protein value to 50% of meat from mammals.

Sources: (1) Pierret and Dourojeanni (1966)

(2) Pierret and Dourojeanni (1967)

(3) Rios et al (1973)

In Brazil it has been estimated that wild fauna provided 17 to 20% of the protein requirements of two villages located on the Trans-Amazon highway near Altamira, while in another older village it contributed only 2% because of the destruction of the fauna (Smith, 1976). In the first case the contribution was equivalent to about 25 gr/day/person. Near Santarem, also on the Trans-Amazon highway but in a sparsely populated region, it was estimated in 1978 that 246 gr/day/person of game meat ~~were~~ was obtained. In the cities of the Brazilian Amazon, as in those of the Peruvian Amazon, the consumption of game meat is high and it is greatly sought after.

The species that contribute most to the rural diet in the Amazon region are large animals such as Tayassu tajacu, T. pecari and Mazama americana, and small species, especially Cuniculus paca, Geochelone denticulata, Dasyprocta spp. and Dasypus spp. Large and small animals each contribute about 50%, and it is worth noting that the small animals are as important (in general slightly more so) than the large animals because the former are easier to manage in rural areas.

7.2.2 Hides and skins

No general assessments are available on the volume of hides and skins of wild animals produced in Latin America, but it is still unquestionably large even though it has decreased several times in the last decade because of the bans imposed by the countries and the greater zeal shown by governments in their enforcement. The largest volume of hides and skins has always come from the jungles of the Orinoco and the Amazon and from other forest regions of the continent, including the Gran Chaco as well as treeless regions such as the Mato Grosso Swamp and similar areas rich in fauna.

From 1965 to 1976, Peru alone exported more than 5 million hides, chiefly of Tayassu tajacu, T. pecari and Mazama americana, ~~and~~ together with nearly 500,000 skins, chiefly of Felis pardalis and Lutra amazonica, and, in a much smaller proportion, Panthera onca and Pteronura brasiliensis, among other felines. During the same period more than 500,000 reptile skins were exported, chiefly Caiman sclerops and Melanosuchus niger, (Peru, Dirección General Forestal y de Fauna, 1977). These statistics took account of contraband, which was estimated ~~in a proportion~~ as equivalent to the value of legal exports prior to the prohibition decreed in 1973, which authorized the continued exportation of hides of animals used in human consumption but prohibited all the rest. Similar information was found in many other countries, giving a picture of the enormous volume of trade based on wild fauna, which as shown by Dourojeanni (1972), exceeded the trade of wood in the Peruvian Amazon until 1972.

Another type of hunting to obtain skins took place mainly on the coasts of Peru, Chile and Uruguay, involving the seals Otaria flavescens and Arctocephalus australis in Peru and Chile and the second of those species in Uruguay. But in this case, as will be seen below, the hunting was -- at least in theory -- more controlled and somewhat less destructive. Finally, mention should be made of the hunting of chinchillas, which ~~lead~~ has led to their virtual extinction in the wild state.

7.2.3 Wool

The only wild animal that produces wool in the hemisphere is the vicuña, a species that lives in the high Andes of Bolivia, Peru, Chile and Argentina, and which will be discussed in connection with the management of fauna.

7.2.4 Guano and other products

Guano-producing birds were quite important as a source of natural organic fertilizer on the coasts of Peru and Chile. Today their importance has dwindled to a minimum, owing both to the decline in the bird population and to the appreciable increase in the demand for fertilizers. This matter will be considered more fully in the section on management of the fauna.

The wild fauna offers many other benefits through the uses that the population makes of its products: shells from marine turtles for tortoise shell, and armadillo shells for musical instruments; feathers for fans or for decorative displays in which large numbers of butterflies and other insects also are used; fat from animals such as the dolphin in folk medicine; condors for ritual ceremonies and an infinite number of organs from the most diverse animals for potions and other magical uses; etc. ~~etc~~ Because these uses often require individuals of rare species they frequently have a severe impact on populations.

One interesting and positive case of the use of fauna is that of the management of the cochinilla (Dactylopius coccus), a coccid parasite of the prickly pear which provides dyes of high quality for the cosmetics industry, among others. Its management permits the maintenance or ~~planting~~ introduction of a plant cover that helps limit erosion and at the same time yields substantial earnings in semiarid areas where there are few alternatives. At present Peru is the leading world producer, having doubled its production in the last 12 years; it currently produces well over 200,000 kg/year. Honduras and Mexico are other major producers.

7.2.5 Live animals

There was a huge traffic in live animals in the hemisphere until quite recently. It is still important but is merely a dim reminder of what it was before the governments imposed severe restrictive measures on it. Nearly 80% of this trade consisted of primates and various psittacidae in equal proportions. The rest comprised not less than 120 different species, seldom the same from year to year, which were recorded in the customs statistics and were intended mainly to supply private and public zoos. Many of the apes, and all of the birds, were used as pets a decade ago. A substantial proportion of the apes was already being used in biomedical research at that time, and this proportion has increased to the point where it is now virtually the only source of the demand for primates, as the countries began to prohibit their export or populations were exhausted.

An idea of the volume of trade in live animals can be obtained from the fact that between 1965 and 1974 Peru exported nearly 2 million individuals. About 40,000 monkeys were exported legally each year, and -- according to estimates -- as many were exported illegally. At that time the leading species was Saimiri sciureus (76%), followed by Cebus apella, Lagothrix sp., Saguinus sp., Cebuella pygmaea and six other species.

The capture of animals for ornamental purposes or for their use as pets can be eliminated without major problems if necessary. The capture of specimens for exhibit in zoos is on the whole tolerable because large numbers are not required, although there is usually excessive pressure on the rarest species. If, moreover, the methods of capture are inefficient and cause much loss of life in such cases, even this objective of capture can be dangerous

to certain species. But where the conflict is most difficult to resolve is in relation to the capture of species used for scientific research, and particularly in biomedicine. There is no doubt that laboratory animals have contributed greatly to the progress of science, and above all to the discovery of new drugs and to their risk-free use in humans ~~without risk~~. These needs are far from disappearing. Nonetheless, unlike the situation in the past when these animals were abundant, today they are used with great restraint and without waste.

Table 78 shows present requirements for neotropical primates and estimates for the year 2000 for the United States, the European Community and Japan, which are the leading world producers of medications, especially those involving scientific innovations. As may be seen, the amounts required are very small. In the year 2000 29,000 animals will be required, or ~~which represents~~ scarcely 36% of the number exported legally and illegally from Peru alone, which was never the largest supplier of primates. It should be noted that no primate has become extinct in that country, despite the substantial destruction of tropical forests and the capture of apes. At present Bolivia is by far the leading Latin American supplier of primates. In 1977 that country alone exported 62% of the animals imported by the United States, followed by Panama with 14% and Paraguay with 10% (Muckenhirn and Cohen, 1978).

Table 78. Number of non-human neotropical primates required for biomedical research in 1980 and 2000.

Species	United States		European Community		Japan		World		Total
	1980	2000	1978	2000	1979	2000	1980	2000	2000
Saguinus myxtax)	2,200	4,000							4,000
Saguinus labiatus)					800	1,500			1,500
Callithrix jacchus (b)	200	400	1,645	2,500					2,900
Antus trivirgatus	1,500	3,000			90	600			3,600
Saimiri sciureus	4,500	6,000	385	1,500	1,635	4,000			11,500
Soquinus spp. (a)			105	2,000					2,000
Cebus spp.							50	500	500
Cebuella spp.							200	3,000	3,000
Total	8,400	13,400	2,135	6,000	2,525	6,100	250	3,500	29,000

Notes: (a) Including S. mystax, S. labiatus and S. fuscicollis labiatus.

(b) Many of the C. jacchus are bred in the United Kingdom.

Source: PAHO, personal communication (1980).

The United States, for example, required about 34,000 monkeys in 1977, of which only 24% were of Latin American origin. The Saguinus are required for research in hepatitis, viral oncology, immunology and physiology of reproduction; Callithrix jacchus for general research, physiology of reproduction, teratology and safety tests of medicines; Aotus trivirgatus for chemotherapy treatment of malaria and studies of immunology and vision; and Saimiri sciureus for general research, tests of medicines and research on nutrition and the cardiovascular system. Other species of neotropical primates, such as Cebus and particularly Callicebus, are potentially important but their use still requires much basic research. If, as is already occurring in Peru and Brazil, primates are managed rationally or bred, there is no reason whatsoever to oppose their supply for medical science, all the more since the numbers actually required are and continue to be small; in addition, this is an excellent means of utilizing a fauna which otherwise would not contribute direct socioeconomic benefits. Moreover, developed countries such as the United States and Great Britain already are breeding a number of neotropical species, and eventually will be able to supplant the countries to which primates are native (US Department of Health, Education and Welfare, 1978).

The case of the African species Cercopithecus aethiops is interesting. The annual United States requirement, estimated at 2,100, comes largely from the islands of St. Kitts, Nevis and Barbados, where it was introduced during the period of slavery and where today its population is estimated at 90 to 120,000. These animals are preferred to those from Africa because they are less contaminated (PAHO, personal communication, 1980).

Other species are used for biomedical research, such as the armadillo (Dasypus novencinctus) for leprosy and genetic studies, Didelphis marsupialis for immunology, and peccaries for physiological studies; these are of great

value because they are not affected by the African swine pest.

7.2.6 Sport hunting

Sport hunting in the area of the study has not reached the level of importance attained in Europe and North America, nor is it similar to that found in Africa until a decade ago. Actually, this activity has remained more or less at an incipient level, with a modest economic impact and with little or no enforcement of hunting laws. The countries in which it is most important and most strictly regulated are Argentina and Mexico. In the other countries its development has been limited to a very small number of urban dwellers and rural landowners. In any case, this sport is found at the highest levels of society and has not been democratized, unlike what has happened in North America.

The most common large native game animals at present are the deer *Odocoileus virginianus* and the puma *Felis concolor*. In the past there were such other important animals as *Antilocapra americana*, *Ovis canadensis*, *Hippocamelus antisensis*, *Blastocerus dichotomus*, and *Ozotocerus bezoarticus*, which have become quite rare because of this type of hunting. Other large game animals that have been important in some degree in the various regions are the bear *Tremarctos ornatus* and the jaguar *Panthera onca*. ~~The~~ small game animals have included a variety of species of partridges and doves, wild rabbits and vizcachas of the pampas and the Andes. Aquatic birds, ducks, coots and woodcocks also have been a great attraction for sport hunters. In general, hunting has developed in natural or semi-natural mountain or plains areas, with or without forests, but not in tropical rain forests where the lack of visibility makes it too difficult.

Sport hunting has prompted groups of enthusiasts to promote and achieve the introduction of several exotic species in the continent, some of which have adapted well to certain regions. These include the wild boar, the stag and the hare, among others, in Argentina. On the other hand, the introduction of the stag and the doe in Peru was recessive. Also introduced, with limited success, have been pheasants and quail, among other game birds. The ecological impact of the successful introductions has been great and unquestionably adverse for native species.

Despite its limited development, sport hunting has been important locally and continues to offer significant economic potential through its great multiplier effect, if the fauna is managed for this purpose. A few countries have established hunting lands or reserves, state as well as private, but they have not been managed properly. In other cases -- such as Paraguay, Argentina and Peru -- there have been or are tourism companies offering safaris, often in open violation of the laws in force, because of the substantial profits that they obtain by providing ~~prohibited~~ forbidden trophies. Nevertheless, in Latin America these activities are neither as extensive nor as serious as in Africa.

7.2.7 Tourism

The fauna is a tourist attraction to be seen and photographed as well as hunted. Obviously, the land fauna of Latin America and the Caribbean is far less spectacular than that of Africa, and the tourism centering upon it is much less developed than on that continent. Nonetheless, such animals as the Galapagos turtles and iguanas, the condors and guano birds of Peru, the vicuñas of the central Andes, the elephant seals of the Valdez peninsula in Argentina, the readily visible and highly diversified fauna of the Mato Grosso swamps and of the Gran Chaco, and the whales of the Ojo de Liebre and Guerrero Negro lagoons in the lower part of the Baja California peninsula in Mexico are so impressive that they have already generated a large and increasing flow of tourists.

Obviously, in Latin America as elsewhere in the world, tourism for sightseeing tends to focus on the fauna to be found in national parks and other protected areas, which moreover have unique scenery and/or other equally important attractions. Thus, it is difficult to single out the role of fauna as an attraction for domestic or international tourism, but there can be no doubt that it plays a major part.

7.2.8 Industry and trade

Despite the significant volumes of hides, skins, wools and other products extracted from the fauna resources of Latin America, there has been little and in many cases no industrial and commercial development based on these products. Virtually all of them were and are exported or smuggled as raw material, without any treatment or processing whatsoever, and often are acquired by the exporter -- legally or illegally -- at ridiculous prices. Only a very few tropical

countries have established tanneries, chiefly to process crocodile hides. In the temperate countries of Latin America and the Caribbean, especially Argentina, processing has reached the point of finished products of very high quality, but this is an exceptional activity and is based on breeding (text missing).

7.3 Present use of fishery resources

The total production of marine and inland fish increased rapidly after the Second World War, from only 20 million tons in 1940 to over 70 million tons in 1970 (FAO, 1976). Present extraction, including inland fisheries, provides 6% of the world supply of protein and 18% of the animal protein. This trend has been seen in Latin America, whose seas have contributed significantly to that production; in particular, the anchovy (*Engraulis ringens*) of the southeast Pacific alone accounted for an average of 15% of world fish production from 1968 to 1972.

7.3.1 Marine fishery resources

Table 79 summarizes data on catch and potential fish production of the principal maritime regions surrounding the continent. As may be seen, the potential is very great in the southeast Pacific; that region, together with the northwest Pacific (17,400 million tons), the northeast Atlantic (14,600 million tons) and the west-central Pacific (10,400 million tons) is one of the richest seas in the world. Next in importance are the southeast Atlantic, the west-central Atlantic, and finally the east-central Atlantic. In 1975 the seas adjacent to Latin America accounted for 14% of world fish production, and had 29% of the estimated potential. Although the estimates in Table 79 are based on a recovery of the anchovy -- which has not occurred, as is well known -- they indicate that

the seas of Latin America are utilized to a much lesser extent than others ~~with~~ 23% of the potential, whereas in the northwest Pacific, the west-central Atlantic, the Mediterranean and the Black Sea, as well as the east-central Atlantic, over 60% was utilized in 1975.

Table 79. Catches and potential production of marine fish, crustaceans and cephalopods by principal maritime regions of Latin America (in thousands of metric tons).

Maritime region	Catch					Estimated potential	Utilization in 1975 (%)
	1965	1970	1972	1974	1975		
West-central Atlantic	1,192	1,208	1,298	1,334	1,350	6,400	21
Southwest Atlantic	489	1,032	774	886	824	8,500	10
East-central Pacific	575	861	923	1,023	1,233	6,000	21
Southeast Pacific	8,054	13,621	5,445	5,232	4,516	13,300 (1)	34
Total Latin America	10,310	16,722	8,440	8,475	7,923	34,200	23
Total world	42,498	57,705	52,775	56,689	55,289	116,800	47

Note: (1) Assuming full recovery of anchovy populations.

Source: FAO (1976).

Fishing does not have the same significance for all countries. In the small nations of the Caribbean it provides as much as 25.2 kg/person per year, whereas in the largest countries of that region its contribution is 14.6 kg/person per year. In Haiti, among the latter, it is only 0.9 kg/person per year. In Colombia, Venezuela, the Guianas and Central America each inhabitant has an average of much less than 10 kg per year. In Argentina consumption is even lower, and in Peru -- despite a dramatic increase in consumption -- fishing has been oriented chiefly toward industry and export. For the same reasons, we find that in the Caribbean region there are about 28,000 fishing vessels less than 7 m in length and only 1,300 exceeding that ~~figure~~ size, which may indicate the difference between small-scale and industrial fishing.

One little-known problem is that related to the impact of recreational ocean fishing, which in some countries is already quite significant. By the year 2000 this activity will have spread to the extent that proportional reductions in commercial fishing will be required to prevent stocks from being depleted.

In the northeast Atlantic all of the principal deep-water fish have been exploited, and herring populations have suffered severe losses. In many areas adult fish can no longer be caught. This case is symptomatic of what has been happening in other ocean regions, and indicates the mounting pressure exerted by the developed countries adjacent to those regions on the tropical and subtropical seas of the developing nations. Accordingly, in 1975 and 1976 the latter countries broadened their jurisdiction over the seas. This attitude is logical since the fleets of non-Latin American countries took 94% of the total catches made outside their own coasts in 1972. Moreover, it is assumed that this action will permit greater control of extraction (FAO 1976, FAO 1977).

Nevertheless, the case of the anchovy in Peru seems to show that action to extend territorial or jurisdictional waters will not suffice to rationalize fishing. According to E. del Solar (1980), the climax biomass of that species may have been as much as 30 million tons, and has now fallen to 800,000 tons owing to irrational fishing for the manufacture of meal. This activity, which lasted only 20 years (1951-1972), reached a catastrophic peak. According to the same author, this was followed by the period of the hake (Merluccius galli), for which the present rate of extraction may last about 17 years (1966-1983). We are now in the period of the sardine (Sardinops sagax), the future of which is already threatened. E. del Solar refers to these as "periods of plundering"; it might be noted that they were preceded by that of the bonito (Sarda chilensis). It is true that Peru was under international and economic pressure but the decisions that led to this calamitous situation are its sole responsibility, all the more so because the Peruvian Ocean Institute, a scientific institution of great prestige and competence, never concealed the facts of the situation.

Numerous species of cetaceans are found in the seas of Latin America, especially those of the south. Among these, there is still a great deal of hunting for the sperm whale (Physeter catodon), as well as the minke or Rudolphi finback (Balaenoptera borealis) and the sei or lesser finback (B. acutorostrata). Many other species are heading for extinction, including the blue whale (B. musculus), and now are protected by prohibitions based on international agreements and national legislation. Nevertheless, there is still a great deal of completely illegal or pirate whaling which respects no restriction and which nonetheless finds willing markets, including that of Japan. Table 80 shows Japanese imports of whale meat, and Table 81 shows the quotas established by the International Whaling Commission (IWC) of which Chile, Panama and Peru are members. With regard

to this latter table, it should be noted that the quotas refer only to ~~hunting~~ whaling in international waters.

Table 80. Japanese imports of whalemeat from Latin America, in metric tons.

Country of Origin	1976	1977	1978
Peru	1,492	1,450	2,019
Chile	88		
Brazil	48	320	319
Total Latin America	1,628	1,770	2,338
Total world	32,476	36,760	34,006

Source: Japan Tariff Association.

Table 81. Whale quotas established by the IWC and catches in the southern hemisphere (number of whales)

Species	1977-78		1978-79	1979-80
	Quota	Catch	Quota	Quota
Minke	5,690	5,000	6,221	8,102
Bryde's	-	-	-	224
Sei	771	565	-	-
Sperm	5,598	4,537	4,857	580
Total	12,369	10,102	11,078	8,946

Source: IUCN Bulletins 9(7/8) 1978 and 10(8/9) 1979.

Cases similar to that of the whales -- i.e., species that if well managed can make a great contribution to human welfare, but when over-exploited proceed inexorably to extinction -- are those of the dolphins and the sea turtles. Dolphins, virtually ignored a decade ago by Latin American fishermen, have become an increasingly sought prize, with total disregard for their population. Sea turtles, on the other hand, have always been hunted extensively, both on the beaches where they spawn and in the ocean. Practically all of the species found in Latin America have small populations or are in danger of extinction, including the green turtle (Chelonia mydas), the Carey turtle (Eretmochelys imbricata) and the mounted turtle (Caretta caretta). The destruction and human occupation of places of oviposition also have a highly adverse impact on turtles.

The term krill refers to various species of planktonic crustaceans, but more particularly to Euphausia superba which is the dominant and key species in the food chains of the Antarctic ocean, and which is also the basic food of whales. The southern ocean may contain as many as a quadrillion of these tiny animals, which in terms of weight are equivalent in protein to meat. In the past it was believed that they could be harvested annually with a sustained yield of 160 to 1,000 million tons, i.e., in sufficient amounts to multiply world fish catches several times. However, more recent studies have estimated that the maximum harvest should lie between 15 and 50 million tons. ~~Nevertheless,~~ still other studies have shown that the taking of only 2.5 million tons would reduce the food available to whales by 5%, which obviously would not contribute to the recovery of populations of these mammals. There is controversy in this regard, since prior to the commercial hunting of whales their probable annual consumption was 190 million tons. The whales still remaining consume not more than 50 million tons, apparently leaving a large amount usable by man. Still, it is likely that other species, including seals, have taken the place of the whales.

At present, fishing for krill involves ships of no less than 23 countries. The only Latin American nations among these are Argentina, Brazil, Chile, Cuba and Uruguay. While catches are still small they are growing, especially as solutions are found for the technical problems of extraction and above all marketing, one form of which is meal for cattle and poultry. Because of the restrictions on fishing in the 200 miles of jurisdictional or territorial waters that have been ~~established~~ declared, and the overfishing of waters adjacent to their territory, many developed countries -- especially Japan and the USSR -- are interested in krill.

7.3.2 ~~Continental~~ Inland fishery resources

Catches of fish in the interior waters of South America are tending to decline. Indeed, the catch fell from 230 million metric tons in 1965 and 250 million metric tons in 1970 to only 169 million tons in 1974 and 171 million tons in 1975. It is highly probable that the same or worse is occurring in Central and North America and in the Caribbean. As for the rest of the world, one is struck by the high and increasing fish production of the interior waters of Asia, which, reaching 7,393 million tons, alone accounted for 71% of the world total in 1975. Africa was in second place with 1,498 million tons, followed by the USSR with 944 million tons. These figures give an idea of the potential that remains to be developed in Latin America, where aquaculture is incipient. The only exception is the seeding of species of trout and mackerel in cold waters, and the incomprehensible attempt to replace native species of the Amazon basin with Tilapia. The tendency of the few Latin American fish farmers to give highest priority to the introduction of exotic species, instead

of domesticating or at least managing native species, has led to ecological disasters. One of these occurred in Lake Titicaca with the introduction of trout and the accompanying destruction of native species, some of them endemic, without improving the standard of living of the population, since the trout were used only for export.

Freshwater neotropical mammals such as the porpoise (Inia geoffroyensis), the silver dolphin (Stenodelphis blainvillei) and three species of Sotalia have not been exploited heavily up to the present, but a change seems to be under way. On the other hand, the manatees or sea cows (Trichechus manatus and T. inunguis) have been hunted vigorously almost everywhere in the hemisphere and are now becoming extinct. Their absence is felt in canals and other river navigation works where the aquatic vegetation is no longer controlled naturally.

7.4 Present use of domesticated or semidomesticated fauna

As indicated above, stockraising in Latin America is based essentially on species imported from Europe by the Spanish and Portuguese during and after the conquest. In modern times, stockraising and poultry farming have been benefited by many of the breeds selected in developed countries, so that breeders using more or less advanced techniques usually employ the same genetic material as elsewhere in the world. It should be noted in passing that this situation is symtomatic of a serious problem which will be discussed below. However, extensive operations at a low technical level are still based heavily on native cattle, i.e., descendents of ~~the~~ animals brought centuries ago, which have made up in hardiness and adaptation what they have lost or never had in terms of productivity. Therefore, responsibility for preserving the genetic stock of the dozen or slightly more species of domestic cattle does not lie solely with the

regions in which they originated, but with Latin America as well. As a matter of fact, the existing genetic variations among breeds, subspecies or species, or within them, provide the basis for adaptation to new situations and for the future increase of livestock production.

The introduction of the technique of artificial insemination has revolutionized the prospects of zoogenetics, particularly in the breeding of bovine cattle, which makes extensive use of frozen semen. There are also intensive methods of genetic evaluation and selection, used in combination with the foregoing. This has brought about a tremendous increase in the productivity of stockraising in the developed countries, and in some areas of Latin America as well. Moreover, livestock populations can be modified to a greater extent in a few decades than in all of history. One not entirely desirable side effect of these advances is the reduction in populations of breeds, subspecies and species regarded as less competitive. Of the total number of bovine breeds existing in 1970 in Europe and the Mediterranean basin, 115 indigenous breeds were threatened with extinction, and by 1975 only 30 remained (Launernier, 1975). For the world as a whole, and considering all species, the situation is very serious; an unknown number of breeds have already been lost, together with the wild forebears of several domesticated species. All of this can deprive the stockraising of the future of the advantages obtained from cross-breeding and back-crossing, techniques which have benefited the continent greatly, at least at the beginning when breeds of temperate countries were crossed with those of tropical countries, producing heterosis.

Contact between primitive man and the wild fauna led in many cases to taming and domestication. Such has been the case in Latin America, and although the number of animals domesticated is not large this is due chiefly to the scarcity of species as important as those found in the Asian and palearctic

regions. On the other hand, the neotropical region has contributed the largest number of domesticated plants, many of which are highly important (potatoes, maize, cotton, sugarcane, beans, peanuts, etc.). The domesticated species of fauna in this region are the guanaco -- which through selection has given us the llama and the alpaca -- the guinea pig, a dog, a turkey, a duck, and very recently the chinchilla as well.

Whealer et al (1977), on the basis of a study of animal bones found in caves in the central Andes of Peru, have developed four alternative models to interpret the phenomenon of primary utilization of camelids during the pre-ceramic period in that region: specialized and selective hunting of vicuñas (Vicugna vicugna) and guanacos (Lama guanicoe) to support a sedentary life; management of semidomesticated camelids; and pasturing of domesticated and/or semidomesticated camelids. As the authors note, the first three models are sequential rather than alternative, while the fourth is a sort of synthesis, and also indicates that the others could have existed simultaneously to some extent. Pires-Ferreira et al (1977) point out that the human populations of the area studied were stabilized with the appearance of the camelids in about 7000 B.C., and that this process culminated in the domestication of camelids between 2500 and 1750 B.C. More recently, as is well known, the selective breeding of guanacos (Lama guanicoe) evolved the llama (Lama glama), used especially for meat production and as a beast of burden; and the alpaca (Lama pacos), used for wool and meat. These animals are not really separate species, as demonstrated by the fact that all of their hybrids are fertile. Moreover, there are many more refined selections of these animals, such as the suri or huacayo alpacas, the colored llamas and all of their presumed hybrids, including those bred with the vicuña which also are fertile (Macagno, 1956). The husbandry of llamas and alpacas reached its zenith under the Inca empire, and the breeding of alpacas

is again drawing attention in Bolivia and Peru.

The guinea pig or cobayo (Cavia porcellus) was domesticated by the ancient peoples of the Andes, probably two or three millennia ago, and also has become highly important to stockraising as a source of valued meat and skins. Some modern breeds are raised for both products and reach substantial size (Luna de la Fuente and Moreno, 1966).

The native or Barbary duck (Cairina moschata) and the turkey (Meleagris gallopavo) are the only edible birds that have been domesticated in the hemisphere, and probably were introduced in Europe by Christopher Columbus. They also exist in the wild. The South American hairless dog (Canis familiaris incae) is depicted in the pre-Columbian pottery of several cultures, including ~~those of~~ the Chimu and Chancay ~~in~~ of Peru. This animal, whose lack of hair is the consequence of its evolution as a tetralogical variety (evidencing a familiar syndrome of ectodermal hypoplasia), was used in antiquity as a watchdog, for food and for magical and curative purposes (Weiss, 1970).

The chinchilla (Chinchilla chinchilla) is a special case because its domestication -- if it can be called that -- has been very recent and is due to the extermination of its natural populations for the high value of its fur. Chinchillas bred in captivity, which are highly refined breeds, are incapable of readapting to natural conditions and are a major economic resource.

Without exception, these domesticated neotropical species are greatly neglected in terms of husbandry. Aside from isolated attempts, the technology used in their breeding is primitive and their genetic resources are being lost; this is especially true of the llamas and alpacas. Despite their productive and economic potential, which in the case of guinea pigs, llamas and alpacas is truly spectacular, these species are victims of the prejudices inherited from

the colonial era. They have been neglected in favor of foreign species in the priorities and preferences of private entrepreneurs as well as government officials.

7.5 Genetic erosion and/or extinction

Because South America is a vast and comparatively underpopulated continent, few well-known species have become extinct. Indeed, recent studies have led to the "rediscovery" of animals that were thought to have disappeared long ago, such as the yellow-tailed monkey (Lagothrix flavicauda)(Mittermeir el al, 1975), the wild dove (Penelope albipennis)(Macedo, 1978) and the Chaco peccary (Catagonus wagneri) (Wetzel et al, 1975). Other animals, including the chinchilla (Chinchilla chinchilla), are apparently extinct in their natural state but survive as tamed or domesticated species. Thus, in the case of mammals, no South American species appears on the lists drawn up by Goodwin and Goodwin (1973), Ziswiler (1965) and others. Nevertheless, this situation is by no means cause for satisfaction, since no fewer than 16 birds have become extinct on various islands of the Caribbean and about 38 small mammals (notably insectivores, bats and rodents) have disappeared from the Caribbean and Central America. One bird also has become extinct in the Galapagos islands (Ziswiler, 1965).

Among the less conspicuous species, however -- i.e. invertebrates in general -- the situation may be drastically worse; the means of determining its magnitude are few and highly difficult. Invertebrates in general, which are more dependent on specific ecosystems (something like plants), suffer the same fate as plants when their habitat is drastically altered or destroyed. The destruction of the vegetation of the coastal hills of the South Pacific has meant the extinction of several thousand species, of which nothing is known.

T. Lovejoy (personal communication, 1980) has estimated the probable losses of animal and plant species in the tropical forests of Latin America by the year 2000 at 33% if the rate of deforestation is moderate, and at 50% if

the rate of deforestation is high. In the first case this would mean a loss of 100,000 to 333,000 species, and in the second case from 150,000 to 500,000 species. The losses obviously will be greater for the area studied as a whole, and also considering ocean and freshwater environments. Lovejoy (1980) further estimates global genetic erosion in all other habitats at 8%.

Among the most threatened species of vertebrates, those that can be mentioned as examples and as most widely known, are the mountain tapir (Tapirus pinchaque); the spectacled bear (Tremarctos omatus); the deer Blastocerus dichotomus, Ozotocerus bezoarticus, Hippocamelus bisulcus, H. antisensis; the manatee (Trichechus inunguis); the nutrias Pteronura brasiliensis, Lutra felina, Lutra platensis and Lutra incarum; the river turtles (Podocnemis expansa, P. unifilis) the sea turtles (Chelonia mydas, among others); various alligators (Melanosuchus niger, Caiman crocodilus yacare, Caiman latirostris), and naturally many whales. As for the less conspicuous species, such as birds and small mammals, the great majority of the many in serious danger of extinction are found in the Caribbean islands, on other islands and in Central America, where the ecosystems to which they belong have already been reduced to a minimum.

Populations of other conspicuous species whose situation was alarming two decades ago have increased appreciably, as in the case of the vicuña (Vicugna vicugna), the condor (Vultur gryphus) and the Amazon primates, to mention the major successes resulting from international agreements, the initiation of management programs and/or more effective government protection. In the case of the Amazon fauna there is no question that the most important cause of pressure in the past -- i.e. commercial hunting -- has declined considerably because of the interest shown by governments in the form of national bans, the

establishment of the Intergovernmental Technical Committee for the Conservation of Amazon Flora and Fauna, a number of binational agreements and the ratification of the Convention on International Trade of Endangered Species. Regrettably, the benefit of reduced pressure from commerical hunting is being lost because of the increase in a threat that, while not new, is becoming evermore important. By this we obviously mean the expansion of the agricultural frontier.

One especially serious situation is the risk of extinction facing the vertebrates of continental waters, especially fish, because of damming, pollution, channeling and sedimentation, ~~among~~ as well as other factors. Pollution is probably the most important of these, given the susceptibility of freshwater ecosystems to chemical and physical changes and the fact that its impact will inevitably become greater with each year.

Moreover, many marine species are highly susceptible to extinction due as much to overexploitation as to pollution. Both of these factors have their maximum impact in estuaries and on coral reefs. Unfortunately, it is much more difficult to know what really happens underwater than on land.

7.6 Prospects for the use of fauna and environmental repercussions

7.6.1 Fishery resources

As noted earlier, world maritime fishing reached its peak in 1970; since that time it has remained stable or has tended to decline slightly, demonstrating that populations of traditional fish are being fully exploited as a whole although it is obvious that some species are being overfished to an alarming extent. At present the total world catch is about 60 million tons of traditional ocean fish, and this seems to be the potential that can be taken with a sustained yield and not, as sometimes stated, 100 million tons.

Hence ~~Because of this fact~~ the coming decades are not expected to see an increase in catches, as ~~since~~ the present level of technological development will not permit it. The maintenance of the volume of the catch over time has been due largely to the addition of new species to replace traditional ones whose populations have been decimated. This will continue, and will involve ever-smaller species with ever-shorter cycles. These worldwide trends will not be seen fully in Latin America, which -- as already noted -- has a significant potential that has not been entirely utilized from the standpoint of sustained production.

For this region, FAO (1979) indicates that catches of deep-water species that have declined, such as the anchovy, could be increased considerably through careful management. A similar possibility, though offering less spectacular results, also exists for shallow-water species. On the other hand, FAO indicates that a greater fishing effort would make it possible to increase catches of hake and similar species in the seas near the southeast coasts of South America, particularly the hake found on the Patagonian shelf. Nonetheless, these populations are already receiving a great deal of attention, and by the end of the present decade there may not be many to take. There are also unutilized resources in other places, especially in the southern ~~south~~ and tropical waters; but because most of this potential embraces a wide variety of species, none of them abundant, their commercial development poses and will continue to pose serious problems of marketing. There are also possibilities of increasing the production of shellfish and cephalopods, but this will require a major effort of consumer education. On the other hand, crustaceans are generally overfished everywhere.

The theoretical potential of renewable marine resources is very great: as much as 10 to 100 times that of the traditional fisheries. But this obviously includes plankton and very small vertebrates, and it is unlikely that there will

be a significant level of fishing for them in the years ahead, with few exceptions. One of these might be the krill; another would be fishing in medium-depth waters.

For Latin America as a whole, there are also excellent possibilities of significantly expanding freshwater fishing. The available techniques include not only fish farming in semi-natural or specially-built ponds, but also breeding in interior and coastal natural waters, in pens and cages, and in canals and caverns. Moreover, aquaculture combined with agriculture has proved to be an efficient means of converting organic waste into human food. The main problem, in addition to the often limited supply of water in certain areas, is the deterioration of water quality caused by industrial, agricultural and mining pollution. Aside from these possibilities, there is an urgent need for the rational management of natural populations of fish, particularly those of the Amazon and Orinoco regions, which preferably should include the control of present methods of extraction.

Insofar as known, climatic changes up till the year 2000 will not affect potential catches to an appreciable extent. Rather, they could cause changes in the composition of species as well as in productivity by regions. On the other hand, changes caused by man such as pollution and its consequences will have a visible adverse impact on fisheries, slightly reducing harvests up till the year 2000; but ~~however,~~ unless the trend of pollution is altered its effects will be very severe thereafter.

7.6.2 Management of the fauna

Since ancient times the wild fauna has ~~have~~ served the twofold purpose of diversion for ~~of~~ the rich and survival for ~~of~~ the poor. Since antiquity also, the management of fauna has been viewed and undertaken as a means of satisfying idle

whims as well as vital needs. In a utopian world of social justice both approaches and both experiences could be combined in one, providing mankind with an excellent alternative form of land use. Such an ideal situation has been found in the past and exists in the present, although only to a limited extent.

The vicuña is without question the most intensively and best managed of all species found in a wild state in Latin America. Since 1965 Peru has had a strict program for the recovery of natural populations, which began to bear fruit in 1977 with increasing takes of animals in the area upon which the program was centered at the ~~outside~~ outset: the Pampa Galeras National Reserve in Ayacucho, Peru.

In 1965 the vicuña was near extinction. Fewer than 5,000 of these animals remained in Peru, and the situation was even worse in neighboring countries (Pierret, 1968). In 1964 a relatively large concentration had been located in Pampa Galeras, an icy plateau in the Nazca highlands. There were 700 to 1,000 animals on about 60,000 ha. (Pierret and Dourojeanni, 1967). Thereafter, thanks to the protection that was instituted, the population rose to over 38,000 by 1978 (Brack, 1978). In that year the total number of vicuñas counted in Peru was 55,500. The present population is about 45,000 in Pampa Galeras and its surrounding areas, and over 80,000 in the country as a whole. The annual increase in protected populations is 20 to 23% (Brack 1979, Hofmann 1979).

Since its initiation in 1964 and 1965 the project has been aimed at the economic and social advancement of the poorest <u>campesinos</u> of the Andean altiplano. It should be noted that the natural pastures found at over 4,000 meters above sea level are of very poor quality, and moreover bear the effects of centuries of overgrazing. As a result, their carrying capacity is scarcely 1/2 native sheep per hectare. Under these conditions the yield of the land is insignificant. It was believed that the high value of vicuña wool, meat

and other products could complement or replace current forms of production, with less damage to the environment. Calculations showed that productivity per hectare could be increased by 100 to 150% with little investment and simple technologies (Pierret 1968, Dierret and Dourojeanni 1967, Dourojeanni 1972, Dourojeanni and Ponce 1978). More recent technical and economic feasibility studies have confirmed these initial assessments, and plans therefore were made to expand the project to 9 million hectares of marginal Andean uplands, which are to be repopulated with 3 million vicuñas by the years 2010-2020 (Brack, 1979).

In a project similar to the vicuña program in Peru, but on a smaller scale, ~~the~~ management of the capybara (Hydrochoerus hidrochaeris) has been undertaken on the Venezuelan plains. This animal has great potential as a source of meat and leather. As in the case of the vicuña, its productivity is very high and far exceeds that of exotic livestock under similar conditions, which makes it an alternative with a high economic return. Several studies, including those of Ojasti (1970, 1971, 1973), Ojasti and Medina (1972), Escobar (1973), Gonzales (1972, 1974, 1977) and Gonzales and Parra (1973), confirm this fact; some enterprising stockmen have begun ~~the management of~~ to manage these animals on part of their lands with notable success.

In 1975 the Peruvian government imposed a strict ban on the capture and sale of primates, which led to a sharp reduction in supply that coincided with similar restrictions in other countries. In order to meet the demand through rational management, a project was developed with the assistance of the Pan American Health Organization (already carrying out a successful program for extensive management in the Pacaya-Samiria National Reserve), for intensive management on an island near Iquitos and at a breeding station established in that city. The operation has proved economically profitable and safe from the standpoint of conservation of the species (Neville et al 1976, Castro 1975,

Kleiman 1977). In Brazil a program for the breeding of species of the genera Saguinus and Leontopithecus has been under way for several years with noteworthy results (Coimbra-Filho 1965, Coimbra-Filho and Magnanini 1972, Coimbra-Filho and Maia 1976, 1977); management of these species in natural areas also is being undertaken (Magnanini 1977). There is a great deal of information on the management and breeding of these animals in South America and the United States (Kleiman 1977 and Pan American Health Organization 1976).

Other land species managed in some degree include deer and other large game animals, for example those introduced in Argentina from Europe, which after proper establishment have shown comparatively good tolerance of the great pressure of hunting to which they are subject. The same has been true in Peru on two of its government hunting reservations (Dourojeanni 1972, Peru. Dirección General Forestal y de Fauna 1977). Nogueira Neto (1973) prepared an extraordinary compendium, referring essentially to Brazil, of popular and scientific experiments in management, breeding and captivity, taming and the first steps towards domestication of numerous vertebrates, including several mammals. Some of those he mentions as particularly interesting are Myocastor coypus, Cavia aperea, Dasyprocta spp., Cuniculus paca, Hidrochoerus hidrochaeris, Tapirus terrestris, Mazama gouazoubira and Blastocerus dichotomus. Several of these species also have been singled out as of interest to Peru by Dourojeanni (1968), and at present are the subject of breeding programs that are being carried out by the Ministry of Agriculture of Peru in Jenaro Herrera and by the Brazilian Forestry Development Institute in Manaus. The goal of these programs, as in other cases, is to obtain economic benefits from the fauna that will justify the massive investments required for their preservation.

Among the vertebrates of inland waters (excluding fish) that have attracted the greatest attention of specialists with a view to management

for production purposes are the nutrias, crocodiles, river turtles and aquatic birds. The case of the nutria (Myocastor coypus), although older, is quite similar to that of the chinchilla. Hunted to the brink of extinction for the high value of its fur, this animal -- which was ~~farmed~~ found commonly in southeastern Brazil, in Paraguay, Uruguay and large areas of Argentina and Chile, began to be bred in captivity even before ~~its~~ scarcity caused its price to rise sharply. Thus, since the third decade of this century ranchers in Buenos Aires and Corrientes provinces have fenced in lagoons and streams, which gradually led to the present form of hyperintensive management of this species, drawing upon the experience of breeders of fur-bearing animals in Europe and North America (Dennler, 1941).

Crocodiles, like other reptiles, have always attracted man and many cultures have deified them -- e.g., the Chavin of ancient Peru -- or have made them the subject of all sorts of legends (Ravines, 1975). In more recent times they have been hunted for their hides. The South American species have been severely exploited and several already appear on lists of animals in danger of extinction. For this reason, there is increasing interest in the management of their populations, as done with certain species in other regions of the world. Rivero-Blanco (1973) in Venezuela is among those who have studied the possibilities of management of the baba (Caiman crocodilus) and of the black alligator (Melanosuchus niger), finding it to be technically and economically feasible. In Peru a project is under way with the same objective for the white alligator (Caiman sclerops) and the aforementioned black alligator. Other studies under management have been made by Hofmann (1968) and Otte (1979) in Peru, and earlier by Medem (1963) and others in Colombia.

A very similar but more advanced program in terms of accomplishments is that conducted in Brazil with the river turtle (Podocnemis expansa). J. Alfinito

and others (Brazil. Ministry of Agriculture, 1973) have devised a simple and economic procedure for reducing the very high mortality in the egg and during the first days after hatching, and for the repopulation of rivers which have been overharvested. Similar work has been done on a smaller scale in Venezuela (Ojasti and Rutkis 1965, 1967).

Aquatic birds have never been managed effectively in South America, but in some cases the essential steps have been taken to this end, as on Lake Junín in Peru (Dourojeanni et al 1968), where censuses were taken and specific measures proposed for their use as game birds.

Guano-producing birds are the best and most significant example of the management of species of wild fauna of marine ecosystems. The guano produced by a cormorant (Phalacrocorax bougainvillii), a sula (Sula variegata) and a pelican (Pelecanus thagus) was of great economic importance for millenia, and particularly during the last century. After the conquest guano was scarcely used and accumulated in enormous quantities. After independence, extraction was begun in Peru in such a chaotic manner (even using dynamite) that the population of birds fell to hardly 1 to 2 million. It was not until 1909, with the establishment of Compañía Administradora del Guano, that scientific management procedures were applied, including detailed censuses and control of predators and parasites; as a result, annual production rose from 30 to 40,000 MT to 250,000 MT with a population of 20 to 30 million birds; a maximum of 35 million birds was reached in 1956, when 330,000 MT of guano were collected (Gamarra, 1969). With the explosive growth of anchovy fishing and certain prolonged hydroclimatic changes, the population has dwindled to fewer than 2 million birds at present. Although its rational management continues, this resource is no longer as significant as in the past.

Sea lions were managed acceptably not very long ago both in Peru (Piazza, 1959) and in Uruguay (Vaz Ferreira, 1950, 1968). The species involved in this program were Otaria flavescens and Arctocephalus australis. Unfortunately -- at least in Peru -- the hunting of these species is no longer based on principles of management, and -- as in the case of the guano birds -- has been aggravated by the magnitude of fishing activity.

The cases reviewed briefly above provide a mere glimpse of what can be achieved through the management of wild fauna in the decades ahead to take advantage of the opportunity that this resource offers for the social and economic development of vast regions of the continent. Indeed, the wild fauna is frequently the sole or best alternative for the use of marginal lands, i.e., those that pose severe limitations for such conventional activities as farming, stockraising or forestry. Such areas include arid or desert regions, rugged mountain slopes, very high or very cold lands, marshy areas, forests that are still inaccessible for the extraction of wood and, especially, protective forests. Marginal lands make up the largest part of those still available on the continent, and moreover a large proportion of the cultivated land also is in this category. This explains the poverty of the campesinos who occupy them and the severe soil erosion that they cause.

For example, if the fauna of the Amazon were managed -- and there is no reason to doubt the technical possibility of doing so -- it would be possible to maintain the large contribution of the wild fauna of this region to the rural diet (Pierret and Dourojeanni 1966, 1967, Rios et al 1973, Dourojeanni 1978). It could also make a major contribution to the economy in the form of hides, skins, live animals for zoos, pets or biomedical research, etc. Furthermore, there are possibilities for some degree of processing, as in the case of tanning and skinning plants.

The management of fauna for hunting and/or tourism also affords a superb opportunity in terms of the value added that it generates. In the Gran Chaco, a plant formation covering soil that is largely unsuitable for agriculture, hunting is a concrete means of utilizing the ecosystem without destroying it (Dourojeanni et al, 1979). The same can be said of many other arid, semiarid or mountainous regions. In forest regions hunting for sport can be organized in conjunction with forestry operations in a multi-use approach.

The fauna can be managed not only in natural areas, but also -- as in countries of temperate regions -- in agricultural or stockraising areas as well. The vicuña, deer and stags are well known examples of this, but one may add guanacos, ostriches, vizcachas and many others as well.

The management of wild fauna of the most valuable species can repay the cost of protecting other species. This has occurred in the rescue of the vicuña, which provided a return covering the cost of recovery of the guemal (Hippocamelus antisensis) and the condor (Vultur gryphus), among many other species in the entire project area.

In the context of a more ecologically-oriented type of regional development, ~~actually~~ truly based on the potential for better use of land, the management of fauna would have an important place beside agriculture, stockraising, forestry or fishing. This possibility has been demonstrated in theory for the Peruvian Amazon region and for other areas of the hemisphere in which marginal lands predominate (Dourojeanni 1976, Tovar et al 1973). As stated at the outset, however, it has not yet been applied in relation to areas for comprehensive management, but rather on the basis of species having a high economic value. The challenge of the decades ahead is precisely that of moving from the present selective form of management to total management of the fauna of land vertebrates.

The scientific and technical tools available to achieve this are adequate and can be introduced gradually. To begin, management can be introduced through properly drafted legislation compatible with the resources available for monitoring its implementation. In a later stage this general legislation can be made more specific for each region of the country. The result would be permanent national or local bans and local seasonal bans geared to actual conditions; regulations concerning types of weapons, calibers and methods of hunting; minimum game quotas, established locally; areas of strict reserve and others for hunting; etc., etc. Clearly, this is a very extensive type of management, and already exists in some degree in all of the Latin American countries, but is rarely followed. The defect usually lies not in the law but in its enforcement.

A next stage would be extensive management, in which the assessment of populations to be managed is no longer based on censuses but rather on harvest data. This implies the putting in place of a more sophisticated system of hunting licenses and the existence of an effective and qualified local authority that can set annual quotas for game and adjust them each year, decide upon the size and location of hunting areas, and impose rules regarding the amount of game caught or killed by sex, as well as other aspects. In agricultural areas and in tropical or subtropical forests it is essential to leave 10 to 50% of the area under primary or secondary forest cover, in tracts or belts, to provide transitional zones that are especially suitable for small fauna, the type which is hunted most extensively in the Americas. Hunting reserves are valuable, especially when they are placed under the control of a rural community.

There are several options for the production of fauna in forests used for the extraction of wood. A recent study in Brazil showed that the wages of forest industry workers would have to be raised to levels that would be unprofitable for the company if it became necessary to replace the meat of wild animals

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that they consumed with beef, which is not only more expensive but also less nutritious because of its high fat content. To avoid this, it proved economical to leave reserved areas of 5,000 to 10,000 ha. in two to four blocks for each 100,000 ha. of forest under management, in addition to protecting the vegetation on the banks of rivers and streams. At the same time, there is need for tree farming methods using natural regeneration, maintaining the diversity of timber-yielding species which also are fruit-bearing. This is not necessarily opposed to a considerable simplification of the original ecosystems, which can even favor certain species that feed on trees whose density increases (such as deer) in clearings, on boundaries and at the edge of roads where palatable fodder grows. This last example is typical of artificial forests and has occurred in reforestations with pine in the Orinoco region and eucalyptus in the Peruvian sierra (with Mazama americana and Odocoileus virginianus, respectively).

Intensive management, based on direct or indirect censuses of fauna and on the manipulation of the biotope and biocenosis, is not necessarily visionary, as demonstrated by the cases reviewed in the foregoing section. It is a matter of routine in extensive regions of North America and is practiced in Europe. It includes control of predators and of competition for food and space, control of diseases and parasites, an increase in the carrying capacity of the biotope through the cultivation of food plants or those providing shelter for reproduction, direct feeding during critical periods for the population or at least the provision of salt, etc. Its implementation obviously requires a high technological level, but it is known to be potentially profitable, as fauna ranches have demonstrated in Africa, North America and Oceania.

A later stage, involving larger investments, is hyperintensive management through animal breeding stations, a possible first step in domestication as mentioned in reference to chinchillas and nutrias, and an alternative for

many other animals.

7.6.3 Protectionism versus Conservationism

With the annihilation of wild fauna a strong current of public opinion has begun to demand the survival of species. Such a reaction is essential to offset or balance the utilitarian and shortsighted tendencies that are behind the destructive exploitation of fauna, which is seen so strikingly in the case of the whales. But it must be kept in mind that the principal cause of the extinction of species is the appalling situation of injustice and poverty that prevails in the world, not excluding Latin America and the Caribbean. The destruction of the Amazon ecosystems, with the loss of the species found there, is due incomparably more to migratory and impoverished agriculture than to the organized action of large national or multinational companies. Clearly, there is an intimate link between the two phenomena, but what cannot be ignored is the presence of hordes of poor people who destroy both the fauna itself and its environment in order to survive.

This fact, common in the regression or degradation of all natural ecosystems, must be kept firmly in mind when a strategy is being designed to prevent the loss of genetic resources with potential value for mankind. It would be neither moral nor possible to attack the only alternative that society provides for large groups of the population to meet their vital needs. Ultimately, the only means by which the wild fauna will be protected is to make clear its contribution to human welfare, thereby justifying the investments entailed in its management. In other words, the wild fauna should be conserved -- that is, utilized in the best way -- for the benefit of present and future generations.

This is where a serious conflict arises with those who, out of conviction or for other reasons, call for the protection of wild animals per se, with no purpose other than that based on ethical and esthetic concepts and ignoring

factors related to the betterment of mankind and the satisfaction of basic needs. The vicuña, to the humble campesino of the altiplano, is meat that he eats and wool that he sells at a good price; but the affluent city dweller sees the vicuña as the most sublime expression of divine creation. The bullet that pierces the heart of a vicuña, fired by a game warden as part of a strict management plan, endangers the species no more than the stab or electric shock that kills an animal in the slaughterhouse. The difference is purely emotional. But the killing of Indochinese refugees has evoked no greater protest than that of ~~the~~ baby seals or whales.

The management of fauna has never caused the disappearance of a species, although like any science or technique it is susceptible to error. On the other hand, the prohibition of hunting or closed seasons have seldom yielded any results. The vicuña was protected by more than 20 laws when its population was hovering at the brink of extinction. It was saved only when a management plan was designed and put into effect.

These problems are due largely to an error of strategy committed by the very people responsible for management. Indeed, because the first step in the management of rare species is the recovery of populations, there has often been an impression that this is the only objective. It is logical to prevent the ~~exploit~~ exportation of tens of thousands of monkeys for use in experiments or as pets; but at the same time, it should be explained that the controlled sale of a few thousands of these animals -- bred or obtained from managed areas -- is essential for the advance of medical science, endangers no species, and moreover is an excellent source of foreign exchange and employment for people who otherwise would plunder the forest because of the lack of other opportunities. Regrettably, public opinion is not properly informed about these facts and is

fertile ground for demagoguery and deception. The need to impose bans and the campaigns mounted to enforce them often end by causing true revulsion at the use of certain wild fauna products, as is happening with many furs and skins. One should ask what will happen when the population of certain animals is again large enough to support harvesting and that use becomes the sole justification for preventing or slowing the total destruction of the ecosystem in which the specie lives. Is not the world, with its present protectionist bent, digging a grave for the very species that it seeks to maintain?

Moreover, it should be kept in mind that the establishment of national or regional systems of conservation units should permit the protection of all species of fauna. With this in mind, such systems should be expanded, refined and properly administered. The wild fauna outside national parks and other protected areas in any of the numerous categories that exist should be subjected to management and should produce as much as in any of the protected areas devoted especially to that purpose.

In the future there must be a harmonious coexistence of totally man-made environments such as cities, in which zoos perform the function of maintaining species or intensively-cultivated tracts with few wild animals; seminatural environments, for example natural pastures or forests in which cattle are bred or wood is produced and which also support wild animals under management; and natural environments, part of which are set aside for the management of fauna and part as strict reserve areas where animals are totally removed from the impact of man. Any attempt to provide absolute protection everywhere at the same time is dangerously utopian and is a denial of the importance of the fauna for the future of mankind.

Besides the severe constraints placed by these problems on the management of fauna, there are others which are more conventional but also important. They

include the skepticism of political authorities regarding the potential of the fauna and even the need for its protection, which means minimal budgets and continuing neglect; the lack of trained manpower -- more a consequence of the foregoing than a problem in itself; and the lack of international technical cooperation on a significant scale. Nevertheless, these difficulties dim by comparison with the ruthless attacks made on those who are working professionally in the management of fauna by amateur protectors of nature, who -- confusing rational utilization with extermination -- rather than seeking a union of efforts in a fruitful symbiosis, are responsible for the concerted weakening of those whose task is to restore balance in man's relationship with the wild kingdom.

The management of fauna is a form of land use, especially for the poorest lands, which should be placed on an equal footing with agriculture, stockraising or forestry in the planning of rural development. As already seen, the main obstacle to the attainment of this objective is the opposition of many of those who advocate the conservation of nature but are ignorant of the fundamental rules of ecology which they seek to apply, gradually eliminating any possibility that the fauna will contribute to the betterment of mankind.

The efforts of the decade that is beginning must therefore be directed toward the restoration of a balanced approach toward the wild fauna. Such a policy is equally opposed to annihilating exploitation and to protectionism taken to extremes. In both of those immoderate and unbalanced attitudes there are vested interests and a great deal of ignorance, which as always is bold. In between are science, the welfare of mankind and the future of the species.

7.7 The most probable balance in the year 2000

The greatest efforts that can be regarded as feasible up till the year 2000 to prevent the extinction of animal species in Latin America and the

Caribbean will not suffice, and major losses can therefore be expected. The smaller these losses, the greater will be the opportunities upon which human development will be based in the next century. Nonetheless, most of the species that will become extinct will be invertebrates and their absence will be noted only through the alteration of certain biological processes which are not necessarily visible. One can also expect the disappearance of vertebrates, particularly small species but also some large and well-known ones.

If conservationism -- i.e., common sense -- prevails over protectionism, the year 2000 can be expected to see the optimum management of several species of vertebrates, especially vicuñas and guanacos, capybaras, crocodiles, deer and stags, primates, etc. These animals will be used both for the production of meat, hides and skins and for recreational hunting and tourism; and this will lead to industrial development and will have a significant multiplier effect.

The raising of exotic species will have been rationalized somewhat and although it will be the activity occupying the largest area, the rate of expansion of pasture lands will be much lower then than now, favoring a more intensive form of stockraising with a tendency toward the greater use of stables and pens. Unfortunately, the loss of local genetic material will reduce the possibilities of improving the adaptation of such animals to ecosystems with extreme conditions. The raising of native species could occupy large areas that are clearly marginal for exotic animals, especially sheep, which should be replaced by South American camelids. But in spite of the desirability of this alternative the evidence indicates that it will be implemented only in part.

As for fishing, it has already been pointed out that this activity can be expanded significantly only at the expense of food and planktonic species,

because of the exhaustive and successive use of available contingents of traditional species. Latin America and the Caribbean still have a comparatively great potential or margin of populations of conventional species, but before the year 2000 this region will be in the same situation as other continents.

8. NATURAL AND ANTHROPIC ECOSYSTEMS

8.1 Present situation and representativeness of the network of national parks and protected areas

According to the latest List of National Parks and Similar Reserves (IUCN 1980), there are at present no fewer than 232 national parks and other protected areas denoted as national reserves, national sanctuaries, historical sanctuaries, biological reserves, wildlife reserves and natural or national monuments, among others, in Latin America and the Caribbean. The category of national park is the most numerous at the regional level and in each country as well, with few exceptions. This list includes only conservation units that meet specific legal, administrative and management requirements; thus, the number of units may in theory be greater than that indicated, but they are of limited practical value because of their deficiencies.

Although the oldest national park in the region is El Chico (Mexico), established in 1898, it can be argued that the national park movement did not really begin until the 1920s and 1930s. At that time Mexico, Argentina and -- to a lesser extent -- Chile and Brazil laid the foundations of their national systems of conservation units. Unquestionably, the leading country in that movement was Argentina; under the inspiration of Perito Moreno, the most outstanding of all the individuals who created and developed the national parks of the continent, Argentina brought under protection 90% of the area of its present system of conservation units, with seven national parks covering over 2 million hectares. As Table 82 shows, 74% of the conservation units have been established since 1960, and 50% during the 1970s. In other words, it is on the whole a very new system. Beyond any doubt, the countries that have made

the greatest efforts during the last decade are Costa Rica, Venezuela, Peru and Brazil. It might be noted that the last three South American countries mentioned have 48% of the protected area of the entire region studied, excluding a new national reserve established very recently in Peru.

Table 82. Rate of establishment of conservation units in Latin America and the Caribbean.

Date	Number	Date	Number
Before 1900	1	1940 to 1949	12
1900 to 1909	0	1950 to 1959	15
1910 to 1919	0	1960 to 1969	55
1920 to 1929	4	1970 to 1979	116
1930 to 1939	29	Total	232

Source: IUCN (1980).

In addition to the conservation units mentioned, there are 11 biosphere reserves, located in Bolivia (2), Chile (3), Mexico (2), Peru (3) and Uruguay (1). They cover a total area of 3,224,848 hectares, which to a great extent are superimposed on conservation units; 78% of this area is in Peru. Two areas also have been classified as world heritage sites: Galapagos (Ecuador) and Tikal (Guatemala) national parks. The establishment of the biosphere areas resulted from the UNESCO Program on Man and the Environment, while the world heritage sites were established under the Convention on Protection of the World Cultural and Natural Heritage. Because not all of the countries are active in the program mentioned and/or are not parties to the Convention, the areas selected up to the present are not necessarily comparable in interest or value to others that may exist.

The largest conservation units on the continent are Canaima in Venezuela (3,000,000 ha), Pico da Neblina in Brazil (2,200,000 ha), Bernardo O'Higgins in Chile (1,761,000 ha), Manu in Peru (1,532,806 ha), Pacaya-Samiria in Peru (1,387,500 ha), Serranía La Neblina in Venezuela (1,360,000 ha), Amazonía in Brazil (1,000,000 ha) and Yasuni in Ecuador (1,000,000 ha). Regrettably, about 80 (34%) of the conservation units -- particularly the oldest ones -- have areas of less than 10,000 ha. In this connection, Table 83 shows the regional distribution of conservation units and their areas. The Andean region has by far the largest number of conservation units (81) as well as the largest area under protection (16,879,200 ha), and alone accounts for 51% of the entire protected area of Latin America and the Caribbean. It is followed by the Southern Tier (43 units and 8,720,804 ha) and the Atlantic region (41 units and 6,541,118 ha). The region of North America is least represented with only 20 conservation units covering a mere 175,578 ha.

Table 83. Area of conservation units in Latin America and the Caribbean and their expansion in the 1970s.

Region / Country	Area in 1970 (km2)	Number of units	% of national territory	Area in 1980 (km2)	Number of units	% of national territory	Average size of units in 1980 (km2)
NORTH AMERICA							
Mexico	1,545.34	13	0.08	1,755.78	20	0.09	87.79
Total	1,545.34	13	0.08	1,755.78	20	0.09	87.79
CENTRAL AMERICA							
Belize							
Costa Rica				2,732.90	16	5.37	170.81
El Salvador							
Guatemala	331.86	4	0.30	818.00	2	0.75	414.00
Honduras							
Nicaragua				162.00	2	0.10	81.00
Panama				2,871.22	4	3.72	717.81
Total	331.86	4	0.07	6,584.12	24	1.21	274.34
CARIBBEAN							
British Antilles							
Netherlands Antilles				53.50	2	5.39	26.75
US Antilles	64.10	2	18.58	64.04	2	18.56	32.02
Bahamas				505.48	2	3.62	252.74
Barbados							
Cuba	243.05	4	0.21	243.05	4	0.21	60.76
Dominica							
Grenada							
Guadeloupe							
Haiti							
Jamaica				20.00	2	0.18	10.00
Martinique							
Puerto Rico							
Dominican Rep.	50.30	1	0.10	2,198.00	5	4.54	439.6
St. Lucia							
Trinidad and Tobago				226.38	6	4.42	37.73
Total	357.45	7	0.15	3,310.45	23	1.39	137.93
ANDEAN							
Bolivia				2,000.00	1	0.18	2,000.00
Colombia				36,094.00	29	3.16	1,224.62
Ecuador	100.00	1	0.04	18,374.54	6	6.79	3,062.42
Peru (1)				38,686.71	13	3.01	2,975.89
Venezuela	14,218.32	7	1.55	73,636.75	32	8.04	2,301.15
Total	14,318.32	8	0.30	168,792.00	81	3.58	2,083.85

Table 83 continued

ATLANTIC							
Brazil	3,016.70	11	0.03	48,714.23	26	0.57	1,873.62
French Guiana							
Guyana				116.95	1	0.05	116.95
Paraguay				10,760.00	5	2.64	2,152.00
Suriname	3,080.00	6	1.89	5,820.00	9	3.56	646.67
Total	6,096.70	17	0.06	65,411.18	41	0.70	1,595.39
SOUTHERN TIER							
Argentina	26,414.12	12	0.95	24,295.62	16	0.87	1,518.48
Chile	788.53	4	0.13	62,718.33	23	10.04	2,726.88
Malvinas Is.	0.37	2	0.003				
Uruguay	26.14	4	0.01	194.45	4	0.11	48.61
Total	27,229.16	22	0.76	87,208.04	43	2.43	2,028.09
SOUTH AMERICA	47,644.18	47	0.26	321,411.58	165	1.82	1,947.95
LATIN AMERICA AND THE CARIBBEAN	49,546.97	71	0.24	333,061.93	232	1.63	1,429.45

Note: (1) Excluding Aguada Blanca (366,000 ha).

Sources: IUCN (1971)
IUCN (1980)

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Table 83 also shows that the percentage of area protected in the region studied is 1.63%. This is undoubtedly insufficient, but it should be kept in mind that hardly a decade ago only 0.24% of the area was protected. In other words, between 1970 and 1979 the protected area increased by 670%, which is truly significant. In this regard, the Andean region has the highest proportion of total area protected (3.58%) as well as the conservation units with the largest average size (208,385 ha). Next are the Southern Tier (2.43% and 202,809 ha), the Caribbean (1.39% and 13,793 ha), Central America (1.21% and 27,434 ha), the Atlantic region (0.70% and 159,539 ha) and North America (0.09% and 8,779 ha). As may be seen, in the Atlantic region the average area of conservation units is considerably larger than in the Caribbean, even though the percentage of area protected is much lower. The area of each conservation unit is a key indicator of its ability to preserve the genetic stock that it contains.

In Table 84 an attempt is made to analyze the representativeness and coverage of Udvardy's biogeographical provinces (1978) in the system of conservation units of Latin America and the Caribbean. The results are merely indicative given the problem of locating conservation units on Udvardy's map, especially when these units are situated in more than one biogeographical province, and given the large scale of the map and the inaccuracies and imperfections that still characterize it. Still, the exercise brought out some important facts which will be explained first in terms of the area studied as a whole and then region by region. At the outset, it is apparent that several biogeographical provinces have no protected areas: the Chihuahuan, Tamaulipan, Sinaloan, Yucatecan, Babacu, Chilean Sclerophyll and Patagonian. Many other provinces are represented (again in terms of Latin America and the Caribbean as a whole) by areas covering less than 0.5% of the total province.

Such is the case of the Californian, Sonoran, Madrean-Cordilleran, Guerreran, Cuban, Lesser Antillean, Brazilian Planalto, Caatinga, Campos Cerrados, Chilean Araucaria Forest, Monte, Argentinian Pampas and Uruguayan Pampas provinces. Only 19 of 53 biogeographical provinces have more than 3% as protected areas, the percentage that can be regarded as the minimum to ensure adequate protection. They are the Panamanian, Cocos Island, Guyanan, Bahamas-Bermudan, Colombian Coastal, Amazonian, Venezuelan Dry Forest, Venezuelan Deciduous Forest, Llanos, Colombian Montane, Galapagos Islands, Lake Titicaca, Gran Chaco, Easter Island, Valdivian Forest, Chilean Nothofagus, Puna and Southern Andean.

Table 84. Representativeness and coverage of existing conservation units in relation to Udvardy's biogeographical provinces.

Region	Biogeographical province code	Area of conservation units (km2)	% of province protected	Number of units	Average size of units (km2)
NORTH AMERICA	1.7	50.09	0.18	1	50.09
	1.8	60.00	0.04	6	10
	1.9		-	-	
	1.10		-	-	
	1.21	1,416.37	0.23	10	141.63
	8.1	117.00	0.06	1	117.00
	8.13		-	-	
	8.14	112.32	0.06	2	56.16
	8.15			-	
Total		1,755.78	0.09	20	
CENTRAL AMERICA	1.21		-	-	
	8.1	818.00	1.06	2	409.00
	8.2	2,871.22	4.20	4	717.80
	8.16	2,862.90	0.89	17	168.40
	8.43	32.00	100.00	1	32.00
Total		6,584.12	1.22	24	
CARIBBEAN	8.4	226.38	18.87	6	37.73
	8.38	505.48	3.52	2	252.74
	8.39	243.05	0.21	4	60.76
	8.40	2,282.04	2.37	9	253.56
	8.41	53.50	0.44	2	26.75
Total		3,310.45	1.39	23	
ANDEAN	8.3	6,450.00	3.59	4	1,612.50
	8.4	530.00	3.72	2	265.00
	8.5	65,580.06	5.92	12	5,465.01
	8.6		-		
	8.17	12,058.01	5.23	23	524.26
	8.18	5,132.86	11.97	7	733.27
	8.19	1,213.00	1.60	2	606.50
	8.21		-		
	8.24	3,400.70	2.07	2	1,700.35
	8.25		-		
	8.27	43,322.88	10.78	6	7,220.48
	8.28		-		
	8.30		-		
	8.33	5,957.54	2.28	8	744.69
	8.34	5,090.00	3.30	5	1,018.00
	8.35	9,585.00	1.54	3	3,195.00
	8.36	2,000.00	0.54	2	1,000.00

Table 84 continued

	8.37	1,198.15	0.55	3	399.38
	8.44	6,912.00	86.79	1	6,912.00
	8.47	361.80	4.36	1	361.80
Total		168,792.00	3.58	81	
ATLANTIC	8.4	5,296.95	0.75	10	529.69
	8.5	26,600.00	1.86	2	13,300.00
	8.6	10,000.00	0.66	1	10.000.00
	8.7	2,961.78	1.37	8	370.22
	8.8	3,947.50	0.21	7	563.93
	8.9	102.50	0.04	1	102.50
	8.20	1,011.00	0.11	2	505.50
	8.21	10,710.00	3.74	4	2,677.50
	8.28	1,000.00	1.11	1	1,000.00
	8.29		-		
	8.30	3,781.45	0.22	5	756.29
	8.32		-		
Total		65,411.18	0.70	41	
SOUTHERN TIER	5.4	45.89	28.00	1	45.89
	6.4	630.93	?	1	630.93
	8.8	555.00	1.96	1	555.00
	8.10	13,890.68	10.33	3	4,630.22
	8.11	16,304.98	13.91	3	5,434.99
	8.21	1,416.01	0.33	4	354.00
	8.22	116.00	0.47	1	116.00
	8.23		-	-	
	8.24	281.45	0.38	3	93.81
	8.25	448.51	0.04	2	224.30
	8.26		-	-	
	8.31	85.00	0.02	1	85.00
	8.32	273.45	0.11	5	54.69
	8.36	8,030.00	28.23	2	4,015.00
	8.37	45,130.00	10.82	16	2,820.62
Total		87,208.40	2.43	43	
SOUTH AMERICA		321,411.58	1.82	165	
LATIN AMERICA AND THE CARIBBEAN		333,061.93	1.63	232	

Note: Several errors detected in IUCN (1980) have been corrected, such as the location of Amazonia National Park in the Amazonian province when it is actually in the Madeiran.

Sources: IUCN (1980)
Udvardy (1978)
Table 2.

For each of the regions into which the study area has been divided the data point to a critical situation in North America, where four of the nine biogeographical provinces are not protected and where only two are protected with areas covering about 0.2% and the others have less than 0.06% protected. Moreover, all of the conservation units are very small. The situation is somewhat better in Central America, but the Madrean-Cordilleran province is not protected and the Central American province has only 0.89% of its area protected. In the Caribbean there is little protection in the Cuban and Lesser Antillean provinces. In the Andean region -- which has the best protection -- there are no protected areas in the Madeiran, Gran Chaco, Monte and Campos Cerrados provinces; furthermore, the Equadorian Dry Forest, Pacific Desert, Northern Andean, Yungas, Puna and Southern Andean provinces are represented by units covering less than 3% of their area. In the Atlantic region only the Gran Chaco province is well protected, thanks to Defensores del Chaco National Park, Paraguay (750,000 ha); most of the other 11 have much less than 3% of their area protected, and two of them have no protection whatever (Babacu and Uruguayan Pampas). Finally, in the Southern Tier there are five biogeographical provinces with adequate protection, seven with protection of much less than 3% of the province area, and two with no protection at all.

In summary, Table 84 shows that the Latin American and Caribbean system of conservation units, while better and more representative than what might have been assumed a priori, is still far from perfect. The Andean region is most developed, followed by the Caribbean and Central America. The regions in which greatest efforts must be made to improve the system are North America and the Atlantic, followed by the Southern Tier. The magnitude of the work to be done is apparent in the case of Brazil, where despite a 16-fold increase

in the area protected in only the last 10 years, less than 0.57% of the national territory has yet been protected, and where two biogeographical provinces still have no protected areas.

Another aspect worth mentioning is the still meager development and understanding of the significance of national parks and other marine conservation units. There are several of these on the continent, such as Paracas (Peru), Galapagos (Ecuador), Peninsula Valdez (Argentina), Cocos Island and -- to some degree -- Tortuguero (Costa Rica), Los Roques, Mochima, and Isla Margarita (Venezuela). Unfortunately, however, their establishment has not been based on planning that takes into account their ecological representativeness; rather, the motivation has come from other factors, usually related to the protection of conspicuous species such as seals or sea cows, sea turtles, whales, penguins, guano and marine birds or sea lizards, or the most spectacular coral reefs. Furthermore, many of these conservation units are too small and/or protection within them is greatly reduced because small-scale and game fishing is tolerated. It is therefore essential to review what has been done and design a system of marine conservation units based -- as on land -- on the protection of representative examples of each system. Only in this way will the conservation units play their essential role in the maintenance of the genetic heritage.

In addition to the conventional conservation units included in the United Nations List of National Parks and Similar Reserves, most of the countries have other areas of protection and controlled use covering much larger areas than that of the conservation units. Such is the case of the national forests, ~~with~~ which cover 5,885,502 ha in Peru, for example, or the protective and water reserves, which cover 12,939,877 ha in Venezuela. The proportion of these

areas in the principal biogeographical provinces has not been analyzed, nor is it worthwhile to do so, since in general they are not protected or much less managed, being legally demarcated areas. Among the few exceptions to this situation are the A. von Humboldt National Forest in Peru (645,000 ha) and the Tapajoz National Forest in Brazil (600,000 ha).

In all of Latin America and the Caribbean there has been little or no effort to protect traditional anthropic ecosystems with the simultaneous aim of preserving stable and environmentally balanced agricultural lands and the cultures established on those lands long ago. In the same context, there is also no preservation of typical dwellings, folklore and other cultural features that can afford examples of optimized development and a high quality of life.

8.2 Current problems

The foregoing section has analyzed only one aspect of the conservation of natural ecosystems, i.e., the representativeness of protected areas in terms of zones of natural life -- in this case the biogeographical provinces -- and their intrinsic value in terms of size. This section takes up the topic of protection, management and utilization of already established conservation units, aspects which can modify some of the conclusions already drawn. Actually, a properly selected example of adequate size is of little value if it is not preserved, managed or utilized and remains -- as frequently remarked in Latin America -- only "on paper."

In theory, the conservation units included in the United Nations List (op. cit.) are those which meet not only the requirement of legal existence but others of an administrative nature, such as having a budget and personnel. Nevertheless, that document also takes into account that many conservation units can "protect themselves" or can be protected with very modest administrative

efforts. Taking these elements as a starting point, it is important to know how many of the parks listed perform the role for which they were established, and to what extent. Regrettably, it has not been possible to develop figures for this purpose, which would also have to include situations such as that of units which, though provided with personnel and resources, have a deficient administration. From a qualitative standpoint the countries in which park administration is well implemented are Argentina, Brazil and Costa Rica; those in which it is moderately well implemented are Venezuela, Ecuador, Peru, Chile, Paraguay, Cuba, Dominican Republic, Trinidad and Tobago and Suriname. In the other countries the situation is deficient to very deficient, but in several of the conservation units of the countries mentioned in the first two groups the situation may be as bad as or worse than that of units in the group classified as deficient to very deficient. Some national parks with great prestige -- such as Canaima in Venezuela -- are in a virtual state of abandonment; in others -- such as several of the Argentine national parks in the lake region -- the purposes for which they were established are being increasingly diluted (Dourojeanni, 1979).

Another aspect is that of management plans. It is unquestionable that the majority of conservation units lack this instrument, and that in many cases where it exists the responsible personnel do not know how to apply it or do not accept it because of the lack of resources or for other reasons. Some notable examples in this regard are Brazil and Costa Rica. Miller (1980) provides abundant data on management plans.

The great majority of conservation units of Latin America and the Caribbean are not visited by the public, or their visitors pay no heed to the essential values that these units embody. Most of the visitors in many countries use nearby national parks for weekend recreation such as picnics, or for water

sports or sports which -- like soccer and volleyball -- can be played anywhere else. In contrast, other parks -- such as those of Argentina, those of south-central Chile and Canaima National Park in Venezuela -- are visited by people more aware of natural values, including a large number of local tourists. Apart from these two cases, there are 150 national parks and equivalent reserves that receive no visitors other than persons engaged in scientific research and government personnel. Such is the case of Peru, where only three of the 13 parks are visited by the general public.

The lack of personnel and budget, of management plans and their implementation, and of visitors are interconnected causes and consequences of a single problem that can be summarized as the ignorance and hence the lack of interest still shown by decision-makers in the majority of governments with regard to this national responsibility. Naturally, another factor is the lack of knowledge on the part of the public. For this reason, many well-established conservation units still have no certainty of survival in the face of the pressures of settlement, petroleum exploration and extraction and tourism development. To cite only one example, in 1976 the Paraguayan government reduced the size of Caaguazú National Park from 200,000 ha to only 6,000 ha, among other reductions of conservation areas which also affected protective forests. Serious threats of this kind face numerous conservation units of several countries of the continent.

As recently as June 1980 the Minister of the Environment and Natural Resources of a country in the Andean publicly stated that protectionism has been exaggerated, creating "too many national parks," an assertion that lacks any technical justification whatever for the country in question.

It should be pointed out that virtually all of the Latin American biosphere reserves are in the same situation of complete inertia in terms of the objectives for which they were created. The basic reason is the lack of financial resources for planning and research.

8.3 Special cases of threatened natural ecosystems

8.3.1 Mangrove swamps

Mangrove swamps, which are forests comprising species of *Rhizophora*, *Avicennia*, *Laguncularia* and *Conocarpus*, as well as *Pterocarpus*, *Clusia* and *Bravaisia*, among others, are found in coastal areas where fresh water is mixed with sea water. They occur especially in the muddy soils of river deltas, but also in protected areas on islands or where the vegetation affords protection against the direct pounding of waves. The mangrove swamps of the Americas are known as "western" and are characterized by their less abundant flora compared to the "oriental" swamps (those of Asia, Australia and the east coast of Africa). These swamps support a very rich fauna and are intimately linked to important biological processes that contribute to the general productivity. For example, they provide food in areas of procreation for fish of commercial and game importance, among other marine organisms; they regulate the movement of fresh and salt water; and they are primary producers of carbon, with 100 gr/m3 per year vs. only 20 gr/m3 per year on the high seas (FAO, 1979).

The largest concentrations of mangrove swamps in South America occur in the deltas of the Magdalena, the Orinoco and the Amazon, as well as on Lake Maracaibo and on the coasts of Brazil. They are also found on the coasts of the Guianas, Venezuela and Ecuador. On the Pacific they reach only as far as the northern tip of Peru. Central America, North America and the Caribbean have equally important formations of mangroves in almost all of their coastal

areas. Nonetheless, this unique ecosystem has been shrinking throughout the area studied because of forestry operations, artificial drainage and pollution. Forest extraction involves primarily the utilization of tannin from leaves and bark and/or fuelwood, charcoal, posts, rustic furniture and other products. Mangrove swamps often are the base for vast plantations of bananas, among other coastal crops, ~~with~~ large areas having been transformed into tillable land in Suriname and other countries. The chemical pollution of the continent and the petroleum residue from tanker ships, and the installation of marinas and other tourist facilities, also play a major role in the deterioration of these forests.

A number of conservation units protect mangrove swamps, but considering the diverse composition of these ecosystems it is unlikely that such units are sufficient. The conservation units with mangrove swamps include Laguna de Tacuarigua, Laguna de la Restinga, Mochima and Morrocoy in Venezuela; Monte Pascoal in Brazil; etc. Hueck (1978) is one of the many experts who believes that the mangrove swamps can be managed rationally for a variety of productive purposes without major problems, all the more since natural regeneration is easy. Nevertheless, nothing has been done in this regard, aside from experimental programs.

8.3.2 The Galapagos Islands

The Galapagos Islands or Columbus Archipelago is regarded as one of the places of greatest natural value and scientific importance in the world. These islands are located in the Pacific ocean 1120 km off the coast of Ecuador. There are 17 large islands and more than 100 small ones, with a total area of 7,844 km2 and a population of about 4,500.

The main problem in the conservation of this world heritage is due to the introduction of species, including 10 mammals and about 250 plants, 20 of which are especially harmful. Among the mammals, severe damage is caused by dogs and cats, introduced long ago, which are active predators; and goats, pigs, burros, bovines and other herbivores, which also were introduced many decades ago; these animals compete unfairly with native species and have eliminated certain plants from the highly restricted ecosystems in which they are maintained. Agricultural settlement or expansion on unsuitable lands and/or with inadequate techniques has been another important factor in the past, particularly on the islands of San Cristobal, Santa Cruz, Floreana and Isabela.

MacFarland (personal communication) regards as inevitable the extinction of some of the 11 subspecies of turtles (Geochelone elephantopus) that still exist, one in the very near future. According to Hendrickson (1976), of the 15 taxa defined only a few -- limited to the two large islands of Isabela and Santa Cruz -- will survive at the end of the century. As for the land iguanas (Conolophus), one of the two species is virtually extinct on two of the islands. The Hawaii petrel (Pterodroma phaeopygia) is another species whose population is acutely affected by the animals introduced. However, ~~the~~ invertebrate species are much more vulnerable than the more conspicuous animals. For example, it has been estimated that of 80 species of endemic land snails, 20 are in imminent danger of extinction on a single island (MacFarland, personal communication; Smight, 1966). Birds and small reptiles are better able to protect themselves, but on certain islands their situation is bad. Plants also suffer greatly; to mention only one case, two species of Scalesia have been virtually eliminated by goats, surviving only in inaccessible ravines.

The populations of Arctocephalus australis galapagoensis and Zalophus californianus wollebaeki have recovered well. The penguin (Spheniscus mendiculus) and the cormorant (Phalacrocorax) have populations estimated at 2,000 and 1,800 individuals, respectively, concentrated in the cold water areas of Fernandina and Isabela islands. Regrettably, these are the very places where fishing is being developed most intensively.

At present, 88% of the area is protected with increasing effectiveness, and only 12% is subject to agricultural and urban encroachment. But the development of tourism is becoming so extensive that the number of visitors is nearly quadruple that of the inhabitants, creating new problems that require the application of concepts of integral development in order to avoid a complete breakdown of society. Koford (1966) has suggested several measures for better conservation of the islands, which are still valid or have been largely implemented during the last 15 years.

8.3.3 Coastal areas in general

Coastal areas (excluding mangrove swamps in this case) have been subjected to strong pressure from man since ancient times because of their capacity for providing food, especially where fresh water is also available. In the last 30 years, and particularly during the past decade, this situation has worsened dramatically with the development of recreation and tourism, both due in turn to social and economic progress and to the availability of independent and cheap transportation. Thus, wherever there are beaches, accessible cliffs and a tolerable climate, people use the sand and waves for their recreation and sports and the rest of the seaside for game fishing, underwater hunting, motocross and other recreational activities and water or land sports. In addition, coastal areas frequently are a preferred location for infrastructures of all kinds -- especially highways and railways paralleling

the sea coast, cities, airports, industrial plants and port installation -- while the action of rivers, ocean currents and prevailing winds tends to concentrate all forms of pollution; the result is one of the most altered and degraded ecosystems (actually an ecotone) that can be found on earth.

Latin America and the Caribbean are no exception to this universal problem, except on the coastal belts of the extreme south of the continent where they have been preserved because of the harsh climate and sparse population. Graphic cases can be found, such as Tortuguero National Park in Costa Rica, where the sea turtles that come to lay eggs must push aside heaps of rubbish, notably plastic objects, bottles and the residue of processed wood carried by the currents, chiefly from far-off Colombia. Outside the park these turtles find beaches that are similarly polluted, where they are hunted by man and his dogs or where human settlements and activities are incompatible with their reproductive process. The hot coasts of Brazil and the slightly colder coasts of Peru are also affected by these problems, despite their great length.

In the Caribbean region the coastal area suffers an even greater impact because of the high population density, and the situation is most critical from the economic and social standpoint. The main problems are the over-exploitation of coral reefs, pollution of the sea -- especially by discharges of petroleum and ballast water -- over-fishing of commercially important species, the degradation of coastal landscapes, encroachment of sand and muddying by the sediments carried by rivers from basins denuded of trees. Ray, Miller et al (1979) have devised a strategy for the conservation of living marine resources and processes in that region, assigning priority to areas and selecting sites which would be suitable for the management of multiple resources, as in the case of shrimp, crocodiles, manatees and wet habitats. With this in mind, they studied the vulnerability of each resource, and among other measures proposed protected areas for the

conservation and monitoring of natural resources.

Suspended sediments merit additional comment because they have other serious effects on aquatic life. Because of erosion on the mainland or dredging, they can reduce photosynthesis or even kill such plants as sea grass (Thalassia) and/or greatly lower the oxygen level in the water of bays, affecting numerous sensitive species. Coral and other living organisms also can be killed by the physical action of deposited sediments. The filling of estuaries to reclaim land eliminates the possibility of development of fish and shellfish, especially shrimp, which require gradients of salinity.

The lack of marine national parks is a critical deficiency that should be corrected as soon as possible.

8.3.4 Coastal hills

These ecosystems, found on the desert coasts of Peru and Chile, are formed by the phenomenon of thermal inversion which in turn is caused by the presence of the cold Humboldt current, the trade winds of the South Pacific and the high Andean mountains on one side, and by the electrostatic condensation of the mists thereby created on the other. A rich and diverse flora of endemisms has been developed in these areas because of their isolation. The fauna, especially invertebrates, is equally abundant and diverse.

This zone of natural life, in its various manifestations, now occupies only about 2,000 km2 in Peru and much less in Chile. However, insofar as known, it covered not less than 15,000 km2 only five centuries ago when it supported major population centers. The introduction of Indo-European livestock -- bovines, equines, and especially goats -- destroyed these ecosystems almost totally, transforming them into deserts or semideserts, whereas they had been cultivated on terraces and the springs had supplied the human population and herds of camelids. Deforestation for fuelwood and charcoal and for other purposes,

coupled with the destruction of new growth by the livestock and grazing on branches, eliminated any possibility of natural restoration, all the more since arboreal vegetation is essential for the capturing of moisture. Only one significant example of this type of ecosystem remains: the Atiquipa hills in the southern department of Arequipa, Peru. There is only one small conservation unit, a short distance north of Lima, which is totally insufficient in view of the endemism that exists in each isolated area. Ferreyra (1976) gives an extensive list of species of the hills, among the 600 known seed or flowering plants, which are in greatest danger. He points out that the most typical genus is Nolana with 80 species, of which no fewer than 40% are threatened by air pollution from mining actitivies in southern Peru.

It is therefore necessary to establish new conservation units; but more than that, it is essential to attempt to recover this alternative for capturing moisture for productive purposes, or at least for environmental improvement, recreation and tourism. There is optimism about the technical feasibility of doing so, which has been amply demonstrated by the Ministry of Agriculture of Peru and by the Center for Research on Arid Zones of the National Agrarian University in Lima. Success in this regard would create a true oasis in the middle of the coastal desert (López, 1980).

8.3.5 The Araucaria forests

There are two plant formations on the continent with species of Araucaria as a conspicuous element: the Araucaria angustifolia forests of southern Brazil and northern Argentina (Misiones) and the A. araucana forests of south-central Chile near the Argentine border. At present both of these cover very small areas and continue to be affected by the factors that have reduced their size so greatly: agricultural expansion, fires and forestry operations. The last of these was very important in the case of Brazil;

for years, it accounted for 85 to 90% of Brazilian wood exports, which until the early 1960s exceeded one million cubic meters per year (Hueck, 1978). There are no reliable data on the area now covered by these formations. In the case of the Brazilian araucaria it was estimated at 76,000 km2 in 1956 (Maack, 1956), but today it is unlikely that there are more than 10,000 km2 of seriously degraded forests. Reis (1978) seems to confirm this, noting that in the state of Paraná the forest area has dwindled from 87% to only 7.5% during the last 100 years, and that commercial reserves of araucaria will be exhausted by 1985. However, the Brazilian Statistical Yearbook still puts the total area of forests with araucarias at 163,000 km2. As for the Chilean-Argentine araucaria, it is doubtful that more than 3,000 km2 remain. As indicated in Tables 15 and 26 of this study, the annual rate of extraction of South American tropical conifers was 14.4%, and the annual rate of deforestation 11%, including Podocarpus forests.

The seeds of both species are edible and highly nutritious, and have been part of the human diet since time immemorial. Their wood is of excellent quality, their regeneration is easy and their growth is good; all of these reasons argue for a more intelligent use of the species and for reforestation with them, which has been undertaken only on a rather modest scale, above all in Brazil.

The araucaria forests of Brazil are protected at present by the small national parks Aparados da Serra and São Joaquim, as well as smaller conservation units. The araucaria forests of Chile and Argentina are included in a few national parks near the border between the two countries.

8.3.6 Podocarpus forests

No less than 20 species of Podocarpus are found in Latin America. As conifers yielding wood of excellent quality they have been heavily exploited everywhere, and the plant formations that they dominate have been reduced to a minimum throughout their area of dispersion, which was quite large. Although the Podocarpus, like the araucaria, seldom appears in pure stands, in many cases these trees are sufficiently numerous to give their name to the forest. Such is the case, for example, of Podocarpus lambertii in the valleys and low hollows of the Brazilian planalto, P. montanus and P. rospigliosi in cloud-covered tropical and subtropical regions of the Andes, P. andinus in the southern Andes, etc.

The preferred species is undoubtedly Podocarpus rospigliosi, because of its excellent wood and straight trunk, but because of exploitation and the expansion of the agricultural frontier, this and all other species are in danger of being lost. The ecosystems in which they grow are little known and poorly protected, and the existence of endemic fauna and flora is assumed.

8.3.7 Other unique forests

In the southern Andes of Argentina and Chile there still remain several species of trees that form ecosystems with ~~a very special~~ unique value because of their scarcity on the continent. Among these are forests of Libocedrus, Nothofagus obliqua and N. procera, Fitzroya cupressoides and F. patagonica, etc. The protection given to them at present is reasonably good, but still insufficient.

Farther to the north, a similar situation occurs with stands of Puya raimondi in Bolivia, Chile and Peru; with the limited distribution of Prosopis tamarugo, highly valued for the recovery of desert areas; and with associations dominated by Pinus and Quercus in Central America and the Caribbean. The conservation of the genetic stock of natural pines is an

urgent and timely need for the future development of the forestry sector.

8.3.8 The Mato Grosso swamp

The Mato Grosso swamp covers about 175,000 km2 in the Brazilian state of Mato Grosso, on the border with Bolivia and Paraguay. To some extent, this area is an extension of the cerrado and is subject to high humidity because of its low altitude, the nature of its soils, rainfall and the influence of the Amazon rain forest. The swamp contains species indigenous to the cerrado and the Amazon region, manifesting an unusual explosion of life. This ecosystem, which traditionally has been used for very extensive grazing, is increasingly at risk because of the short-sighted approach taken to development in the region, with unsuitable farming and stockraising techniques, hydroelectric projects, drainage and other "environmental improvement" works ~~which~~ that are not always based on ecological principles and ~~which~~ fail to consider the utilization of the area's natural productivity, which from every standpoint would be the best foundation for sustained development. At present there are two conservation units in the swamp, Cará-Cará and Pantanal Matogrossense; expansion of the latter unit is planned. Clandestine hunting, especially for crocodiles, is another serious problem in the region, as is overfishing.

8.4 Prospects for development

Under this heading, two aspects should be addressed in the present chapter on natural and anthropic ecosystems. The first refers to the optimized utilization or ecologically-based development of these ecosystems and of all others. This aspect is discussed at length in other chapters under the headings of agriculture, stockraising, forestry, fishing, management of the fauna, etc., and will not be considered here. The second concerns the mechanisms for conservation of examples of natural ecosystems in the form of national parks and similar reserves. The principal ~~efficiencies~~ deficiencies have been indicated in the

brief analysis presented at the outset; obviously, future efforts should be aimed at their correction.

Ideally -- and to some extent arbitrarily -- the objective would be to establish conservation units that protect 5 to 10% of the national territory in areas of sufficient size and form to ensure the energy flows of the ecosystems involved and thus the survival of all species. If this were to be implemented, it could be expected that the present area of conservation units in Latin America and the Caribbean would total between 1 and 2 million square kilometers by the year 2000; evidently, what is not preserved by then cannot be preserved later, since the natural ecosystems will have been occupied -- i.e., transformed or degraded. Some countries, such as Zaire in Africa and Chile and the Netherlands Antilles in the Americas, have already exceeded the maximum percentage indicated. Others, including Venezuela, are very near. Costa Rica, the British Antilles and Ecuador have slightly more than 5% of their territories protected, while Panama, US Antilles, Dominican Republic, Trinidad and Tobago, Colombia, Peru and Suriname fall between 3 and 5%. Considering also the tremendous increase in protected areas during the last 10 years, which has doubled the number of conservation units established over a period of 70 years and has multiplied the area of such units sevenfold, it can be said that if the trend continues the 5% goal can be exceeded before the year 2000.

Indeed, there are many proposals for new conservation units in nearly all the countries. Peru, for example, has studies in various stages for the establishment of additional five units, which would incorporate about 3 million additional hectares into its system, providing protection for 6% of its territory. Even Costa Rica, which already has a high percentage of protection, is considering the establishment of no less than three new protected areas.

Similar plans are being studied in Paraguay, Bolivia, Colombia, Panama, Ecuador and other countries.

Clearly, as protected areas expand there will be increased resistance from other forms of land use which will be reflected in social, economic and political conflicts that in some cases will lead to the loss of already protected areas. But this natural reaction has not been serious or widespread up to the present, and can be weathered with appropriate strategies (Miller, 1980).

It should be kept in mind that the criterion of a minimum percentage of the national area is not ~~valid~~ sufficient in itself. Ecosystems with very small or small areas may require much higher percentages; on the other hand, ecosystems covering very large areas may require smaller percentages. The latter is the case of Brazil, which -- despite its immense size -- is an ecologically uniform country in comparison with the Andean countries, for example. Accordingly, it is essential to devise more sophisticated approaches in such cases, just as Brazil has done, establishing Pleistocene refuges based on birds, lepidoptera, botanic specimens and lizards, and designing its system of conservation units on the basis of the results, among the other factors usually considered (Jorge Padua, Rocha et al, 1979).

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9. MINERAL RESOURCES AND THE ENVIRONMENT

Latin America and the Caribbean together make up an environment that is very rich in mineral resources and virtually self-sufficient in all those required for the development of the region. Furthermore, it has extensive reserves that will enable it to continue exporting a very significant share of its production. Obviously, this overall assessment is not always valid for every subregion, nor for all the nonfuel minerals discussed in this chapter.

At the world level, where mineral production should nearly double by the end of the century, the situation is less encouraging; it has been calculated that the estimated (economically accessible) reserves of a number of minerals may be exhausted before the year 2000 or soon afterward. These include industrial diamonds, silver, mercury, zinc, sulfur and tungsten (before 2000), and lead, tin, copper, fluorine, platinum and nickel (before 2020) (US Bureau of Mines, 1976). However, the efforts made to increase mineral reserves have almost always been successful in recent years. Many of these minerals are still abundant in Latin America, especially copper, silver, tin, nickel, and ~~as well as~~ diamonds, which will place this continent in a situation of comparative advantage. Moreover, the dependence of the developed countries on the developing nations for most mineral products will increase even more ~~further~~ between now and the year 2000.

Mining is faced with the serious problem of increasing production costs and fluctuating prices. Developments in this regard obviously will be linked to the quality, quantity and types of exploitation (from a technical standpoint) of potential and marginal reserves. The mineral resources available in the earth's crust are immense and their extraction -- which on the whole is technically

feasible -- is a function of costs and prices. The mix of substances and recycling, as well as the conservation or substitution of products, will take on increasing importance in the future. Mineral exploitation of the rich ocean bottoms also is possible and probably will begin before the year 2000.

Table 85 shows, by regions and countries, the nonfuel mineral products that Latin America and the Caribbean produce in the largest proportions and which are significant in terms of world production. Iron ore, bauxite and copper are the mineral products that in general have played the dominant role in the value of merchandise exports of each country.

The exploitation of mineral resources is one of the non-agricultural human activities with the greatest impact on the environment; not only at the work site, with methods known as open-cut and others that are used to work low-grade deposits, but also at a great distance because of the pollution of watercourses, air and ultimately the soil caused both by extraction itself and by the processes of concentration, refining and others that are part of the metallurgical industry. The environmental impact of mining is also felt more subtly through the recreational and micro-economic activities that are developed around mining centers; these are often located in unique and fragile ecosystems which thereby suffer the effects of irrational sport or commercial hunting, the destruction of remaining forests for agricultural or other purposes, etc. The part played by miners and workers on large-scale engineering projects in the disappearance of species such as the spectacled bear, vicuña, Andean deer, guanaco~~s~~, ostrich and others is well known in the southern Andes but is not limited to that region.

Mining disturbs a significant part of the land area, especially in the "mining" countries, though obviously to a much lesser extent than stockraising and farming. But unlike the latter, mining transforms the soil absolutely and

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irreversibly, and moreover has a singularly detrimental effect on the landscape, with repercussions felt many kilometers from the site. The greatest part of the damage is done by excavation, and another substantial proportion by the ~~disposals~~ disposal of tailings and other residue. Extensive areas also are affected by plants and other installations, deposits and houses or camps, which are seldom esthetically acceptable. The mineral resources whose extraction has the greatest impact on the land are sand and gravel, with quarries sometimes covering hundreds of acres; others are copper, iron, clays and phosphate rock. ~~The~~ possibilities for ~~recovering~~ reclaiming the land are limited and in any case entail very high costs. Finally, mention should be made of the risks involved in the mining of ocean bottoms which can be particularly serious because of the long period between generations of the life forms that will be affected; because the fine sediments removed from the bottom and brought to the surface in these operations will take many years to return to the sea bed, seriously affecting surface and other species; and because most of the manganese nodules -- which also contain nickel, copper and cobalt that will be extracted from the sea -- will be a polluting waste and their processing will require massive inputs of energy and chemical reagents that will contaminate the sea even more.

Other aspects of pollution by mining and metallurgy have been discussed earlier in this report. Here we wish to mention only one specific feature of the problem: the difficulty of imposing minimum environmental guidelines on mining activity in Latin America and the Caribbean. Those ~~undertaking~~ engaged in mining operations are aware of the consequences of their activities, but pressed by costs, they ignore most of the recommendations in order to avoid or hold down ~~such costs~~ expenses. In countries with mining economies this situation reaches an extreme

because the public or private mining agencies and companies are all-powerful and do not condescend to obey the directives of government departments responsible for environmental affairs. If the latter exert pressure the mining companies immediately argue that the outlays required would endanger the mining industry responsible for the problem, though this is seldom true.

10. THE PROBLEM OF ENERGY

The "energy crisis," rather than a problem faced by Latin America and the Caribbean or by other regions of the world characterized by developing economies, is simply the manifestation, beginning in 1973, of the instability of the energy balance of most of the industrial powers of the capitalist world, which are dependent for the 55% of the petroleum they consume ~~and~~ but do not produce within their own territories. In 1972, Europe was obliged to import 95% of its petroleum from other countries, while Japan imported 100%. Even the United States -- the world's leading producer -- obtained 12.5% of its supply from external sources. The prospects indicate that this dependence will increase further. The "crisis" arose when the producing countries imposed certain conditions that had been the province of the large companies which now control only part of the petroleum operations. However, this part includes the key commercial aspects of transportation, refining and distribution, which in the last analysis has meant spectacular and continuous increases in consumer prices, in both importing and producing countries. This situation has ~~led to~~ made it ~~the economic feasibility of exploiting~~ economically feasible to exploit petroleum deposits that had been bypassed earlier, but at the same time has compelled all of mankind to address the need to save energy and to seek new sources, as well as to reconsider old but relatively neglected ones. To some extent, this has been accompanied by an unforeseen concern regarding the real problem of a world scarcity of petroleum: maximum production will occur sometime between 1990 and 2010, and will decline gradually thereafter. For the present, one thing certain is that petroleum production capacity is not increasing as fast as demand, and it is possible that by the end of the 1980s there will already be a constriction of supply.

This chapter presents a brief analysis of the situation in Latin America and the Caribbean with regard to this world problem, the possibilities ~~regarded~~ considered as most viable for alleviating its effects, and -- obviously -- the most probable environmental consequences of each alternative.

10.1 Situation and prospects of conventional energy sources

10.1.1 Reserves

Table 86 presents an estimate of reserves of conventional energy sources for most of the Latin American and Caribbean countries. As may be seen, the least favored region is Central America, followed closely by the Caribbean. The Andean region is best endowed in general, ~~and~~ and particularly in the categories of oil, natural gas and hydroelectricity. Brazil has the largest reserves of coal. Argentina and Brazil are especially rich in uranium. As for petroleum, it is well known that Venezuela and Mexico are the most favored countries, and in fact are among the ~~countries~~ nations with the largest reserves in the world.

Reserves of plant fuels have not been quantified in Table 86. In a recent OLADE/UNDP study (1979), on which the table is based, it is estimated that reserves of conventional energy sources, including plant fuels, are distributed proportionally as follows: petroleum (14%), natural gas (7%), hydroelectricity (67%), coal (6%), uranium (2%) and plant fuels (4%). This underscores once again the potential role of hydroelectric energy, and therefore the importance of watershed management.

Table 86. Reserves of conventional energy sources in Latin America and the Caribbean.

Region / Country	Petroleum mm3 (as of 1/1/78)	Natural gas gm3 (as of 1/1/78)	Hydroelectricity TWh (1970)	Coal mtm (present)	Uranium ~~tm~~ MT (present)
NORTH AMERICA					
Mexico	2,225.9	850.0	97.0	439.7	5,000
Total	2,225.9	850.0	97.0	439.7	5,000
CENTRAL AMERICA					
Costa Rica			30.9		
El Salvador			6.4		
Guatemala	2.5		36.0		
Honduras			30.8		
Nicaragua			20.0		
Panama			27.4		
Total	2.5		151.5		
CARIBBEAN					
Barbados	0.2	8.0			
Cuba			6.0		
Haiti			3.8		
Jamaica			2.4		
Dominican Rep.			1.0		
Trinidad and Tobago	103.3	240.0	1.0		
Total	103.5	248.0	14.2		
ANDEAN					
Bolivia	55.6	141.0	128.4		1,000
Colombia	152.6	180.0	334.3	343.8	
Ecuador	260.7	141.0	150.4		
Peru	116.1	37.0	286.8	118.0	
Venezuela	2,893.6	1,160.0	304.0	440.0	
Total	3,478.6	1,659.0	1,203.9	901.8	1,000
ATLANTIC					
Brazil	139.9	34.0	900.5	1,400.0	21,000
Guyana			40.8		
Paraguay			47.1		
Suriname			23.0		
Total	139.9	34.0	1,011.4	1,400.0	21,000

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Table 86 continued

SOUTHERN TIER Argentina Chile Uruguay	 397.9 69.9	 230.0 56.0	 148.0 197.0 7.5	 251.0 294.0	 24,000 5,000
Total	467.8	286.0	352.5	545.0	29,000
SOUTH AMERICA	4,086.3	1,979.0	2,567.8	2,846.8	51,000
LATIN AMERICA AND THE CARIBBEAN	6,418.2	3,077.0	2,830.5	3,286.5	56,000

Notes: mm3 cubic megameters
gm3 cubic gaseous gigameters
TWh tarawatts/hour
mtm megatons

Source: OLADE/UNDP (1979) based on Oil and Gas Journal (1977) and on reports by OLADE (1977), the Bariloche Foundation (1977) and CEPAL (1975).

10.1.2 Consumption

Table 87 shows electric energy production in 1976, by type of generating plant, for each country of Latin America and the Caribbean. Hydraulic production is the principal source of electric energy (58%), followed closely by thermal (41%). At that time nuclear and geothermal sources were still incipient; even now, in 1980, they continue to be of little significance despite the entry into service of nuclear plants in Brazil. The thermal source of electric energy is essentially petroleum, but in some countries coal and gas also are used, though not yet on a substantial scale.

Per capita generation of electricity for the entire region is 657 KWh/person, with 54.9% of consumption used for industrial purposes, 21.1% by households and 24.0% for other purposes. These figures show comparatively little variation among regions.

Table 87. Electric energy production by type of plant in the countries of Latin America and the Caribbean (in gigawatts/hour).

Region / Country	Hydroelectric	Thermal	Nuclear	Geothermal	Total
NORTH AMERICA					
Mexico	17,729	28,333		550	46,612
Total	17,729	28,333		550	46,612
CENTRAL AMERICA					
Costa Rica	1,456	190			1,646
El Salvador	716	203		280	1,199
Guatemala	340	910			1,250
Honduras	493	97			590
Nicaragua	405	635			1,040
Panama	110	1,398			1,508
Total	3,520	3,433		280	7,233
CARIBBEAN					
Barbados		288			288
Cuba	53	7,145			7,198
Haiti	159	50			209
Jamaica	145	2,233			2,378
Dominican Rep.	175	2,515			2,690
Trinidad and Tobago		1,067(b)			1,067
Total	532	13,538			14,070
ANDEAN					
Bolivia	890	240(b)			1,130
Colombia	10,080	5,263(a)			15,343
Ecuador	628	1,257			1,885
Peru	6,500	2,150(b)			8,650
Venezuela	10,524	12,752(b)			23,276
Total	28,622	21,662			50,284
ATLANTIC					
Brazil	81,468	6,915(a)			88,383
Guyana		398			398
Paraguay	645	55			700
Total	82,113	7,368			89,481

Table 87 continued

SOUTHERN TIER Argentina Chile Uruguay	 5,000 6,234 1,220	 22,756(a) 3,042(a) 1,580	 2,572		 30,328 9,276 2,800
Total	12,454	27,378	2,572		42,404
SOUTH AMERICA	123,189	56,408	2,572		182,169
LATIN AMERICA AND THE CARIBBEAN	144,970	101,712	2,572	830	250,084

Note: Thermal energy produced by petroleum, except when coal and gas(a) or gas alone(b) also are used.

Source: CEPAL (1978).

As Table 87 shows, there is still considerable dependence on thermal sources for the generation of electric energy. This dependence is not commensurate with the energy potential available, since hydroelectric energy represents 67% while petroleum accounts for only 14% of the reserves of conventional energy sources.

However, energy consumption does not refer only to electricity. Considering it in its broader sense, we find that fuelwood and to a lesser extent charcoal account for as much as 20% of total energy use in Latin America and the Caribbean. Table 88 shows the relative shares of energy sources in Brazil and changes from 1960 to 1973, while Table 89 shows the proportions for Central America.

Table 88. Relative participation of energy sources in Brazil (in percentages).

Sources	1960	1967	1973
Solid fuels (coal and others)	3.6	3.9	3.2
Liquid fuels (petroleum derivatives)	37.6	39.4	48.4
Natural gas	0.1	0.2	0.3
Hydraulic and nuclear	14.1	15.7	20.7
Photosynthetic (fuelwood, charcoal, sugarcane bagasse, etc.)	44.6	40.8	27.4

Source: Thibau (1977), based on Comité Brasileiro de Energia (1973).

Table 89. Relative participation of energy sources in Central America (in percentages)

Country	Fuelwood and Charcoal	Bagasse	Petroleum	Geothermal and Hydraulic
Costa Rica	28	12	58	5
El Salvador	37	9	48	6
Guatemala	41	7	49	3
Honduras	45	6	45	4
Nicaragua	25	12	58	5
Panama	13	6	79	2
Nonweighted Average	31	9	55	5

Note: Information for 1975.

Source: Gewald (1980), based on SIECA (1978).

10.1.2.1 Petroleum and natural gas

From any standpoint, petroleum is now the largest industry in the world. Not only does it account for nearly half of world energy production, but its processing yields a wide range of products that are virtually indispensable for development as it is now conceived. Natural gas is constituted by the most volatile components resulting from the process of formation of petroleum, and its exploitation began simultaneously with that of oil, although it has not expanded in the same degree.

Latin America and the Caribbean began to develop their petroleum reserves soon after the first commercial extractions in the world, but the knowledge of the real extent of reserves is more recent. Table 90 shows the volumes of production, exports, imports and consumption of crude and refined oil for each country and region for 1978. In production of crude the obvious leaders are Venezuela (791 million barrels), Mexico (485 million barrels) and Argentina (163 million barrels). Next are Trinidad and Tobago, Ecuador, Brazil, Peru and Colombia. Venezuela alone accounts for 44% of the production of the study area and, together with Mexico, produces 72%. The table makes it clear that ~~whole~~ entire regions are extremely poor in petroleum, especially Central America, and that the countries in those regions are major importers of crude. Obviously, the leading importer of crude is Brazil (329 million barrels), which accounted for 62% of the total amount imported by Latin America and the Caribbean in 1978. The principal exporters are -- as is well known -- Venezuela (454 million barrels) and Mexico (133 million barrels), together accounting for 86% of the area's exports. Substantial volumes also are exported by Trinidad and Tobago and Ecuador. Peru will soon export crude, together with Bolivia which is

the smallest exporter at present. Petroleum generates 61.8% of Venezuela's earnings from merchandise exports, 40.9% for Ecuador, 19.5% for Bolivia and 7% for Trinidad and Tobago, but only 1.6% for Mexico.

Table 90. Production, imports, exports and consumption of petroleum in Latin America and the Caribbean in 1978 (millions of barrels).

Region / Country	Production		Imports		Exports		Consumption
	Crude	Refined	Crude	Refined	Crude	Refined	
NORTH AMERICA							
Mexico	485.3	321.8		10.6	133.2	0.7	331.8
Total	485.3	321.8		10.6	133.2	0.7	331.8
CENTRAL AMERICA							
Costa Rica		3.4	3.7	3.5			6.9
El Salvador							4.5
Guatemala		5.1	5.8	4.4			8.3
Honduras		3:2	3.4	0.6			3.8
Nicaragua							6.1
Panama		15.2	16.7	0.4		4.8	13.4
Total		26.9	29.6	8.9		4.8	43.0
CARIBBEAN							
Bahamas							
Barbados	0.3	1.2	0.6	1.4	0.03	1.1	1.5
Haiti				1.7			1.7
Jamaica							
Dominican Rep.		9.4	11.3				14.6
Trinidad and Tobago	83.8	83.0	56.8		51.2	75.6	4.9
Total	84.1	93.6	68.7	3.1	51.23	76.7	22.7
ANDEAN							
Bolivia	11.8	9.8		0.2	2.9	0.1	7.6
Colombia	47.7	57.4	8.8	7.8		11.1	46.5
Ecuador	73.7	29.0	0.2	1.9	44.8		30.9
Peru	56.7						
Venezuela	790.6	358.1			454.4	262.1	109.5
Total	980.5	454.3	9.0	9.9	502.1	273.3	194.5
ATLANTIC							
Brazil	58.5	380.1	328.9	7.1		1.8	385.4
Guyana				4.6			4.6
Paraguay		3.1	2.5	0.6			3.1
Total	58.5	383.2	331.4	12.3		1.8	393.1

Table 90 continued

SOUTHERN TIER Argentina Chile Uruguay	162.8 6.3	174.8 34.4 13.5	15.3 27.1 15.1	1.3 2.3		2.4	173.5 36.7 12.8
Total	169.1	222.7	57.5	3.6		2.4	223.0
SOUTH AMERICA	1,208.1	1,060.2	397.9	25.8	502.1	277.5	810.6
LATIN AMERICA AND THE CARIBBEAN	1,777.5	1,563.4	528.8	55.1	686.9	362.9	1,269.3

Note: IDB estimates for all of Latin America and the Caribbean.

Source: IDB (1978).

Proven reserves of oil and gas in 1978 and their potential production are shown in Table 91. As may be seen, Mexico's reserves exceed those of Venezuela; the two countries together have 86% of the reserves of the entire study area. At the present rate of production the Mexican reserves will be exhausted in 66 years and the Venezuelan reserves in 23 years (from 1978). The distribution of natural gas reserves is similar to ~~those~~ that of oil, with Mexico and Venezuela having 80% of the total; however, they should last longer because of their lower rate of extraction. The figures in Table 91 are clear evidence of the need to seek alternative sources of energy, which is even more critical considering the trend-based projections of consumption. In fact, production of crude has been declining in relation to consumption since 1973 (187% in 1973, 148% in 1976 and 140% at the end of 1978).

Table 91. Proven reserves and years of potential production of crude oil and natural gas for countries of Latin America and the Caribbean (1978).

Country	Crude oil		Natural gas	
	Reserves (millions of barrels)	Potential production (years)	Reserves (millions of m3)	Potential production (years)
Argentina	2,390	15	190	26
Barbados	80	266		
Bolivia	91	8	104	45
Brazil	1,144	19	34	21
Colombia	801	17		
Ecuador	1,500	20	35	
Guatemala	12			
Mexico	28,500	66	1,655	79
Peru	600	11	32	15
Trinidad and Tobago	750	9	170	38
Venezuela	18,199	23	1,192	34
Latin America and the Caribbean	54,087	30	3,538	40

Source: IDB (1978).

10.1.2.2 Hydroenergy

As we have seen in the chapter on water and at the beginning of this chapter as well, hydroenergy is the alternative with greatest potential in Latin America and the Caribbean. This fact is by no means unknown, and although ~~its~~ development has been comparatively neglected in favor of the use of petroleum, there are ~~as~~ now large-scale works under construction which will bring the situation into balance during the 1980s. The most spectacular are those being built on the Paraná river (Itaipú, Yacyretá and Corpus), but there is also Salto Grande and several others in South, North and Central America. Itaipú will produce 72 to 80 billion kwh per year, and is the most ambitious hydroelectric project ever undertaken by man. Yacyretá will produce 17 billion kwh. With these two works, from which Paraguay will obtain 50% of the production, that country probably will become the world's leading exporter of energy, since by 1989 the energy at its disposal may be 20 times greater than ~~the~~ projected national demand (World Bank, 1978). The Salto Grande project on the Uruguay river will generate 6,700 million kwh per year.

In Central America the hydroelectric projects under way include Pueblo Viejo Chixoy, Guatemala (300 MW); Aguacapa, Guatemala (90 MW); San Lorenzo, El Salvador (180 MW); El Arenal, Costa Rica (157 MW); Corobicí, Costa Rica (174 MW); El Cajón, Honduras (292 MW); and Copalar, Honduras (350 MW). Before 1985 nearly 1.7 million hydroelectric kilowatts will have been added to production capacity in Central America, together with a smaller geothermal capacity, which will be essential in reducing imports of petroleum and their adverse effects on the balance of payments (IDB, 1978).

10.1.2.3 Fuelwood and charcoal

Wood is the primary domestic fuel of the rural population in developing countries, and -- according to FAO (1979) -- of many of the urban poor as well. It is estimated that more than 1.5 billion persons use fuelwood each day for cooking and heating. Total consumption of fuelwood in the developing countries is estimated at 1.2 billion cubic meters per year, of which half is used for cooking, one third for heating and the rest for agricultural and industrial purposes. Fuelwood supplies 80% of all the energy consumed in the rural areas of the developing countries, apart from human and animal energy (FAO, 1979). It is also stated that in 1979 wood and its byproducts supplied three times more energy than that generated by hydroelectric sources (Earl, 1975).

In Latin America and the Caribbean ~~the~~ dependence on fuelwood as an energy source is less than in other continents or regions, such as Black Africa where fuelwood ~~represents~~ provides 75% of total energy consumption. Nonetheless, it accounts for 9% in Central America and the Caribbean and 29% in South America (World Bank, 1978), as may be seen in Table 92. Furthermore, fuelwood represents 81.8% of the unsawn timber produced in the study area. The impact of the collection of fuelwood is not serious in tropical rain forests, where the population is small even on the periphery and where the humidity permits the generation of much combustible material. It is critical, however, in arid and semiarid regions such as the central Andes or the northern Peruvian and southern Ecuadorian coasts, and the coastal hills of Peru and Chile, to mention only a few examples. In those places the search for fuel goes from the gathering of dead trunks and dry branches to the cutting of mature trees and later the felling of green trees, pulling up stumps and roots. This is followed by the removal of shrubs, and finally even vegetation that has no use as fuel. This sequence is illustrated perfectly by what happened in the

Andes, where the extraction of Polylepis and Buddleia trees was followed by the use of Lepidophyllum shrubs and finally even rushes such as Distichia muscoides. The final stage, again found in the Andes, is the gathering of dung. It is believed that in Asia, the Near East and Africa about 400 million tons of dung are burned annually, and that each ton burned may mean the loss of up to 50 kg of cereal (FAO, 1979). These losses have not been estimated for Latin America.

Table 92. World consumption of wood-based fuels as a percentage of total energy consumption in coal equivalent (1974).

Region	Commercial energy (1) (millions of MT)	Wood-based fuels (2) (millions of MT)	Total (millions of MT)	Wood-based fuels as % of total
World total	7,084	456	7,540	6
Developed economies	5,994	53	6,047	1
Developing economies	1,090	403	1,493	27
Southeast Asia and Oceania	100	92	192	48
South Asia	115	88	203	43
China and rest of Asia	492	49	541	9
Middle East and North Africa	87	22	109	20
West and Central Africa	12	36	48	75
East and South Africa	13	39	52	75
Central America and Caribbean	110	11	121	9
South America	161	66	227	29

Notes: (1) Including energy generated by coal, lignite, petroleum and gas, and hydraulic and nuclear sources.

(2) 1 m3 of wood-based fuel equivalent to 0.33 MT of coal.

Source: World Bank (1978) based on UN Statistical Yearbook (1974) and FAO Forest Products Yearbook (1973).

The high consumption of fuelwood is due largely to the inefficient way in which it is burned, which in Latin America is primarily in open fires. In Latin America fuelwood is used to an appreciable extent for the manufacture of bricks and in commercial baking ovens, with very primitive and usually inefficient techniques. Another problem associated with the predominant use of ~~firewood~~ fuelwood at present is the high energy consumption required to gather it.

10.1.2.4 Nuclear energy

One advantage of nuclear energy with respect to hydroelectric energy is that it can be produced near consumption centers, thereby avoiding the costly transmission of electric energy by cable. However, its disadvantages are many. As already noted, one of the main drawbacks is the waste and other pollutants created; another is the risk inherent in a technology that is still dangerous because it is not totally controlled at the normal operating level. Brazil and Argentina -- soon to be joined by other countries -- are developing and will continue to develop this technology, for which many regions have the necessary reserves of uranium.

10.1.2.5 Coal

As Table 92 shows, reserves of coal in Latin America are on the whole limited. They are being exploited where they do exist, especially in Brazil.

10.2 Situation and prospects of nonconventional energy sources

10.2.1 Solar energy

A recent OLADE/UNDP study (1979) pointed out the excellent opportunities available in two-thirds of the territory of Latin America -- where three-fourths of its population lives -- to utilize solar energy because of the global solar radiation received during the best and worst months. Obviously, the development of this source requires the availability of appropriate equipment making it possible to tap solar energy for cooking in high mountain areas, hot water

for bathing or other uses, heating, distillation and the ~~manufacturing~~ manufacture of ice. Such equipment, all of which is relatively simple, constitutes what can be regarded as a first step in the direct utilization of solar energy, and is expected to be developed to some extent in the study area before the year 2000.

However, there is already a second technological step based on the storage of energy, which makes it possible to overcome the problem of the alternation of day and night or of sunny and cloudy periods, and to capture and concentrate greater proportions of solar radiation. There are prototypes at the home level, as well as tests on a larger scale with solar furnaces. The main problem is the high cost of the energy obtained with presently known techniques.

10.2.2 Wind energy

The coastal areas of Colombia, Venezuela, Brazil, Uruguay, Argentina, Chile, Peru and Ecuador, as well as the Caribbean Islands, offer reasonably good conditions for the use of wind energy. On the other hand, southern Argentina and Chile have truly exceptional conditions in this regard, which justify the effort to design equipment that can harness the immense power generated by their high winds.

Wind energy is utilized relatively well in the Southern Tier, but is virtually unknown in the Andean and other regions, where not even the most conventional windmills are used.

10.2.3 Geothermal energy

At present geothermal energy is used only in Mexico (since 1973) and El Salvador (since 1975). Two new installations are under construction in El Salvador and Nicaragua. In the other regions this source is not utilized, and there has been very little study of it. Nonetheless, a recent OLADE report indicates that there are abundant possibilities in South America, throughout

Central America, Mexico and in much of the Caribbean; in addition to the facilities just mentioned there are about 25 sites of interest, six of which have feasibility studies completed or under way. Chile has three sites in this situation, but the majority (13) are in Mexico, Central America and the Caribbean.

10.2.4 Small-scale hydraulic works

Small-scale hydraulic works are used to a very limited extent in Latin America and the Caribbean to generate energy, and there are no programs to expand them despite their great potential for rural areas. Small thermal plants are built alongside waterways and waterfalls with permanent flows because of the lack of knowledge of simple technologies and of adequate equipment in the market.

10.2.5 Heat recovery

Defining heat recovery as transformation of the energy contained in the exhaust gases of thermal conversion processes, two main sources may be distinguished: thermoelectric plants and industrial processes in which little use is made of the thermal energy contained in fuels, as in the case of certain steelmaking and metallurgical operations (OLADE/UNDP, 1979).

The first situation applies particularly to steam and gas turbine plants, with very low thermodynamic yields: 20 to 35% depending on the type, size and age of equipment. In the second case, although a substantial amount of energy may be available from the gases created in the process, it is used ordinarily for consumption in the plant itself, with only surpluses released for public service (OLADE/UNDP, 1979).

10.2.6 Bituminous shale

Bituminous shale -- also inaccurately called bituminous schist -- is a fine-textured sedimentary rock whose interstices contain "kerogen," the source of carbon. Brazil has large potential reserves of this substance, estimated at about 24% of the world total. Reserves of shale recoverable with present technologies in that country amount to about 8×10^9 cubic meters of petroleum, nearly 50 times its proven reserves of petroleum.

The Iraté reserve alone has 80% of the known reserves in Brazil. In the São Mateus do Sul region, where there is a pilot plant, reserves in an area of 80 km2 are estimated at 103 million cubic meters of petroleum, 10 million tons of sulfur, 4 million tons of liquefied petroleum gases and 600 million cubic meters of gases. The pilot plant has a capacity of 2,000 MT/day and the shale is processed with technologies developed in Brazil (OLADE/UNDP, 1979).

10.2.7 Biomass

The industrial use of the biomass for energy production is not entirely new; among other cases, it was undertaken to supply military requirements during World War II. Since that time it has continued to receive some attention, and there are numerous plants in operation which utilize such substances as the residues of forestry operations to provide all the energy needed by the plants. However, the new prospects are much more ambitious. According to estimates made by Earl (1975) and other authors, the total energy that could have been obtained merely from the unused annual increase in the tropical forests of the world would be equivalent to nearly one-half the world consumption of energy from all sources. Adding to this the possibility of making rational use of the biomass existing elsewhere -- such as forests and natural vegetation in other places or ecosystems of the world and the residues of forestry, agriculture,

stockraising, agroindustry and urban fuels -- it would be possible in theory to supply more than the entire human consumption of energy without destroying the resources.

The biomass can be used directly without processing, as in the case of fuelwood, or through transformation into coal, anhydrous ethyl alcohol, biogas, briquettes and other products.

10.2.7.1 Forest resources

The forest resources used and usable for energy purposes may be grouped by origin as follows: fellings in natural forests, residues of forestry operations, residues of wood processing, and fellings in artificial forests planted expressly for energy purposes. Among these four possibilities, the principal one in Latin America is unquestionably the first. Although such natural forests could be managed to produce fuelwood on a sustained-yield basis, this is not done; hence the severe adverse ecological impact of this activity. The residues of forest extraction, although abundant, are not used; those of industrial plants are used, but to a minuscule extent. Furthermore, such industrial residues are usually burned for the sole purpose of preventing blockage or dumping in rivers, which they pollute heavily. Finally, plantings to supply fuelwood are ~~something new~~ a novelty and there are none in production except in Brazil, where the purpose is production of charcoal for steelmaking.

The Bariloche Foundation, mentioned in the OLADE/UNDP report (1979), has drawn chiefly on FAO forestry statistics to estimate the total contribution to energy production that could be obtained through 1995 from the forest resources of Latin America and the Caribbean. The report refers to the forms of extracted and collected fuelwood, and residues of extraction and sawmills; depending on the region, the contribution is between 9 and 40% at present and will be between 5 and 13% in 1995. The maximum percentages in this

regard are found in the Atlantic (Brazil) and Andean regions. The same source estimated the impact of such utilization on forests at only 0.3% of stocks in 1995 as an average for all of Latin America, and at 0.7% as a regional maximum.

Brazil has estimated its total future consumption of coal for the domestic steelmaking industry at over 21 million tons in 1985. These requirements will be met in nearly equal parts by reforestation with eucalyptus in Minas Gerais and elsewhere (10 million tons), and by natural forests, particularly in the cerrado (11 million tons). In that year the steel plants will have 1,500,000 ha of eucalyptus stands (Thibau, 1977).

The production of alcohol from wood has already been envisaged in several countries of the world, but particularly, again, in Brazil. The process consists of hydrolysis in three phases with concentrated acids, which permit 95% of the celluloses to be transformed into sugars; the yield is 590 kg of sugar per ton of wood. Thereafter the process is identical to that used with sugarcane or cassava, i.e. through fermentation; the yield is about 200 liters of anhydrous alcohol per ton of dry wood. Although the technology is still expensive, it is believed that falling prices will soon make it economically feasible.

In speaking of alcohol it is very important to consider the utilization of agricultural crops such as sugarcane and cassava for its manufacture. In principle, sugarcane is the most appropriate crop; but because it is more demanding of soils than cassava, the latter has greater potential for being grown on large areas. The alcohol produced can replace up to 20% of the volume of gasoline without altering the carburation system of motors, giving a higher-octane and less polluting product. The National Alcohol Program of Brazil is already producing about 9.5 million liters of ethyl alcohol per day, chiefly

from sugarcane but to an increasing extent from cassava, for which a plant producing 60,000 lt/day has already been installed. The main problem was in the cost of raw material, and can be solved through greater ~~production~~ output and higher productivity; these matters are now being addressed. But the aspect that must be considered in this approach is the impact that it will have in a not entirely foreseeable future on vast areas of natural forests that probably will be burned to make room for plantings of cassava, which will yield much less ethyl alcohol per unit of area and will require inputs of energy -- especially fertilizers -- in order to be profitable.

Table 93 shows the contribution of forests to the energy produced by the biomass that OLADE/UNDP assumes will exist in 1985 and 1995 (OLADE/UNDP, 1979).

10.2.7.2 Agricultural residues

~~The~~ plant residues that remain in fields after the harvest can be used to generate energy, to maintain soil fertility or to feed cattle. The use made of them depends on many factors, which seems to leave some room for energy use. The OLADE/UNDP study finds that -- except in a few regions -- the amounts are not very significant and their use in 1985 and 1995 will be primarily in mixtures with livestock residues for the production of biogas (see Table 93).

10.2.7.3 Livestock residues

The dung and urine of domestic animals can continue to be used as fertilizer, as dry fuel and also -- as assumed in the OLADE/UNDP study (1979) -- to produce biogas. Table 93 shows the contribution of this type of residue expected in 1985 and 1995 in Latin America and the Caribbean.

10.2.7.4 Agroindustrial residues

Agroindustrial residues such as sugarcane bagasse, cassava residues, black liquor from cellulose chemical pulp plants, coffee hulls and coffee pulp, rice husks, oilseed residues, gases produced in the manufacture of charcoal, etc., in addition to their use in the manufacture of food -- especially for animals -- and fertilizers, are and will continue to be used for the production of energy. Above all, they are expected to be utilized as in the past to produce the energy consumed by agroindustrial processes themselves. Table 93 shows the probable contribution of this type of residues to the production of energy from the biomass in 1985 and 1995 (OLADE/UNDP, 1979).

10.2.7.5 Urban residues

In this category, besides the usual wastes from domestic activity, the OLADE/UNDP report (1979) considers the solid waste produced in communities of over 20,000 inhabitants by tertiary activities and in general all wastes whose collection, transportation, storage and elimination are carried out by municipalities or by the users themselves. Liquid sanitary wastes were not included. The study assesses their importance on the assumption that they will be used to produce motive power and electricity (Table 93).

10.2.7.6 Biogas

Biogas can be produced through the anaerobic digestion of organic matter containing carbon and nitrogen in certain proportions. It can be obtained from agricultural, stockraising, agroindustrial and human residues, but the latter were excluded from the study which is summarized in Table 93.

10.2.7.7 Anhydrous ethyl alcohol

The OLADE/UNDP study (1979) on which the information presented in this chapter is based considers only the production obtained from sugarcane and cassava. The comments made earlier should be taken into account in this regard.

10.3 Probable development of energy supply

In supplying the growing consumption of energy by the population of Latin America and the Caribbean up till the year 2000, an increasingly important contribution will be made by certain conventional sources, especially hydroelectric energy and nuclear energy. On the other hand, petroleum will gradually give way to nonconventional sources of energy.

Among the latter, the biomass will supply approximately one-third of total energy demand in 1995; this means a substantial decrease from the 50% that it represents at present (Table 93), although in absolute terms it will nearly double. The demand for energy will rise at a cumulative annual rate of 6.5%, whereas the supply of energy from the biomass will increase by only 3.6% since its utilization depends largely on the growth rate of the population. On the other hand, total energy consumption -- especially that of the industrial sector -- responds to other factors. This can be seen in Table 93, where the highest growth rates are in alcohol and industrial residues, associated with industrial plants, while forest resources are in last place with a cumulative annual rate hardly exceeding 1.3% (OLADE/UNDP, 1979).

Table 93. Energy resources to be produced in Latin America and the Caribbean in 1985 and 1995.

Source	1975	1985	1995
Forest resources	6,710	7,589	8,783
Agricultural residues	1,770	2,900	4,950
Stockraising residues	3,040	4,390	6,160
Agroindustrial residues	1,754	3,204	5,501
Urban residues	589	1,027	2,047
Alcohol	8	204	443
Total	13,871	19,314	27,884
Estimated demand for energy resources	27,990	53,700	97,760
Biomass resources as % of demand	49	36	28

Note: Values in tep.

Source: OLADE/UNDP (1979) based on data from the Bariloche Foundation.

In 1995, however, the contribution from forests will continue to lead among biomass sources (30%), followed by stockraising (20%), agroindustry (19%), agriculture (17%), urban residues (12%) and alcohol (2%). This assessment in the OLADE/UNDP report (1979) is the most sophisticated now available, but some sources predict a greater share for alcohol obtained from wood and agricultural crops, as discussed above. Furthermore, there is need for study of the impact of forest plantings and the management of natural forests, especially for the production of fuelwood, charcoal and alcohol.

Considering all nonconventional energy sources together, the study indicates that in 1995 these could cover 11% of the total requirements of Latin America and the Caribbean; but if the alternative development strategy mentioned in the study is carried out, it is possible that they will provide 5 to 15% more. These contributions will permit a significant decrease in the share of hydrocarbons and coal. The contribution from these sources will have a particular impact on rural areas, where they will meet 35% of total requirements, of which rural household demand will account for 41%.

After 1995 the industrial sector will gradually occupy the dominant position. The energy sources making the largest contributions and with fastest growth will be solar energy in particular, followed by biogas and charcoal briquettes. Also making substantial contributions, but with slower growth, will be fuelwood and ordinary charcoal, followed by plant residues, geothermal energy and alcohol. The sources making small contributions but with rapid growth will be small hydroelectric plants and urban residues, leaving heat recovery and wind energy with the smallest shares (OLADE/UNDP, 1979).

11. HEALTH AND ENVIRONMENT

11.1 General considerations

The link between health and the environment is extremely close because it involves host-parasite relationships and the dynamics of populations, altered in this case by man and his tendency to increase his numbers beyond all natural parameters. Diseases of humans and of domestic animals (and, in fact, the natural enemies of domesticated plants as well) are merely an expression of the resistance of the environment, which attempts to reestablish a proportionality among populations of species.

As occurs in nature, the populations most affected by diseases are the worst-nourished. In the case of human beings one must add the effect of the extraordinary crowding that occurs in city environments -- especially among the poor -- where the situation is aggravated still further by the lack of potable water supply, sewerage and other services that are essential for the maintenance of a minimum level of hygiene. There is also the problem of industrial and urban pollution, which ~~also~~ again affects the poor much more severely.

Urban and rural poverty, which continues to afflict most of the inhabitants of Central America and the Caribbean, is therefore the primary cause of health problems. Obviously, the origin of diseases is not human, although many ~~of the~~ human effects on the environment are related to those diseases and aggravate their ~~consequences~~ impact, as will be seen below ~~with regard~~ in relation to some of the most important specific cases.

The following paragraphs briefly review the principal health problems most directly related to the environment.

11.2 Some of the most important problems

11.2.1 Schistosomiasis

Schistosomiasis or bilharzia (Schistosoma mansoni) is an increasingly serious disease in the tropics because the development of water resources affords favorable conditions for ~~the~~ dispersion of the mollusks (snails) that transmit it. While it is not too serious in Latin America, this disease already is known in Brazil and Venezuela, and in the Caribbean as well. The presence of the snail (Biomphalaria spp.) in a number of hydrographic systems -- including the Rio de La Plata where it is endemic -- suggests that it may be propagated to other places where large-scale hydroelectric projects are undertaken with dams and especially irrigation systems. Such is the case of works on the Paraná, the Uruguay, the Bermejo and other rivers, where the disease can be introduced through the adaptation of the alternate host and the immigration of infected humans.

The risks of propagation of schistosomiasis to humans are reduced enormously when appropriate sanitary conditions are present, such as potable water supply and treatment of household wastes. The damage also can be limited by education, medication, testing and vaccination. New schistosomiacides have been developed by the pharmaceutical industry. For Latin America this disease is a latent risk with the probability of increasing toward the end of the century, although in this continent it obviously will not become as serious as it now is in Africa or Asia.

11.2.2 Malaria

Malaria is one of the most widespread diseases in the tropical world and also in Latin America and the Caribbean, where the Plasmodium is transmitted by Culicidae of the genus Anopheles. Because of the habits of

the vector, this disease is closely associated with fresh water and its utilization by man, which often creates favorable conditions for its dispersion, through irrigation works and especially irrigation by pools, for example in rice-growing. Well-known methods to control the vector with pesticides applied in the places where it lays its eggs and in houses have succeeded in eradicating malaria from vast areas of the continent, although this has had an adverse impact on the fauna not subjected to treatment; the same thing happens when the method used is drainage. Unfortunately, any omission in the malaria control program allows the disease to reappear, as has occurred in large areas of Peru.

As an illustration of the precarious balance that prevails, it is worth mentioning the recent finding by R. Lord of the Pan-American Center for Human Ecology and Health that Anopheles darlingi, in Bolivia, proliferates after the cutting of forests because water is then exposed to light; this stimulates the growth of aquatic plants such as Eichornia and Pistia, thereby favoring the multiplication of the Anopheles mosquito. On the other hand, the adult prefers shade, and when there are no trees it seeks refuge in houses, increasing the risk to humans (P. Freeman, personal communication).

11.2.3 Yellow fever

Yet another of the most serious diseases of Latin America and the Caribbean, yellow fever today is confined to scattered areas thanks to the chemical treatment against the vector of the virus, the Culicidae Aedes aegypti. The larvae of this vector establish themselves preferably in water handled directly by man or in water that he stores unintentionally or for the use of cattle. But these treatments are not applied everywhere in the countries, which means that new and smaller foci can appear. Because the reservoir hosts of the disease are various wild animals, outbreaks are limited to areas of recent

settlement or forestry operations.

11.2.4 Rabies

Rabies is a disease transmitted by various carnivores as well as by vampires and certain bats and their arthropod parasites. Its incidence is greatest among cattle of tropical and subtropical regions. Bats are especially dangerous because of their large numbers and because they can carry or transmit the virus with or without the appearance of clinical symptoms of rabies. Some of the methods proposed for the control of animals that carry rabies, especially bats in tropical stockraising areas, may have serious effects on the natural balance of their ecosystems affected by treatment, and have given rise to heated debate. The matter is especially controversial because bats are highly important in limiting the populations of many insects, some of which are harmful.

11.2.5 Foot-and-mouth disease

Foot-and-mouth disease, as is well known, is one of the major health problems faced in stockraising in South America. It is an extremely contagious viral disease that attacks ruminants and swine, sheep and goats, causing the death or debilitation of entire herds. The two methods most commonly employed to cope with it are massive vaccination and the slaughtering of infected animals. But because vaccines are expensive, uncertain and greatly dependent for their effectiveness on the cooperation of stockmen, the procedure followed by the countries that are now generally free of the disease is the slaughtering of herds. It should be noted that foot-and-mouth disease affects wild animal populations by contagion from domesticated animals, and in some cases vice versa.

This disease, though common in Colombia, is unknown in Panama and in other parts of the Central American isthmus, Mexico and the United States, largely because of a natural barrier of ~~wild forest~~ wilderness known as the Darien "gap". This explains the concern ~~regarding~~ about construction of the section of the Pan American Highway which, by crossing the Darien "gap", will connect South America with Central and North America, making it virtually impossible to prevent the spread of the disease. Precautions are being taken -- such as a ban on cattle within 40 km of the entire Colombian-Panamian border and similar measures -- but, for various reasons, the likelihood of their success is limited, especially in the medium and long term.

This is the proper point to note that the construction of highways has a serious environmental impact per se, apart from the settlements that they bring, and that one of these effects is precisely the propagation of diseases and pests of man and of his plants and domesticated animals.

11.2.6 Chagas' disease

This is a very widespread disease in the poor rural areas of Latin America, from Argentina, Chile and Uruguay to Central America, and especially in hot and dry regions. It is an American form of trypanosomiasis ~~which is~~ and extremely serious, especially the cardiac type which causes high mortality. The vectors are reduviid bugs, particularly those of the genus Triatoma, which lives in proximity to man, in his houses and on his farms. As with the other diseases, its ~~spreading~~ propagation is associated with transportation; this aspect therefore should be considered in the design of new highways, and especially in the planning of settlements in arid or semiarid ecosystems, including the Gran Chaco.

11.2.7 Other diseases

As stated at the outset, nearly all of the diseases are related to problems of the environment. This applies to the ones already mentioned and

other such as onchocerciasis, caused by a filaria of the genus Onchocera transmitted by a Simulium, leprosy, leptospirosis, plague and histoplasmosis; and to diseases associated with more "urban" problems such as cancer (carcinogenic pollutants) and cardiac diseases (the pressure of modern life).

11.2.8 Dangerous vertebrates

Because of their relationship to a crucial aspect of conservation, namely the erosion of the genetic stock, mention should be made here of vertebrate animals that are more or less directly injurious to man, and which therefore cause reprisals that in some cases can annihilate them and moreover are not always discriminating.

Among fish we may mention all those that can harm man seriously by biting -- sharks, morays and barracudas -- which are a serious problem in the entire Caribbean and in Central America, as well as on the North Atlantic coast of South America; piranhas in many South American rivers; the candirú of the Amazon basin, which invades the genital organs; and rays and various poisonous and venemous fish. Furthermore, several fish are hosts of human parasites such as diphyllobothrium, clonorchis and other trematodes. Many species, such as sharks and dogfish, cause severe damage to fisheries, destroying nets and equipment or disturbing operations; this is common in the Gulf of Mexico.

With the exception of poisonous snakes, reptiles are not a problem for the safety of man in Latin America. The neotropical poisonous snakes belong to the Elapidae and Crotalidae families; the most dangerous genera are Bothrops, Lachesis and Crotalus and to a lesser extent Micrurus. However, mortality is not high even though accidents are frequent. Mexico has two lizards, the Gila monster (Heloderma suspectum) and the pearl lizard (H. horridum), the only poisonous ones that exist. They are now becoming extinct because of abusive repression and commercial hunting.

Birds can be highly injurious agricultural pests that are difficult to fight, especially in areas of recent settlement where the fields are surrounded by forest. Nonetheless, the problems they cause have not been overcome satisfactorily anywhere because their indiscriminate elimination, besides being costly, has serious repercussions in the proliferation of pests controlled by certain species; another factor is the ever-present danger of extinction of certain rare species that are part of the avian complex of each crop. Birds are a particularly serious problem for rice-growing. In addition, they pose a continuing risk to commercial and military aviation, and the statistics show a large absolute number of accidents although these are relatively insignificant. Such accidents do not necessarily cause human death, but do require expensive repairs. Finally, birds can also cause diseases such as histoplasmosis, ornithosis (psittacosis) and others.

Mammals also can be a direct cause of problems for man, as agricultural and forest pests, as predators of livestock and fauna under management, and as pets. Furthermore, as already noted, many are reservoir hosts of human diseases.

12. NATIVE CULTURES

It can be assumed that the people who make up national societies know, have an idea, or at least are able to find out what the immediate future holds for them, and moreover have a greater or lesser opportunity to take part in decisions about that future. This is, perhaps, completely true only for certain social levels, and is much more a possibility than a concrete fact for the groups farthest removed from power. But it is totally irrelevant for those human groups which for various reasons are not part of the mainstream of society. They include -- in addition to the poorest of the poor -- those who are part of certain native cultures that, conditioned by particular natural environments, show no real integration whatever with the national society to which they theoretically belong. The reason is that whenever such integration is attempted, they simply lose their ethnic and cultural identity once and for all.

In addition to the evident right of these cultures to survive as such, they contribute incalculable benefits which are virtually unknown by the technologies in fashion, which formerly disparaged them, attributing to them a primitivism that today is known to have no meaning. In other words, when the vast majority of these native cultures have disappeared, human science will only then begin to reckon the benefits that would have been derived from a mutual association rather than the extermination that has gone before. But the problems are by no means being resolved; rather, the dangers posed to latter-day native cultures are greater than in the past, and their survival is threatened to a much greater extent than is that of fauna and flora species. It must be said that although man deserves priority consideration, the conservation of his

nonconventional cultures is of a moral complexity so great that it makes the conservation of animal and vegetable species incomparably easier. The central problem lies in the profound internal contradiction in attempting to bring native cultures into line with the national society of which they are part, while seeking to maintain their identity at the same time.

12.1 General considerations

Beyond any doubt, Latin America and the Caribbean are the region of the world in which the greatest and most harmonious racial and cultural integration can be found today. The pre-Iberian population belonged entirely to the so-called "Mongoloid" subspecies, and to the races known as meso-American, Andean, pampa-patagonian, Atlanto-tropical and redskin. Of these, the races now predominant in the study area as a whole are the Andean and meso-American, with their centers in Peru and Bolivia in the former case, and in Mexico and Guatemala in the latter. Although the other races are now small in number, they are precisely the ones that constitute the main body of the native cultures, and the ones that have disappeared or are near extinction. There is need for a historical understanding of this particular and contrasting situation, in which two of the five neotropical human races have very large populations that are well integrated in national society, while the others have infinitesimal populations that have not been integrated.

For reasons that need not be explained, the Spanish conquistadors found three great cultures. Two of them were flourishing, dominated by the Aztecs in Mexico and the Incas in Peru. They also found another great but disintegrated culture, the Maya, in southern Mexico and Guatemala. All of these cultures were preceded and accompanied by many others. In North and Central America, mentioned should be made of the Otomi, who seem to be the trunk that produced the Maya-Quiché, the Mixtecs and Zapotecs, the Totonacs, the Olmecs,

the Chichimecs and others. In the Andean region the Incas were preceded by the Chavín, Nazca, Chimú, Mochica, Paraca, Wari and other cultures. Unlike the earlier cultures, that of the Aztecs -- and especially that of the Incas -- displayed strikingly imperial features, seizing enormous territories and imposing administrative controls which, while foreshadowed, had never before been applied with such rigor. The Inca empire stretched from southern Colombia to much of Chile and embraced northern Argentina and Bolivia, Ecuador and Peru, where laws, language, religion and customs were imposed.

The conquistadors had no great difficulty in supplanting the imperial power after the initial resistance had been overcome. They administered in the same way as their predecessors and were astutely indulgent of the native language, the religion -- which they tolerated in hybrid form -- and many of the earlier institutions which, it should be noted, were very well suited to their own objectives of colonial exploitation. The Spaniards mixed voluntarily with the subject peoples, and this brought about an ever-greater degree of cross-breeding which has reached its maximum expression in the Mexican people of today and -- to a slightly lesser extent -- in the central Andes. In the areas where the Andean and meso-American races had predominated they have maintained their ethnic and cultural presence, although in both aspects one can observe a whole continum from total mingling of the races to the maintenance of great purity in remote areas (the least common case). The modern cultures of Mexico, Peru and Bolivia are essentially the result of this process, which -- as will be seen below -- in general permits the coexistence of attitudes of profound inter-racial closeness and striking discrimination. The fact that the conquistadors encountered peoples with civilizations sufficiently advanced (in relative terms) that they did not appreciate liberty enough to defend it to the death is in large measure what has led to the

situation prevailing in those countries.

In contrast, the other three neotropical races were found by the Spanish and Portuguese at a much less advanced stage of social development, in which gathering, hunting and fishing were still the basis of their existence or in which agriculture was still very rudimentary. There were regular conflicts between these peoples and tribes and those of the great cultures mentioned earlier. With the coming of the Spanish and Portuguese, who initially invaded their lands in search of treasure and afterward to exploit the riches of nature, the conflicts reappeared (wars, rebellions, European diseases). The situation was stabilized in only a few places, such as the famous Jesuit reductions in Paraguay and some other religious missions on redskin lands. For the redskins, the pampa-patagonians and the Atlanto-tropical peoples freedom was something that they still had and did not wish to give up, fighting steadfastly for it. Furthermore, when forced to live in peace, they were never really useful as laborers for the colonial exploiters, who could not make them work as they wished.

The movement for independence was led by the creoles, descended from pure Spanish blood, and by the mestizos with the most white blood. However, they were supported decisively by other mestizos and by Andean and meso-American peoples as well. At this time the problems for the redskin, Atlanto-tropical and pampa-patagonian races became acute.

The most serious situation arose in the Southern Tier where the pampa-patagonian nations and tribes were cruelly exterminated, by similar means and on the same pretexts as the ~~redskins~~ Indians in the United States, but much more efficiently than in that country. As early as the colonial period, the indomitable Araucanians had been virtually annihilated; but during that period and afterwards there was also extermination of the Calchaquies, Omaguacas,

Quilmes, Atacamas, Lules, Juries, Tapes, Tibues, Corondás, Quiloazas, Caracarás, Charruas, Puelches, Querandies, Tehuelches, Onas, Yámanas and Alcalufes. Virtually nothing is known of those nations. Their present populations are dying out and they are inexorably condemned to extinction in the near future. Likewise, little remains of their cultures.

The situation of the Atlanto-tropical peoples was slightly different, since the majority had no contact or only sporadic contacts with the pre-Inca and Inca cultures. The Incas and their predecessors sometimes used soldiers of Amazon tribes in their armies, as mercenaries well known for their courage and ferocity. The Spaniards who settled on the Pacific had little contact with them, except ~~in the case of~~ for a few tribes of the upper Amazon. The Portuguese had more extensive relations with these tribes, as did the Spaniards who settled on the Atlantic coast of South and Central America and in the Caribbean, where they came in contact with the Guaikurú and Guaraní tribes in the south and with Caribes and Chibchas in the north, among others. Relations with these natives had been bad in Central America and the Caribbean since colonial times, but in South America the most serious problems emerged after independence.

The impact of the South American tropical republics on the natives of the Amazon and Orinoco regions, members of the Arawak, Tucano, Pano, Ge, Tupi and other groups, was felt first in the expansion of settlement. Later, great violence accompanied the exploitation of natural rubber, chestnut trees, wild fauna, wood, gold, diamonds and -- in our own day -- petroleum. The most tragic episode was the exploitation of rubber, which even in modern times has brought scenes of massacre and enslavement which are still recalled vividly. As recently as the last two decades there have been reports of massacres of natives, including one in which the air force bombed a village for incredibly trivial motives which moreover had been totally fabricated by

vested interests.

But these events are increasingly rare, and the natives rather must face another problem which is much more serious: the mounting pressure on their lands, of which tens of millions of hectares have already been taken, by poor campesinos and in some cases by rich entrepreneurs who come from elsewhere. The former case is most common in the Andean region, where the Quechuas and Aymaras of the altiplano -- i.e., campesinos of the Andean race -- as well as mestizos of that origin, descend by the millions into the Amazon region, causing the problem of migratory agriculture discussed earlier in this report. In the Atlantic region, in Brazil, the problem is similar with the increased migration of people from the northeast to the "official" Amazon region. But in Brazil there are also conflicts caused by large estates. Forestry operations are another major disturbing factor, although up to the present their impact has been less serious than that of the others because they do not necessarily take land away from the natives. The new forms of long-term forest extraction contracts covering large areas will have a more acute impact on the natives than that felt in the past.

In summary, the native cultures of the Andean and meso-American races have maintained themselves comparatively well and have evolved to the point where they can be considered as integrated in their national societies. On the other hand, the native cultures of the redskin and especially the pampa-patagonian races have virtually disappeared. The Atlanto-tropical native cultures have been decimated but are still the most numerous of the less socially advanced cultures, and some of them remain in a pristine or nearly pristine state. Their present area of distribution coincides closely with that of the tropical forests remaining in South America. This situation, and the events that led to it, explain why the Argentine and Chilean populations are essentially

caucasoid; the same is true in all countries where the native mongoloids were exterminated or had no opportunity to intermingle. In contrast, there has been a great deal of mixing in areas where the Andean and meso-American cultures predominated. In most of the Latin American and Caribbean countries, except in the Southern Tier, racial mixing has been complicated enormously by the massive introduction of Central African slaves and Chinese coolies; this was followed by the immigration of workers from Japan and -- in the case of the former British and Dutch colonies -- from other parts of Asia, ~~especially~~ notably Hindus and Indonesians. Adding to this the comparatively recent immigration by Europeans of diverse origins, especially Italians, one obtains some idea of the privileged genetic mix which characterizes the peoples of Latin America and whose maximum expression is found in Peru. Paraguay and northwest Argentina are a special case in which the Guaraní population was absorbed by the Europeans, leaving Guaraní as the second language of all inhabitants of those regions. This did not occur elsewhere, even with Quechua in Peru or Bolivia.

For the reasons stated, the following comments refer only to the problems of the native cultures of the Atlanto-tropical, pampa-patagonian and redskin races.

12.2 Present situation

The largest native populations of South America are found, in descending order, in Brazil, Peru, Venezuela, Guyana, Suriname and French Guiana, Colombia, Bolivia and Ecuador. The next largest concentrations are in Argentina, Paraguay and Chile. The populations in Brazil and Peru are the largest, followed by those of Venezuela and the Guiana region. In relative terms, Peru probably has the largest population of natives. In North and Central America the largest native populations are found in Mexico, Guatemala and Panama, in that order.

In countries such as Nicaragua and Costa Rica there are still a few small tribal groups, but even these are practically nonexistent in the Caribbean.

The extinction of native peoples and their cultures is not a matter of primary concern in Latin America, and in many countries evokes less interest than the conservation of animal and plant species and of ecosystems. In fact, governments usually are more generous with areas set aside for national parks or equivalent reserves than with those set aside for native communities. Nor are they taken into account in the development plans for the regions in which they live.

The most significant efforts to improve the welfare of native peoples have been made by the Brazilian government through an institution created especially for this purpose, which has established a network of areas reserved exclusively for the natives of most tribes, in which they have autonomy. Reserve areas or reservations have been established in other countries as well, but not always with the size and characteristics that would be desirable. In Peru, where nothing concrete had been done until well into the 1970s, there has been introduction of the concept of the "native community," with inalienable ownership granted to native groups, theoretically with great flexibility as ~~regards~~ to the size and location of lands. A large number of communities have been awarded property titles, but these do not always meet foreseeable needs, even for the medium term. Moreover, many countries have made no provision to ensure a minimum territory for their native groups. Legislation providing special benefits for native groups exists in all of the countries, either in national constitutions and basic and general laws, or in special laws. The nature of this legislation varies widely from one country to another; some are paternalistic and view the native as a child or an irresponsible person, while others give him full citizenship. The common feature of all is their ineffectiveness in preventing

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a worsening of the situation of native peoples.

As a matter of fact, even in the countries with the best legislation, appropriate institutions and the most carefully devised strategies, the situation of the natives is growing worse. This is due to many factors, the main one sometimes being the excessively small area awarded, plus the poor quality of the land and the limited endowment of natural resources. In other cases it is due to the influence of religious organizations, political groups of the extreme left, bureaucratic agencies and various scientists -- particularly anthropologists who deliberately or unwittingly bring about processes of drastic acculturation with the real or apparent intention of integrating the natives into the national economy. These groups, especially the religious and political ones, often use the natives for their own purposes; moreover, they usually know nothing of the relationships between these cultures and the environment, which they are helping to destroy. Frequent examples of this are the placement of natives in conventional farming and stockraising, in forestry operations of the all-consuming type or in commercial hunting, not to mention the alteration of ancestral customs that allowed the population to remain in balance with available resources. It is due also to legislation that grants full citizenship and thereby entails military service, documents, property titles, compulsory education -- i.e. everything that is good and proper for ordinary citizens but which also implies the loss of cultural independence. Underlying all, the dilemma for the natives is the classical one: to be or not to be.

One particular, though not very frequent, situation is that which arises in a few national parks and equivalent reserves where there are tribal groups. The policy adopted in these cases is usually to prevent all contact by the visiting public with native villages, and to interfere in the life of the natives only when outside parties may affect the natural stability,

such as hunting with sophisticated firearms, the use of chemical substances, etc. In any case, these groups remain free to move from the park to areas that are suitable for agriculture or forestry, where they can live in a more conventional manner. This policy is often attacked by religious organizations. Nonetheless, the proof of its advantages from the standpoint of the natives themselves is that they are moving into such areas in growing numbers, rejecting contact with settlers and "civilization" in general. Needless to say, this is a vexing problem for the park administration, since -- besides the pressure on fauna resources -- it often leads to sharp conflicts among tribes or tribal groups.

12.3 Prospects

The prospects for the native communities of Latin American are clearly poor. The drastic reduction foreseen in the natural forests where they live, the ineffectiveness of most measures taken by the countries, the mounting pressure of settlers on their land and their resources, the acculturation caused by the very measures intended to benefit the natives -- these are some of the factors that undoubtedly will result in a substantial dwindling of their populations by the year 2000. At that time, perhaps as many as 50% of the tribes will have disappeared as such.

There has sometimes been discussion of the possibility of holding back development rather than confining the native peoples. This is utopian but it is the only hope.

13. THE UNDERLYING CAUSES

This chapter presents a brief and straightforward review of some of the principal causes of the situation that has been described. Although Latin America and the Caribbean are not exceptionally well endowed with natural resources, the situation of those that are deficient can be improved with relative ease. Hence there seems to be no justification for the low level of economic and social welfare in most of the region. The reason that springs to mind most forcefully is what can be called in general terms the poor and sometimes very poor management of natural resources, especially those which are renewable. But this itself is the consequence of other factors, and there is a chain that forms a vicious circle which is far-reaching, complex and unbroken. Study of the matter shows, as everywhere, that the fundamental cause of human misery in Latin America and the Caribbean is social injustice, rooted in every human being who carries within himself the ability to help or hurt his fellow man. The apparent difficulty in comprehending the general consequences of acting essentially on the basis of individual, family or group benefit has a dramatic impact on the life of nations, which it harms indelibly through the irrational exploitation of the common heritage, i.e. the riches of nature.

13.1 Economic causes

Injustice is expressed essentially through the economic relations among countries, among groups within a nation, and among individuals. At the first of these levels, it is unquestionable that Latin America and the Caribbean have not yet been entirely freed from neocolonialism, and much less from imperialism. This point, so often stressed, will not be discussed further here; it should merely be recalled that the object of neocolonialist and

imperialist policies is renewable and nonrenewable natural resources. That is the motive that underlies most of the great plunderings such as overfishing, the destruction of tropical forests for stockraising, the use of the best and sometimes the only farmland to grow export crops, etc. The heedless exploitation of mineral resources, with massive emissions of pollutants, also is associated with these policies, as are many of the projects that affect water resources. The pattern thus woven is so dense and sophisticated that if it were necessary a direct or nearly direct link could be found between each environmental problem and the economic ~~dominance~~ domination of Latin America and the Caribbean by other continents.

But the area covered by this study is far from being only a victim; the same policies are followed in the region as a whole, and especially within each country. The latter phenomenon, known as domestic colonialism, occurs with a harshness equal to that shown by the Europeans during the classical colonial era. One manifestation of it is the exhausting exploitation of the resources of the Amazon region to supply the developed areas of the Andean countries, with no benefit whatever for the local population.

Colonialism, neocolonialism and imperialism, besides having a direct impact on the resources that they exploit carelessly -- on the well-known pretext that the profit margin would otherwise be negligible or nonexistent -- have other harmful effects as well, through the introduction of inappropriate technologies and obviously the penetration of markets, imposing patterns of consumption, equipment and machinery that is not necessarily the most suitable. The international and bilateral sources of economic and financial cooperation are often the instruments of such action, ~~whether~~ intentionally or not. One such case is the "green revolution" and another is the persistent attempt to introduce the consumption of bread made from imported wheat where the traditional

bread is made from maize, cassava or plantain, to cite only two examples among hundreds.

13.2 Social causes

Most of the environmental problems that afflict Latin America and the Caribbean can be attributed directly to poverty and its consequences. Among those most closely related to poverty are the erosion of soils, the destruction of natural forests and the extinction of fauna. But poverty also means illiteracy, ignorance and sometimes misdirected rebelliousness, all of which worsens human relationships with the environment. This is manifested in the burning of forests because of carelessness or on purpose, the intentional dumping of refuse, destruction of ornamental vegetation in cities, etc.

Poverty does not explain all of these cases; some damage to the environment is associated strictly with the highest social classes of countries, such as sport hunting and fishing without regulations of any kind, the movement of recreational vehicles in natural areas protected because of their fragility (such as deserts), urban expansion on the best farmland, and others.

Other adverse effects on the environment are due to local habits of complex origin, although in general they are influenced by outside circumstances; these include the burning of pastures to renew the green foliage and the digging of fully pitched furrows on mountain slopes. In some cases the environmental impact actually is the consequence of ancestral traditions, as when rare species are hunted for magic rituals, curative potions and the like.

The countries in which the least social polarity exist -- i.e., where there is a large middle class and skilled labor force -- are in a better position

to structure future relations between man and the environment than those, still too numerous, in which a small and all-powerful ruling class dominates a ~~small~~ limited middle class and a vast urban and rural poor class. In these latter cases it is especially difficult to introduce a consistent population policy. The church still plays a primary role in this regard in Latin America and the Caribbean. That institution often finds itself in agreement with the geopolitical theories of certain governments which hold that, regardless of the actual situation of available resources, the entire territory should be occupied in the shortest possible time.

In Latin America, as in other countries with developing economies, there is often a peculiar notion of public morality in which anyone who does not take advantage of his position to benefit himself is regarded as a fool. This tendency has ~~decreased~~ lessened considerably during the last two decades, but is still strong and adds another stimulus to natural temptation. Nonetheless, experience shows that the public morality of this continent is much higher than those who distrust and slander us would care to admit, and much higher than what the press of the developed countries considers most profitable to tell its readers.

Finally, mention should be made of the pivotal role played by the highest social classes, descended from the colonial creole aristocracies, in promoting protectionism as opposed to the optimum use of renewable natural resources, with disastrous consequences for the management of flora and particularly of fauna in several countries of the hemisphere.

13.~~8~~ 3 Political causes

Many environmental consequences are the direct result of political decisions taken within the context of government plans, adopted arbitrarily with good or bad intentions. Development policy, especially as regards

agriculture, has the most direct impact on natural resources. Policies concerning settlement, agrarian reform, fishing, forestry, water resources, petroleum and mining determine the treatment given to the various resources affected, and are in turn subordinated to the general political approaches followed in the countries, which with a single exception are free-enterprise economies.

The opening of new lands, whether through settlement or through irrigation and the occupancy of the entire national territory, are two political constants in all of the Latin American countries. Both have a profound impact on soil, water, flora and fauna resources; this is true not only in the areas which are targets for action, but more especially in all areas that receive no attention because funds are used elsewhere. Thus, increased productivity is on the whole ignored, and even less attention is given to conservation of the renewable natural resources which would make higher productivity possible. The tendency up to the present has been to conquer and to expand, not to consolidate. When there has been consolidation, it has been due much more to private initiative than to government action or incentives.

13.4 Planning

Planning has two phases which are both critical and decisive for the situation of renewable natural resources. The first is the process of selecting programs, projects and goals, which is not always based on valid studies or on a full knowledge of the potential of resources and the ecological consequences of their use. The second is the failure to assign adequate or any priority to natural resources, i.e. the giving of equal weight to all needs to be met through action.

Planning is of no value unless the government uses it as its guiding instrument. In this respect, the most common case is that decisions are unplanned and completely improvised to deal with situations of the moment.

13.5 Administration

Administration is responsible for many of the environmental problems in the countries of the region because of its centralism, excessive bureaucracy, and general inefficiency. Centralism -- i.e. the concentration of administrative resources and sometimes action as well in the capital and the most important cities or ~~nearly~~ nearby areas, while more distant regions are given no attention or receive it in an unplanned and minimal fashion -- is one of the main problems, coupled with an excessive concentration of decision making that paralyzes administration. Bureaucracy has other manifestations, such as the excessive number of administrative personnel compared to professionals and technicians, which is well-known in Latin America; moreover, the few skilled personnel work in offices and not in the field. The proliferation of administrative officials is usually due to excessive zeal in the monitoring of government expenditure, which requires an endless chain of approvals, verifications and reviews that increase the costs of operation and ~~, in particular,~~ often hinder it to the point of absurdity.

Another situation, opposite to the foregoing, occurs when, as a result of the traditional centralist excesses, ~~certain~~ governments order abrupt administrative decentralization and deconcentration. One consequence of such decisions is that they demolish the organized management of natural resources and place delicate decisions -- some having irreversible repercussions -- in completely inexpert and often unqualified local hands. A similar problem is created by the exceptional instability of the government agencies that administer natural resources, with continual reorganizations that change their names, the scope of their responsibilities and their methods of action. Ministerial departments become independent government agencies and a few years later resume their earlier form; executive functions are assigned to them

and then taken away; etc, etc. In some countries, even without changes of government, personnel devote most of their energy to reorganizing their own institutions.

At this time, for the reasons mentioned above, there are countries in Latin America where no forest service really exists; many have no agencies or departments responsible for soil conservation or watershed management. In most of them the management of national parks and protected areas and the management of fauna are minimal, while the problem of environmental pollution is an undefined responsibility for a large number of government departments and offices.

Although some countries have established entire ministries concerned with renewable natural resources, experience shows that the situation is no better there. The main reason is the "functional" type of organization that they have adopted, which hinders the solution of specific problems. In other cases the problem is the excessive size of the institution or the absence of links with the sectors that affect resources, such as agriculture. Autonomous departments of renewable natural resources are more successful than those attached to ministries of agriculture but have less influence in decisions about the agricultural sector, which is a greater disadvantage in the long run.

The policy on salaries for government employees in Latin America is one of the fundamental causes of the inoperativeness of public administration. Besides being poorly paid, civil servants often are mistreated. Salaries for professionals in some countries are less than 50% of ~~that~~ those earned by their colleagues with equal qualifications in private enterprise; as a result, ministries usually have personnel of lower quality, and when they are good they are placed in high-level ~~positions~~ posts so that they can be paid more, but not necessarily in the positions where they are competent. This is a critical

problem for research personnel, because those with the most advanced scientific degrees function as department heads instead of conducting research. Thus, the mobility of skilled personnel is striking, and there is a massive flight of talent among countries or outside the continent (to the United States and international organizations).

The inefficiency of planning causes heated intersectoral and intrasectoral conflicts with regard to budgets. Incredible distortions result, as in the case of a country in the Andean region whose budget for the agricultural sector is allocated with over 85% for irrigation in just one of its natural regions, the smallest and not the most populated. Farming, stockraising, agrarian reform, forestry, research, marketing, agroindustry and even water resources management, not to mention the rest of the country, must be content with the remainder, which is immeasurably inadequate.

13.6 Legislation

Legislation on natural resources in Latin America is adequate, although far from perfect. The main problem is the feasibility of enforcing it. In other words, laws are usually enacted without reference to administrative problems, which means that many of them -- especially those which are essential for implementation of the principle of sustained yield -- remain strictly on paper. An associated problem is their great susceptibility to change. Laws, especially under military regimes, are amended and changed so often that virtually none has any possibility of demonstrating its value over time. Furthermore, legislation on renewable natural resources usually is approved more because it is in vogue to have such laws than because of a true political conviction of their necessity. One immediate consequence of this is the meagerness of incentives and of the facilities or benefits provided for users of resources who comply with the law, renewing them for future generations.

13.7 Consciousness-raising and education

These are perhaps the most critical elements for breaking the vicious circle mentioned above, especially the first. The question of the environment has now left the stage of total ignorance in Latin America and the Caribbean and is clearly at a point where there is concern, but at a very superficial level. In other words, although people talk about the environment and politicians accept recommendations about legislation concerning ~~with regard to~~ it, there are still very few citizens and politicians or government officials with a full knowledge of the magnitude of the problem and its implications for the national society. As a result, laws are enacted and not obeyed, agencies and institutions are established without financial resources, and when there is a serious conflict between the development and conservation approaches development usually wins.

It will take a very great effort to create a genuine political and public awareness of natural resources. Protectionism has contributed much to distorting the incipient trend of opinion, making it seem that conservation means taking care of wild animals in the same way as domestic ones, beautifying parks and gardens and preventing urban environmental pollution. The most frequent topics in the Latin American press are the extinction of certain spectacular species of fauna and flora, cruelty to animals, the beauty of natural landscapes and the impurity of the air. Most of the decision-makers, with reason, regard these questions as completely subordinate to the great problems faced by the nation, and ignore them together with others that are actually ~~indeed~~ of tremendous significance.

When those in power are more disposed to acknowledge the real meaning of conservation of natural resources, another obstacle arises: the difficulty of demonstrating the socio-economic benefits that may be derived in the brief

periods within which government officials usually want to see the results of their action. This is a very serious problem for certain measures regarding soil conservation or watershed management and even in reforestation, i.e., works whose payout period is much longer than the term of any administration. The only way of overcoming this logical obstacle is through the profound conviction of leaders and people about their necessity.

One might ask which is the best way of changing attitudes -- to make public opinion aware first so that it will call for the necessary political decisions, or to seek this awareness first among decision-makers? There is little doubt that the second means is better and faster, since the resources needed to make public opinion aware can be obtained only at first with government support. Furthermore, the urgent need to address certain environmental problems makes it impracticable to lose time. Obviously, the ideal course of action would be to undertake both tasks at the same time, if this is possible.

In the change of attitudes priority attention must be given to interdisciplinary and intersectoral integration, doing away with preconceptions about areas of responsibility and priorities which cause government agencies to work in watertight compartments, and result in uncoordinated and even conflicting actions, such as the simultaneous establishment of national parks and the concession of part of their territory for oil exploration.

Environmental education involves various levels: primary and secondary education, university education in general, university education specializing in the management of natural resources, technical education and vocational training. Each level should receive a meticulously designed and specific treatment. In primary, secondary and higher general education, study units should be added or present ones modified so that they may contribute to an understanding of the

principles of ecology as applied to management. Little or nothing is being done at this level now, despite the efforts made by some countries, owing chiefly to the practical problem of instructing the tens or hundreds of thousands of students in each nation.

The most serious problem in specialized areas of resource management is that upon graduation many of the professionals and technicians lack even the slightest idea of their leading role in the situation and development of environmental conditions in their countries. Those who learn how to build highways or dams are unaware of the impact of the works that they will build; even agronomists, animal husbandry specialists and foresters have no knowledge of their responsibility as administrators of the resources of soils, fauna and flora. They believe that their role is essentially to produce food or other goods but not to conserve the bases of that production. Moreover, except in forestry, virtually no agronomic profession includes courses on ecology in its broad sense. There are sometimes courses on agricultural ecology or the like which afford no possibility for broadening viewpoints. In other professions with a great impact on the environment -- civil engineering, architecture, medicine, mining, etc. -- there are no courses of this kind.

Apart from this general problem, in virtually all countries of the region the basic range of professions necessary for the management of natural resources does exist, although there is a total lack of centers for the training of people to manage wildlife and national parks and protected areas. Other resources, such as soils, forests, fishing, water and domesticated flora and fauna, are covered by numerous university training centers. On the other hand, there are serious deficiencies in the fields of erosion control, watershed management, management of natural forests and a few others. The main problem in nearly all universities of Latin America and the Caribbean ~~arises from~~ is due to the

tightness of budgets, which is seen either in the low level of teacher salaries or in the lack of resources for research and dissemination, or both. The consequences are very similar to those of the problems indicated in relation to government employees.

What can be described as an inadequate situation, but easily improved to some extent at the professional or university level, is manifestly poor as regards the training of technicians, experts, supervisors and specialized ~~workers~~ personnel. Latin America is characterized by an inverted pyramid in which university professionals are much more numerous than middle-level personnel and skilled workers. There are very few training centers for the latter, seldom more than one per country and per basic speciality, and they graduate small classes that are totally out of proportion with the large numbers of university graduates. At this level too, a great many specialized fields lack any programs.

13.8 Research and extension

Although there is evidence that the present state of knowledge, including the recovery of ancestral knowledge slighted in the past, would permit the management of natural resources to be incomparably better than it has been, there is a continuing need for further research to meet the challenges of the future. At the same time, extension services should be strengthened in order to close the enormous gap between present know-how and its application.

Because of the deficiencies that have been discussed, current research on the management and conservation of natural resources is limited, fragmented and uncoordinated. In many cases it is a mockery of research, undertaken merely because it is fashionable to do research and because it is a function to be performed and a requirement to earn a salary and obtain promotions. In such cases, which are quite common, research is nothing more than a shot into the air. This is another consequence of the lack of planning and the failure

to implement plans and programs.

When research is useful and deserves to be known, the findings remain on the shelf because of the lack of institutional resources for publishing them and because the numerous specialized journals are in a chronic state of financial insolvency; they appear only when they can, and once published, are not distributed despite the small number of copies printed. Assistance for the publishing of periodicals and other media for the dissemination of new scientific knowledge is essential for the success of research in Latin America and the Caribbean.

14. CONCLUSION

No attempt will be made here to review the conclusions that might be drawn from each of the foregoing chapters, inasmuch as they ~~cover~~ deal with such a diverse range of topics, covered so briefly, that in themselves they can be regarded as conclusions. Rather, this chapter brings together some general concepts which, as a sort of summation, may help provide an overall picture of the situation.

Latin America and the Caribbean are not particularly well endowed with natural resources. As we have seen, aside from regional differences, there is in general a limited availability of soils that are naturally suitable for agriculture and stockraising. On the other hand, the region has extensive areas covered with tropical forests, mountains and deserts and semideserts. Its forests, while abundant, are in no way as rich as those of other continents. Water, despite its unequal distribution, is abundant, as are many minerals. Likewise, the region as a whole has sources of energy. Its flora and fauna are highly diverse, giving it some advantages and as many disadvantages.

Because agriculture has the greatest impact on the environment, even where there is a large proportion of soils of appropriate quality, in the case of Latin America and the Caribbean -- which lacks such soils -- this activity has already left an especially deep imprint, especially when one considers the low average density of the population. Actually, farming is not the leading cause of this situation; rather, it is due essentially to stockraising, which displays highly irrational features. The principal effect of this type of stockraising, and to a lesser extent of agriculture as well, both of which cause the destruction of natural resources, is a massive loss of the resource which is most scarce: soils. To counter the low productivity of food, virtually all of the countries have opted to expand the

agricultural frontier through spontaneous or controlled settlement, which usually leads to migratory agriculture, or through costly irrigation. The alternative of intensifying cultivation and stockraising, i.e. increasing productivity, has never received comparable attention. Much less has serious consideration been given to the need to maintain the bases of agricultural production, which explains the great backwardness in ~~terms of~~ watershed management, erosion control, reforestation for ~~protection~~ protective purposes and other actions.

This policy has to some extent been the consequence of the availability of vast territories, and in part the same situation will prevail up till the end of the century. But the tremendous increase expected in the human population, and the fact that the lands still "available" have characteristics that make them even less suitable for agriculture and stockraising than those now in use, suggest that environmental problems will worsen and will cause a collapse in the early decades of the 21st century. By then the conventional forms of agriculture and stockraising will truly be unable to feed the people of the region.

Obviously, there are many technological alternatives that can prevent the pessimistic predictions from coming true. Moreover, it is a fact that some modern nations which are overpopulated and have destroyed their environment have been able to restore the bases of production to a large extent. But this has been achieved with great sacrifices, and especially with severe restrictions on individual freedom. How much easier it is to manage resources well right now, when they are not completely lost, than to be obliged later to level mountains for terrace farming, to plant trees on bare rock, to recover valuable species from zoos and botanical gardens or to bring water from one side of the country to the other and reclaim agricultural land from deserts that did not

exist before. Furthermore, during the process that the trends show Latin America and the Caribbean to be undergoing, there will be an irretrievable loss of unknown opportunities for development, including the countless species that will become extinct.

The analysis of each resource shows clearly that if present concepts of development are modified this part of the world can feed its ~~present~~ current and projected population well and provide it with a quality of life matching that of the rich countries. The specific changes necessary are in some cases easy and in others more profound, but basically they imply the breaking of certain conventions and patterns of production and consumption imposed by the "western and christian" culture, in favor of a geniune expression based on a social and ecological reality that is still hardly understood. ~~It is~~ This by no means ~~a question of returning~~ implies a return to the past, but it is important to ~~incorporate~~ integrate traditional technologies with imported ones and with scientific advances, and not to accept only the latter at any cost. One might even speak of the need for entropic development, at least for some time. However, this is practically impossible, at least under ~~the~~ present political and economic conditions.

It is ~~considered~~ likely that the next two decades will see a consolidation of this change of attitude, of which there are already indications. But it is also likely that the environmental destruction caused by the present approach will aggravate the situation greatly before the new ideas are put into effect to a sufficient extent. This will depend largely on the behavior of those who have already understood the need for a change in human relationships with the environment, and who have an immense task before them. It will also depend on the support they receive.

The integral and integrated development of natural resources, especially renewable ones, is always desirable. But in lands where there are severe limitations

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on conventional uses, it becomes imperative. Thus, much of what can be expected in the future will depend on the harmonious integration of all disciplines and sectors that come together in a given area. Only in this way, closely united, will they be able to achieve results that justify the action taken, providing the benefits to which their people are entitled, if they know how to obtain them.

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