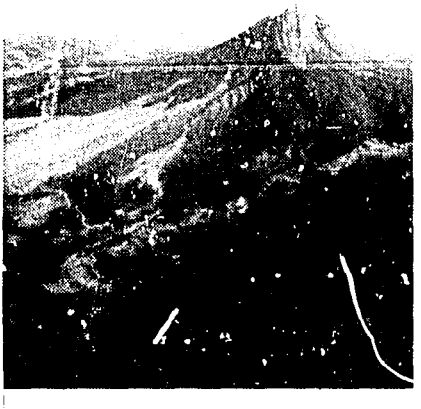
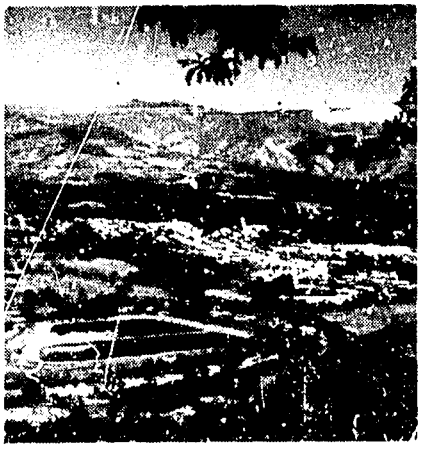
COSTA RICA

COUNTRY ENVIRONMENTAL PROFILE

A FIELD STUDY





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Country Environmental Profile

A Field Study

by

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Preface

This Country Environmental Profile (CEP) of Costa Rica is one of a series of environmental profiles funded by the U. S. Agency for International Development, Bureau for Latin America and the Caribbean (LAC), Office of Development Resources (DR). The scope of work for this in-country study was developed jointly by the AID mission in Costa Rica; Frank Zadroga, AID regional environmental officer for Central America (REMS/ROCAP); Robert Otto, AID environmental officer (LAC); and Gary Hartshorn.

Contractual arrangements for this CEP were carried out by the Tropical Science Center (TSC), a private, nonprofit Costa Rican association concerned with man's enduring relationships with natural resources in the tropics. Publication arrangements were handled by the AID mission in Costa Rica. TSC contracted local specialists to prepare sector reports during the last trimester of 1981. These review documents were edited and condensed into the present synthesis by Gary and Lynne Hartshorn.

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WHAT IS SCIENCE FOR?

When Albert Einstein was asked this question he answered it with another question, "Tell me, what are children good for?"

We cannot look for romantic definitions of science in these times of crisis or war; these problems may take two decades or more to remedy. Any review of human history will show that shocks have helped to redirect political, economic and social destiny, and the quality of life has become better thanks to the millions of repeated successes, in all fields, that have permitted man to considerably dominate nature. Many men and women have participated in this gigantic adventure: history has recorded the acts of wise men and this has contributed to the generalized concept that science is something confidential and mysterious; but virtues and defects, successes and failures must also be considered when our species is involved with perpetuation and development.

Science, then, is good for growing and developing; the greatest difference between rich and poor countries is not the misery of the poor and the opulence of the rich, but the amount of resources each one dedicates to science and technology. Germany and Japan did not lift themselves from the ruins of WWII only with the economic help they received, nor from the political systems they adopted, but because both countries gave an undeniable priority to the sciences; obviously, both the available resources and a democratic political system are needed, but sound growth cannot be achieved without the coherent and vigorous component of science and technology.

Loans and charity will not alleviate the crises in the world. Consequently, our society needs ample and profound restructuring, establishing new agreements between the different social forces; reorienting and stimulating production, decreasing consumption and protecting the environment; only in this fashion will we successfully face the great challenge of forging an advanced, just, and dignified democracy.

Edgar Mohs (La Nación 5 Feb. '82)

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Institutional Abbreviations

Acronyms	Spanish/English Names
A y A	(see ICAA)
AID	Agencia para el Desarrollo Internacional U.S. Agency for International Development
ASCONA	Asociación Costarricense para la Conservación de la Naturaleza Costa Rican Association for the Conservation of Nature
BCIE	Banco Centroamericano de Integración Económica Central American Bank of Economic Integration
BID	Banco Interamericano de Desarrollo Interamerican Development Bank (IDB)
BIRF	Banco Internacional de Reconstrucción y Fomento World Bank (IBDF)
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza Tropical Agronomy Teaching and Research Center
CATSA	Compañía Azucarera del Tempisque, S. A. Tempisque Sugar Company
CEPAL	Comisión Económica para la América Latina Economic Commission for Latin America (ECLA)
CICA	Centro de Investigaciones en Control Ambiental (UCR) Environmental Control Research Center
CIDA	Agencia Canadiense para el Desarrollo Internacional Canadian International Development Agency
CIDPA	Centro de Investigación y Diagnóstico en Parasitología (UCR) Research and Diagnostic Center for Parasitology
CITA	Centro de Investigaciones en Tecnología de Alimentos (UCR) Food Technology Research Center
CODESA	Corporación Costarricense de Desarrollo Costa Rican Development Corporation
COIM	Convenio Cooperativo Intermunicipal Intermunicipal Cooperative Agreement
CONAI	Comisión Nacional de Asuntos Indígenas National Commission for Indian Affairs

CONICIT	Consejo Nacional de Investigaciones Científicas y Tecnológicas National Research and Technology Council
DGEC	Dirección General de Estadística y Censos Statistics and Census Office
DGF	Dirección General Forestal (MAG) Forest Service
DRPA	Dirección de Recursos de Pesca y Acuicultura (MAG) Fisheries Resources and Aquiculture Office
DSA-MS	Dirección de Saneamiento Ambiental-Ministerio de Salud Environmental Health Office
DVS	Departamento de Vida Silvestre (MAG) Wildlife Department
FAO	Organización de las Naciones Unidas para la Agricultura y la Alimentación U. N. Food and Agriculture Organization
GOCR	Gobierno de Costa Rica Government of Costa Rica
ICAA	Instituto Costarricense de Acueductos y Alcantarillados Institute of Aqueducts and Sewers
ICE	Instituto Costarricense de Electricidad Electricity Institute
ICORENA	Instituto Costarricense para la Conservación de los Recursos Naturales Institute for Natural Resources Conservation
ICT	Instituto Costarricense de Turismo Tourism Institute
IDA	Instituto de Desarrollo Agrario (nee ITCO) Agrarian Development Institute
IFAM	Instituto de Fomento y Asesoría Municipal Municipal Advisory and Development Institute
IGN	Instituto Geográfico Nacional National Geographic Institute
IICA	Instituto Interamericano de Cooperación para la Agricultura Interamerican Institute for Agricultural Cooperation
IMAS	Instituto Mixto de Ayuda Social Social Assistance Office
IMF	Fondo Monetario Internacional International Monetary Fund
IMN	Instituto Meteorológico Nacional National Meteorological Institute
INA	Instituto Nacional de Aprendizaje National Training Institute
INCAP	Instituto de Nutrición de Centro América y Panamá (office Guatemala) Nutrition Institute for Central America and Panama
INCIENSA	Instituto Costarricense de Investigación y Enseñanza en Nutrición y Salud (MS) Costa Rican Institute for Research and Teaching in Nutrition & Health
INCOP	Instituto Costarricense de Puertos del Pacífico Costa Rican Institute of Pacific Ports
INISA	Instituto de Investigaciones en Salud (UCR) Health Research Institute
INSA	Instituto Nacional Sobre Alcoholismo National Alcoholism Institute
INVU	Instituto Nacional de Vivienda y Urbanismo National Housing and Urban Institute
ITCO	Instituto de Tierras y Colonización Lands and Colonization Institute
ITCR	Instituto Tecnológico de Costa Rica Costa Rican Technological Institute

JAPDEVA	Junta Administrativa Portuaria y de Desarrollo Económico de la Vertiente Atlántica Atlantic Coast Economic Development and Port Authority
MAG	Ministerio de Agricultura y Ganadería Ministry of Agriculture and Livestock
MEIC	Ministerio de Economía, Industria y Comercio Ministry of Economy, Industry and Commerce
MOPT	Ministerio de Obras Públicas y Transportes Ministry of Public Works and Transport
MS	Ministerio de Salud Ministry of Health
OCAF	Oficina de Control de Asignaciones Familiares Family Assistance Office
OEA	Organización de Estados Americanos Organization of American States (OAS)
OFIPLAN	Oficina de Planificación Nacional y Política Económica Office of Economic Policy and National Planning
OLADE	Organización Latinoamericana de Energía (office Ecuador) Latin American Energy Organization
OPSA	(see SEPSA)
OTS	Organización para Estudios Tropicales Organization for Tropical Studies
PNUD	Programa de las Naciones Unidas para el Desarrollo U. N. Development Program (UNDP)
PNUMA	Programa de las Naciones Unidas para el Medio Ambiente U. N. Environmental Program (UNEP)
PRONASA	Programa Nacional de Saneamiento Ambiental (DSA-MS) National Environmental Health Program
RECOPE	Refinadora Costarricense de Petróleo, S. A. Costa Rican Petroleum Refinery
SENAS	Servicio Nacional de Aguas Subterráneas National Groundwater Service
SEPSA	Secretaría Ejecutiva de Planificación del Sector Agropecuario Executive Secretariat of Agricultural Sector Planning
SINAPROMA	Sistema Nacional de Protección y Mejoramiento Ambiental National System of Environmental Protection and Improvement
SNE	Servicio Nacional de Electricidad National Electricity Service
TSC	Centro Científico Tropical (CCT) Tropical Science Center
SPN	Servicio de Parques Nacionales (MAG) National Parks Service
UCR	Universidad de Costa Rica University of Costa Rica
UNA	Universidad Nacional Autónoma National University
UNED	Universidad Estatal a Distancia State Correspondence University
WHO	Organización Mundial de la Salud World Health Organization of the United Nations

I.

Executive Summary

This country environmental profile of Costa Rica (CRCEP) financed by USAID was carried out during the last trimester of 1981 by the Tropical Science Center (TSC), a private, non-profit Costa Rican association concerned with man's enduring relationship with natural resources in the tropics. Sixteen experts familiar with Costa Rica's natural resources, institutions, culture and environmental problems contributed to this CRCEP.

Costa Rica has well-deserved, world-wide recognition for its stable democracy, rapid decline in population growth rate and exemplary system of national parks. Nevertheless, the country faces increasing pressures on natural resources along with concomitant environmental deterioration. The current economic crisis--the most severe in the country's history--will have profound and possibly unpredictable consequences for natural resources and environmental conservation. Increased agricultural productivity and exports are expected to lead the way out of the economic morass, yet the best agricultural lands are being degraded by pervasive soil erosion and eliminated by sprawling urbanization. Extensive deforestation has nearly destroyed any potential for large scale commercial forestry, while threatening the economic viability of hydroelectric, potable water and irrigation projects.

This CRCEP analyzes the status of natural resources development and conservation; the causes and probable consequences of natural resources destruction; the severity of environmental deterioration and the prognosis for slowing or reversing it; and institutional involvement in the development of natural resources and environmental conservation. Specific sections of this report review historical and cultural aspects, Indians, demography, nutrition and health, forests and forestry, wildlands, wildlife, coastal and near-shore marine resources, soils and land use, agriculture and cattle, water resources, energy sources, environmental contamination, environmental law and related institutions. Conclusions and principal recommendations are summarized below.

SOME HISTORICAL ASPECTS OF CULTURAL RESOURCES

Despite its small size and substantial distance from Mayan and South American cultures, Costa Rica has provided resources for prehistoric cultures. Pre-Columbian cultural Mesoamerica extented south into the Guanacaste-Nicoya region, where a sizeable population lived in the Tempisque basin. The central intermountain valleys and Caribbean lowlands form a large and complex archaeological zone that was sparsely populated by Indians from South America. The southwestern archaeological zone of Diquís, part of the Greater Chiriquí culture, is best known for the enigmatic stone spheres. Grave robbers (huaqueros) and amateur archaeologists have decimated the national archaeological heritage. Existing legislation controlling trade in artifacts is seldom enforced.

Current Costa Rican culture has been forged over more than four centuries by colonialism, independence, republicanism, dictators and democracy. Social patterns were established in the Seventeenth Century partly by the early success and later decline of the cacao economy. Municipal rule, established in the Eighteenth Century, helped foster Costa Rican individualism and social identification. The Nineteenth Century was a fundamental period in the development of Costa Rican culture: Independence (1825), the First Republic (1848), founding of the Universidad de Santo Tomás (1843), local emphasis on public education, ascendancy of coffee and coffee-growers and growing independence from the Catholic Church profoundly influenced impressive cultural gains. Though these cultural developments extended well into the Twentieth Century, they were altered by international events such as wars and economic changes. European influence declined as Costa Ricans turned to the United States, Chile, and Argentina for advanced education. Compared to the Nineteenth Century, the Twentieth Century has been disappointing culturally, though growing appreciation exists for the national parks system and

Indian cultures. The 1940-41 reopening of the Universidad de Costa Rica should have been a cultural milestone, but weak training and unrealistic goals have hindered cultural advancement. The political events of 1948 had contrasting effects by revitalizing democratic ideas, while establishing mediocrity and inefficiency in the Civil Service.

Recommendations

Enforce existing legislation protecting the country's archaeological heritage; require adequate financial and political support for the National Museum.

Strengthen cultural heritage through both the education system and popular media.

INDIANS

Despite the wholesale decimation of indigenous populations during the early colonial period, Costa Rica still has six ethnic Indian groups, plus two ethnic descendent groups. Current estimates of the Indian population range from 11,000 to 19,000. Most of the 278,839 ha of official Indian Reserves are in the Cordillera de Talamanca. These Indians practice traditional shifting cultivation, an ecologically sound use of forest resources when the population density is low. The Indian's most serious environmental problems are the loss of their reserve land and exploitation of natural resources within their reserves. Existing legislation protecting Indian cultures and their natural resources has been weakly and inconsistently applied. The new mining law and exploration for petroleum directly affect Indian Reserves. State involvement in mining could easily circumvent the legislative intent to protect Indian lands and people. The Talamanca Indian groups negotiated an agreement with the government to permit petroleum exploration and exploitation on Indian Reserves; however, it is uncertain if the agreement will effectively protect Indian culture and land.

Recommendations

Conduct environmental and anthropological studies to determine the potential effects of mining and petroleum exploration and exploitation upon the Indian communities in their Reserves.

Strictly and effectively enforce the Indian Law; provide adequate financial support for CONAI.

CONAI must set aside petty politics and fulfill its legal and ethical mandate.

DEMOGRAPHY

Costa Rica's estimated 1979 human population was 2.2 million, with the majority living in the Central Valley. Twentieth Century population growth rate averaged 2.1% /year, 1901-1950; 3.3%/year, 1951-1975 (one of the highest in Latin America); and 2.6% since 1975. The population boom was due to a marked decline (33%) in crude death rates and an increase in birth rate. Life expectancy (73.1 years, 1980) is exceptionally high for a developing country; it is largely due to effective public health programs.

The striking decline in population growth rate in the past two decades is due to a dramatic reduction in the birth rate from a high of 48.3 births per 1,000 inhabitants in 1955-60 to 29.6 births/1,000 in 1975. The largest decline occurred in 1965-70 when there was not an organized nor foreign assisted family planning program. Costa Rica is unusual in that family planning information and services effectively reach the lower classes, e.g., 64-78% of rural women used contraceptives in 1976. However, the birth rate has increased slightly in the past few years, perhaps due to lack of government support for family planning.

If the trend in population growth rate evident by 1975 were to continue to decline to 2.2%, the country is projected to have a population of 3.4 million by the year 2000. If the rate hovers at 2.6%, there will be about 4 million Costa Ricans in the year 2000. Even if replacement fecundity were reached in the year 2000, demographic inertia would put the definitive population at 5.9 million for the year 2090. However, this would require an unusually rapid decline in fecundity that is unlikely in the current social context.

Costa Rica's major demographic problem is not simply the various projections of future population, but rather how population growth relates to land availability, utilization, and tenure. Population density in relation to arable land (currently 225/km^2) indicates the country is close to the saturation level for the best land. Thus the population projections for the year 2000 and beyond must be taken seriously if agriculture is to remain the keystone of Costa Rica's socioeconomic development.

Recommendations

Establish and promote a national demographic policy that will stabilize population growth to a level compatible with national development capability.

NUTRITION AND HEALTH

Based on vital statistics, nutritional status and life expectancy rates, Costa Rican health is at the level of many industrialized nations. This clearly indicates that good health is more dependent on social policies than level of economic development. Benefits from education, justice, environmental sanitation, standard of living, preventive medicine and social security are of greater magnitude in Costa Rica than those observed in other Central American countries.

Among variables that promote good health, the control and prevention of infectious diseases have substantially reduced morbidity and mortality rates. Quantity of food intake has remained nearly constant, but there is a trend to increased consumption of animal protein and of a more varied diet. Changing dietary habits is increasing the risk of obesity and the pathology associated with it. The present economic difficulties will add more stress to the already limited food budget of the poor, causing increased malnutrition and chronic infection.

Recommendations

Costa Rica's outstanding advances in public health must be maintained in spite of the current economic crisis.

Maintain the national infrastructure to continue programs of immunization, rural water supply, latrine, health care and nutrition in spite of the current economic difficulties.

Improve health education in order to increase individual responsibility in the maintenance of good health.

FORESTS AND FORESTRY

The varied physiography and climate of Costa Rica support 12 ecological Life Zones, each with an impressively diverse biota. Two Life Zones, *Tropical moist* and *Tropical wet*, cover nearly half of the country. Of the 12 Life Zones, only the *Tropical Subalpine rain paramo* (0.2% of the country) is naturally without forest cover. By 1977 only 15,900 km^2 (31%) of forests remained, largely on the Cordilleras de Talamanca and Central, and in northeastern Costa Rica. More than half the deforestation currently estimated at 60-70,000 ha/year, has occurred since 1950. Demand for land rather than for timber, is the primary cause of deforestation.

Valuable land has traditionally been forest-cleared land; natural forests therefore were of little economic value and invasion by forest-clearing squatters to demonstrate land possession was a natural result. DGF preoccupation with timber traffic rather than deforestation is illustrated by the area deforested being triple the amount authorized for cutting by the DGF. ITCO settlers are responsible for an appreciable amount of legal and illegal deforestation.

Of the 15,900 km^2 of remaining forest in 1977, 4,183 km^2 are in national parks and equivalent reserves; 2,788 km^2 are in Indian Reserves; while 11 Forest Reserves cover 4,338 km^2. At a deforestation rate of 70,000 ha/year, the 4,600 km^2 of unassigned forest will be cut by 1985. The DGF regards the decreed forest reserves as exploitable timber reserves, yet most of them occupy critical catchment areas, where their hydrological functions have much greater value than does the timber.

The well-developed sawmill industry utilizies 76% (DGF 1980) of installed capacity; inadequate information is available for other timber industries. The timber industry has minimal involvement with its sources of raw materials. Despite inclusion of production forestry in the USAID Conservation of Natural Resources loan, natural forest management possibilities are bleak.

Reforestation efforts totaling less than 4,000 ha are negligible when compared to deforestation. Forest plantations have been established for cosmetic and tax purposes, often on agricultural land, rather than on lands needing reforestation. Without establishing major forest production either from natural forest management or plantation forestry, Costa Rica will have to import most of its wood (as is now the case for wood products) before the end of this century.

Recommendations

The DGF must comply with and enforce the Forestry Law, particularly to control deforestation; ITCO should not be allowed to ignore and abuse the Forestry Law.

All Forest Reserves should be evaluated according to land use capability and forestry potential: those Forest Reserves, or portions thereof, occurring in critical catchments should receive absolute protection and be reclassified as Hydrologic Reserves.

The reforestation program needs to be restructured to stimulate forest plantations where they are needed most, to massively increase the area reforested each year, and to improve the matching of species with site.

The timber industry must become actively involved in sustained yield forestry; they should not receive government assistance when the industry collapses from lack of raw material.

WILDLANDS

Wildlands are forest areas legally protected or managed for a variety of purposes ranging from resource exploitation to absolute protection, including environmental recreation and education. Although Costa Rica has not legally adopted national conservation objectives for managing wildlands, truly impressive achievements in conservation have occurred. Forty-five wildlands units (Fig. I-1) comprising nine management classes have been legally established: 11 Forest Reserves (433,805 ha); 13 National Parks (399,138 ha); 7 Biological Reserves (18,346 ha); 13 Indian Reserves (278,839 ha); 2 Wildlife Refuges (7,530 ha); 7 Protection Zones (14,800 ha); 1 Cultural Monument; 4 Recreational Areas (666 ha) and 1 National Monument (218 ha). Legally established wildlands occupy about 952,000 ha, equivalent to 19% of the country. However, only the national parks, biological reserves, wildlife refuges, recreational areas and National Monument are adequately protected and administered.

Except for the recently decreed La Amistad Bi-National Park, all wildlands units have been created without prior ecological and cadaster studies. The management objectives and categories, geometric shape, boundaries and justification for most units do not coincide with the area established. Consequently, many wildlands units require boundary adjustments, management plans and expropriation of private inholdings.

Recommendations

Legal national conservation objectives should be established as a basis for development of a national conservation strategy.

Conduct an independent evaluation of Forest Reserves and Indian Reserves that is similar to the recently completed evaluation of National Parks and Equivalent Reserves.

Consolidate the national system of wildlands: define objectives; prepare management plans; provide adequate protection and administration; and expropriate private inholdings in each unit.

Allow continued use of private inholdings (to be expropriated) within designated wildlands only so long as the land is utilized appropriately.

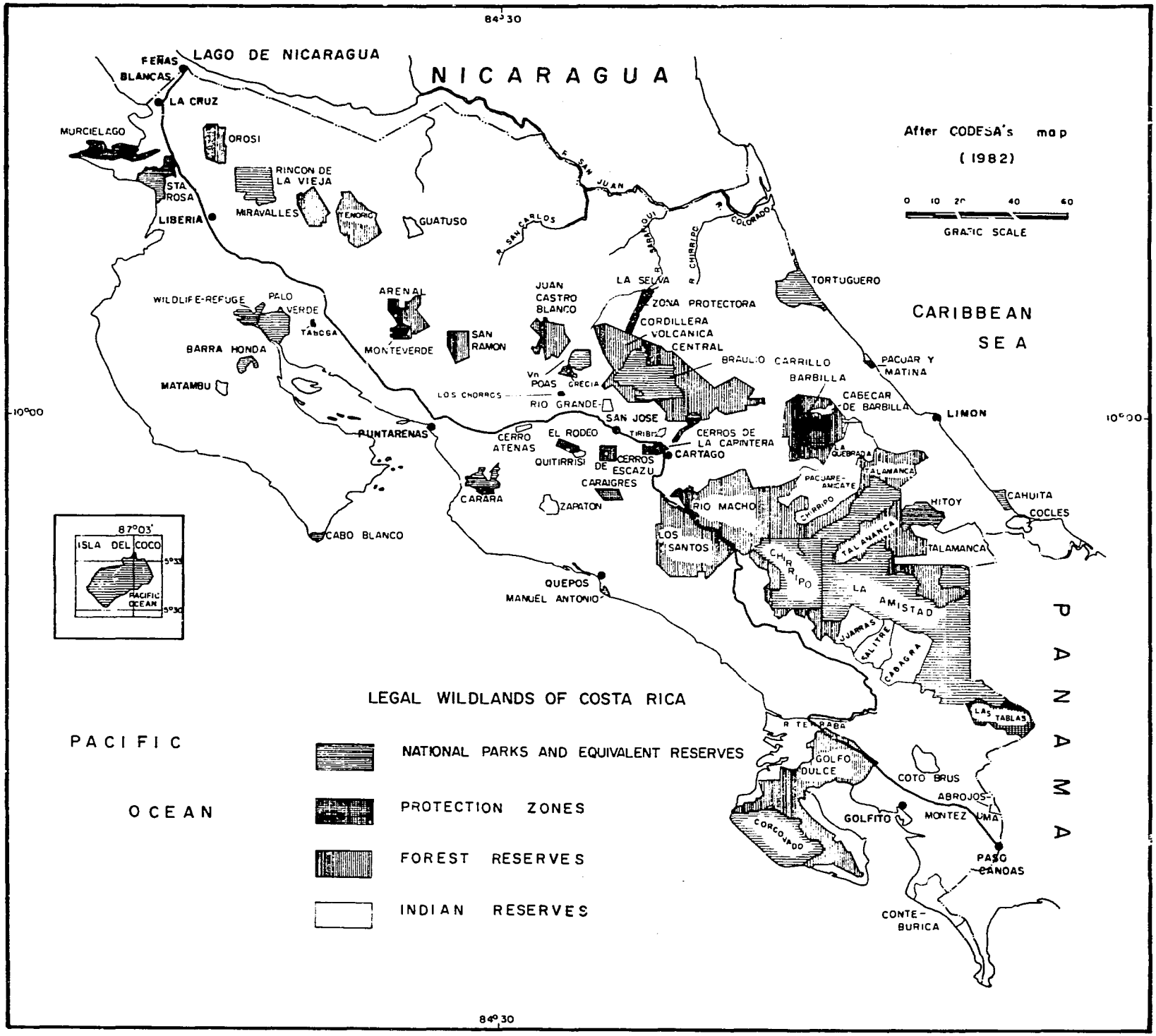

Figure I-1.—Wildlands units legally established by the government of Costa Rica.

WILDLIFE

Costa Rica has a fairly well-know herpetofauna of about 360 species, an avifauna of some 850 species and a mammal fauna of 205 species. Much less is known about invertebrate groups, although arachnids, lepidopterans and some coleopterans are now receiving concentrated study. Though Costa Rica has few endemic species, a substantial number of species have restricted distributions, particularly in the highlands and in the Golfo Dulce lowlands. Four classes of wildlife resources are recognized: endangered species, species used by man, pest species and species without any direct importance to man.

Of the endangered herpetofauna, the golden toad is protected in the Monteverde Cloud Forest Reserve, the green turtle nests on the protected Tortuguero beach and the Pacific Ridley turtle nests on the protected Ostional and Nancite beaches. The two endangered crocodilians maintain good populations in the lowland Pacific national parks and wildlife refuge.

Seven of the 11 endangered bird species are large birds of prey. Two officially endangered bird species are thriving in protected wildlands: the Scarlet Macaw in Corcovado; and the Quetzal in Monteverde, Chirripó, Braulio Carrillo and Poás. Hunting outside of protected wildlands does not seem to be endangering any bird species except perhaps the Great Curassow, Crested Guan and Muscovy Duck. The local predilection for cage birds threatens the Yellow-headed Parrot, Yellow-tailed Oriole, Dark-backed Goldfinch and the Yellow-bellied Siskin. Pesticides seem to be causing toxicity problems in the lower Tempisque heronries. A few bird species are serious pests.

All cat and monkey species are among the 16 officially endangered mammal species, plus two highland squirrels, the tapir, manatee, and giant anteater. Jaguars, ocelots, giant anteaters and tapirs appear to require large tracts of protected forest for survival. A UNA study shows that white-tailed deer, collared peccary, common opossum, armadillo and paca are important sources of protein in rural areas. Hunting with dogs is a major problem in the unprotected forest reserves and occasionally so in the national parks and equivalent reserves. Pocket gophers, cotton rats, and vampire bats are major mammal pests.

Recommendations

Define wildlife policy functions and responsibilities, and increase coordination and cooperation of the institutions involved with wildlife.

Approve the proposed Wildlife Law, then implement and enforce it.

Provide additional wildlands units to protect migratory waterfowl in Guanacaste and to protect one or more forest corridors for bird and mammal altitudinal migrations on the Caribbean slope.

Train wildlife biologists in areas of pest control, population biology, and management.

COASTAL AND MARINE RESOURCES

The Pacific coast is almost five times longer than the Caribbean coast and is also more complex, with much greater tides, rocky headlands, sandy beaches, deepwater bays and major estuaries. Yet the only coral reef occurs at Punta Cahuita on the southern Caribbean coast. Although mangroves occur on both coasts, they are much more extensive on the Pacific coast where major estuaries and associated mangroves occupy 15% of the coastline. Nearly half the mangrove forests have been destroyed for tannin, firewood, charcoal, saltworks and shrimp ponds.

Scenic beauty is considered the most important coastal resource, especially along the northern Pacific coast where there is extensive tourist development. However, coastal development has been chaotic and largely uncontrolled, with little concern for natural resources such as potable water, or environmental problems such as contamination. Location of tourist facilities, industrial complexes or port structures is often based on political pressures and local interests.

Commercial fishing is largely restricted to Pacific waters; seasonal catching of lobster and green turtles occurs along the Caribbean coast. Fish catches from the littoral Pacific have decreased since the mid-70's even though the fishing fleet continues to increase, suggesting that Costa Rica should not expect larger catches from her littoral fisheries.

Aquiculture operations are developing rapidly in the country. Commercial rearing of shrimp and crayfish is a capital- and technology- intensive operation; hence the rearing of filter-feeding molluscs may be a more appropriate enterprise for rural coastal inhabitants. Fish culture primarily involves rearing Tilapia in ponds.

Recommendations

Develop coastal and marine resources through an integrated national policy to overcome the existing inadequate administrative structure.

Reform existing legislation to include relevant concepts of the Law of the Sea and to facilitate integrated coastal zoning.

SOILS AND LAND USE

Agricultural production has traditionally served as the primary source of national economic development and is expected to play a key role in the current program for economic recovery. Past and future use of the country's soils will largely determine the possibilities for sustained increases in agricultural productivity. Preliminary estimates of land capability indicate the following maximum sustainable use of Costa Rican soils: 9,437 km^2 (19% of the country) for permanent productions of annual crops; 4,656 km^2 (9%) for permanent pasture; 8,158 km^2 (16%) for perennial crops; 16,088 km^2 (32%) for production forestry; and 12,491 km^2 (24%) requiring absolute protection. Higher class lands can be used less intensively, e.g., a perennial crop can be grown on land classified for clean-tilled crops, but not *vice-versa.*

In 1980 there were about 19,000 km^2 of pasture and 2,250 km^2 of clean-tilled crops (including bananas and sugar cane). Pastures apparently occupy up to 76% of lands suitable for annual crops--an under-utilization of

soil capability. Extensive deforestation of potential production forests in the past two decades for pastures is an over-utilization of soil capability. The conversion to pasture of low-fertility soils on steep topography in high rainfall areas causes serious soil erosion and poor productivity.

National estimates of hydric erosion suggest 17% of the country is severely eroded and 24% is moderately eroded; flat plains and primary forest suffer little hydric erosion. Serious and widespread erosion (30% of the area) occurs on the Pacific side with another 30% moderately eroded. A rough estimate of soil loss is 680 million tons/year to erosion, of which over 80% is caused by overgrazing pasture lands. Since topsoil is essentially a non-renewable resource, the soil loss seriously threatens not only the country's agricultural productivity, but the economic viability of hydroelectric, potable water, irrigation and forestry projects as well.

Soil degradation is not limited to erosion losses; physical compaction, repeated burning, poor road design and construction, chemical toxification and inappropriate land use are also contributing to the pervasive deterioration of Costa Rica's soils. The rapidly expanding megalopolis (from Paraiso to Atenas by the year 2000) is eliminating some of the country's best agricultural soils. Planning and zoning for the greater metropolitan area is *post facto*, responding to political and speculative forces rather than considering the unique productiveness of these irreplaceable soils.

Recommendations

Investigate pasture soils in various life zones and pasture conditions to ascertain effects of extensive grazing.

Classify land according to capability as prerequisite for increasing and sustaining agricultural productivity.

Develop under-utilized lands now in pasture, but suitable for annual crops to increase agricultural productivity.

Critically review and evaluate Central Valley urbanization and recommend legal, political, administrative and technical means to minimize the elimination of excellent agricultural lands.

AGRICULTURE AND CATTLE

The agricultural sector has traditionally played a key role in Costa Rica's socioeconomic development and is expected to make even more substantial contributions to solving the current economic crisis. Agriculture accounts for 28% of national employment, 19% of GNP, and 74% of export income. The top exports are coffee, bananas, beef and sugar. Major agricultural imports include basic grains, fruits and vegetables, and animal feeds. Costa Rica has the technical capability to produce all its own food except for wheat, but has not done so due to crop preferences, low yields, high costs, lack of incentives, and cheaper imports.

Increases in agricultural production over the past decade were due to expansion of area under cropping rather than higher yields. Depressed prices for traditional exports have accentuated the balance of payments deficits. Crop diversification is promising, but major successes in increasing agricultural exports require marketing outlets, technical and financial assistance and strong support from the government.

Beef cattle production has increased dramatically over the past two decades, as is reflected by the dominant position of pasture land among farm uses. Mini-farms (< 20 ha) are more efficient producers of beef (383 kg/ha/yr) than family size (122 kg/ha/yr; 20-200 ha) or large farms over 200 ha (162 kg/ha/yr). The cultural predilection for beef cattle is reflected by the sacrifice of income just to continue as a beef rancher and the strong attraction for investors who become absentee owners or gentlemen farmers.

Increased cattle production can best be attained by intensifying management of cattle farms, rathers than continuing expansion of pasture on marginal land. Improving pastures and adopting rotation grazing systems would do more to increase beef cattle production than the other incentives proposed in the National Development Plan. The national production goal of 91,600 tons of beef for 1982 is unrealistic.

Recommendations

Encourage a GOCR priority to increase agricultural exports and investigate import substitutions as well as give technical and financial assistance.

Emphasize high-value, non-traditional crops, many of which are already grown in Costa Rica on a small scale, in agricultural diversification projects.

Increase production of beef by intensifying farm management, particularly pasture quality and use, rather than by continued expansion of pasture onto marginal lands.

WATER RESOURCES

Rugged topography and high rainfall provide Costa Rica with an incredible richness of water resources, conservatively estimated at 9 million Kw of hydroelectric potential and 350 m^3/second of sustained groundwater flow. A progressive development strategy by ICE has led to the development of numerous hydroelectric projects that now generate 99% of the nation's electricity and permit the sale of excess electricity to neighboring countries. Rural electrification programs have reached 70% of the population. The escalating cost of electricity has caused an appreciable drop in the annual growth of demand and has precipitated numerous disconnections by urban poor who can no longer afford electricity.

Unfortunately, ICE is not complying with its legal mandate to conserve, defend and protect the country's watersheds. Virtually every major watershed is being degraded by deforestation and inappropriate land use. Unless critical watersheds for both existing and potential hydroelectric projects are protected, the economic feasibility and viability of their hydroprojects will be seriously jeopardized.

ICAA and rural municipalities supply potable water to 98% of the urban area and 62% in rural areas. Even if new projects are completed as scheduled, demand is expected to exceed supply by the late 1980's. ICAA also ignores protection of water supplies due to the mistaken

attitude that other institutions are responsible for watershed protection and pollution control.

Irrigation information is ambiguous, perhaps due to the diffusion of responsibility among several government institutions. Although irrigation could substantially increase agricultural productivity, the lack of national policy, experience and expertise must be overcome. The environmental and socioeconomic aspects of the Morácia irrigation project have not been adequately evaluated.

Watershed deterioration is increasing the risks of flood damage, particularly at the eastern base of the Cordillera Central and along the narrow floodplains of the Central Valley. Ciudad Neilly is probably the most poorly located community in the country.

Recommendations

Define national development policy for water resources; a technically qualified secretariat should coordinate the various institutions involved in the protection, supply, use and recovery of water.

Protect critical watersheds from deforestation and inappropriate land use; declare hydrologic reserves and delegate their protection to the responsible institution (e.g., ICE, ICAA).

ENERGY RESOURCES

Costa Rica's dependence on imported energy increased dramatically over the past decade: 80% is now imported. Although hydropower produces 99% of the country's electricity, that is only 19% of the country's total energy consumption. Petroleum is the principal component of imported energy; it fueled rapid growth of the transport sector. With Mexican assistance, Costa Rica is drilling two test wells in 1982 to determine if petroleum deposits in southeastern Talamanca are commercially exploitable. The petroleum deposits are thought to be small and costly to exploit.

According to OLADE, Costa Rica's petroleum import costs will more than double by the year 2000, given a low GNP growth rate and constant petroleum cost. If the country recovers economically, a medium rate of increase in GNP would require $ 550 million for petroleum imports in 1985.

Even if commercial petroleum is found, Costa Rica must adjust energy consumption trends to national renewable energy resources. Diversification of local energy sources and substitution for imported energy must become national policy. The transport sector's inflexibility and dependence on imported diesel is the most intractable component of an energy substitution program.

Costa Rica's responses to the energy crisis have been largely counter-productive. Government subsidy of diesel fuel and fiscal policy favoring import of diesel vehicles stimulated a 50% increase in diesel consumption from 1974 to 1979. Because the RECOPE distillery in Moín could not meet the national demand for diesel fuel, direct import of diesel fuel increased 600% during those same years. The lack of a national energy policy and institutional coordination in energy matters has greatly hindered the government's capability to effectively and rationally deal with the energy crisis.

Recommendations

Continue to accelerate development of hydroelectric and other renewable energy sources to attract energy-intensive industry and promote substitutes for imported energy.

Rationalize the consumption of petroleum derivatives, particularly diesel fuel, by reducing imports and subsidies, restricting the import of diesel vehicles and substituting hydroelectric power.

ENVIRONMENTAL CONTAMINATION

The exceptional social, economic and demographic changes of the past 40 years have profoundly affected the environment, principally due to modern consumerism. Environmental protection measures lag far behind imported and local technological advances. Potable water quality is quite good except for rural systems outside the control of ICAA. Nevertheless, organic matter, industrial and domestic effluents and sediments still contaminate the country's rivers--the most serious national contamination problem. The Central Valley rivers are highly polluted with anionic detergent effluents. Contaminated river water is often used to irrigate vegetable crops in the Central Valley.

Key aquifers for the metropolitan area are being contaminated by garbage dumps, careless use of pesticides and fertilizers, and lack of sewer systems. Coastal aquifers are particularly susceptible to salt water intrusion and contamination by organic matter and agro-chemicals.

The generally massive and indiscriminate use of pesticides makes them pervasive contaminants of air, food, water, and menaces to human health. Although the government has restricted the use of organochlorates, they are still readily available and widely used. Pesticide problems arise frequently from lack of education and understanding of the function and hazards of pesticides. Copper toxicity ruined 50,000 ha of excellent agricultural soils in southern Costa Rica.

Solid wastes are probably the most inadequately managed, yet widespread contaminants in the country. Central Valley urban centers not in the COIM have large problems with solid waste management.

Air pollution comes principally from automotive exhausts; industrial contamination of air is minor in the metropolitan area. Narrow and congested city streets greatly accentuate localized air pollution. San José has abnormally high levels of acid rain and high levels of particulate matter in the air. Vehicles are also the major source of noise pollution, especially on San José's narrow streets and at bus stops.

Occupational health statistics suggest an enormous amount of occupational stress, yet only 10-15% of laborers use protective clothing. Pesticide poisoning is quite common, but few workers seem to take the risks seriously.

Quality control and inspection of commercial foods has been largely ignored in Costa Rica. The government food control laboratory is contaminated, overcrowded and overwhelmed with technical difficulties.

Recommendations

Government agencies concerned with environmental contamination and protection must coordinate activities to protect public health.

Increase research on the effects of contaminants on man and environment.

Enforce existing laws concerning environmental contamination.

ENVIRONMENTAL LAW

An information center for environmental law does not exist, plus the classifications system used in legal information sources does not recognize environmental law as a distinctive body of law. ASCONA's lawsuit to annul the executive resolution reducing the size of Palo Verde National Park was one of the first civic attempts to challenge environmental problems or threats in the courts. The UCR Institute of Legal Research is analyzing environmental legislation.

There is an abundance of legislation, norms, decrees, and principles that directly or indirectly concern natural resources and the environment. Environmentalists working for the enforcement and implementation of existing laws can effect considerable protection and conservation just using the legal tools already available. Unfortunately, many of these efforts have been left to the overloaded public sector, with the consequence that most conservation-type laws seem to be ignored or not enforced by government officials.

The hierarchical ranking of legal norms is (from the top) international treaties, laws approved by the legislative assembly, executive decrees, regulations and administrative resolutions and agreements. Expansion of public sector involvement with natural resources and the environment means that these activities are controlled primarily by political forces. Thus government programs and policies may be major causes of environmental deterioration. Another consequence of political dominance is that legal questions become subservient to political goals and interests.

Civil and penal mechanisms available to the conservationist include defense appeals; edicts; restraining order of an administrative act, the effects of an administrative act, or the execution of an administrative act; the accusations before the Public Ministry, administrative authority, transit tribunal or for misdemeanors. Three actual case studies are reviewed:

(1) ASCONA's suit to annul reduction in size of the Palo Verde National Park;

(2) unauthorized construction of a house in the 200 meter coastal zone; and

(3) lack of judicial enforcement of the Forestry Law's norms controlling deforestation.

Recommendations

The legal area of environmental law should be recognized by all components of the Judicial System.

Each new law with probable environmental consequences should contain extensive and explicit norms for environmental protection.

Draft an environmental code to simplify the environmental legal situation and to assign specific functions to existing institutions, eliminate overlap and derrogate all legal norms in opposition to the code.

Appoint an environmental prosecuting attorney.

Strengthen the independent power of the Judicial Branch to serve as an effective balance to the growing power of the public sector dominated by the Executive Branch.

INSTITUTIONAL ANALYSIS

Costa Rica does not have a national environmental policy that integrates all sectors; rather, each sector defines its own policies and objectives. Institutional goals are often too general and grandiose to affect specific policy; consequently few goals are attainable and few institutions seriously try to implement sectoral environmental policy. Existing policy is usually a response to problems, rather than a strategy for rational utilization of natural resources and environmental protection. The fragmented sectoral approach to policy formulation occurs without formal interinstitutional coordination. Although OFIPLAN is charged with coordinating government projects and policy, it does not take responsibility for implementation.

Human resources are marginally adequate in most institutions. The Civil Service system fosters mediocrity and stagnation, while the best qualified and dynamic professionals prefer private enterprise. The current economic crisis could provoke a massive brain-drain of top professionals leaving the country for foreign employment. University admissions and graduation policies are not based on potential employment demand, thus 50% of the university graduates do not find employment in their chosen fields.

International and bilateral financial aid is important to natural resources development and environmental conservation. Particularly noteworthy are the USAID grants to ASCONA for conservation education. Foreign investments in public sector development projects are projected at US $ 600-700 million per year, which is only a fraction of estimated costs just for the proposed Boruca hydroelectric project, a tripling of area planted to sugar cane to produce alcohol, electrification of the transport sector and petroleum exploration. Costa Rica has not taken advantage of the Mexican-Venezuelan petroleum agreement offering up to 30% of the petroleum bill for attractive loans.

Recommendations

Define government and private institutions' efforts to effect an integrated national environmental policy for environmental management, natural resources conservation and scientific research.

Strengthen SINAPROMA to influence national and sectoral projects involving natural resources and the environment.

II.

Introduction

Objectives

The purpose of a country environmental profile is to pull together in one definitive document the information, data and analyses on national environmental problems and to identify possible environmental improvement programs that could be undertaken by the government and/or private sector with financial assistance from international agencies. Specific objectives are to identify major existing and potential problems and areas of concern for natural resources and environmental management, to conduct an analysis of the impact of these problems on the society and economy and to provide an overview of Costa Rican government institutions, policies, and resources related to natural resources conservation and environmental management.

This country environmental profile was carried out for USAID-Costa Rica during the last trimester of 1981 by a team of local specialists contracted by the Tropical Science Center, a private, non-profit Costa Rican association concerned with man's enduring relationships with natural resources in the tropics. Sixteen specialists intimately familiar with Costa Rican culture, environment, natural resources and institutions participated in the preparation of background documents analyzing each sector. These sector reports were edited and condensed into the present synthesis by Gary and Lynne Hartshorn.

Principal Physical Features

Geography and Physiography

With an area of 51,000 km^2, Costa Rica is the second smallest republic in Central America, bordered by Nicaragua on the north and Panamá on the south. Geographic coordinates are 8^0 03' to 11^0 13' N latitude and 82^0 32' to 85^0 57' W longitude. The 24 km^2 Coco Island lies about 500 km southwest of the mainland at 5^0 32' N and 87^0 04' W and is the only oceanic island belonging to Costa Rica. Costa Rica's greatest length is 480 km on a northwest-southeast axis, while the narrowest width between the Pacific and Caribbean coasts is only 118 km. The flat, regular Caribbean coastline of 210 km contrasts strikingly with the very irregular, rocky Pacific coast. Four peninsulas—Santa Elena, Nicoya, Osa and Burica from north to south—extend Costa Rica's Pacific coastline to 1,016 km. The Nicoya and Osa peninsulas shelter the deepwater gulfs of Nicoya and Golfo Dulce, respectively. The Pacific coast is characterized by rocky headlands interspersed with short, sandy beaches. Extensive mangroves occur on the deltas of major rivers draining to the Pacific, e.g., Río Tempisque, Río Grande de Térraba.

Costa Rica is dominated physiographically by a sequential series of mountain ranges running northwest-southeast. The northernmost Cordillera de Guanacaste consists of four isolated volcanic massifs, with Volcán Miravalles the highest at 2020 m. About 40 km southeast, the disjunct Volcán Arenal (1,633 m) continues to be active after a major eruption in 1968. West of its volcanic namesake, Lake Arenal separates the Cordillera de Guanacaste from the non-volcanic Cordillera de Tilarán. The impressive Cordillera Central consists of four volcanic massifs: Poás (2705 m); Barba (2906 m); Irazú (3432 m) and Turrialba (3339 m). Although Volcán Irazú erupted in 1963-65, Volcán Poás is now quite active. The passes between volcanoes differ greatly in the two volcanic cordilleras. The low elevation (300-500 m) passes in the Cordillera de Guanacaste were not effective biological barriers; roads now cross each pass. The much higher passes (1500-2000 m) in the Cordillera Central and rugged topography continue to impede major highway crossings. At its northwestern end the Cordillera de Talamanca forms the southern rim of the intermountain Central Valley. Continuing eastward into western Panamá, the Talamancas include ten peaks over 2,950 m with Chirripó (3818 m) the highest in Costa Rica.

The densely populated and agriculturally productive Central Valley (often incorrectly called the Meseta Cen-

tral or Central Plateau) includes the national capital San José, plus three provincial capitals, Cartago, Heredia and Alajuela. Low hills between San José and Cartago divide drainage into the Río Grande de Tárcoles to the west and the Río Reventazón to the east. Separate railways along these river systems to coastal ports played a key role in coffee export and cultural development of the Central Valley (see next section). Coastal ranges in southern Costa Rica form two other intermountain valleys, El General and Coto Brus. These lower valleys are not nearly as important agriculturally as the Central Valley, largely due to the absence of recent volcanic ash deposits.

Extensive lowlands occur in northern Costa Rica, extending from the Cordillera de Guanacaste foothills to the Caribbean coast. These vast Caribbean lowlands below 500 m elevation cover about 20% of the country. North of Limón, extensive fresh water swamps are quite prevalent inland from the coastal strand. Nearly two-thirds of the Caribbean lowlands are drained by rivers flowing north to Lake Nicaragua and its Caribbean outlet, the Río San Juan. South of Limón the rugged foothills of the Cordillera de Talamanca nearly reach the coast, hence the only significant lowlands occur along rivers such as the Banano, Estrella and Sixaola, that flow directly to the Caribbean.

The Pacific lowlands are much more varied, but less extensive than the Caribbean lowlands. From the Panamá border to Punta Leona, the Pacific coastal plain is quite narrow or even absent due to proximity of coastal hills. The Pacific coastal plain widens north of Puntarenas and merges with the broad Tempisque valley. Both the Nicoya and Osa peninsulas are comprised of low (< 1,000 m) rugged hills that confine flatlands to peripheral plains and short, narrow river valleys.

Climate

Although entirely within the tropical latitudinal region, Costa Rica possesses great climatic diversity. Within its borders, 12 distinctive ecological life zones, or "bioclimates" (Fig. II-1) and at least three different rainfall regimes have been identified (Tosi 1966, 1969). It is perhaps the wettest country in the world, with a nationwide rainfall average of 3300 mm/year.

Costa Rica's meteorologic station network was extremely sparse until about 1950. At that time there were less than 25 public and privately operated stations, most of which recorded only total precipitation. Although the number of stations has more than quadrupled since 1950, there are few continous, long-term records suitable for the derivation of statistically meaningful data. The rugged topography and extreme relief plus the settlement-biased distribution of the meteorologic stations make all climatic extrapolations both difficult and unreliable, even over short terrain distances. As Portig (1965, p. 68) stated, Costa Rica, like the rest of Central America, is "an open field for climatological research".

One climatic characteristic of Tropical latitudinal regions is a very slight range of monthly mean air temperatures. Costa Rican mean annual temperatures range from about 26°C on the Caribbean coast and 27.8°C on the warmer Pacific coast to about 4.5°C at the highest elevation on Mount Chirripó (3818 m). Annual ranges of me monthly temperatures are as little as 1° C in the Cent Valley to as much as 3.7° C in the northern Pacific lo lands. Diurnally, temperatures vary from about 9° C the wet season to 14° C in the dry season, Below abo 2,500 m elevation, frost is rare or absent, while abo 1,500 m there are sufficient numbers of hours of critica low temperatures to inhibit the growth of cold-sensiti plant species. In high mountain areas, below-freezi temperatures in early morning hours become increasing frequent with higher elevation. Snow is reported on ra occasions on the high paramos above 3,400 m.

Costa Rican climates are all strongly influenced l marine air masses. The narrow country is bounded l great warm ocean bodies and the large freshwater La Nicaragua. No point in the country lies more than 80 k from a major water body, thus marine—insular inner-tropical rainfall conditions affect the entire country. It doubtful that any point averages less than 1350 mm annual rainfall while most of the country averages mo than 2500 mm (100 inches) per year. Nor are high rainfa areas restricted to the mountainous hinterlands; some the highest rainfall totals (more than 5000 mm per yea are recorded for the seaboard and coastal plains in bot the northeast and southwest.

Only two major areas are drier than the gener average for the country: the northern Pacific lowlanc and the Central Valley. Both areas lie in deep folds b tween major mountain ranges and perpendicular to th easterly and southwesterly (deflected) trade wind flow Both dry areas are characterized by a somewhat longe than average dry season and correspondingly highe monthly totals in the wet season. Their diminished tot rainfall is probably due to moderate rain shadow effect There is also a moderate absolute decrease in precipitatio in the Montane and Subalpine temperature belts. Muc of the ascending air that reaches elevations above 2,500 n has been partially dried by condensation and precipitatio at lower levels. However, these upper areas are as rel atively wet as their lower elevation counterparts becaus of lower temperatures.

Two seemingly distinct rainfall regimes, referred t as the "Atlantic" and the "Pacific" types, are foundec upon a single, predictable pattern controlled by the double passage of the sun overhead. The Pacific regime, locally modified by rain shadow and valley effects, represents a pure form of the predictable pattern of a single extended period of heavy rains between late April or early May and mid-November. In the Atlantic regime, this predictable pattern is overlain by a secondary pattern involving Warm Temperate climatic influences: from mid-November until early May the Subtropical high pressure belt of the northern hemisphere is drawn southwards over Costa Rica. This is a period of generally lower air temperatures, strong easterly trade winds, and dry clear air. These winds pick up appreciable moisture in their passage over the Caribbean Sea and are wedged up by the mountains (Fig. II-2) to bring advective and orographic rainfall to the entire Caribbean coastal plain, foothills and eastern mountain exposures during this normally dry period. During the rainiest months on the Pacific exposure, southwesterly winds are dried out in crossing these mountains from the Pacific lowlands and reach the Caribbean plains with little moisture, partially reversing the two regimes.

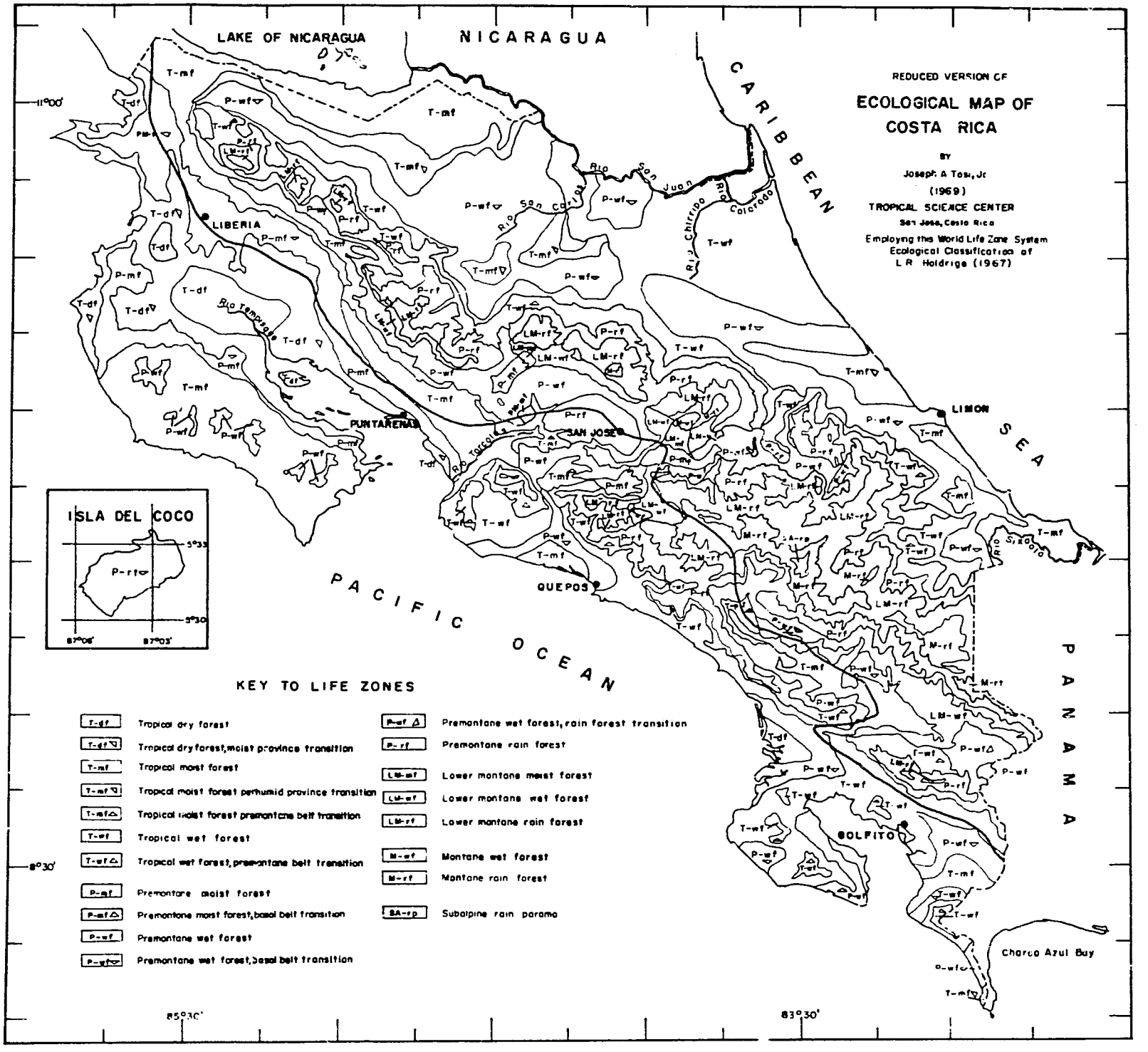

Figure II-1.—Ecological Map of Costa Rica.

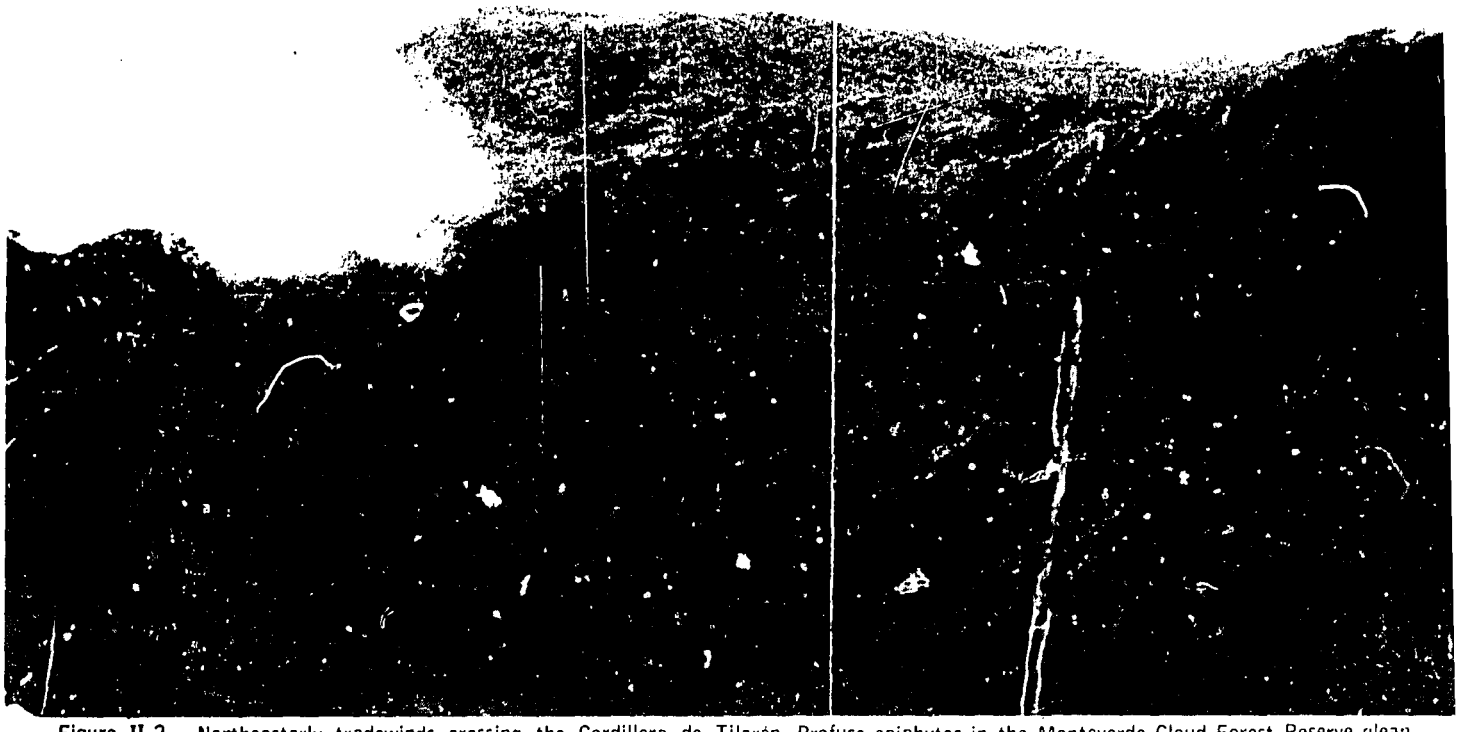

Figure II-2.—Northeasterly tradewinds crossing the Cordillera de Tilarán. Profuse epiphytes in the Monteverde Cloud Forest Reserve glean moisture from the clouds that not only keeps the forest green but the rivers flowing during the dry season (photo G. Hartshorn).

Wherever fogs and mists occur frequently, such as on windward and upper mountain slopes in the condensation or "cloud belt", they constitute a significant source of additional moisture that is not recorded in standard rain gauges. This moisture condenses on the foliage of the natural vegetation and drips to the ground, providing an extra moisture source of considerable importance to upper mountain watersheds. Cloud forest condensation is believed to maintain appreciable base flow in rivers during the dry season months when there is little or no rainfall but abundant clouds and mist.

Geology and Mineral Resources

Historically, geological formation of the Costa Rican portion of the Central American isthmus began about 150 million years ago (late Jurassic). Massive geologic folding gradually created islands in the oceanic gap between the Panamanian tip of South America and nuclear Central America to the north of present day Costa Rica. Known as the Western Archipelago, this chain of islands is now represented by parts of the Santa Elena, Nicoya, Osa and Burica peninsulas (Weyl 1980). Costa Rica's oldest igneous rocks and sedimentary deposits date to the Western Archipelago. Though a continuous land mass apparently did not occur in the late Jurassic and early Cretaceous, the Western Archipelago probably served for the first mixing of Nearctic and Neotropical biota by "island hopping" organisms.

Southeastern Costa Rica was the next scene of geological activity, where major land-building occurred from 70-15 million years ago (late Cretaceous to mid-Tertiary). Eocene volcanic activity formed the igneous rocks of the Cordillera de Talamanca, while marine sedimentation in the Térraba and Limón basins continued through the Oligocene and Miocene. Intense geologic folding uplifted the Cordillera de Talamanca in the early Miocene. Late Miocene volcanic activity formed the igneous rock of the Cordillera de Tilarán.

The third major phase of land building occurred in the Quaternary, due to general uplifting, continued sedimentation in the Limón and Térraba basins, and volcanic activity in the Cordillera Central and Cordillera de Guanacaste. The Quaternary vulcanism produced extensive depositions of pyroclastics around the two cordilleras. Rhyolitic ash and tuff are more prevalent around the Cordillera de Guanacaste, whereas andesitic ash is more common around the Cordillera Central.

Mineral resources are not abundant in Costa Rica. Some gold and silver deposits are mined in the Cordillera de Tilarán and on the Osa península, but mining contributed only 2% to the GDP in the mid 70's (Kurian 1978). Other potentially exploitable mineral resources include manganese on the Nicoya peninsula, magnetite sand on southern Caribbean beaches, bauxite (35% Al_2O_3) in the El General Valley, copper in the Cordillera de Talamanca and sulfur in Cerro El Congo.

Petroleum exploration is concentrated in the Talamanca valley south of Limón, where the Mexican government is collaborating in drilling two test wells in 1982. Methane is known to occur in the Talamanca valley, near Moín and at Sándolo beach, but the potential is unknown. Solar evaporation of sea water along the northern Pacific coast produces several thousand tons of salt per year.

III.

Human Resources

III-A. SOME HISTORICAL ASPECTS OF CULTURAL RESOURCES

Geographic and Pre-Colombian Elements

Recent investigations into Costa Rican prehistory demonstrate that indigenous human populations generated remarkable cultural diversity. The Pre-Columbian trade networks and other types of cultural diffusion as well as the ecological diversity of this region fostered cultural abstraction.

Human migrations and human settlements usually obey dictates of climate and substrate. Northwestern Costa Rica is similar to the Pacific coastal lowlands extending north to the Isthmus of Tehuantepec. Along this subhumid corridor the prehistoric cultures of Mexico expanded southward. Pyramids and other samples of monument-building remain as representatives of these people, reaching as far south as El Salvador; but the limits of Mesoamerican culture of maize stopped in Guanacaste and Puntarenas provinces where they met wetter forest. On the eastern side the South American tribes familiar with the rainforest environment moved north along the Caribbean lowlands. Traders from Pacific South America and the Antilles brought diverse cultures into contact. It is likely that migrants established themselves in those environments most similar to what they had left. Thus, despite its small size, Costa Rica has had a rich and diverse sequence of prehistoric cultures that can be grouped into three main types, more or less conforming with the natural boundaries of mountains, climates and general ecology.

Mesoamerican Element, Guanacaste-Nicoya

The northwestern portion of Costa Rica (a prehistoric cultural zone referred to as Guanacaste-Nicoya) represents the southernmost extension of cultural Mesoamerica. The rugged Nicoya peninsula to the southwest and the rest of Guanacaste province are called by the archaeologists the Greater Nicoya Sub-area, a Pre-Columbian cultural unit that also encompasses a portion of western Nicaragua.

The broken Pacific coastline, with numerous bays, coves and headlands played an important role in the establishment and shaping of Pre-Columbian cultures, providing varied marine and estuarine resources. The long dry season restricted settlements to proximity to year-round streams. The large and fertile Tempisque plain was heavily populated in Pre-Columbian times and constituted the principal area for cultural development of Greater Nicoya.

Polychrome wares, elaborate lapidary and stonework characterize this area and testify to an extensive trade with the rest of the Mesoamerican area. Important sites include Nacascolo, Filadelfia, Nicoya, Sámara, and El Viejo plus the islands of Chira and San Lucas in the Gulf of Nicoya.

The Central Area and Caribbean Slope

The central area and the Caribbean slope, a large and complex archaeological zone, make up a mosaic of several sub-zones the archaeologists put together on the basis of stylistic similarities of artifacts that point to some shared traditions. The South American tribes that pioneered the Caribbean lowlands left a much more scattered array of cultural traits than in the Greater Nicoya area. Elaborate gold jewelry and jade carvings, suggestive of Panama-Colombian traits, have been found in the Atlantic lowlands—Siquirres and the so-called Línea Vieja sites being the most representative. Recent discoveries in the vicinity of Turrialba suggest the existence of Paleoindian cultures, i.e., a preceramics settlement where weapons and other household utensils were chipped from hard stones. This site requires further study but may well represent one of the earliest human settlements in Costa Rica.

The highland central area includes the Central Valley and the rugged mountains that extend westward, nearly to the Pacific Ocean. A large number of sites have been discovered, but the most significant of them is Guayabo, near Turrialba.

The Southwestern Area, Diquís

The archaeological zone of Diquís in southwestern Costa Rica is the least know and understood. Nevertheless, Diquís is considered culturally to be part of the sub-area known as Greater Chiriquí, taking its name from the Chiriquí Province of Panamá where it seems better-developed as a unit. The most conspicuous artifacts of the Diquís area are the stone spheres; gold ornaments of clear Chiriquí influence are another trait of the area but disparity is also encountered, as in the so-called Bisquit Ware.

Huaqueros (grave robbers and amateur archaeologists) have devastated Pre-Columbian archaeological sites containing the media-rich expressions of the earlier inhabitants. Though uncontrolled excavations of sites began in the early 1800's and despite the efforts of a few scholars to restrict digging, grave robbing has continued.

Many sites have been exposed in the process of development. Good examples include the building of the Atlantic railway nearly a hundred years ago when the entrepreneur Minor C. Keith assembled large sets of artifacts for shipment to the United States. These artifacts now form the nucleus of such collections as those of the American Museum of Natural History and the Brooklyn Museum. Also, in the late Nineteenth Century when Costa Rica adopted Victorian tastes such as the collection of curios, the local well-to-do established private collections of archaeological items. These collections are scientifically useless, primarily because of the absence of accompanying site information. Though the Protection Law of 1938 prevents sale of artifacts, trade in artifacts has reached an acute stage due to the lack of enforcement.

Efforts by the National Museum to enforce the existing legislation have met with the insurmountable barrier of politicians or campaign benefactors who are themselves collectors and often international dealers. There is little local awareness of the need for archaeological documentation to establish the national heritage. Government funding for the rescue and preservation of artifacts is ridiculously low, an obvious oversight in a country attempting to develop tourism. Of the extensive system of national parks and equivalent reserves established over the past decade, only one of them, Guayabo, has been recognized by the local authorities purely on the basis of archaeologic values; this occurred primarily under pressure from various foreign agencies.

Historical Development of Costa Rican Culture

The Nineteenth Century constitutes a fundamental period in the historical development of Costa Rica and its culture. Costa Rican democracy arose with Independence from Spanish rule and the peculiar "political culture" that evolved from its dynamic character as well as the strong pervading character of the action of Independence itself. Nineteenth Century Costa Ricans, regardless of ethnic origins, became citizens (citoyen) and very much a part of the local "Politeia". The Costa Rican gradually became conscious of his bearing upon and within society and the immediate territory, but most of all, conscious of his "intimate identity", to which he yields as a free man through reason and reflection.

Nineteenth Century Costa Ricans were guides at th me time they were guided, able to set the limits of the own individuality—or liberty—as a means to learn an develop the basic traits of their culture. Thus, the develo ment of the "political culture" evolved as the necessa expression of a general feeling that the right to dissent not a threat to democracy, on the contrary, *THE* necessa conditions of democracy. This understanding of "politic culture", through an interaction of all participating el ments of the State, was developed and eventually turne into a "civic culture" and can be considered the root c Costa Rican-ness.

Under Spanish rule the function of colonists depende on established social status which determined politic dominance by nobility while commoners remained as th ruled majority. By local political development Costa Rica social dynamics contrasted immediately with the rigid an inoperative political infrastructure of the colonial regim elsewhere. Costa Rican republican processes filled the in stitutional void that resulted from Independence.

During the Seventeenth Century social patterns wer established by the material assets resulting from caca (and other lesser crops) production in hands of no bility. But a series of horizontal events led to the deca dence of production and consequently of the proprietors These events contributed favorably to the leveling o economical relativity of the people, a de-classing of sorts but not the loss of political power by the elite.The smal property pattern, the lack of labor, the equality and sharing of all nobility, the autonomous practice of common law and common rights as a response to the obstructionist, absolutist and centralizing authority of the Crown, the "Audiencia" and the "Capitanía de Guatemala", are the main causes in the progressive social and material identification among groups.

By the end of the Colonial period it was possible to identify the true colors of the criollos, as they left their rural isolation to participate as a group, directly or indirectly, in the political and revolutionary events. This intervention helps explain the pervasive individualism and urge to "defend" liberties that are hidden in Latin Americans and surface sporadically in present-day guerillas. But it also aids in establishing the capacity of Latin Americans to interrelate with the ruling class.

In the middle of the Eighteenth Century civil and ecclesiastical forces were directed toward the formation of urban nuclei that would unite the scattered rural population under the rule of municipal authority. Once the municipal regime was established it became the basic Costa Rican administrative unit. Family administration, a result of the municipal regime, cast shadows over the validity and effect of a government by general consensus. But the stronghold of Costa Rican democracy lies in the family unit.

Nineteenth Century pragmatic individualism and spontaneous liberalism formed the bases for institutionalizing family and group interests; this is why "education" became the domain of a neighborhood, rather than a matter of State and thus led to greater social mobility.

Thus, what was apparently a very slow process acquired a momentum among the elite, a necessity to attain

the goals that preserve individuality. Decentralization of the State through the municipal regime proved beneficial in many ways: political interrelationships with the State; administrative development; and group attitude in politics. The paradox was that some villages could not afford the establishment of schools, hence public education suffered.

Up to 1848, the powers depended and planned according to needs as they became obvious. In the case of education as the source and promoter of culture, two events were paramount: the founding of the Universidad de Santo Tomás (1843) and the founding of the Republic (1848) under the government of José María Castro Madriz and his patricians as well as some of the first intellectuals of the new generation of free-born Costa Ricans.

The Universidad de Santo Tomás was a response to the grave problem of public education. It served as a center of learning and a normative force of nationality. From its start it was open to varied philosophical movements and ideologies. By 1888, its last year, most of its graduates had become part of the administrative apparatus of Government. Indirectly, the creation of this center of learning established the independence of higher education from Spain and the Church.

By 1845 Costa Rica traded directly with England and the Hansa. Coffee was the only productive industry. When Juan R. Mora ascended to power, another social change took place: the coffee growers, a very local elite, became decision and policy makers. The dynasty of these "cafetaleros" started its long reign, becoming particularly significant around the 1870's when Tomás Guardia was President of Costa Rica. Money and national income, a result of the coffee boom, helped to bring about cultural awareness and support, albeit mostly for the elite.

During the late Nineteenth Century Mauro Fernández, a follower of Spencer and promoter of public education, was responsible for the establishment of free public instruction, e.g., the founding of the Liceo de Costa Rica and Colegio Superior de Señoritas. The latter was especially innovative because education of women was only beginning to be considered appropriate. By 1895 the Costa Rican schooling system was well established.

Cordial relationships between Church and State since Colonial times were now being tested. The Church had maintained its domain on public education but committed outright neglect of those duties outside parochial Sunday schools. The expulsion of Monsignor Bernardo Thiel ended the prepotence of a corrupted clerical class and opened the way to secular education. Higher education and particularly the Colegio de Cartago suffered a severe blow with the expulsion of the Jesuits, many of them avant garde liberals who were excellent educators.

At the turn of the Century, Costa Rica had experienced 80 years of drastic changes. its independence from Spain and the Roman Church, financial stability, a population of 100,000 with a high percentage of Europeans, an education system, diplomatic relations with prosperous nations and an already solid reputation as a sound democracy. The characters and tone of the Nineteenth Century, molding force of Costa Rican ways, continued well into the Twentieth Century. Molding forces especially of France and England helped Costa Rica find an identity. Goals randomly reached through a series of political and economic events led to a well-defined trend. The statistics of the Nineteenth Century in terms of creating and founding of educational and cultural institutions as well as the products of its intellectual tone, are yet unsurpassed. The period from 1900 to 1950 is particularly sterile in achievements and meaningful in its negative influences on the established cultural patterns and momentum. The rise of competing coffee exporters in Latin America (Brazil, Colombia) debilitated Costa Rican national income. The banana industry was economically promising and marked the beginning of a more stable commerce with the United States. The outbreak of World War I closed European markets to Costa Rican coffee. Elitist parents sent their children for education in the United States rather than Europe; the middle class and those on government scholarships turned to South American universities, especially in Chile and Argentina. The cultural influence of Europe on Costa Rica was severed at the critical moment when, after 50 years, the nationals were willing to adopt European systems. Instead, youths were exposed to North American pragmatism at a time of emphasis on the importance of U. S. markets and investments.

The Stock Market Crash of 1929 debilitated CR-US trade and the German Crisis of 1933 shattered the recently re-opened European markets. Low per-capita income, insecure markets and social discomfort resulted. The reopening of the University of Costa Rica in 1940-41 marked what should have been the most significant event of this century in matters cultural, but it turned into a paradox: the University absorbed the best teaching elements from the Europeanized, lyceum-like high schools, but the training was not sufficient for the university or college level. The foundation for unrealistic and inefficient education goals has continued up to the present even though education (elementary through university) requires up to one third of the National Budget.

The political events of 1948 had contrasting effects on local life: corrupted political and administrative practices were abolished and democratic ideas revitalized; but the Civil Service regime established mediocrity and inefficiency in public administration at a crucial time for the development of Costa Rica. The last years of World War II held a potential for national progress through combined agriculture, technology and conservation as international markets were eagerly consuming to rebuild Europe.

In the past 30 years, the intellectual tone and thus the cultural aspects of Costa Rican life have had little significant effect. The early 1970's saw the creation of a Ministry of Culture, Youth and Sports, ideally suited to revitalize popular culture. After a short period of trial and error that resulted in isolated events of some significance, it became an instrument of political partidism and disrupted even the isolated intellectual groups, bankrupted some of the already functioning institutions and brought the "cultural climate" of the country back to where it was in the sterile decades of 1915-1930. This failure was due to the lack of realistic programs.

The Current Economic Crisis

In less than two years the Costa Rican currency has decreased in value by about 600%. The country is sad-

dled with enormous foreign debts, estimated at four billion dollars for both the public and private sectors. Costa Rica has one of the highest per capita debts in the world. It is not the purpose of this CRCEP to analyze the causes nor future of Costa Rica's economic crisis; however, it affects all aspects of Costa Rican society, politics, culture, as well as the environment and natural resources.

The new president, Luis Alberto Monge, campaigned on the slogan "Let's return to the land". Costa Rica's natural resources—soil, forests, water, minerals, marine—are looked upon as a way out of the economic crisis. Agricultural productivity must be increased substantially to provide food, to permit import substitution and to generate greater export earnings. Yet simple expansion of the agricultural frontier will only exacerbate the already serious problems with deforestation, watershed degradation, soil erosion and loss of genetic resources. (These issues are treated in later chapters of this CRCEP).

As indicated in Dr. Mohs introductory quote (p iv) only the Costa Rican people can solve the current economic crisis. The historical development of Costa Rican culture, the individualism and love of the land and the strong commitment to democracy are all being severely tested by this crisis. But if the country overcomes these economic problems, her cultural background will have played a key role and contributed once again to the uniqueness of Costa Rica.

III-B. INDIANS

"Our America has been and is Indian territory by nature. Even before the arrival of the Spanish conquerors our continent was inhabited by peoples that had accomplished a considerable social, scientific and economic development that was not appreciated by the Europeans who submitted the indigenous populations to their laws, destroyed their cities and populations and incorporated them into a strange and enslaving system" (Acosta & LeFrank, 1980).

As a result of this process, Costa Rica has small indigenous populations that are dispersed in several parts of the country. Indigenous populations are currently restricted to small, natural physiographic regions (Table III-1). In the southern Caribbean region there are two overlapping main groups: *Cabécares* inhabit the region of Moravia de Chirripó, Estrella, San José de Cabecar, Telire, and Pacuare, while *Bribrís* live in the Talamanca valley and nearby areas of Cocles. *Guatusos* or *Malekús* occur in the northern Caribbean region in the population centers of El Sol, Tonjibe and Margarita on the Guatuso plains. *Miskitos* (also called Sambos Mosquitos) occasionally visit the Guatuso region during migratory phases. The *Borucas* (or *Brunkas)* occur in the southern Pacific region, principally in Boruca, Curré, and Maíz. Also in the region are the *Térrabas* (or *Terbis)* in the Térraba area. A group of *Cabécares* live in Ujarraz, while some *Bribrís* live in Salitre and Cabagra. The *Guaymíes* have population centers in Guaymí de Coto Brus, Abrojos-Montezuma and Conte Burica along the Panamanian border.

Ethnic groups considered as descendents of native Indian populations include the *Chorotega* populations in Matambú, Matambuguito, Guatíl, Santa Bárbara, Hondores in Guanacaste province; and a small group of *Huetares-Pacacuas* in Quitirrisí de Mora and Zapatón de Puriscal of the central region.

Table III-I. Estimated Indian population given by various sources. The Indian population represents less than 1 % of the Costa Rican population.

Reserve	MEBW-RB[a]	ITCO	CONAI
Talamanca	4,000	6,000	2,276
Ujarraz-Salitre Cabagra	2,000	2,800	1,740
Boruca-Térraba	2,100	2,100	1,353
Guaymí de Coto Brus	400	1,500	316
Conte Burica Guaymí	300	850	769
Abrojos-Montezuma	200	700	310
Quitirrisí	—[b]	200	475
Guatuso	200	520	202
Matambú	—[b]	200	402
China Kicha	—	—	—
Estrella-Telire	900	1,500	844[c]
Chirripó	2,800	2,800	2,500[c]
TOTALS	12,900	19,170	11,187

a MEBW stands for Dr. María Eugenia Bozzoli de Willie; RB for Dr. Ramiro Barrantes.

b Dr. Bozzoli de Willie believes that the inhabitants of Quitirrisí and Matambú are no longer Indians but rather descendents of Indian groups.

c CONAI is the National Commission for Indian Affairs; 1980 Census of Indian Communities.

d R. Ocampo data.

Over thousands of years indigenous population lived in harmony with their environments. At low population densities the practice of shifting agriculture uses long rotations to allow for recovery of soil fertility. Hunting and fishing usually provided a good protein supply, while the rational utilization of forest resources provided resins, medicinal plants, fruits, food and other necessities.

Problems arise for Indian groups when non-Indians exploit natural resources traditionally held communally by Indian tribes. Legislation exists to protect Indian lands and culture (Table III-2) but the laws are weak and inconsistent. A law passed in 1976 attempts to remedy part of this problem, but as of 1981, it has not been very successful.

Two current environmental issues affect Indian areas: One is the mining law and the other is exploration for petroleum. The Caribbean Indian reserves are situated on lands with mining potential. CONAI has come out against mining in the Indian reserves because of the negative effects on the Indian population as well as the environment. The Costa Rican Indian Association has stated, "We consider that the social and economic reality of the country makes mining legislation a priority. The exploitation should be carried out taking into account all

the environmental norms established to minimize the damaging effects of the mining industry."

The Legislative Assembly has approved the Mining Law with the following environmental provisions for the Indian reserves: "The concessions given to individuals for the exploitation and exploration of mineral resources in the Indian reserves must be approved by the Legislative Assembly. The law that approves such concessions must protect the interests and rights of the Indian communities. Legislative procedures will not take place if it is the State that directly does the exploration and exploitation." Thus State involvement in mining could easily circumvent the legislative intent of protecting indigenous peoples and land.

Table III-2. Indian reserves, areas and locations in Costa Rica.

Reserve	Area in Hectares	Province
Chirripó	75,824	Cartago-Limón
Estrella	13,616	Limón
Talamanca	62,253	Limón
Telire	9,187	Limón
Guatuso	2,744	Alajuela
Guaymí-Coto Brus	7,500	Puntarenas
Abrojos Montezuma	1,480	Puntarenas
Conte Burica	12,558	Puntarenas
Boruca Térraba	31,983	Puntarenas
Salitre Cabagra	56,561	Puntarenas
China Kicha	2,459	Puntarenas
Matambú	1,710	Guanacaste
Quitirrisí	963	San José
TOTAL	278,839	

Exploration for petroleum has been done at different points in history in the Talamanca valley by various foreign oil companies without apparent success. In 1978 a new exploration attempt was begun on lands within the Talamanca Indian Reserve. For the first time negotiations were carried out between the government and the Indian community of Talamanca. The result of this dialog was the signing of an agreement for the exploration and exploitation of petroleum. It should be noted that of the eight clauses in the agreement, only one refers to contamination or alteration of the environment.

Even though there is ample legislation regarding lands occupied by Indians, there are no explicit programs for environmental protection. Although the intent of the laws is to protect the environment of the Indian reserves, Indian lands and population have been somewhat abandoned by the responsible institutions. The Indian Reserve Guards are a patrolling body of great importance for the protection of the environment, yet currently their numbers are being reduced. At present there are no studies concerning the effects that the exploration for and exploitation of petroleum can have on the environment, as well as on the Indian cultures. Neither the new Mining Law nor the agreement reached for the petroleum exploration is specific with respect to environmental and anthropological protection of Indian reserves.

III-C. DEMOGRAPHY

Population Growth Patterns

According to the population census of 1973 and based on birth and death rates observed thereafter, the estimated population of Costa Rica in 1979 was 2.2 million. For a territory of 51,000 km^2, the density for that year was 43.1 persons/km^2. Most of this population lives on about 6% of the national territory in the intermountain Central Valley.

There are several sources of population data for Costa Rica. The best appear to be the works of Thiel, Fernández-Guardia, Soley-Güell (Stone 1975), Ortega (1977), Fernández et al. (1976), and Rosero (1980). The territory was virtually unpopulated at the time of its discovery and conquest by the Spaniards, probably as a result of a combination of factors, including the exuberance of vegetation and profuse rains that made agriculture difficult. In fact, the largest Indian population developed in the Tempisque Basin where the land is less mountainous and the climate drier than in the rest of the country.

Estimates of Archbishop Thiel suggest no more than 27,000 Indians lived in the territory at the time of Spanish conquest, but other estimates set the figure at 80,000 by 1563 (Seligson 1980). This indigenous population was decimated by smallpox and measles (imported from Europe), malnutrition, violence and other calamities resulting from transcultural domination (Bolaños 1981, Seligson 1980). Thus, in about two decades there were only 7,000 Indians left. One century later the Indian population had shrunk to 2,000, and in an additional 40 years, to a mere 1,000 Indians. While the Indian population of Costa Rica declined dramatically in the Sixteenth and Seventeenth Centuries, the Spanish increased modestly in the Seventeenth Century (Table III-3). During 60 years of Spanish domination there was a decrease in population of a magnitude almost unheard of in modern times, even through war. About 200 years were required for the population to double to reach a mere 53,000 people. Thereafter, the population grew at a rate of 1.7% per year during the Nineteenth Century and 2.1% annually over the following 50 years (1901-1950). Population growth rate averaged 3.3% during 1951-1975, declining to 2.6% by 1976 and remaining rather constant since then.

The sluggish population growth during the first two centuries was caused by infectious diseases and poor nutrition in infants and preschool-age children. The recent trend in declining rate of growth, so typical of more developed nations, is concurrent with a general improvement in family planning and changes in education, housing and other features affecting the standard of living. With a growth rate of 2.2% per year the

population estimate for the year 2000 is 3.37 million (Table III-3). However, this is not an estimate of population equilibrium (see p. 19).

Birth and Death Rates

The characteristics of population dynamics in Costa Rica are evident since 1920 when reliable data became available. During the Depression and the Second World War, death rates declined by 33%, but birth rate remained constant. The 1950's marked the beginning of population growth as the crude death rate (including all ages) exhibited a marked decline, while the birth rate increased from 44 to 47 per 1000. These changes produced the high growth rate of 3.7% per year, when the population growth rate of Costa Rica was one of the highest in the world.

Table III-3. Growth Patterns of the Population of Costa Rica.

Year	Population x 10^3	Period	Average Annual Growth Rate (%)
1552	27.2		
		1552-1611	-0.6
1611	15.5		
		1611-1801	0.6
1801	52.6		
		1801-1900	1.7
1900	303.8		
		1900-1950	2.1
1950	858.2		
		1950-1975	3.3
1975	1,964.9		
		1975-2000	2.2
2000	3.377.5		

The pressure brought about by increased survival of infants (children under one year of age), and unexpected increases in family size, most likely induced behavioral and social adaptations resulting in decreased fecundity. The result was a notorious and abrupt decline in birth rate from 38 per 1000 in the late 60's to 29 in 1975. Since then the trend has slowed to the point of a slight reverse in 1979-1981.

Life Expectancy at Birth

The considerable reduction in infant deaths has been the main contributor to the rapid change in life expectancy at birth (LEB). The country had an unusually low LEB (29.5 years) in the mid-Nineteenth Century, a time marked by extreme poverty, disease and occasional famines. Even in 1929, the LEB of 40.7 years was comparable to those of the poorest African nations and lower than that of Haiti. In 1950 the LEB was 56 years, revealing that socioeconomic development had been operating within the Costa Rican democratic system much before the era of social reform (1942-48). The trend has continued up to th present; in 1980 Costa Rica had LEB rates (female = 76.1, male = 71.5) comparable to those of advance European nations. Obviously, the gains in the 1970 have been smaller than in previous decades. Neverth less, progress has been steady due to continued gains i social development, such as establishment of the rur health program and other government interventions. Fc example, an increase of 5 years in LEB during 1970-7 occurred in areas where the coverage of the rural healt program was at least 75%, in contrast with a gain c only 2.4 years in regions without the benefit of th program. This explains the faster increase in LEB in th rural area as compared to the urban, where the prograr is not in effect (Villegas 1977, CELADE 1976).

Fecundity

Several excellent fertility surveys have been con ducted in Costa Rica (Gómez 1979; Asoc. Demogr Costar. 1978, 1979) that together with the observe trends in births, reveal profound changes in reproductiv behavior in Costa Rica. As mentioned earlier the greates decline in birth rate occurred in the period 1965-70, when *there was not* an organized family planning program or foreign assistance in this field. In other words, the chang was brought about by an endogenous societal response quite independent of outside influences.

Further important reductions in birth rate occurre after 1970 through incipient family planning program to limit family size. In 1976, 78% of rural couples wer using contraceptives (Table III-4). In general, the pill i preferred for birth control in both urban and rural areas Sterilization is a surprising second with identical rates i both areas. There was a national scandal when illega sterilizations were revealed, and this has modified th rates since 1977. The use of condoms has declined in th metropolitan area as other methods of birth control hav become available.

Important fecundity decreases were recorded since 1960 for women of all ages and for each five year period (Table III-5). Changes were more marked for women ove 29 year old, especially in the period 1970-75, probably reflecting availability of services through the rural health program. Relative increases in fecundity were recorded among young women during the period 1975-77.

There are strong social determinants of fecundity such as education of the mother, income, proclivity towar change and related variables. Studies by CELADE (Behr and Guzmán 1979) reveal a negative trend in fecundity i all social classes that was unexpectedly more marked i the "middle" and "low, non-agrarian" classes. The lowes class showed the least gain. The contribution of each o these groups to the total women in reproductive age in dicates that the lower classes are the most important When compared to other countries there are not suc marked differences in behavior among the four groups which emphasizes the trend toward a uniform level o information and availability of services in Costa Rica.

Table III-4. Percentage of Adult Population Using Contraceptive Methods in Costa Rica, 1964-76. Sources: Gómez 1979; Encuesta Nacional de Fecundidad 1976.

Method	Metropolitan area 1974	Metropolitan area 1976	Rural area 1969	Rural area 1976
1. Pill	1	21	9	23
2. Female sterilization*	6	16	4	16
3. Condom	19	13	1	5
4. I. U. D.	0	7	2	5
5. Rhythm	15	5	4	4
6. Withdrawal	10	5	3	5
7. Other	0	7	2	6
TOTAL	51	74	25	64
Has Used Sometime	66	87	40	78

* Includes all, regardless of etiology.

Table III-5. Percent Decrease in Fecundity, by Age, Costa Rica. Source: CELADE, DGEC, Rosero, 1980.

Age, years	QUINQUENIA 1960-65	1965-70	1970-75	1975-77	Total 1960-77
15-19	9.0	8.1	-2.0	-2.9	12.3
20-24	14.6	21.6	13.4	-2.9	40.3
25-29	10.2	27.4	22.9	-5.1	47.2
30-34	13.8	26.6	30.9	0	56.2
35-39	3.6	33.0	36.1	6.5	61.4
40-44	1.1	21.6	42.0	12.5	60.7
45-49	0	25.0	33.3	37.5	68.7
Global Rate	10.3	24.3	24.8	22.8	47.7

Future Population Estimates

Considerable controversy has been evident in Costa Rica regarding population growth in relation to production, availability of food, resources and conservation. The theoretical estimates are shown in Table III-6 for the years 2000, 2020, and 2040. According to the Population Council (L. Mata 1979), the definitive population for Costa Rica could be 5.9 million if replacement fecundity is reached in the year 2000. The population would then be about 3.7 million, in accord with estimates in Table III-3. However, to attain replacement fecundity by the year 2000, an unusually rapid decline in fecundity would be necessary, and several hypotheses (Ortega 1977) seem to indicate that such a case would not likely occur. Furthermore, demographic growth has its own inertia which can not be altered drastically or in a short span. If in the year 2000 fecundity is just sufficient for replacement of each generation, the "demographic inertia" will require 90 more years to attain zero growth. During this interval, there would be a further increase of 2.2 million people (Table III-6). This projection by the Demographic Council should dispel any worry of a possible demographic regression in Costa Rica, and should cause much concern to those interested in economic development, standard of living, environmental quality and conservation of natural resources.

Table III-6. Theoretical Population Estimates for Costa Rica, 2000-2040. Sources: Population Council 1975; Rosero 1980.

Concept	Population Estimates 1	2	3
Year fecundity reaches "replacement" level	2000	2020	2040
Population in year of replacement (millions)	3.7	6.1	9.8
Year of zero population growth	2090	2110	2130
Percent population increase after the year of replacement	59	44	37
Population attained the year of zero growth (millions)	5.9	8.8	13.4

Land, Food and Population

Protein-energy malnutrition (PEM) is one of the main health problems in developing countries. Furthermore, food production has become a major issue in national objectives, not only in developing countries, but in industrial nations as well.

PEM results from an interaction between low availability of food and impaired consumption and utilization of food. Population increase generally results in decreased land available for agriculture and per capita food production. This is actually happening in many parts of the world and is a possibility for Costa Rica under the present socio-political structure.

Costa Rica has counteracted arable land reduction and exhaustion in recent years by such measures as expansion of the agricultural frontier, importing food and using more fertilizers and pesticides. The results of such measures include environmental deterioration, formation and persistence of urban slums, progressive depopulation of some rural areas, conversion of arable land into urban areas and roads, and increase in the price of land.

Several hypotheses of demographic growth have been advanced (Ortega 1977, Table III-7). The most accepted one, "medium", is based on an expected decline in the current population growth. This medium hypothesis estimates the population at 3.38 million by the year 2000. However, if the present growth rate is maintained (as a result of crisis, impoverishment, recurrence of malnutrition and disease), the population will reach 4 million in the year 2000 (L. Mata 1979).

Land availability according to various population estimates is shown in Table III-7, suggesting that Costa Rica is at or over the brink of land saturation. It is estimated that about 2,000 m^2/capita are required for subsistence agriculture. If a more stringent estimate of land availability is set (10%, owing to the extensive areas used for cattle, or uncultivated) then Costa Rica is already saturated.

Table III-7. Area and Arable Land, Costa Rica by the year 2000.

Demographic Hypothesis [a]	Population (millions)	Area, m^2 per capita: Intermittent agriculture (20%) [1]	Area, m^2 per capita: Intensive agriculture (10%)
Replacement	3.03	3,358	1,678
Low	3.18	3,196	1,598
Medium	3.38	3,014	1,507
High	3.62	2,814	1,407
Constant	4.00	2,541	1,270

[a] CELADE, DGEC
[1] 2,000 m^2 *per capita* required to generate the food.

It was mentioned earlier that the population density of Costa Rica was 41 inhabitants per km^2 in 1979. This estimate is based on the assumption that the whole territory is suitable for agriculture, as is the case of countries predominantly constituted by flat, fertile land (The Netherlands, Bangladesh). If only 20% of the land in Costa Rica is appropriate for cultivation (Tosi 1974, Fournier pers. comm.), the 1979 population density would have been 215/km^2 of agricultural land, an impressive figure in the modern context. The projections for the year 2000 must be taken seriously if agriculture is to remain the keystone of the country's economy. A Costa Rican population of 3.4-4.0 million by the year 2000 equals 333-392 inhabitants/km^2 of agricultural land, densities comparable with contemporary countries (e.g., India, Indonesia, Bangladesh) suffering serious development problems (L. Mata 1979).

The deteriorating relationship between population and land is strongly affected by the present injustice in land distribution (Stone 1975, L. Mata 1979, Bolaños 1981). According to Seligson (1977) and the World Handbook of Political and Social Indicators (L. Mata 1979), arable land tenure in Costa Rica in 1973 included 58% of the landholders with less than 4% of the land; 1% of the landholders held 25% of the arable land; 80% of the farms had a total of 467,000 ha, or 45% of the land assuming 20% of the land is arable. There is an urgency to initiate improvements in land distribution and utilization models of production, and demographic policy, within the current framework of democracy and peace (L. Mata 1976, 1979).

III-D. NUTRITION AND HEALTH

Nutrition is determined by adequate food consumption and low prevalence of infectious diseases, as well as by other environmental factors (the latter are addressed in the environmental contamination chapter). This postulate is different from an orthodox view that food itself is the main (and often single) determinant of nutritional status. Epidemiological studies in many regions of the world have shown that low food availability (i.e. situations of natural disaster, war, and famine) can result in malnutrition. However, analysis of the food situation even in such countries as India and Bangladesh demonstrates that food is generally available to satisfy the needs of the population, but malnutrition remains highly prevalent. Detailed long-term studies in Guatemala and Costa Rica (L. Mata 1978a, 1981a) show that children with infectious diseases lose weight and do not grow normally, while poor children grow well during periods of good health.

Mortality and Infectious Diseases

During the first quarter of this century, in Costa Rica one child of every four infants born alive died before reaching the first birthday (Fig. III-1). Rates declined gradually during the Depression (L. Mata 1981b) and the trend was constant from 1926 through the early 70's. The period 1964-1980 illustrates one of the most outstanding accomplishments in health in the Americas, when infant mortality decreased from those high figures to the very low of 17.7 deaths per 1,000 in 1981.

Figure III-1 shows a high correlation between infant mortality and death due to diarrhea. The correlation is stronger with postneonatal infant mortality in association with the weaning process and the fading of congenital and breast milk immunity. The comparison with neonatal mortality is not so clear. During 1942-1948 infant survival could be related to social reforms and available maternal health services. From 1948 to 1964 social disruption and marked migration from rural areas to urban centers may have slowed the trend toward decreased diarrhea mortality. Furthermore, during that period, early weaning of infants increased and breast-feeding was partially supplanted by cow's milk--changes induced in part by the medical profession and by formula milk manufacturers. Furthermore, population increase influenced by premature weaning is almost always correlated with a rise in incidence of diarrheal disease.

Infant survival rates after 1972 appear related to marked improvements in the quality of life, i.e., improving gross national product and national per capita income, potable water and other socioeconomic and health indicators (L. Mata 1978b). The creation of the Rural Health Program in 1973 and extension of Social Security Health

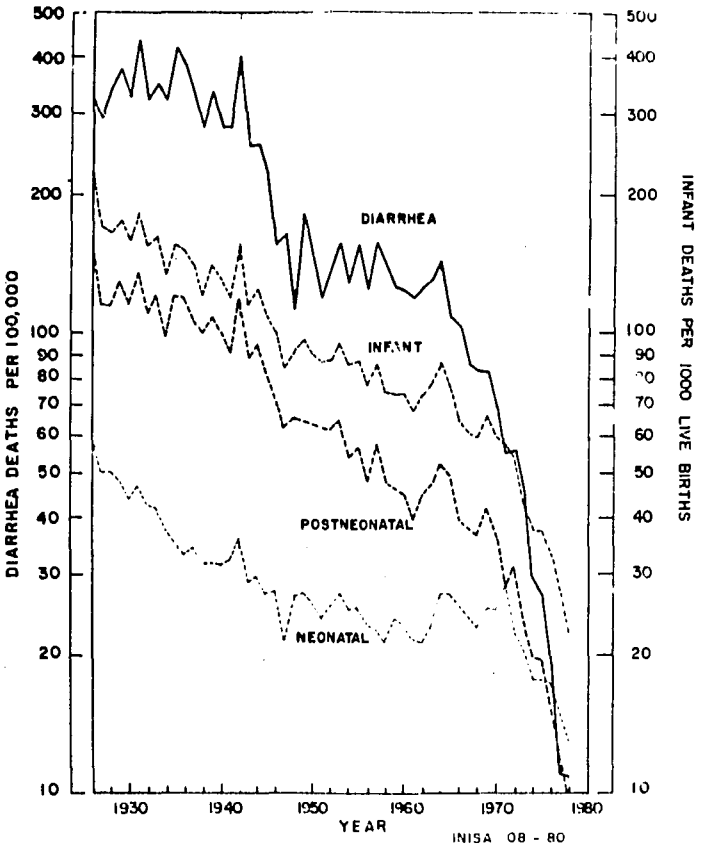

Figure III-1.—Infant mortality (neonatal, postneonatal and total) per 1,000 live births, and death rates due to diarrheal disease per 100,000, Costa Rica, 1926-1978. The first decline in mortality due to diarrhea was coincidental with significant social and economic reforms (1942-1948). A revolution, social unrest, migration and demographic explosion marked a span of stagnation (1948-1964) of the previously observed trend. Stability, and social and economic development coincided with the last decline (1965 to now). Note the concordance of peaks of increased diarrhea deaths and infant mortality.

Services (Mohs 1980) brought about mass immunization, treatment of parasitic diseases, surveillance for malaria, education in health and nutrition, counseling of family planning, and community organization on health-promoting activities (Mata and Mohs 1976).

Life expectancy at birth (LEB) is improving in rural areas faster than in urban centers, a situation determined in all probability by faster and better coverage of rural populations with health services. In the cities mothers are expected to bring their children to centers and clinics for vaccinations, but primary health care in rural areas is provided in periodic visits to homes enabling effective provision of vaccines and other services. Certain factors increase the risk of death, particularly at later ages, and are more prevalent in cities, i.e., water and air pollution, food contamination, environmental stress (tension, noise, violence) and risks derived from lifestyles and dietary habits including hypercaloric diets and overconsumption of drugs. Evidence seems to indicate that the quality of life is at present better in certain rural areas than in the cities.

Changes in mortality rates are the result of improvements in the quality of life due in part to better education, income, and direct government-provided health services. From 1967 to 1977 significant reductions in deaths due to communicable diseases were influenced by immunizations, medical treatment and an overall improvement in housing, water supply and sanitation. Reduced perinatal deaths were influenced by better obstetric and early pediatric health care. In fact, an important increase in social security services has occurred and more than 95% deliveries, nation-wide, are in clinics and hospitals.

As shown in Figure III-1, the decline in diarrheal diseases has been dramatic, probably due to improvement in personal hygiene and environmental sanitation. Costa Rica's sales of soap, toothpaste and toilet paper are the highest in Central America. The diarrheal disease death rate was as high as 400 per 100,000 at the beginning of the Century, comparable to rates observed in some African countries today. The rapid decline reached a low of 5.5 per 100,000 in 1980.

Laboratory studies at INISA demonstrate that most diarrheas are associated with rotaviruses, although enterotoxigenic bacteria, *Shigella* and *Campylobacter*, appear in significant numbers. In general, about two-thirds of all cases of diarrhea in the field and in the hospital are diagnosed as having at least one etiologic agent (L. Mata 1981b).

Along with diarrhea, acute respiratory infections are the main causes of infant mortality. As diarrhea mortality declined, respiratory infections attained an even more important role. No epidemiologic studies have been carried out in Costa Rica on respiratory diseases.

Great advances have been made regarding prevention of measles, whooping cough, tuberculosis, poliomyelitis and diphtheria, by vaccination, especially since the Rural Health Program was started in the early 70's.

Nutritional Status

Studies sponsored by USAID and the Family Assistance Office (OCAF) demonstrate that food production and imports have been adequate in the last decade. In spite of the recent national negative balance of payments, food produced for local consumption plus imported foods so far satisfy nutrient needs of the entire population (Table III-8). Yet some families find it difficult to meet minimum "food basket" requirements. One economic investigation revealed that most families in the urban area can purchase necessary food, but the lowest 10% of the population have difficulty. The situation appears magnified by the overestimated nutrient requirements set by WHO/FAO (L. Mata 1978b, 1979).

Studies by INCAP (1969) and the Ministry of Health (MS 1978) using Weight/Age criterion to determine malnutrition were inconclusive when compared with WHO statistics for Height/Age. Levels of deficiency in height or "stunting" in Costa Rica are more in accord with improvements in hygiene and health. These arguments support the concept that the dark panorama of malnutrition in the past was magnified in part by the high incidence of infectious diseases, particularly diarrhea, measles, acute respiratory infections and whooping cough. All of

these diseases have a known capacity to induce chronic malnutrition and to precipitate severe forms of malnutrition.

If such is the case, one would expect that the nutrient intake of children has not varied significantly in the past decade. Mean intake of calories and protein by rural Costa Rican families seems to have been constant. Since poor rural children consume more food during healthy periods it appears that any increase in nutrient utilization may have been due to a reduction in infectious disease. It is logical to propose that the increase in intake might be related to a decrease in diarrheal disease and other infections.

Table III-8. Food availability, kilograms per capita, balance sheets for Costa Rica, 1972-1978. Adapted from Chaverri (1980).

Food Group	1972	1975	1978
Beans, corn, rice	298	311	277
Wheat flour (all imported)	33	29	32
Sugar	48	53	57
Beef and derivatives	21	34	31
Milk and derivatives	104	106	103
Oils, fats	18	19	19
Fish and sea food	3	4	4

The severe forms of malnutrition (kwashiorkor and marasmus) are disappearing in Costa Rica, and the ward for treatment of such cases at the National Children's Hospital was closed three years ago. There has been a shift in prevalence of severe edematous malnutrition (kwashiorkor) to the wasting marasmus. Acute malnutrition now makes its appearance at younger ages, sometimes in the first six months. The reasons are related to differences in etiology. A recent tabulation of cases seen in 1981 at the Children's Hospital (E. Mohs pers. comm.) indicates that most were due to causes other than deficiencies in food intake.

The main factors determining malnutrition in Costa Rica today are severe, or massive infection with viruses, bacteria or parasites; congenital and other prenatally-determined defects; child abuse; and psychomotor retardation. Not much can be done to prevent such cases, excepting a continued effort to improve personal hygiene and environmental sanitation in order to curtail infection; other causes such as child abuse require counseling and more heroic measures.

Vitamin and protein deficiencies have become rare in the last 20 years. Goiter, a nutritional response to lack of iodine in the diet, occurs most frequently in people living in the highlands. Since 1975, goiter has been reduce by 60% as a consequence of iodine fortification of consur able salt and access to iodine-containing foods.

Of the eight tropical diseases WHO has listed fc global eradication, only malaria and leishmaniasis remai a problem in Costa Rica but they do not represent significant health hazard for the general population.

Health Programs and Research

Rural and Community Health Programs emphasiz immunization, control of parasitic infection, family plar ning, nutrition and health education, and organizatio of health in the community (Mata and Mohs 1976, Villega 1977). These programs have suffered during the curren economic crisis but services continue uninterrupted OFIPLAN has launched "community participation" op portunities to help population sectors in greatest need.

Potable water supply programs to supply all rura populations are moving slowly due to the current economic crisis. The latrine program, vital to maintaining the low levels of parasitism currently prevailing, has been ham pered in the last years, and some populations of squatters colonizing new lands without latrines and water supply will create new foci of parasitic and diarrheal disease.

Programs to cover diverse aspects on nutrition, healt and sex education are carried by radio and television as part of family-planning orientation. Costa Rica has a high literacy rate and access to information. Laboratory-developed technology can be transferred to rural health personnel (Nalin et al. 1978).

Food programs are not reaching all the populations (Cervantes 1981) and these programs have not shown any impressive nutritional impact on the population served (Murillo and Mata 1980). Food distribution has been criticized because it does not correct the root of the problem, but creates dependence, cultural aberrations, and significant bureaucracy.

IMAS devotes about one half of its resources to maintain the bureaucracy in charge of the housing program. Furthermore, it is questionable if the "poorest of the poor" trapped in the critical poverty stratum (Galofre 1981) have the opportunity to seek housing aid.

With regard to INSA, its efforts and methodology are not questioned, but there is doubt that the control of the alcoholic should be the main approach to the problem. Legislation to control spirits and expending facilities is urgently needed, while actions like those of AA must be encouraged as a better way to control and prevent severe alcoholism.

Significant advances in health care in Costa Rica depended on technology developed elsewhere (L. Mata et al. 1979) but there have been advances in research and developments within the country itself. The decade of 1930

was one of pioneers in research in health, and that of 1950, of organizers of university curricula and teachers of medicine, microbiology and other health-related professions. An important crop of scientists became available in the 60's and 70's and several research institutes flourished during the 70's. At present, the following centers are devoted to research in health in Costa Rica:

Instituto de Investigaciones en Salud (INISA), UCR

Centro de Investigación en Tecnología de Alimentos, UCR

Centro de Investigación y Diagnóstico en Parasitología, UCR

Laboratorio de Investigaciones, Hospital Nacional de Niños

Instituto Clodomiro Picado, UCR

Centro de Investigación en Hemoglobinopatías y Sustancias Afines, UCR

There are also other centers and institutes with activities related to health, for instance in the fields of sociology, psychology, and economics.

Local health scientists are beginning to gain recognition for their research. To illustrate, in the last decade a parasite of man previously unknown to the world was described in Costa Rica *(Angiostrongylus costarricensis)* and later confirmed in other Latin American nations; male sterility has been epidemiologically traced to overexposure to 1,2-dibromo 3 chlorpropane, heavily used in banana plantations; an appropriate technology to save children's lives was developed in Costa Rica and is being applied worldwide; several studies on congenital malformation and hereditary defects are under way; methods to promote breast-feeding and increase survival of rural children have been described. Undoubtedly, much is to be gained by the preservation and further development of the research infrastructure.

IV.

Natural Resources

IV-A. FORESTS & FORESTRY

Holdridge Life Zones and Natural Vegetation

This section offers generalized descriptions and distributions for each of the 12 Life Zones (Figure II-1) that occur in Costa Rica. Table IV-I gives the areal extent of each Life Zone. The Life Zones serve to help locate the resources to be covered in the following sections. Holdridge et al. (1971) is the primary source of the following descriptions.

1. Tropical Dry Forest

Centered on the lower Río Tempisque, the *Tropical Dry Forest* Life Zone is ringed by a variable band of cool-wet transitional forest, occurring as a narrow fringe around the Golfo de Nicoya and along the Pacific coast from the head of the Nicoya peninsula to the Nicaragua border. Six effectively dry months per year is only about one month longer than for the climatic association in this Life Zone. Edaphic associations occur south of Liberia on soils derived from rhyolitic ash and on the black

Table IV-I. Extent of Life Zones in Costa Rica (from Holdridge et al. 1971)

Life Zone	UNIT km²	UNIT (%)	TOTAL km²	TOTAL (%)
1. *Tropical Dry*			5,263	(10.3)
2. *Tropical Moist*			12,366	(24.2)
a. Non-transitional	10,373	(20.3)		
b. Cool-dry transition	153	(0.3)		
c. Cool-wet transition	307	(0.6)		
d. Cool transition	1,533	(3.0)		
3. *Tropical Wet*			11,549	(22.6)
a. Non-transitional	8,892	(17.4)		
b. Cool transition	2,657	(5.2)		
4. *Tropical Premontane Moist*			2,402	(4.7)
a. Non-transitional	716	(1.4)		
b. Warm transition	1,686	(3.3)		
5. *Tropical Premontane Wet*			6,950	(13.6)
a. Non-transitional	2,606	(5.1)		
b. Warm transition	4,344	(8.5)		
6. *Tropical Premontane Rain*			5,008	(9.8)
7. *Tropical Lower Montane Moist*			102	(0.2)
8. *Tropical Lower Montane Wet*			767	(1.5)
9. *Tropical Lower Montane Rain*			3,781	(7.4)
10. *Tropical Montane Wet*			51	(0.1)
11. *Tropical Montane Rain*			2,759	(5.4)
12. *Tropical Subalpine Rain Paramo*			102	(0.2)

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montmorillonite clay soils in the Tempisque basin. Hydric associations of mangroves occur in the Golfo de Nicoya and in protected bays along the Pacific coast.

The *Tropical Dry Forest* is a low, semideciduous forest with only two strata of trees. Canopy trees are usually 20-30 m tall with short, stout trunks and large, spreading, flat-topped crowns, usually not in lateral contact with each other. Many canopy trees have thin, often compound leaves that are dry-season deciduous. Bipinnately-leaved mimosoid and caesalpinoid leguminous trees are the most conspicuous canopy component. Understory trees are 10-20 m tall, with slender, crooked or leaning trunks and small open crowns with more evergreen species than in the canopy. Rubiaceae is a prominent understory family. Shrub layer is 2-5 m tall, dense in openings, often multiple-stemmed and armed with thorns or spines. Ground layer is sparse except in openings. Woody vines are common, but herbaceous vines are uncommon. Epiphytes are occasional, with bromeliads the most conspicuous.

2. Tropical Moist Forest

Tropical Moist Forest is not only the most extensive Life Zone in Costa Rica but also the most discontinuous. Substantial tracts of *Tropical Moist Forest* occur on the Nicoya Peninsula, the lower valleys of the Río Grande de Tárcoles, south of Lake Nicaragua, the El General Valley and delta of the Río Grande de Térraba, near the mouth of the Golfo Dulce, the coastal lowlands south of Puerto Limón, and the Estrella and Sixaola Valleys. *Tropical Moist Forest*, cool transition, occurs on the Pacific flank of the Tilarán and Guanacaste Cordilleras between Atenas and Santiago, and in the Turrialba valley. *Tropical Moist Forest*, cool-wet transition, occurs northwest of Limón, in San Carlos, and around Upala and Lago Caño Negro. The *Tropical Moist Forests* on the Pacific flank of the Cordilleras are mostly an atmospheric association due to a longer than typical dry season caused by rain-shadow effects. The remaining areas of *Tropical Moist Forest* are close to the climatic association.

Tropical Moist Forest is a tall, multistratal, semideciduous or evergreen forest. Canopy trees are 40-50 m tall, mostly with wide crowns and tall, slender boles unbranched for 25-35 m, mostly less than 100 cm dbh, often with high, thin buttresses and smooth, light-colored bark. Subcanopy trees to 30 m tall, mostly with narrow crowns. Palms, especially *Scheelea rostrata*, are usually abundant, except in cool transitional areas. Understory trees are mostly 8-20 m tall, with round to conical crowns, leaves often with long drip tips. Shrub layer consists of dwarf palms and giant, broad-leaved herbs. Ground layer is generally bare except for occasional ferns. Herbaceous vines and woody lianas are abundant. Epiphytes are also abundant.

3. Tropical Wet Forest

The second most extensive Life Zone in Costa Rica is the *Tropical Wet Forest* with two large blocks at opposite ends of the country: The Sarapiquí and Tortuguero plains in the northeast, and the lowlands surrounding the Golfo Dulce. *Tropical Wet* Forest also extends up the Pacific coastal lowlands to the mouth of the Golfo Nicoya. A substantial band of *Tropical Wet Forest*, cc transition, occurs in the Atlantic foothills all the way frc the Panama border to Volcán Orosi. Other *Tropical W Forest*, cool transitional areas, occur inland of the *Tropic Wet Forest* in the southern Pacific lowlands. In a gener sense, most of the *Tropical Wet Forest* Life Zone in Cos Rica is near the climatic association with a brief effecti dry season (Pacific side) or no effective dry seasc (Atlantic side).

Tropical Wet Forest is a tall, multistratal, evergree forest. A few canopy species are briefly deciduous, b it does not change the overall evergreen aspect of tl forest. Canopy trees are 45-55 m tall, with round umbrella-shaped crowns, clear boles to 30 m and attai ing 100-200 cm dbh. Smooth, thin, light-colored bark an high buttresses are common. Subcanopy trees are 30-40 tall, with round crowns, slender trunks, generally lackin buttresses. Understory trees are 10-25 m tall, with narro conical crowns and slender boles, often twisted or crooke usually with smooth dark bark, occasionally cauliflorou Stilt-rooted palms are often abundant. Shrub layer i 1.5-2.5 m tall with abundant dwarf palms; unbranche treelets and giant broad-leaved herbs are occasiona Ground layer is sparse with a few ferns and *Selaginella* Epiphytes are abundant but not as conspicuous as th large-leaved herbaceous climbers. Woody lianas are no common and epiphytic shrubs and strangling trees ar rare. *Tropical Wet Forest* is the most species-rich Lif Zone in Costa Rica.

4. Tropical Premontane Moist Forest

Non-transitional *Tropical Premontane Moist Fores* is restricted in Costa Rica to two intermountain basins the densely populated Central Valley from San José t Turrúcares, and the San Ramón valley. An extensiv band of *Tropical Premontane Moist Forest*, warm transi tion, occurs in the northwestern lowlands between th *Tropical Dry Forest*, cool-wet transition, and the *Tropica Moist Forest*. The juxtaposition of a *Premontane* Lif Zone between two basal belt *Tropical* Life Zones is consequence of the geometry of Holdridge's diagram Inspection of the diagram shows the biotemperature does not decrease below 24° C as the rainfall increases from about 1500 mm to more than 2200 mm. The non-transitional *Tropical Premontane Moist Forests* are the most altered Life Zone in Costa Rica with no significant areas of primary forest remaining. The non-transitional *Tropical Premontane Moist Forest* Life Zone is considered near the climatic association.

Tropical Premontane Moist Forest is a two-layered semideciduous, seasonal forest of medium height. Canopy trees are mostly dry season deciduous, about 25 m tall, with characteristically broad, flat or umbrella-shaped crowns and relatively short, stout trunks, often with thick, fissured or flaky bark. Compound leaves are very common. Understory trees are 10-20 m tall, evergreen, with round to conical crowns and short, twisted or crooked boles with smooth or moderately rough bark. Shrub layer is dense, 2-3 m tall, of single or multiple-stemmed woody plants, some armed with spines. Ground layer is sparse. Epiphytes are rare. Tough, supple, thin-stemmed woody vines are abundant.

5. Tropical Premontane Wet Forest

Non-transitional *Tropical Premontane Wet Forest* occurs in three areas of Costa Rica: the lower slopes of the El General Valley in a peripheral position to *Tropical Moist Forest;* in the Turrialba area; and in a broad arc on the lower slopes of the Valle Central, extending in a narrow band along the Pacific flank of the Tilarán and Guanacaste Cordilleras. *Premontane Wet Forest,* warm transition, occupies a large part of the San Carlos lowlands; the Santa Clara plains from Parismina to Puerto Viejo de Sarapiquí, near Guápiles, through Siquirres and Puerto Limón south to the Panamanian border; a narrow band from San Isidro to the Río Cabagra in the El General Valley; a substantial band in the Puerto Cortés-Palmar-Sierpe area; the Corvocado Basin and eastern and southern portions of the Osa Peninsula; three areas south of Ciudad Neily adjoining Panamá; and an arc from the Río Turrubaritos to Quepos. *Tropical Premontane Wet Forest,* warm-wet transition, occurs in the San Vito-Coto Brus area. Most of the *Tropical Premontane Wet Forest* Life Zone can be considered near to the climatic association, although some areas of an atmospheric association occur.

Tropical Premontane Wet Forest is medium to tall, semi-evergreen forest with two or three strata, with a few canopy species dry-season deciduous. Canopy trees are mostly 30-40 m tall, with mostly round to spreading crowns, relatively short clear boles. Buttresses are common but small. Bark is mostly brown or gray, moderately thick and flaky or fissured. Leaves are often clustered at the twig ends. Understory trees are 10-20 m tall with deep crowns and smooth, often dark bark. Stilt roots and long, strap-shaped leaves are common. Tree ferns are occasional. Shrub layer is 2-3 m tall and often dense. Ground layer is generally bare except for ferns. Epiphytes are present but not conspicuous. Climbing herbaceous vines are abundant. Most trees are covered by a thick layer of moss.

6. Tropical Premontane Rain Forest

This Life Zone occurs along the Atlantic slope of the Talamanca, Central and Tilarán Cordilleras; completely rings each volcano in the Guanacaste Cordillera; and in relatively narrow bands on the Pacific slope of the Talamanca Cordillera and the Fila Costeña (coastal range separating the El General Valley and the Pacific coast) as far northwest as Cerro Turrubares. The *Tropical Premontane Rain Forest* Life Zone is near the climatic association.

Tropical Premontane Rain Forest is an evergreen forest, intermediate in height, with two or three strata. Canopy trees are mostly 30-40 m tall, with round or umbrella-shaped crowns and straight branches. Buttresses are common but small. Bark is brown, black or gray, moderately thick, mostly flaking or fissured. The subcanopy is very dense with trees 15-25 m tall, slender trunks often unbranched for most of their length; narrow, round to conical crowns; and thin, light or dark-colored bark. Palms are common in well-drained situations. Understory is also very dense and may be difficult to distinguish from the subcanopy stratum. Understory trees are 8-15 m tall, often with leaning, crooked or twisted trunks and relatively long crowns with horizontal branches; many trees with stilt roots. Tree ferns are common in the understory. The shrub layer is 2-3 m tall and very dense. Dwarf palms are uncommon in the shrub layer. Ground layer consists of a nearly complete cover of ferns, *Selaginella,* and broad leaved herbs, often with bluish leaves. Epiphytes, woody vines, and herbaceous climbers are very abundant. Moss and epiphytes cover practically all surfaces.

7. Tropical Lower Montane Moist Forest

This Life Zone occurs in three small areas of Costa Rica--north and southwest of Cartago and around the town of Zarcero. These small areas are considered near the climatic association for the Life Zone.

Tropical Lower Montane Moist Forest is an open evergreen forest of intermediate height with two tree strata. Canopy trees are mostly *Quercus,* 30-35 m tall, with heavy, gnarled branches and thick, twisted boles and thick, scaling or rough bark. The understory is fairly open with evergreen trees to 20 m in height, with slender trunks and round to conical crowns. Shrub layer is 2-5 m tall, fairly dense, with soft-wooded plants and often with large leaves. Ground layer is mostly open, with scattered broad-leaved herbs and grasses. Although a few epiphytic trees occur, epiphytic herbs and mosses are inconspicuous.

8. Tropical Lower Montane Wet Forest

Tropical Lower Montane Wet Forest Life Zone is primarily restricted to central Costa Rica, with the most substantial area along the southwest flank of the Central Cordillera; also south of San José and Cartago and in the Dota Valley. Small outliers occur on the Pacific flank of the Tilarán Cordillera, in the upper valley of the Río Chirripó del Pacífico, and on the Pacific flank of the Talamanca Cordillera near the Panamá border. These forests are considered to be the climatic association for this Life Zone.

Tropical Lower Montane Wet Forest is an evergreen forest of intermediate height and two tree strata. Canopy trees are mostly 20-25 m tall, but some *Quercus* are taller, with short, stout trunks dividing into numerous long, heavy, twisting, ascending branches, producing wide, umbrella-shaped billowing crowns. Buttresses are uncommon. Bark is thick, mostly flaking or fissured. Understory is fairly open, with trees 5-10 m tall, with spreading crowns. Shrub layer is relatively dense, 2-3 m tall and palms are uncommon. Ground layer is well-covered with ferns, *Begonia,* aroid vines, and a thick layer of moist, rotting leaves. Small orchids, bromeliads and ferns are common epiphytes. A thin layer of moss grows on tree trunks. Herbaceous vines, especially Araceae, are common on and near ground level. Large, coiled lianas are occasional to common.

9. Tropical Lower Montane Rain Forest

This Life Zone occurs extensively on the windward flanks of the Central Cordillera, both flanks of the Talamanca Cordillera, the top of the Tilarán Cordillera and around the volcanic summits in the Guanacaste Cordillera. The forests are mostly in the climatic association for this Life Zone.

Tropical Lower Montane Rain Forest is an evergreen forest of low to intermediate height, with two tree strata. Canopy trees are mostly 25-30 m tall, but *Quercus* may

reach 50 m, with short, stout, often twisted trunks, with rough, dark bark. Branches are thick, sinuous, and relatively short. Crowns are relatively small and compact. Buttresses are uncommon. Understory stratum is often dense with trees 10-20 m tall. Trunks are slender, straight or sinuous, with small, brushlike crowns of twisted branches. Bark is smooth, thin, and mostly dark. Suckers are common at the base of the trunk. Shrub layer is very dense, 1.5-3 m tall, often with flat sprays of small leaves. Ground layer is very well-covered with ferns, sedges, delicate trailing herbs, and patches of moss. Epiphytes (orchids, bromeliads, gesneriads and aroids) are common in the moss covering trunks and branches. Ericaceae and Melastomataceae are abundant shrubby epiphytes. Large-leaved vines are occasional, but large lianas are uncommon.

10. Tropical Montane Wet Forest

This Life Zone is restricted in Costa Rica to the summit and upper southwest slopes of Volcán Irazú. Most of the vegetation near the Irazú crater was destroyed or severely damaged by the volcanic eruptions of 1963-65; hence no data are available for this Life Zone.

Tropical Montane Wet Forest should be an evergreen forest of intermediate height and two tree strata. The canopy should be dominated by *Quercus* spp. Bamboos should be abundant in the shrub layer.

11. Tropical Montane Rain Forest

Tropical Montane Rain Forest Life Zone occurs extensively in the high Talamancas, with small outliers around the summits of Turrialba, Irazú, Barba, and Poás volcanoes. The Life Zone in Costa Rica is considered to be the climatic association, except near the active volcanic craters.

Tropical Montane Rain Forest is an evergreen forest of low to intermediate height with two tree strata. Canopy trees are 25-30 m tall, with short, stout, unbuttressed trunks with rough bark. Crowns are small, compact, rounded, with many thick, short, twisting branches. Leaves are often clustered at the twig tip. Understory is fairly open, with trees mostly 5-15 m tall, with slender, crooked trunks and compact, much-branched, brush-like crowns. Tree ferns are common in the understory. Shrub layer is dense with dwarf bamboos up to 5 m tall. Ground layer is open under the bamboo. Trunks and branches of trees are thickly covered with moss and small herbaceous epiphytes; orchids and ferns are common in the moss. Large epiphytes are restricted to a few species of bromeliads. Woody vines with thick, fleshy leaves are common as canopy epiphytes.

12. Tropical Subalpine Rain Paramo

This Life Zone is the northernmost occurrence of Andean paramo, originally restricted to the highest peaks (Chirripó) of the Talamancas, but extending downward in the Cerro de la Muerte region due to human disturbance. Paramo refers to cold, inhospitable and humid landscape above treeline. In the northern Andes and in Costa Rica, paramo is dominated by shrubs where drainage is adequate, but bogs occur where drainage is poor. Andean paramos are best known for the tree Espeletias (Compositae) that dominate the landscape. Costa Rican paramos and their floristic and physiognomic relationships with Andean paramos are described in detail by Weber (1959)

Deforestation

The previous section indicates that 99.8% of Costa Rica was originally covered with natural forests. By 1977 the country's natural forests had been reduced to 15,901 km² or 31% (Pérez and Protti 1978). More than half of the deforestation has been done since 1950 (Figure IV-1). Current estimates of deforestation are 60,000-70,000 ha/year (OFIPLAN 1978, J. Tosi pers. comm.), equivalent to more than 1% of the country, or 4% of the forests remaining in 1977. The principal cause of deforestation (Fig. IV-2) is the strong demand for land, rather than for timber. General unsuitability for agriculture or pasture has not slowed deforestation on steep slopes with high rainfall and low soil fertility (see chapter IV-D).

Behind the seemingly irrational destruction of forests lies a complex array of causes, including land usage, laws and tenure rights, in combination with individualistic human nature, population growth, economic incentives, and strong foreign influence over the national economy. With population increase of course, the demand for land increases, for land is social security and prestige. Costa Rican common law recognizes explicitly that a person who openly occupies and works land not actively used by another gains "rights due to labor", or for "improvements" proven by land clearing and agricultural usage. An unwritten law of rural people is that possession and use are more important than title alone.

In the last century the government promulgated a series of laws to encourage settlement of public domain lands with rights of full ownership after 3 to 15 years of occupation. According to all reports, most settlers never bothered to register for title, settlement was largely unorganized and haphazard, and, as a result, there has been a nearly total loss of control over the public domain. It is doubtful that the government can clearly identify lands remaining in public domain today.

Under the Civil Code of 1888 and continuing under various laws to the present, legal title to land can be acquired by any person who possesses the land continuously, publicly, and peacefully for 10 years, and who has a "good faith" title. This means that the original squatter cannot claim title but that he can sell his "improvements" to a person who will qualify under this code for legal title. Additional protection is afforded under a 1942 Squatter Law: squatters (precaristas) who possess privately-owned land for more than one year are given possessionary rights. After 10 years of continuous possession, they may claim legal title.

These laws and the court's interpretation of them lead to a serious abuse of intent. Squatting and speculation on both private and public land have become a specialized business involving professional and amateur practioners. Since the original squatter cannot claim title under the good faith rule, he clears only sufficient forest (Fig. IV-3) to qualify for "improvements" while cutting a boundary strip ("carril") around a much larger area of virgin forest. The improvements are sold with the under-

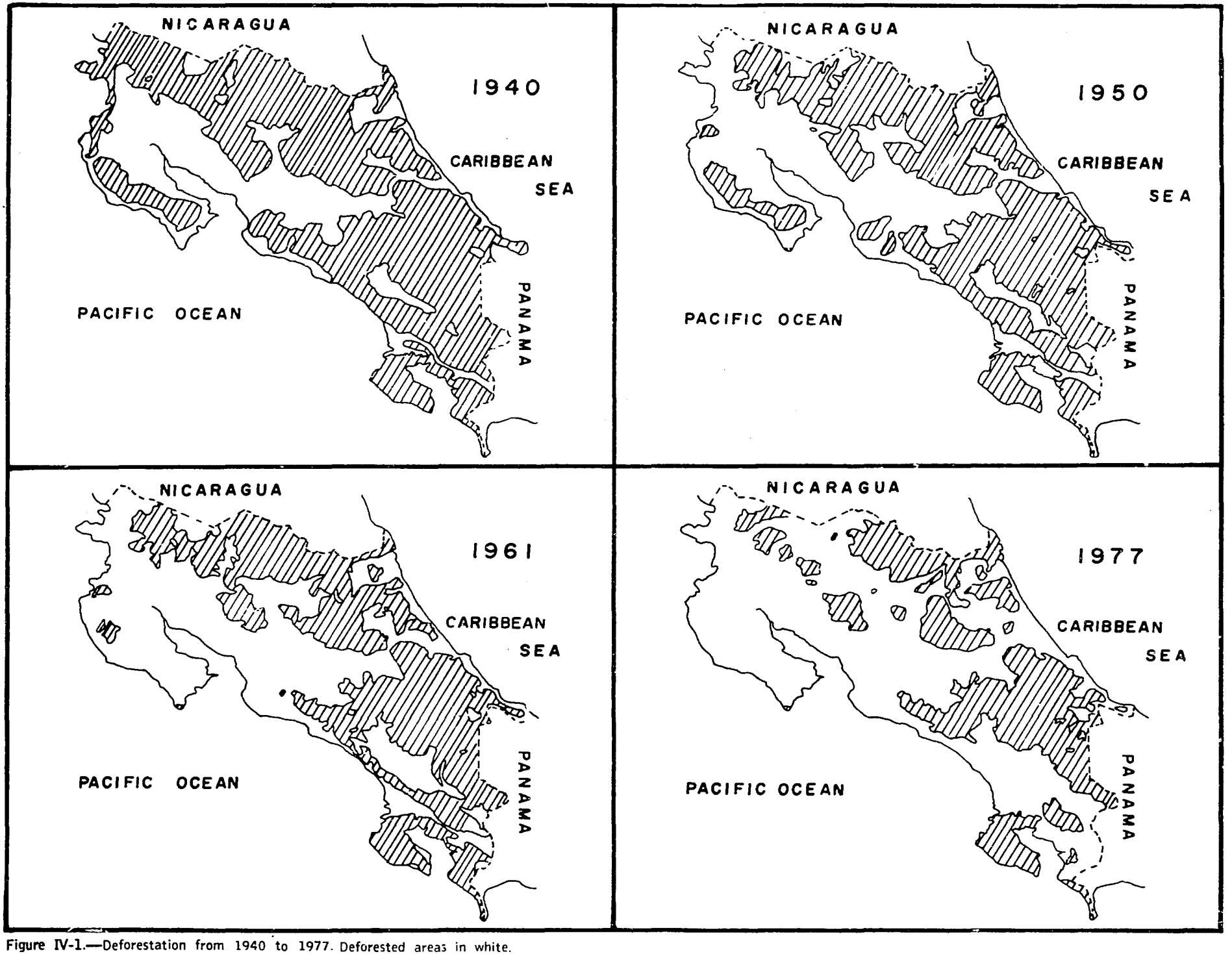

Figure IV-1.—Deforestation from 1940 to 1977. Deforested areas in white.

Figure IV-2.—Conversion of tropical wet forest to pasture in the Sarapiquí region. The advance of the agricultural frontier is destroying the productive potential of forest and soils on the Caribbean foothills (photo G. Hartshorn).

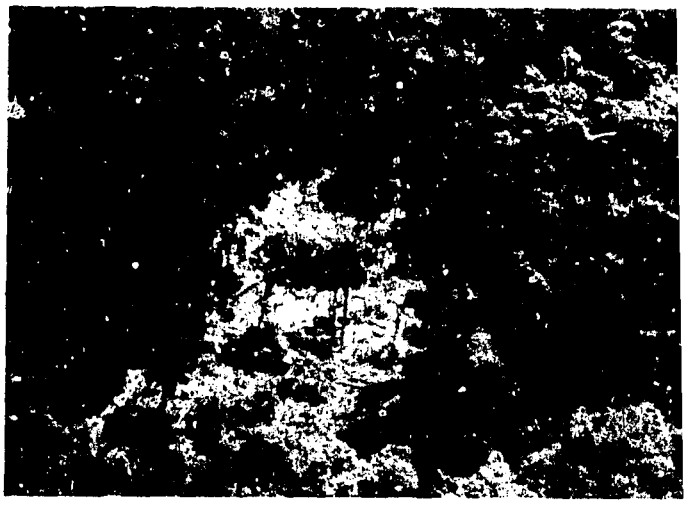

Figure IV-3.—Squatter clearing of tropical wet forest in the Sarapiquí region. This "improvement" is the first stage in the deforestation process leading to extensive and unproductive pasture (photo G. Hartshorn).

standing that the "farm" includes all the land within the boundary strip. The new "good faith" owner continues forest destruction, often selling stumpage to logging contractors who obtain a concession for this timber from the DGF. After 10 years (five if an ITCO title) the good faith owner may obtain legal title. Meanwhile, the original squatter has gone on to repeat the process on another section of virgin forest. Squatters in some instances are apparently financed in their commercial operations by eager purchasers, not infrequently cattlemen desirous of expanding an existing farm or acquiring others.

Although the 1969 Forestry Law prohibited further spontaneous settlements of the public lands, the location of these lands is not registered in government archives and there is no means of enforcement anyway, for the forestry department is both under-staffed and under-organized in this respect. Squatters continue to freely invade public as well as private lands, including in some cases, the forest reserves established by law, fraudulently claiming that possession originated prior to establishment of the reserve.

Years ago, large tracts of land were given to individuals in return for public service or during the land exchange of the 1940's. These private, titled lands are especially subject to invasion by squatters inasmuch as they are often little used by their owners. The presence of virgin forest is known to be an invitation to such invasions, which may occur in a well organized group occupation on a single large farm. Owners, therefore, often arrange to sell off all timber to loggers and establish extensive pasture simply to forestall such events, or they may sell a big farm to ITCO for parcelization into small farms, regardless of land quality for agriculture. The end result in all cases is deforestation and the initiation, except on flat lands, of the soil erosion cycle, for most of this land ends up in extensive grazing use.

Attempts to arrest abuses by law reform have been largely frustrated by vested interest groups such as cattlemen involved in the export meat trade (Shane 1980). Reforms suggested by conservationists at the beginning of the Carazo administration (Tosi 1978) were effectively blocked by inaction rather than by outright rejection. The nationalized banking system continues to provide low interest loans for cattle ranching (regardless of land capability or tenure status). Also, there are liberal foreign investment laws, an excellent overseas market for cheap beef, and cattlemen form a powerful lobby.

According to the Forestry Law, all tree cutting must be authorized by the DGF. In 1980, DGF gave permits to deforest 22,355 ha—only 35% of the forests cut that year. In theory, DGF forest cutting permits are given only when use capability justifies deforestation for agricultural use (Fig. IV-4). In practice, the DGF largely concerns itself with timber exploitation and essentially ignores deforestation for conversion to agriculture or pasture. Squatters are seldom hindered by the DGF, because they usually fell and burn forest to quickly establish their possessionary claims, rather than sell timber. DGF claims that ITCO squatters and colonists are responsible for up to one-half of the illegal deforestation. Wholesale invasions of forests by large numbers of squatters have destroyed some of the country's best potential production forests, e.g., Chambacú, Sarapiquí and Golfo Dulce. The Llanos de Cortés project is particularly disconcerting because both the ITCO forester and executive president during the Carazo administration publicly stated that the Llanos de Cortés forests would not be cut; rather, that enrichment plantings of cashew would help preserve the forests. ITCO proceeded to clear-cut a vast area of the Llanos de Cortés forest and plant cashew trees for the colonists. Although such a procedure provides income for ITCO, it forces the colonist to depend on the State for financial support until his crop matures—if it is successful. Some colonists in Llanos de Cortés burn the brush and young cashew in order to claim indemnization for crop loss from the State.

Status of Remaining Forests

Of the 15,900 km² of forests remaining in 1977 (Pérez and Protti 1978), substantial portions have legal status as reserves. The 4,183 km² of national parks and equivalent reserves (see chapter IV-B) are legally protected from all types of exploitation. Indian reserves total 2,788 km² and are mostly forested, but it is uncertain

Figure IV-4.—Unrestricted logging of tropical premontane moist forest along the Interamerican Highway south of Esparza. These poor soils were put into pasture for a few years, then abandoned (photo M. Tosi).

how severely they will be compromised by petroleum exploration and mining operations, as well as by non-Indian encroachment. In the past decade eleven forest reserves totaling 4,338 km² were decreed (Table IV-2). Although these forest reserves were created without legally specifying ultimate use, they are clearly viewed by the DGF as reserves for timber exploitation. Except for the Arenal Forest Reserve (TSC 1980), not a single forest reserve has been classified according to land use capability. In fact, most of the forest reserves (except Golfo Dulce) are situated in important catchment areas where the forests play a critical role in regulating the hydrologic regime (see chapter IV-E). Timber exploitation of these forest reserves using traditional methods would seriously alter the local hydrologic regime and possibly cause irreparable damages and losses downstream. Many of these critical forest reserves would be more appropriate as hydrologic reserves.

Table IV-2. Forest Reserves and Protection Zones assigned to DGF.

NAME	Area (ha)	Year Decreed
FOREST RESERVES		
Pacuare	400	1973
Grecia	2,848	1974
Río Macho	91,992	1974
San Ramón	7,896	1975
Juan Castro Blanco	14,436	1975
Los Santos	62,000	1975
Cordillera Volcánica Central	72,300	1975
Cordillera de Guanacaste	37,153	1977
Arenal	17,044	1977
Matina	500	1977
Golfo Dulce	79,069	1979
Subtotal	385,638	
PROTECTION ZONES		
El Rodeo	2,085	1976
Río Grande	1,500	1976
Caraigres	4,000	1976
Cerros Escazú	3,600	1976
La Carpintera	2,000	1976
Tiribí	650	1976
Atenas	700	1976
Las Tablas*	19,602	1982
Subtotal	34,137	
TOTAL	419,775	

* Jointly administered by DGF and SPN.

If the legally established national parks and equivalent reserves, Indian reserves and forest reserves are subtracted from the 15,900 km² of forests, only 4,600 km² of unassigned forests remained in 1977. At a deforestation rate of 70,000 ha/year, the unprotected forests will be gone by 1985. Thus the escalating pressure on remaining forests and difficulty for DGF to control deforestation are quite understandable. The exhaustion of natural forest available for exploitation will have profound effects not only on the timber industry, but on the national economy as well.

Management Potential

USAID recognized the importance of demonstrating natural forest management techniques by incorporating production forestry as a major component of the Conservation of Natural Resources loan (032). The GOCR administration is extremely interested in productive forest management and has designated the Sarapiquí area for development of production forestry. The Sarapiquí area is one of the few regions of the country with sufficient forests remaining that are suitable for production forestry

Although there is a generalized opinion that it is not possible to manage tropical forests, the results of recent research at La Selva, Sarapiquí (Hartshorn 1978, 1980), suggest that it is ecologically possible to manage heterogeneous tropical forests for timber production. The strong national demand for saw wood means that sawmills accept practically any log of acceptable size and form, regardless of species. The more complete utilization of native woods makes natural forest management economically feasible. The production forestry component of the AID-032 loan is an excellent opportunity to test and demonstrate forest management techniques that could solve the critical problem of forest conversion to unsustainable agriculture.

Timber Industry

The timber industry has an installed annual capacity of 759,980 m³ and actual production of 582,160 m³/year (Table IV-3). One-third of the sawmill industry uses circular saws and the other two-thirds use band saws. In addition to sawmills, the country has two plywood factories, one paneling company, two carton factories, two match factories and a paper plant. The secondary industries consist of furniture factories, broom factories, wagon shops, and craft shops, none of which is under DGF control.

Of the total number of sawmills, 96 (47.4%) are concentrated in the provinces of Alajuela and Limón where the largest number of logging permits are granted (65% in 1980). San José province comes next with 31 sawmills located in the Southern Pacific area. These three provinces have 64% of the installed capacity and 66% of the actual production of the country's sawmills.

Seventy-six percent of the installed capacity of the sawmills in utilized, which is acceptable in general terms if the low technological level of this type of industry is considered. According to DGF data, San José surpasses its installed capacity by 4%.

Wood consumption by industry follows the same pattern as above with Alajuela and Limón the most active with a consumption of 73% of the total (894,200 m³).

Aside from sawmills the rest of the industries do not provide the required information even though by law they are obligated to do so. When partial information has been obtained, it has been contradictory. For example, plywood factories report they consumed 117,000 m³ in 1973, yet in 1980 they report a figure of 7,800 m³. Some reduction is understandable, given the political situation in Central America and decreasing market opportunities, but a drop of 95% would have resulted in the closing of the industry.

Table IV-3. Sawmills and Production for 1980. Source: DGF 1981.

PROVINCE	No. of Sawmills	Production Capacity m³/day	Production Capacity m³/year	Actual Production m³/day	Actual Production m³/year
Alajuela	56	929	241,540	668	173,680
Limón	42	391	106,160	252	65,520
San José	31	534	138,840	554	144,040
Puntarenas	27	220	57,200	136	35,360
Cartago	20	350	91,000	278	72,240
Guanacaste	16	293	76,180	205	53,360
Heredia	12	206	53,560	146	37,960
TOTAL	204	2,923	759,980	2,239	582,160

The species most frequently used by sawmills include Caobilla *(Guarea grandifolia)*, Laurel *(Cordia alliodora)*, Ceiba *(Ceiba pentandra)*, Chiricano *(Vantanea barbourii)*, Fruta dorado *(Virola koschnyi)*, Cola de pavo *(Hymenolobium pulcherrimum)*, Campano *(Sacoglottis trichogyna)*, Cedro amargo *(Cedrela mexicana)*, Gavilán *(Pentaclethra macroloba)*, Jícaro *(Lecythis ampla)*, Pilón *(Hieronyma oblonga)*, Botarrama *(Vochysia ferruginea)*, plus numerous lower-quality woods for form lumber.

The panelboard industry uses Caobilla *(Guarea grandifolia)*, Cativo *(Prioria copaifera)*, Cedro macho *(Carapa guianensis)*, Ceiba *(Ceiba pentandra)* and Fruta dorado *(Virola koschnyi)*. For decorative veneer, Cenízaro *(Pithecellobium saman)*, Cristóbal *(Platymiscium pinnatum)*, Guanacaste *(Enterolobium cyclocarpum)* and Surá *(Terminalia oblonga)* are preferred.

The wood-turning industry that produces many popular tourist items depends on the colorful woods from the Pacific lowlands: Cocobola *(Dalbergia retusa)*, Ron-rón *(Astronium graveolens)*, Guapinol *(Hymenaea courbaril)*, Nazareno *(Peltogyne purpurea)*, Cristóbal *(Platymiscium pleiostachyum)* and Cenízaro. Most premium woods have become quite scarce due to logging and deforestation. The following important timber species are threatened with extinction outside of national parks and equivalent reserves: *Astronium graveolens* (Ron-rón), *Bombacopsis quinatum* (Pochote), *Calophyllum brasiliense* (María, Cedro María) *Chlorophora tinctoria* (Mora), *Copaifera aromatica* (Camíbar), *Dalbergia retusa* (Cocobola), *Dipteryx panamensis* (Almendro), *Guaiacum sanctum* (Guayacán real), *Hymenaea courbaril* (Guapinol), *Lecythis ampla* (Jícaro, Olla de Mono), *Manilkara zapota* (Níspero), *Minquartia guianensis* (Manú), *Peltogyne purpurea* (Nazareno), *Platymiscium pinnatum* and *P. pleiostachyum* (both Cristóbal), *Sacoglottis trichogyna* (Chiricano, Danto plomillo), *Swietenia macrophylla* (Caoba), *Tabebuia guayacan* (Guayacán), *Terminalia amazonia* (Roble coral), and *T. oblonga* (Surá, Guayabón).

Reforestation

Nurseries

The country has the following types of tree nurseries: regular DGF, DGF research, schools and charity institutions, autonomous institutions, permanent private, and temporary private. The DGF has 12 regular nurseries designed to cover the demand generated by reforestation projects. The installed capacity of these nurseries is 2,775,000 trees and actual production in 1980 was 2,020,682. The principal species produced include Laurel *(Cordia alliodora)*, Ciprés *(Cupressus lusitanica)*, Pino *(Pinus caribaea* and *P. oocarpa)*, Jaúl *(Alnus acuminata)*, Pochote *(Bombacopsis quinata)*, Teca *(Tectona grandis)*, Nogal *(Juglans olanchana)*, Gallinazo *(Dipterodendron elegans)*, and Roble *(Quercus* sp.).

The DGF research department has six nurseries located in rural areas. Almost the entire production of these nurseries is used primarily in demonstration parcels. Installed capacity of 200,000 trees is much higher than production of 61,000 for the year 1980. The species produced vary with the specific research goals of the projects.

There are 13 nurseries associated with schools or charity institutions for environmental education and rehabilitation objectives. The administration, design and implementation initially correspond to the DGF which also supplies labor and necessary materials. After a certain period of time the administration is transferred to the corresponding institution but the DGF maintains general control and provides technical assistance. Any profits from tree sales are returned to the nursery for its operation. The species produced are Ciprés, Jaúl, Pino and a few other species common to the region where the nursery is located. Installed capacity of 1,790,000 seedlings greatly surpasses actual production of 331,238 for 1980.

Two of the autonomous institutions, ICE and ITCO, maintain tree nurseries to fulfill their needs. There are three nurseries with a total production of 369,000 trees in 1980, which is far below installed capacity of 1,350,000 trees. The ICE nurseries are for their reforestation projects, essentially for beautifying and protecting the areas around dams, for donations when they are used to protect watershed areas, and occasionally for sale to the public. ITCO directs its production to reforestation projects and for sale to the public. The main species produced are Teca, Melina and Pino Hondureño *(Pinus caribaea)* by ITCO, and Ciprés and Pino Hondureño by ICE.

Figure IV-5.—Natural regeneration of Laurel (Cordia alliodora) associated with pasture establishment in San Carlos (photo J. Tosi).

Private nurseries have an installed capacity of 2,230,000 trees, but actual production of only 886,500. The exact destination of their production is not known, but at least part of it goes to reforestation in commercial projects for land recovery and protection. One of these nurseries belongs to a university center and is used for teaching purposes.

In addition to permanent nurseries there are 22 temporary ones associated with specific reforestation projects. These nurseries work at full capacity and produce more than 50% of the national production (4,145,000 seedlings per year). The main species produced are Laurel, Melina, Teca, Fruta dorado (*Virola* spp.), Jaúl, Ciprés, Pochote, Roble and Pino Hondureño. Individual nurseries produce 25,000-500,000 seedlings per year. These nurseries have their own administration and technical supervisors. The DGF gathers information for the yearly evaluation of each project.

Planning limitations based on previous year's demand bring about underutilization (62%) of installed capacity for nurseries not allied to specific projects.

Plantations

Accurate reforestation information only goes back to 1970 when the DGF was created. According to the DGF only two types of reforestation take place, natural regeneration (Fig. IV-5) and planned plantings. Natural regeneration has come about as an indirect effect of the relative protection of forest reserves rather than as a result of official decisions; the area in this type of reforestation has not been quantified.

Timber plantings for industrial or promotion purposes include forestry projects under the Forestry Law demonstration forests promoted and established by the DGF, and private reforestation projects with DGF technical assistance.

The Forestry Law (No. 4465) regulates the conservation, protection and rational use of forest and woodlands. The inclusion of private forests and woodlands into forest reserves can be mandatory when it is declared in the public interest or is within a declared forest reserve and voluntary when inclusion is requested. In order to promote voluntary inclusion several incentives are offered: technical assistance for the classification of natural forests and for selection and planting of forest species; exemption of property taxes; deduction from income tax of expenses incurred in forestry activities; tax exemption for benefits obtained from the sale of the forestry products when the management plan has been followed; and credit assistance from the National Banking System to carry out classifications and management plans.

Although established in 1970, it was not until 1979 that the DGF received several projects due to the attractive incentives, specifically the direct deduction from income tax of expenses incurred in reforestation activities. Official support of this measure was set at 16,000 colones per hectare reforested and the procedures and legal details were clarified. Once the procedure was established an interesting phenomenon occurred: the 51 applications covering an area of 11,234 ha were presented by businessmen who were looking for ways to lower their taxes. The reforestation companies that appeared overnight started businesses whereby they offered to lower taxes for persons by selling them one or more reforested hectares and charging them for technical assistance, administration and the value of the land—almost like a real estate business These projects did generate employment for workers, technicians and professionals as well as salesmen but the reforestation value is dubious. The projects are generally centrally located in areas suited to livestock and agriculture and have begun to compete with food production. In some cases, natural forests were cut to be later replanted under the program.

Of the total area (11,234 ha) included in the reforestation program up to 1981, 1,638 ha or only 14% has been reforested. The projects are concentrated mostly in Alajuela (13 projects) and Heredia (11 projects) provinces; however, the largest area is in Guanacaste (4,098 ha). The most popular species are *Cordia alliodora* (947 ha) and *Pinus caribaea* (372 ha).

The demonstration forests have as their objectives the creation of a base for the establishment of plantations and the promotion of forest conservation in areas unsuitable for agriculture or livestock activities. Though insignificant in area, these demonstration plots have great educational value. The DGF shows how to establish and manage a plantation and proposes benefits that could have a multiplier effect on the attitude toward reforestation. Unfortunately, most of these demonstration areas are located in San José rather than in rural areas that have been deforested and where reforestation is most important and desperately needed.

During the 1970-1980 period there were also some private initiatives in reforestation mainly from farmers aware of the benefits that trees offer in protecting and improving streams and watersheds, and as a source of timber for firewood, fence posts and wood for farm use or sale. The DGF has offered technical assistance for these private initiatives that have reforested 2,552 ha. Species most often utilizied are Ciprés, Pino, Pino Hondureño, Eucalyptus *(Eucalyptus deglupta, E. camadulensis), Casuarina equisetifolia*, Pochote and Laurel.

These plantations are concentrated largely in San José province, demonstrating once again a trend to reforest more in the Central Valley than in the outlying areas where the need is greater.

Current Needs

The country has 1,810,000 ha of land best suited to forestry that are currently being used for agriculture or livestock. These areas should be reforested to establish a better environmental equilibrium. From an ecological point of view, 50% of this area should be reforested commercially in large plantings and the remaining 50% should be allowed to regenerate naturally in order to protect other renewable natural resources. From the point of view of the economic development of the country, 450,000 ha should be reforested during a period of 30 years in order to avoid the importation of wood and to maintain a growing trend in wood exports.

According to projections done by OFIPLAN in 1978, the reforestation situation is serious; even if the existing forest is managed and the annual deforestation is reduced, by the year 2012 the country will have a lumber deficit and will have to import this material at a rate of 1,100,000 m^3 in the first year of deficit and increasing to 5 million m^3 annually over a period of 25 years. Considering that the current average price of wood on the international market is US$ 500/m^3, the import of wood will be an impossible burden for the country.

Though reforestation of 450,000 ha is urgent, several conditions are inhibitory: a) the lack of technical experience and cultural tradition make it impossible to reforest 15,000 ha/year in a short period of time; b) investments in reforestation yield profits only in the long-term and thus do not appear attractive to investors; c) current legislation and economics dictate that land has a greater value when clear of trees even if it is not producing: d) a decisive aspect in the government's inability to effect reforestation is the fact that the land that should be reforested is in private hands, thus limiting the application of deforestation and reforestation regulations.

IV-B. WILDLANDS

The term "wildlands" refers to areas of forestry vocation that are either legally protected or receive some degree of management by government or private institutions. Wildlands provide services of facilities to the public depending on their classification and type of management. Use ranges from resource exploitation on a sustained yield basis (e.g., timber, wildlife) to absolute preservation (e.g., genetic resources) and includes environmental recreation and education as well.

At the time of legal establishment wildlands do not necessarily have to be completely forested. Recuperation of degraded lands can be an objetive of wildlands management. However, there is a strong tendency to exclude degraded zones when the boundaries of a new unit (whether national park or forest reserve) are established. This all-too-prevalent attitude means that someone else—but who?—must assume responsibility for these "marginal lands".

Historical concern about the destruction of natural resources dates from 1833. Protection of a two-kilometer radius around the peak of Volcán Barba was decreed in 1888. The first national park was declared in 1945 in the Los Robledales area along the Interamerican Highway south of Cartago; however, uncontrolled logging destroyed the beautiful oak forests along the highway. The founding legislation of ICT declared the area within 2 km of each volcanic crater as national parks in 1955. All national parks were transferred to ITCO upon its creation in 1961. The first biological reserve (Cabo Blanco) and forest reserve (Río Macho) were established in 1963 and 1964, respectively. In 1966 Costa Rica ratified the international convention on the protection of flora, fauna and natural scenic sites. The Forestry Law became effective in 1969, followed by the Wildlife Conservation Law in 1970.

National Conservation Objectives

The impressive efforts in conservation have occurred without the benefit of clear policies and guidelines in a single administrative or legal agency. The government has yet to legally set conservation objectives or administrative programs for the national patrimony. The 1979-1982 National Development Plan (OFIPLAN 1978) called for minimizing environmental deterioration associated with urban growth and forestry, agricultural and industrial development. Such a grandiose objective was to be met by special research efforts to correct environmental degradation and by emphasizing productive activities that contribute to ecological protection. Impressive advances in wildlands protection and management have occurred in the past three years. Despite the creation of a few new national parks and equivalent reserves the overall national situation continues to deteriorate.

A growing public conscience of the importance to protect and to manage natural areas for sustained yields of water, timber and wildlife, as well as for tourism, recreation and education came about during the 1970's. Public and official preoccupation for the future of wildlands was the motivation to formulate a preliminary strategy for natural resources (OFIPLAN 1979). A detailed FAO (1976) study of laws and institutions related to the protection of natural and cultural resources has helped guide a few government institutions to establish a national systems of wildlands.

National System of Wildlands

Most of the actual wildlands protected or managed were established without scientific study of the natural and cultural resources, or an analysis of the local socioeconomic situation. A variety of diverse factors, such as political or personal interests, have strongly influenced the identification and selection of wildlands to be protected. Thus, no organized and logical system of wild-

lands selection exists; rather, a group of areas exist under different management categories with poorly-defined or incorrect objectives. Some units should not be included in the system of wildlands and other units have questionable boundaries or size. TSC (1982) recently completed a detailed evaluation of the entire system of national parks and equivalent reserves.

Wildlands areas fall into the following categories, with principal objectives also given:

Biological Reserve: To protect, conserve and maintain natural phenomena and processes in an unaltered state for scientific research.

Anthropological Reserve (Including *Indian Reserve):* To protect ecosystems and life styles of indigenous peoples and tribes that inhabit forests in low densities and in traditional harmony with their environment, and permitting them to continue their life styles without the influence of modern technology.

National Park: To conserve natural or scenic areas of national interest; to perpetuate representative examples of physiographic regions, biotic communities, genetic resources, and endangered species; and to serve for environmental education and scientific studies.

Water Production Area (Including *Protection Forests* and *Zones):* To maintain or to improve the quality and quantity of water resources, as well as to conserve other natural values.

National Forest (Including *Forest Reserve):* To provide wood, water, wildlife or forage on a sustained yield basis; and to provide areas for recreation in a manner that corresponds to the economic, social and cultural necessities of the general public.

Wildlife Refuge: To ensure in perpetuity wildlife species, populations or habitats; and to serve for scientific or recreational uses when these do not conflict with the principal objectives.

National Recreation Area: To provide recreational opportunities in seminatural areas; to maintain scenic quality and to minimize natural resource degradation.

Natural Monument: To protect and preserve natural features and genetic material; to provide recreational, educational and scientific opportunities if not in conflict with the principal objective.

Cultural Monument: To protect and conserve cultural, historic or archaeologic features; if appropriate, to provide recreational, educational and scientific opportunities.

Pertinent information on each wildlands area is listed in Table IV-4. DGF's Department of Forest Reserves is responsible for eleven forest reserves and seven protection zones, covering 463,670 ha (=9.09% of the country). The 500,000 ha Talamanca Forest Reserve is excluded from consideration because of its confused legal situation. DGF's Wildlife Department administers two wildlife refugia, covering 7,530 ha (0.15%). The National Park Service (SPN) administers 13 national parks totaling 398,666 ha (7.82%), four recreational areas of 666 ha (0.01%), seven biological reserves protecting 18,346 ha (0.36%), and one national monument with 218 ha (0.004%).

CONAI supervises the protection of 16 indigenous reserves totaling 269,000 ha (5.27%). UCR is responsible for a 750 ha (0.01%) segment of the Río Macho forest reserve. TSC owns and administers the 3,100 ha (0.06%) Monteverde Cloud Forest Reserve. OTS owns and administers the 1,361 ha (0.03%) La Selva Biological Station, as well as the Las Cruces Botanical Garden. In summary, the country has about 1,138,200 ha under various forms of protection equivalent to 22% of the national territory within a loose system of wildlands.

Table IV-4. Wildlands Units in Costa Rica (sources DGF, DVS, SPN).

Name	Area (ha)	Year Created	Institution
NATIONAL PARKS			
Volcán Irazú	2,400	1955	SPN
Volcán Poás	4.000	1971	SPN
Santa Rosa	21,500	1971	SPN
Manuel Antonio	690	1972	SPN
Rincón de la Vieja	11,700	1974	SPN
Barra Honda	2,295	1974	SPN
Chirripó	43,700	1975	SPN
Corcovado	41,469	1975	SPN
Tortuguero	18,947	1975	SPN
Braulio Carrillo	32,000	1978	SPN
Isla del Coco	3,200	1978	SPN
Palo Verde	9,467	1980	SPN
La Amistad	207,298	1982	SPN
Subtotal	398,666		
WILDLIFE REFUGES			
Palo Verde	7,500	1978	DVS
Isla Bolaños	50	1980	DVS
Tapantí	5,200	1982	DVS
Subtotal	12,750		
BIOLOGICAL RESERVES			
La Selva	1,361	1953	OTS
Cabo Blanco	1,172	1964	SPN
Monteverde	3,100	1972	TSC
Isla Pájaros, Negritos, Guayabo	12	1973	SPN
Isla del Caño	320	1978	SPN
Hitoy Cerere	9,045		SPN
Carara	7,600	1978	SPN
Subtotal	22,610		
NATIONAL MONUMENTS			
Cahuita	1,700	1970	SPN
Guayabo	218	1973	SPN
Subtotal	1,918		
RECREATION AREAS			
Santa Ana	42		SPN
Prusia	583		SPN
Cariari	13		SPN
Laguna de Fraijanes	13		SPN
Subtotal	651		SPN
FOREST RESERVES	385,638	(see Table IV-2)	
PROTECTION ZONES	34,137	(see Table IV-2)	
INDIAN RESERVES	278,839	(see Table III-2)	
TOTAL	1,138,209		

Management of Wildlands

Forest Reserves and Protection Zones

Of the 18 wildlands units in this category, only two —Pacuare and Arenal forest reserves— have a management plan. An operational plan for all units will be completed this year. Actually, the category of forest reserves (or national forests) and protection zones (or water production area) is artificial, since selection was based simply on the presence of forest or watersheds, without information on the quality or quantity of resource (see Table IV-2). Forest area was usually estimated indirectly and assumed to be exploitable. For example, the Los Santos Forest Reserve totals 13,731 ha, of which only 3,000 ha remains in forest, yet the initial figure is still used as the area for potential exploitation. The Golfo Dulce Forest Reserve is another confusing case, where the estimate of 44,237 ha of production forest was determined from a grossly inadequate map of slopes; plus ITCO has plans for colonization in areas of protection forest within the reserve.

The boundaries of each wildlands unit are marked on 1:50,000 topographic maps, but generally not on the ground. Government personnel have difficulty protecting poorly-defined units, while neighbors and squatters can't respect unknown boundaries. Each wildlands unit contains private property within its boundaries, most with legal title although some have only possessionary or squatter rights. The DGF does not have accurate information on private holdings within wildlands. In some cases other wildlands categories overlap forest reserves and protection zones. The complexity of land tenure contributes to a gradual deterioration in these wildlands because the DGF makes unrealistic promises to private land holders without having the legal and technical means to solve the problems.

The information base is particularly weak about forest reserves and protection zones. There are diagnostic timber inventories for several reserves but they are superficial and inadequate to use as a basis for management and exploitation. In one case (Arenal) where detailed ecological studies were done (TSC 1980), the management recommendations have not been implemented. The excellent TSC model should be repeated for each forest reserve.

Actual management does not exist in any of the wildlands units. Modest protection is provided by one to four forest guards per unit; however, unit administrators who are not professional foresters are usually responsible for more than one unit and, with few exceptions, are not based in a unit. For example, one administrator is responsible for the Los Santos and Río Macho Forest Reserves —172,000 ha with strong pressures from farmers and squatters—and he lives in Cartago.

In most of the forest reserves and protection zones, there is exploitation of timber, firewood, charcoal, wildlife and soil. However, the units have no large concessions. Small land holders uncontrolled by the DGF and with uncertain status and lack of official action, wastefully exploit the natural resources. Particularly disheartening is the destruction of timber in the opening of new agricultural lands, i.e., the Golfo Dulce, Río Macho, and Cordillera Volcánica Forest Reserves. Though exploitation of wildlife, fish and firewood is also common, the DGF does not consider it important. The DGF is unable to effectively manage 18 forest reserves and protection zones covering 9% of the country; uncontrolled deforestation and inappropriate land use are destroying natural resources in critical watersheds.

There are several serious defects or conflicts in the Forestry Law (No. 4465) and its regulations that concern forest reserves; protection zones are not defined, nor are objectives specified. The phrase "multiple-use principle" accompanies virtually all the laws and decrees establishing forest reserves; the phrase is defined in the Forestry Law regulations as "technical administration based on the exploitation of the different resources" (Article 1). The principle of multiple use is the management of renewable natural resources to produce water, timber, wildlife, forage and recreation in such a manner that the economic, social and cultural necessities of the people are satisfied while allowing for resource regeneration, i.e., conservation of the resources in the environment.

Article 35 of the Forestry Law describes forest reserves as forested areas of recognized productive capacity. Forest reserves have defined and marked boundaries. They are destined to rational exploitation based on technical norms that define the annual cut and assure the permanent supply of timber and other forest products. Not a single forest reserve meets the above description. Article 57 states that forest reserves are inalienable and uncolonizable, i.e., forest reserves cannot be legally transferred to private holders. The Forestry Law specifies that the results of prior studies of land use, timber inventory, land tenancy and census of inhabitants are to be published in the law or decree creating a forest reserve. In practice, a forest reserve is created and none of the required studies is conducted.

As in other Latin American countries, Costa Rica has emphasized national parks as the primary category for the protection and management of wildlands (Table IV-4). National parks are the best known conservation units in Costa Rica and the public readily accepts their existence. However, a few of the national parks are not true conservations units. The entire system of national parks and equivalent reserves has recently been evaluated by TSC (1982). Both TSC and CATIE have recommended changes for several conservation units that would bring their names more in line with actual use and function.

The cultural monument and the majority of the national parks still contain private property within their boundaries. Cahuita National Park is the extreme case where the SPN owns only one hectare. The government owes almost US$ 4 million to private property owners in Braulio Carrillo National Park. Private holdings to be expropriated by SPN can continue to be used for non-conservation purposes except for clearing more forest. Private farms within national parks cause management and protection problems for the SPN, as well as inhibiting the development of good rapport with local communities and neighbors. Preliminary planning to locate and delineate new parks would lessen the demands for boundary changes; each general management and development plan completed so far has recommended boundary changes.

National and foreign scientists have conducted research in national parks, especially Santa Rosa and Corcovado. In the preparation of general management and development plans field data has been accumulating, yet the basic data are often inadequate to permit scientific management. Park zones limit the largest portion to an intangible or primitive area for absolute protection; not enough is currently known to assign areas to different uses. Nevertheless, the urgency for ecological studies is not as great in national parks as in forest reserves.

All the units under SPN control have resident staff and facilities. SPN personnel devote most of their time to attending the public and patrolling the unit. With a few exceptions, park management and protection is inadequate; problems with hunters, forest fires, squatters and poor relations with the visiting public continue. Clandestine exploitation of resources within parks still occurs, such as gold diggers in Corcovado National Park. Although it is an old problem, an acceptable solution has not been found.

National Parks, Cultural Monuments and Recreation Areas

Half of the 13 national parks and 1 cultural monument have a general management and development plan. Three national parks and one recreational area have an interpretive and environmental education plan. Only one (Volcán Irazú-Prusia) of the recreational areas has a general management and development plan. The new "La Amistad" Bi-national Park (Costa Rica-Panamá) has a semi-detailed ecological study that is being used to prepare a general management and development plan; La Amistad is the first to have a general plan before the park was legally established.

Each unit has an operations guide for annual management and development plans. The planning of management and development of the units is one of the principal activities of the SPN. Although half of the units still lack generalized long-range plans, adequate progress is being made. But some decisions do not conform with the general management and development plans. The location and architecture of the cafeteria, lookout and exhibition hall at Volcán Irazú built in 1981 is an example. The management plan for Volcán Poás is too development oriented; it may be too costly to maintain.

The law creating the SPN offers no guidance nor regulations on how to manage and to protect national parks and equivalent reserves. Although the SPN also includes biological reserves and recreational areas, the lack of specific legislative authorization to do so could jeopardize the SPN program in these areas. The Forestry Law still contains a few elements relevant to national parks and equivalent reserves that should be assigned to SPN.

Biological Reserves and Wildlife Refuges

Each of the SPN biological reserves has an annual operations plan and some have a general management and development plan. Although the two private biological reserves have much more basic biological information available, neither has a general master plan for management: La Selva has a multi-year operations plan and is preparing a master plan; Monteverde has neither an operations plan nor a master plan. Preparation of general management and development plans for the government's conservation units is progressing adequately.

Figure IV-6.—Rafael Lucas Rodriguez Wildlife Refuge (Palo Verde) along the Río Tempisque. The extensive freshwater marsh (center) is a critical seasonal habitat for migratory waterfowl (photo G. Hartshorn).

As with the preceding category of national parks, categorical changes should be made for some biological reserves and wildlife refuges (TSC 1982). An interesting proposal is to incorporate the private Monteverde Cloud Forest Reserve with the Arenal Forest Reserve to form a national park to protect the Arenal watershed (TSC 1980); ICE has not acted on this proposal. OTS has obtained government agreement to expand Braulio Carrillo National Park in a corridor to ensure the biological survival of the private La Selva Biological Reserve, but the lack of funds has inhibited the expansion.

Public biological reserves and wildlife refuges also have boundary and land tenancy problems. The Nicoya Gulf islands biological reserve obviously does not have boundary problems, but this unit lacks local administration.

Natural resources exploitation in biological reserves and wildlife refuges is prohibited. Some clandestine hunting does occur, but it is thought to have an insignificant effect on local wildlife populations. Significant research activities occur in the Rafael Lucas Rodríguez (Palo Verde) Wildlife Refuge (Fig. IV-6), La Selva and Monteverde. The SPN has specific rules and guidelines controlling research activities and scientific collecting in SPN wildlands.

Indian Reserves

Indian reserves are technically considered wildlands with conservation of renewable natural resources, rather than areas of preservation of cultural patrimony, which may be of greater or at least equal importance to the country. The Indian Law (No. 6172, 1977) explicitly states that lands of forestry vocation must remain so in order to maintain the hydrologic equilibrium of watersheds and to conserve the wildlife. Any exploitation

must be done rationally and be based on sustained-yield principles. In addition to having responsibility for Indian reserves, CONAI has the legal authority to suspend or revoke exploitation concessions that abuse the national resources or threaten the ecological equilibrium of a reserve (see Section III-Indians).

None of the Indian reserves has a general management or annual operations plan. The complete absence of ecological and anthropological studies in Indian reserves makes it impossible to evaluate the degree of acculturation, as well as local use of natural resources. Such studies are needed for they may suggest changing some Indian reserves to a different category where the tribe holds communal title to the land and practices rational exploitation of natural resources.

Except for natural boundaries such as streams, all Indian reserves lack boundary demarcation on the ground. Non-Indian land tenancy in Indian reserves is a major unsolved problem. Despite several laws and decrees in 1976 and 1977 to redefine the boundaries of several reserves and to initiate the consolidation process, most "foreign" holdings in Indian reserves still have not been expropriated. A complete census and cadaster of these properties has apparently not been completed.

Some Indian reserves have superficial timber inventories for commercial exploitation, but otherwise very little is known about the natural resources. Under the current land tenure conditions, it is highly unlikely that any wildlife protection exists nor is there any control of resource exploitation.

IV-C. WILDLIFE PROBLEMS AND PERSPECTIVES

Introduction

A necessary starting point for well-designed and effective programs in wildlife conservation and utilization is a solid working knowledge of the local fauna. In this respect, Costa Rica is fortunate among Latin American countries: due to the work of a long succession of local and visiting naturalists, its fauna is probably the best known in the hemisphere south of the U.S. border. Although details of taxonomic status, local distribution and abundance are still debated for many species, and new species are still being added, the basic faunal inventory is relatively complete, at least for most vertebrate groups. For many invertebrate groups, far less is known but at least some groups have received concentrated study in recent years (e.g., arachnids, butterflies and moths, some beetle groups). Much of this information has been summarized in a book edited by D.H. Janzen and soon to be published by the University of Chicago Press, *Costa Rican Natural History;* and in an ongoing computerized faunal inventory (BIOLOG) being conducted by D.C. Robinson of the Museo de Zoología, University of Costa Rica.

This report will treat mainly the terrestrial and coastal vertebrates (excluding fish) of Costa Rica, including Coco Island. In brief, Costa Rica has a herpetofauna of about 360 species (ca. 210 reptiles, 150 amphibians); an avifauna of some 850 species (ca. 625 breeding birds, 225 nonbreeding migrants and visitants); and a mammal fauna of some 205 species, divided nearly equally between bats and nonflying mammals (Table IV-5). Largely because of the country's small size, rather few species, mostly herps, are endemic to Costa Rica *per se* (and much of this apparent endemism, at least in the Amphibia, may merely reflect taxonomic uncertainties in poorly-collected groups). However, a much more sizeable portion of the fauna consists of species with decidedly restricted distributions; most are found only in Costa Rica and western Panamá ("Costa Rica-Chiriquí" or "Southern Central America" endemics), such that events in Costa Rica could have a significant effect on total species populations. Most such species are found in the highlands; a few, in the humid forests of the Golfo Dulce lowlands.

Problems in Wildlife Conservation

The wildlife resources of Costa Rica can be classified into four groups with respect to their perspectives for management and exploitation: 1) Endangered species; 2) Species used by man; 3) Pest species; and 4) Species without *direct* economic importance to man (Table IV-5). In general, management practices should be directed toward the protection and preservation of endangered species; for usable species, the main objective should be to regulate exploitation practices to assure sustained yields. Control measures for pest species should ideally be specific to the species in question, without jeopardizing other components of the ecosystem. In any case, it is obvious that the vast majority of wildlife species will fall in group 4. These species are functional parts of natural ecosystems, and they may represent or affect essential resources for species in the first three groups. However, they are not subject to intensive management practices, and their preservation will follow upon the protection of intact natural ecosystems. Here, the ideal practice would be to preserve adequate representatives of as many kinds of ecosystems as possible, to maintain total biotic diversity. For highly mobile animals, such as many birds and perhaps some large mammals, this may include protecting corridors connecting ecosystems containing essential but highly seasonal resources.

The following section examines current wildlife policies and practices in Costa Rica in relation to the idealized objectives above. Later sections include specific aspects of wildlife programs in the country.

Reptiles and Amphibians

The large jungle frog *Leptodactylus pentadactylus* is often eaten by campesinos (rural folks) in Costa Rica, but probably not to the extent that its population levels are being severely affected (at least, not in relation to the more drastic effects of deforestation). No other Costa Rican amphibian enters directly into the human economy. The single species of Costa Rican amphibian on the endangered species list, *Bufo periglenes* (golden toad), is an extremely localized endemic, potentially vulnerable to excessive collecting or habitat destruction; virtually the entire population receives complete protection in the Monteverde Cloud Forest Reserve. Most of the other supposedly endemic Costa Rican amphibians are too poorly known for meaningful assessments of either their present status or possible need for protection. However, one potential threat to many species of highland anurans

Table IV-5. Wildlife management perspectives: terrestrial vertebrate groups of Costa Rica (including Coco Island).

Group	Total Nº Species in Costa Rica	Nº Species Endemic to Costa Rica	Nº Species largely restricted to Costa Rica	Nº Species officially considered endangered	Species used frequently by man: Nº	Species used frequently by man:	Pest Species
Amphibians	150	ca.40	ca.35	1	1	food; *Leptodactylus pentadactylus*	NONE
Reptiles	210	ca.20	ca.30	7	2+	food; large lizards-Iguana, Ctenosaur	None; ca. 5 spp. poisonous snakes are occasionally a health hazard in countryside
					2	hides; crocodilians	
					5	food, hides; sea turtles	
					2+	food, sporadically; river turtles	
Birds	850	6	ca.60	11	25+	food & sport; tinamous, gallinaceous birds, ducks, a few others	5+ agricultural pests; certain parrots *(Pionus senilis, Aratinga finschi)*, ducks *(Dendrocygna autumnalis)*, occasionally others (quail, finches, blackbirds, etc.)
					5+	sport hunting; pigeons, doves	
					40	cage birds; parrots, tanagers, finches, orioles, solitaires, etc. occasional use of nestling herons, pelicans, etc. for fish bait	1+ nuisances, chiefly *Quiscalus mexicanus* Occasionally hawks (chicken predators, etc.)
Mammals	205	ca.7	ca.45	16	20+	food, some sport hunting; deer, peccary, large rodents, armadillo, tapir, occasionally rabbit, squirrel, monkey, etc.	3+ agricultural pests (gophers, rodents, occasionally rabbits, squirrels, etc.)
					6	hides, sport hunting, occasionally caged; cats	1+ predators on livestock: coyotes, occasionally cats; 1 livestock pest (vampire bat)

(including some endemics) is the increasingly widespread introduction of trout into highland streams. Costa Rica lacks native fresh-water fish above 1500 m; the introduction of a large predatory species may affect populations of small frogs and toads that require these streams for breeding. If possible, before-and-after studies should be conducted to determine the effects of trout on riparian biota, and a few strategic watersheds should be maintained trout-free, especially watersheds within national parks.

Three groups of Costa Rican reptiles are of considerable economic importance: sea turtles, crocodilians, and large lizards. Of these, the sea turtles (especially the Green, *Chelonia mydas*, and the Pacific Ridley, *Lepidochelys olivacea)* are undoubtedly the most important. Eggs of sea turtles are avidly consumed in the bars of Central America, largely for their (mythical) aphrodisiac properties; the meat of the Caribbean Green Turtle is especially prized; and the hides of some species are heavily exploited. (Notable in this respect was the turtle fishery in Ecuador, where up to 150,000 turtles were killed in 1979 alone. Marking studies have shown that many Ridleys nesting in Costa Rica migrate to Ecuadorean waters. Fortunately, the Ecuadorian turtle fishery was shut down in 1981.)

At the 1979 World Conference on Sea Turtle Conservation in Washington, Ostional and Nancite beaches in Guanacaste were collectively designated as the second most important turtle nesting area in the world due to the enormous numbers of Pacific Ridleys (probably the bulk of the world population) nesting there, as well as smaller numbers of other species. Tortuguero, the most important Caribbean nesting area of the Green Turtle was designated 14th in the IUCN world list of turtle beaches. Each of these beaches represents a particular conservation problem. It should be noted that Costa Rica, as a signatory to the International Convention on the Trade of Endangered Species (CITIES) prohibits the exportation of turtle products. Also, harvesting of turtle eggs or any other interference with turtle nesting beaches is prohibited by Costa Rican law. However, internal consumption of turtle meat is permitted, and licenses to hunt adult Green Turtles off the Caribbean coast are issued (mainly to a cooperative in Limón). Tortuguero and Nancite beaches are within national parks and receive reasonably effective protection against human interference (especially Nancite, due in large part to its inaccessibility). Populations of nesting turtles on these beaches appear reasonably stable; the Green Turtle population may even be increasing (although it is still only a very small fraction of its former size), and its future looks definitely brighter now that the Somoza-owned turtle fishery on Miskito Cays, Nicaragua (a major feeding ground), has been closed. The pioneering work of Archie Carr in studying and promoting the conservation of the Green Turtle has been a major factor in ensuring the survival of the species thus far. However, Green Turtle populations are still in no shape to withstand the more than minor local exploitation. The situation at Ostional is much less favorable. Here the local community has resisted efforts to curb egg harvesting; in flagrant violation of the law, virtually the entire 1980 nesting effort of the turtles was harvested by local people, or destroyed by their dogs and pigs, or by vultures (which descend by the hundreds on exposed nests). This beach has been the object of long-term studies by D.C. Robinson of UCR, who estimates that uncontrolled egg exploitation may have reduced the numbers of Ridleys nesting at Ostional by as much as 50% in 10 years. Whether this means a real reduction in the actual population or a shift to other nesting areas, as yet undiscovered, is not known. A comparative study of Ridley nesting at Ostional and Nancite, funded by UCR, CONICIT, and the U.S. Fish and Wildlife Service (USFWS), and conducted by Robinson and S. Cornelius, is underway to try to determine whether shifts of turtles between Ostional and Nancite occur (evidently *very* rarely), and to evaluate the possible effects of egg harvesting on the Ostional population. The major obstacle continues to be the local population of Ostional—people who have resorted to criminal acts to halt the study. Clearly the most urgent need in sea turtle conservation in Costa Rica is effective protection of the Ostional breeding population at least until the basic studies have been completed, and data are available to permit the designing of a rational plan for exploitation of the eggs (since studies at the essentially undisturbed Nancite beach show that a major proportion of the eggs from early-nesting turtles are destroyed by turtles nesting later in the season, it should be ecologically feasible to harvest many eggs laid early in the season without affecting turtle populations). Legislation to declare the Ostional beach a wildlife sanctuary has been delayed for over two years by partisan politics, jurisdictional disputes, etc. Passage of this legislation would not in itself solve enforcement problems, but it would greatly facilitate channeling funds for this purpose.

Over 100 rural families in different parts of Costa Rica responded to a questionnaire for the National University (UNA) to evaluate the importance of wildlife as food. Two of the six most commonly eaten species were reptiles: iguanas *(Iguana iguana)* and ctenosaurs ("garrobos", *Ctenosaura similis)*. Hunting pressure does not appear to have had a severe effect upon the population of either species so far. Ctenosaurs may be amenable to large-scale captive breeding: a pile of cinder blocks can support a flourishing population! On the other hand, iguanas have been virtually exterminated in some Central American areas (e.g., El Salvador) and their population should be monitored in areas of heavy hunting pressure.

Both species of crocodilians in Costa Rica are listed as endangered, mostly because of the international trade in their hides. At least until the Nicaraguan revolution, a considerable contraband flow of cayman hides from the northern Atlantic slope into Nicaragua is known to have occurred; no hard data are available, and this smuggling has certainly decreased, if not stopped, in the last few years. Although crocodiles in particular are now rare in the northern half of the Atlantic slope, both species maintain sizeable populations in Guanacaste, the Osa Peninsula, and the Sixaola region; perhaps the largest populations, on the Osa, are protected at Corcovado National Park.

No Costa Rican reptile nor amphibian is severely persecuted as a pest. Although poisonous snakes certainly qualify as a hazard in rural life, and are usually killed whenever found, the aggregate effect upon their populations is probably slight. Only the bushmaster *(Lachesis muta)* among the larger species seems restricted to primary forest.

Table IV-6. Endangered Species List and Actual Status. Compiled by Dr. Gary Stiles (1981).

Group and Species	Scientific Name	Actual Status
BIRDS		
Crested Eagle	*Morphnus guianensis*	No definite reports in 20 years; 2 recent sightings require confirmation.
Harpy Eagle	*Harpia harpyja*	Very small population on Osa Peninsula; probably also in Talamancas; extirpated elsewhere.
Solitary Eagle	*Harpyhaliaetus solitarius*	Small population in mountainous regions of Cordillera Central, Osa Peninsula, probably Talamancas.
Black-and-White Hawk-Eagle	*Spizastur melanoleucus*	Rare, wet lowlands to middle elevation on both slopes, now mostly in Osa and Talamancas.
Ornate Hawk-Eagle	*Spizaetus ornatus*	Similar to preceding but perhaps less rare.
Black Hawk-Eagle	*Spizaetus tyrannus*	Uncommon but not rare: forested hilly to mountainous areas, wet lowlands to middle elevation on both slopes.
Orange-breasted Falcon	*Falco deiroleucus*	No reliable records in last 25 years.
Scarlet Macaw	*Ara macao*	Good, probably stable population on Osa Peninsula; a few in Guanacaste.
Great Curassow	*Crax rubra*	Widespread in forest regions; now rare generally except Osa Peninsula.
Jabiru	*Jabiru mycteria*	Population now down to ca. 30-35 birds and evidently still declining.
Quetzal	*Pharomachrus mocinno*	Large, stable populations in most high mountainous areas; not in immediate danger in CR. Adapts well to considerable deforestation.
AMPHIBIANS		
Golden Toad	*Bufo periglenes*	Very local but not rare; virtually entire population within protected area.
MAMMALS		
Giant Anteater	*Myrmecophaga tridactyla*	Extremely rare, even in extensively forested areas.
Margay	*Felis tigrina*	Rare, mountain areas, little known.
Margay	*Felis wiedii*	Very rare, fairly widespread in forest areas.
Mountain Lion	*Felis concolor*	Seldom seen, uncommon to fairly rare overall, more common on Osa Peninsula, Talamancas.
Ocelot	*Felis pardalis*	Now rare in most areas; less rare on Osa Peninsula, in forested mountains.
Jaguar	*Felis onca*	Now rare, limited to large forested areas; most numerous on Osa Peninsula.
Jaguarundi	*Felis yagouaroundi*	Uncommon but by no means rare; adapted to partly deforested areas.
Poás Squirrel	*Syntheosciurus poasensis*	Status unknown; population recently discovered in Talamancas.
Miravalles Squirrel	*Sciurus deppei*	Status unknown, probably rare.
Baird's Tapir	*Tapirus bairdii*	Common on Osa Peninsula and locally in Talamancas; elsewhere uncommon to rare, but by no means in serious danger.
Manatee	*Trichechus manatus*	At best very rare and local, Atlantic slope especially vicinity Tortuguero.
Howler Monkey	*Alouatta palliata*	Common and widespread, able to tolerate much deforestation; not threatened.
Spider Monkey	*Ateles geoffroyi*	Common in most forested areas, lowlands to mid-elevation, good populations in protected areas.
White-faced Monkey	*Cebus capucinus*	Common, widespread, tolerates considerable deforestation; not threatened.
Squirrel Monkey	*Saimiri oerstedii*	Locally common in Pacific SW; adapts well to second growth; not particularly threatened.
Tamarin	*Saguinus geoffroyi*	Has never been definitively recorded from C.R.
REPTILES		
Crocodile	*Crocodylus acutus*	Fairly sizeable populations on Osa Peninsula, Tempisque basin, Sixaola region; rare or extirpated elsewhere.

Table IV-6. (Continued)

Group and Species	Scientific Name	Actual Status
Cayman	*Caiman crocodilus*	Same as preceding, but more common and widespread.
Pacific Ridley Turtle	*Lepidochelys olivacea*	Abundant but under severe pressure at Ostional and elsewhere.
Leatherback Turtle	*Dermochelys coriacea*	Uncommon but not severely threatened.
Green Turtle	*Chelonia mydas*	Total numbers small, but slowly increasing under protection.
Loggerhead Turtle	*Caretta caretta*	Rare.
Hawksbill Turtle	*Eretmochelys imbricata*	Rare to very rare.
	SPECIES WITH REDUCED POPULATIONS	
BIRDS		
All remaining diurnal birds of prey	Accipitridae, Falconidae	Some species declining or rare, others flourishing; probably none as severely endangered as larger eagles, though pesticides and hunting may be affecting Snail Kite, Bat Falcon in particular. Red-throated Caracara also very rare now, only found on Osa Peninsula.
Great Green Macaw	*Ara ambigua*	Has declined drastically on Atlantic slope, due mainly to forest fractionation; evidently must wander or migrate widely to survive, and critical seasonal resources being eliminated.
MAMMALS		
Armadillo	*Cabassous centralis*	Only 1 record for CR; very rare at best.
Grison	*Gallictis allamandi*	Little known, possibly relatively rare.
Olingo	*Bassaricyon gabbii*	Status uncertain.
Cacomistle	*Bassariscus sumichrastii*	Status uncertain.
2-toed Sloth	*Choloepus hoffmanni*	Status uncertain; probably not excessively rare.
3-toed Sloth	*Bradypus griseus*	Locally common; probably not threatened.
*Tepezcuintle	*Cuniculus paca*	Greatly reduced in many areas, but still good populations in some parks.
*Golden Anteater	*Cyclopes didaetylus*	Status uncertain but certainly rare.
*River Otter	*Lutra annectens*	Increasing settlement along Atlantic slope rivers—hunting, fur; considerable reduction.
REPTILES		
Iguana	*Iguana iguana*	Locally reduced but still abundant in mangroves; not severely threatened .
BIRDS		
*Spot-breasted Oriole	*Icterus pectoralis*	Greatly reduced due to cage bird trapping.
*Yellow-tailed Oriole	*Icterus mesomelas*	Very severely reduced due to cage bird trapping.
*Dark-backed Goldfinch	*Spinus psaltria*	Considerably reduced due to cage bird trapping.
*Yellow-bellied Siskin	*Spinus xanthogaster*	Greatly reduced due to cage bird trapping.
*Blue-hooded Euphonia	*Euphonia elegantissima*	Greatly reduced due to cage bird trapping.
*Muscovy Duck	*Cairina moschata*	Hunting pressure, deforestation — severe reductions.

* Species with severely reduced populations but not on Endangered Species List.

Birds

Of the 11 species of birds listed as endangered (Table IV-6) in Costa Rica, seven are large birds of prey (eagles and a falcon). All except the Black Hawk Eagle *(Spizaetus tyrannus)* are moderately to exceedingly rare, but small populations of most species evidently exist in national parks (especially in Corcovado). There are no documented records for Crested Eagles nor Orange-bellied Falcons in Costa Rica in the last 20 years. The total Scarlet Macaw population in Costa Rica is probably on the order of 200-300, with about 10% in Guanacaste (especially Rafael Lucas Rodríguez Refuge and Santa Rosa National Park) and 90% are on the Osa Peninsula (especially in Corcovado). Protection of nests is a problem in Guanacaste: a nest in the heart of the R.L. Rodríguez Refuge (= Palo Verde) was robbed (probably by road-building crew) last year. The Guanacaste population must thus be considered precarious, though the Osa population seems to be secure for the present. Another endangered species, the Great Curassow, once common throughout the lowlands, also appears to be holding its own in such areas as Santa Rosa and Rincón de la Vieja National Parks and is probably increasing in Corcovado since the park was established. Although officially listed as endangered the Quetzal *(Pharomachrus mocinno)* is flourishing in Costa Rica. Viable populations are protected in several large parks and reserves (Monteverde, Chirripó, Poás, Braulio Carrillo) and the species has shown itself able to adapt to fairly extensive deforestation if a scattering of feeding trees and rotten snags for nesting remain. The formerly extensive exportation of Quetzals to zoos and aviaries has been eliminated. The final species officially listed as endangered in Costa Rica is the Jabiru Stork *(Jabiru mycteria)*, which in spite of good breeding success in at least some nests (e.g., Palo Verde) has declined alarmingly in recent years; the total population is probably on the order of 35 birds (J. Sánchez, pers. comm.). The most likely reason for the decline is the draining of many of the Guanacaste lagoons to plant sugar cane and other crops, but pesticide contamination and pot hunting may also be playing a role. These factors will be discussed in turn.

Hunting: Open seasons exist on most gallinaceous species and ducks, tinamous, and several species of pigeons. Approximately 1,000 hunting licenses are issued annually by the Wildlife Department (DVS), of which about half are for small game (including birds). Species most often hunted are Crested Guans, *(Penelope purpurascens)*, Mourning and White-winged Doves *(Zenaida macroura* and *Z. asiatica)*. Band-tailed and Red-billed Pigeons *(Columba fasciata* and *C. flavirostris)*, Black-bellied Tree Ducks *(Dendrocygna autumnalis)*, Spot-bellied Bob-white *(Colinus leucopogon)*, Blue-winged Teal *(Anas discors)*; lesser numbers of tinamous, other cracids, wood quail, and other ducks are also shot. Although there is virtually no enforcement of open season or bag limits (except for Band-tailed Pigeons, which are mostly shot along the Panamerican Highway south of Cartago), and although subsistence hunting by the rural populace is entirely uncontrolled, hunting *per se* does not seem to be having a serious effect upon any Costa Rican birds except the Great Curassow (outside of parks and reserves) and possibly the Muscovy Duck *(Cairina moschata)* and the Crested Guan. Most of these species do well in man-altered habitats; lack of forested areas for nesting may be a problem for Muscovies, but are not for the Band-tailed Pigeons.

Cage Bird Trade: This is a more serious problem, both politically and in terms of its effects on the populations of some bird species. Having a "pajarito" or a "lora" in a cage is an ingrained part of Costa Rican culture, and some of the more highly prized species, e.g., Yellow-headed Parrot *(Amazona ochrocephala)*, Yellow-tailed Oriole *(Icterus mesomelas)*, Dark-backed Goldfinch *(Spinus psaltria)*, Yellow-bellied Siskin *(Spinus xanthogaster)* are quite as entitled to "endangered" species status in Costa Rica as is the Scarlet Macaw (and for the same reasons). Current Costa Rican law permits possession of an unlimited number of cage birds but prohibits their sale or exportation. Although legal exportation of cage birds has virtually stopped, an unknown number, especially parrots, are still smuggled out to Nicaragua and Panamá. Enforcement of the prohibition against selling cage birds is sufficiently lax and spotty that parakeets and parrots and sometimes other species are still openly sold in most public markets, and boys offering nestling parakeets are seen along major Guanacaste highways every nesting season. The DVS has attempted to exert some control by issuing licenses (ca. 1,500 annually) to bird catchers, and confiscating the birds and cages of unlicensed bird catchers, particularly when they try to sell their birds. However, DVS estimate that only 1/3 to 1/4 of all bird catchers bother getting a license, and with only three inspectors for the entire country the chances of getting caught are slight. Moreover, the law makes no adequate provision for the confiscated birds which tend to accumulate in the municipal offices where they receive inadequate care and all too often die. The only real answer to the cage bird problems is better laws, better enforcement, and an intensive program to educate the Costa Rican public (and perhaps captive breeding programs for a few of the more popular and tractable species).

Pesticides: Although the Ministry of Agriculture and Livestock (MAG) has had a team working on a pesticide law for over a year, there has been no legal action, and pesticide use is still entirely uncontrolled. Hard pesticides are used freely: in 1978 alone, Costa Rica imported 22,000 kg of pesticides, including a significant proportion of hard pesticides like DDT, aldrin, dieldrin, malathion, etc. Numerous anecdotal accounts (mass die-offs of birds, fish, snails; birds in the Tempisque River heronries apparently suffering from acute pesticide poisoning) suggest that indiscriminate pesticide and herbicide use is affecting wildlife. Unfortunately, solid factual data are scarce, in large part because only now is a laboratory for analyzing pesticide residues being set up in Costa Rica. There is considerable interest on the part of both local and foreign scientists for monitoring pesticide levels particularly in the Tempisque River and the Nicoya Gulf, critical areas for many of Costa Rica's marine fisheries and sea and shorebird populations. Ironically, in 1980, a number of Brown Pelican eggs taken from the still vigorous Guayabo Island colony and hand-carried to the U.S.A. for analysis by a USFWS employee, were confiscated by the USFWS enforcement branch since the pelican is considered endangered in the U.S.! Thus Costa Rica was deprived of potentially important data on pesticide residue levels in a species known to be extremely sensitive to such contamination. This problem will evidently be solved in the near future. A Center for Analysis of Pesticides is being es-

tablished under the Vicerectory of Research at UCR. The center now has qualified personnel and all the necessary equipment, and hopes to begin an active program of pesticide analysis in early 1982. Adequate laws regulating pesticide use, and accurate information on pesticide residue levels are urgently needed. The conversion of much of Guanacaste (and other areas) to mechanized, large-scale farming of rice, cotton, and sugar cane is still sufficiently recent that early adoption of rational pesticide use policies and practices may prevent the severe effects on such species as pelicans, that were noted in North America, for instance.

In relatively few cases is there cause to regard wild birds as pests in Costa Rica. Black-bellied Tree Ducks are a problem in rice fields in Guanacaste (as they are in many neotropical areas); they graze and trample the young shoots. The only solution so far tried is massive poisoning of the birds, which presents a danger to the ecosystem as a whole; and since the period when the rice is vulnerable to the birds is very short, other less destructive means of preventing such damage should be found—especially since the DVS is attempting to increase productivity of the ducks to provide an additional protein source to local populations (particularly in the form of duck eggs). In any case, under present law the only way a landowner who poisons large numbers of ducks can be prosecuted is for killing them "out of season" or "exceeding the bag limit", both of which are punishable by trifling fines. A few other species are also minor agricultural pests (Bobwhites in bean fields, cormorants in shrimp ponds, kingfishers and herons in *Tilapia* ponds), but the only other relatively serious, widespread problem is the effects of certain parrots *(Pionus senilis, Aratinga finschi)* on corn and certain other crops in parts of the Atlantic lowlands. Part of the problem here lies in the fact that the bird populations themselves are out of control (especially that of *Aratinga finschi)*. Deforestation has removed natural population checks, and agriculture has presented the birds with abundant new resources; drastic measures may eventually be required to solve this problem, but hopefully not before important data can be gathered on the reproduction, movement patterns, and general biology of these birds. Another species engaged in the population explosion, for much the same reasons, is the Great-tailed Grackle *(Quiscalus mexicanus)*. This omnivorous species can be an agricultural pest at times, but the major cause of complaint is its tendency to seek towns, plazas, etc., to form large (and messy, and incredibly noisy) communal roosts. Effective control measures have yet to be devised, and basic biological data on the species in Costa Rica have yet to be gathered.

Although the present system of parks and reserves, if adequately protected, should effectively insure the survival of most of the rich Costa Rican avifauna, it should be noted that this system was not set up according to any coherent master plan of protecting biotic diversity, and certain aspects of this have been neglected. With respect to birds one problem is the high degree of seasonal altitudinal migration of a major proportion of the avifauna. Fully half of the bird species found at 1,000 m in Braulio Carrillo show some degree of altitudinal migration (F.G. Stiles, unpublished data). The avifauna of Finca La Selva, at the base of the last foothills of the Cordillera Central, is enriched seasonally by the visits of up to 30 species of such migrants. A forest corridor from the peaks to the lowlands may be critical to the preservation of migratory routes for many of these species. Such a corridor was contemplated in the proposed extension of Braulio Carrillo national park, but this project had to be abandoned for lack of financing in the 1970's. Accelerating deforestation in this area may make such a corridor impossible in this area within a few years.

Mammals

Sixteen species of mammals are officially given endangered status in Costa Rica: all six species of cats, all four species of monkeys (plus one, *Saguinus geoffroyi*, for which no valid Costa Rican record exists), two rare and poorly-known highland squirrels, and the manatee, tapir, and giant anteater. Information on the present status of many of these species was gathered in a survey of local hunters all over Costa Rica, conducted by C. Vaughan, M. McCoy, and their students at UNA in 1979-1980. Over 500 hunters were interviewed in this survey, which sought to determine which species were encountered in what frequencies, which were still being shot, recent population trends, and which species are or are not able to survive in largely deforested areas. Results indicate that cats show poor ability to adapt to man-altered habitats, and their continued survival depends upon the protection of large areas of forest; the same is generally true of tapirs and the giant anteater. The latter species and the manatee are already extremely rare at best. On the other hand, the monkeys (with the possible exception of the spider monkey) can survive quite well in remnant woodlots, gallery forest, tall second growth, etc., that remain after even quite extensive deforestation; no monkey is truly "endangered" in Costa Rica. Large and healthy tapir populations are found on the Osa Peninsula and in the Cordillera de Talamanca, but elsewhere, even in parks and reserves, tapir densities have been reduced drastically by hunting. Pronounced seasonal population shifts are suspected to occur in large tapir populations, and forest corridors connecting different forest types may be important in maintaining healthy populations.

A related study conducted by the UNA group concerns the use of recent aerial photographs and other data to determine extent and location of forest habitat in Costa Rica. Published figures on species densities will be used to calculate extent of unbroken forest required to support viable populations of various endangered and/or economically important wild mammals. The conclusion will obviously depend upon which density figures one chooses (no studies are available for Costa Rican populations of most species) and how large one assumes a viable population must be. However, given these limitations, it is suggested that for certain species even the present systems of parks and reserves (assuming adequate protection indefinitely, which is clearly unrealistic for forest reserves, at least) may not suffice to guarantee the survival of species like jaguars, ocelots, or the giant anteater. The prime necessity at this point is for studies on as many such species as possible in Costa Rica to provide accurate and applicable data.

Another UNA survey of rural families to determine the importance of wildlife as food has shown that several species contribute major amounts to the rural protein budgets: White-tailed deer *(Odocoileus virginianus)*,

collared peccary *(Dicotyles tajacu)*, common opossum *(Didelphis marsupialis)*, armadillo *(Dasypus novemcinctus)*, and tepezcuintle *(Cuniculus paca)*. All except the last are species that can thrive under extensively man-altered conditions provided woodlots, hedgerows, and second growth continue to exist; just how much exploitation these populations can stand has not been carefully studied, but they seem to be in no danger at present.

The situation of the tepezcuintle is less clear; it seems to be more forest-based than the others, and its population has been greatly reduced by hunting in many areas. Selling tepezcuintle meat is prohibited, but hunting is not; open seasons and bag limits exist only on paper. A few restaurants still openly serve the meat. Programs to reproduce the species in captivity have been haphazard, uncoordinated, and at best only modestly successful. The first reasonably scientific study of the species in captivity, by Y. Matamoros of UNA, has only just been completed; hopefully the application of the findings will significantly improve captive breeding programs, and that this highly esteemed meat may represent a reliable source of protein and farm income in the future.

In general, the importance of forest-requiring species as food in rural areas has declined as forests have receded. Probably most hunting of such species as white-lipped peccary *(Dicotyles pecari)*, brocket deer *(Mazama americana)*, and most cats is now for sport, rather than food *per se*. Some 500 hunters annually obtain licenses to hunt "big game" in Costa Rica; probably at least as many unlicensed hunters are active. As with other species, bag limits and open seasons are at best sporadically enforced. Hunting with dogs is widespread in forest reserves, and sometimes a problem in national parks and other reserves. Although traffic in the hides of cats has ceased on a large scale these animals are still shot as a matter of course whenever encountered by hunters.

Mammal species endemic to Costa Rica are essentially all small highland rodents that vary from supposedly rare and poorly-known forest inhabitants to thriving agricultural pests *(Macrogeomys*, the pocket gopher or "taltusa"). Probably none is currently endangered.

Several wild mammals are agricultural pests in Costa Rica, the most important being gophers in vegetable-growing areas of the central higlands, and cotton rats *(Sigmodon hispidus)* in sugar cane and pineapple plantations, mainly in Guanacaste and San Carlos. Other harmful species include vampire bats *(Desmodus rotundus)* and possibly coyotes *(Canis latrans)*, as well as a variety of native and introduced rodents and lagomorphs. The vampire bat has been studied in detail by Turner (1975), whose findings on movement patterns and host preferences have yet to be vigorously applied in livestock programs. No careful studies of the basic biology of other pest species have been done in Costa Rica, and attempts at control have mostly consisted of haphazard, indiscriminate use of poison. MAG has not supported biological studies of pest species, and in Costa Rica funding and/or employment for biologists wishing to study these species rarely exists. Therefore, the prospects for specific and effective pest control programs that pose the least possible environmental hazards are decidedly poor in the short term.

IV-D. COASTAL & NEAR-SHORE MARINE RESOURCES

Characteristics

Costa Rica has an exceptional geographic position with coasts on the two largest oceans. The very irregular Pacific coast extends for 1,016 km with numerous bays, peninsulas, promontories and estuaries. In contrast, the Atlantic coast of 212 km is quite uniform and lacks the morphological complexity of its western counterpart.

The west coast varies from rocky headlands to sandy beaches, whose form and color have regional differences. The rocky areas are usually platforms of consolidated volcanic rock or loose rocks that are partially exposed at low tide. There are two principal beach types on the Pacific coast: halfmoon and promontory. The former are characteristic of bays and gulfs, usually between two rocky headlands, and are derived from river-carried sediments and nearby sand bars. The less common promontory beach is generally straight and shorter, caused by erosive wave action on exposed rocky areas.

Mangroves are also an especially important feature of the Pacific coast; some 15% of the shore area is in mangroves and associated estuaries. These nutrient-rich waters are the breeding and nursery areas for the majority of commercial fish and shrimp. Coastal mangroves are much less extensive and important on the Caribbean side.

The Pacific continental shelf is more extensive than the Caribbean and with much less slope; the more abrupt Caribbean shelf is partly responsible for the straightness of the country's eastern coast. The Pacific coast has a semi-diurnal tide cycle with two highs and two lows of differing magnitude. Active high tides can exceed three meters. The Caribbean tidal cycle is diurnal with one high and one low tide differing only by centimeters; however, unusual low tides provoke great mortality of exposed coral reefs (Glynn 1968). The tidal fluctuation strongly affects the composition of floristic and faunal communities on both coasts. The littoral flora is richer on the Caribbean side, and the littoral fauna is richer and more abundant on the Pacific side.

Beaches, mangroves, coral reefs and lagoons are the principal coastal habitats. Rocky coasts provide considerable environmental heterogeneity and floral and faunal diversity. The irregular rock surfaces and spaces between rocks support an abundance of sessile and mobile organisms. In addition to their importance for tourists, beaches are another important habitat for a peculiar fauna often associated with the spaces between sand grains. Water trapped in the interstices of sand grains protects the small animals from desiccation by direct sunlight (Dexter 1974).

Mangroves are composed of a particular group of plant species and associated fauna that have specific adaptations for propagule dispersal, the type of substrate, and they handle salinity concentrations appreciably higher than seawater. Mangroves are critical habitat for the reproduction and early development of many marine species for local fisheries, e.g., the Nicoya Gulf.

Coral reefs are limited to the Caribbean coast, particularly around Cahuita point. The Cahuita reef is a typical fringing reef, some 2.5 km long and 1 km wide, covering about 600 ha. In addition to the coral reef community, the Cahuita area also has *Thalassia* (turtle grass), *Sargassum* and sandy communities (Wellington 1974). Despite declaration as a national park in 1970, considerable reef mortality is occurring, probably due to increasing sedimentation from regional rivers (Fig. IV-7).

Coastal lagoons are restricted to the northern Caribbean coast, extending some 120 km north of Limón. They are usually parallel to and just behind the coast and are predominantly fresh water. Narrow bands of mangroves occur near the mouth of canals and rivers; these areas support an important sport fishery for tarpon.

Fisheries

Fishing is a complementary activity of coastal inhabitants that has inhibited significant development of commercial fisheries. Commercial extraction of marine resources is characterized by intensive exploitation of a very few species from well-defined geographic areas. The concept of integrated exploitation is completely lacking, thus there is considerable underutilization of associated species, such as the shrimp by-catch. Utilization of marine resources is seriously affected by the lack of scientific information on exploitable resources. The absence of a central institution responsible for the fisheries sector means that there is almost no policy, coordination, or control of the fishing activities.

Fishing activity is conveniently classified on three levels: artisanal, semi-industrial and industrial. Artisanal fishing is done in small boats (less than 10 m long) and near shore, although some may stay at sea for up to five days. Though artisan fishing occurs on both coasts, it has much greater socio-economic importance on the Pacific, particularly in the Nicoya Gulf. On the Caribbean coast it is primarily concentrated on seasonal catching of lobster and green turtles. Semi-industrial fishing by the shrimp (69 boats) and sardine (12) fleets is done in the 20 km zone of the Pacific in depths less than 100 m. Industrial fishing of tuna in Pacific off-shore waters is done by two vessels (1200 tons); the majority of tuna is exported frozen, rather than canned locally.

Artisanal seine-netting is prohibited in the Nicoya Gulf and in Ballena Bay; however, fishing by line or hand-net is allowed. Tables IV-7 and IV-8 list the fish and mollusks, respectively, frequently captured by artisanal fishermen, as well as the shrimp and sardine catch.

Fishing Organizations

Fishing organizations vary from simple associations to complex chambers and cooperatives. In the industrial sub-sector the most important organization is the Pacific Fishermen's Cooperative (COOPEATUN, R. L.), whose two ships are based in Puntarenas. COOPEATUN's financial operations are endorsed by the government.

The Puntarenas Chamber of Fishermen includes most of the semi-industrial fishing and processing operations for shrimp and sardines. The 69-boat fleet receives government subsidized fuel, that saved them about US$ 1 million in 1981.

The artisanal sector has several organizations of which the more important are the Artisan Fishermen's Chamber and the Fishermen's Cooperative, both in Puntarenas, while the Atlantic Fishermen's Cooperative is dominant on the east coast. The Puntarenas cooperative is the beneficiary of the project "Pacific Fisheries Development Program" financed by the IDB through the Banco Anglo Costarricense. So far the cooperative has 21 fiberglass boats with electronic equipment.

Fish Catches

Beginning in 1966 the annual catch in the Pacific littoral increased significantly, reaching maximum captures in the mid-70's. Since then, total captures have tended to decrease in spite of continued increase in the fleet.

Fisheries exploitation plays an insignificant role in the national economy, although there has been a slight relative increase in the past few years (Chaverri 1980; Villalobos 1981). Fish exports have quintupled, yet fish remain a tiny percentage of total exports. Fish imports represent only about 20% of the national production.

Figure IV-7.—Discharge of sediments into the Pacific Ocean by the Rio Parrita near Quepos. Such high sediment loads are causing serious mortality in near-shore marine communities on both coasts (photo P. Carr).

Table IV-7. Main fish species and crustaceans seized by fishermen in Pacific and Atlantic waters of Costa Rica.

SCIENTIFIC NAME	COMMON NAME	COAST	ABUNDANCE
Carcharhinus leucas	Cazón (sharks)	Pacific	Common
Carcharhinus limbatus	Cazón (sharks)	Atlantic	Common
Sphyrna lewini	Pez martillo (hammerhead)	Pacific	Common
Sphyrna tiburo	Pez martillo (hammerhead)	Atlantic	Common
Ophistopterus ovii	Sardina (sardines)	Pacific	Rare
Albula vulpes	Macabi	Pacific	Rare
Anchoa lucida	Bocona	Pacific	Rare
Anchoa exigua	Bocona	Pacific	Rare
Herengula cluprola	Sardina	Atlantic	Uncommon
Herengula humeralis	Sardina	Atlantic	Uncommon
Opisthonema oglinum	Sardina	Atlantic	Uncommon
Merluccius gayi	Merluza	Pacific	Uncommon
Centropomus unionensis	Mano de piedra	Pacific	Common
Contropomus pectinatus	Gualaje	Pacific	Common
Centropomus undecimalis	Róbalo	Pacific	Common
Centropomus ensiferus	Róbalo	Atlantic	Uncommon
Epinephelus analogus	Mero	Pacific	Common
Pseudopeneus maculatus	Sabroso	Atlantic	Uncommon
Caranx hippos	Jurel	Pacific-Atlantic	Common
Caranx vinctus	Platanillo	Pacific	Uncommon
Hemicaranx atrimanus	Jurelillo	Pacific	Common
Caranx bartholomaei	Jurel	Atlantic	Common
Caranx ruber	Caballa	Atlantic	Uncommon
Selene brevoorti	Palometa	Pacific	Common
Selene peruvianus	Palometa	Pacific	Abundant
Selene vomer	Palometa	Atlantic	Uncommon
Lutjanus guttatus	Pargo (snappers)	Pacific	Common
Lutjanus jordani	Pargo seda	Pacific	Abundant
Lutjanus colorado	Pargo colorado	Pacific	Common
Lutjanus argentiventris	Pargo amarillo	Pacific	Uncommon
Lutjanus novenjasciatus	Pargo negro	Pacific	Uncommon
Lutjanus griseus	Pargo negro	Atlantic	Abundant
Lutjanus mahogoni	Pargo de la mancha	Atlantic	Common
Lutjanus synagris	Pargo de la mancha	Atlantic	Uncommon
Anisotremus taeniatus	Bandera	Pacific	Uncommon
Anisotremus dovii	Cotongo	Pacific	Uncommon
Diapterus rhombeus	Mojarra	Atlantic	Common
Eucinostomus melanopterus	Mojarra	Atlantic	Common
Haemulon flaviguttatum	Roncador	Pacific	Rare
Pammudasys branickii	Roncador	Pacific	Common
Cynoscion othonopterus	Corvina	Pacific	Common
Cynoscion phoxocaphalus	Corvina picuda	Pacific	Uncommon
Cynoscion squamipinnis	Corvina aguada	Pacific	Uncommon
Cynoscion reticulatus	Corvina rayada	Pacific	Common
Isopisthus remifer	Corvina ojona	Pacific	Common
Lamirus effulgens	Corvina ñata	Pacific	Uncommon
Lamirus pacificus	Corvina ñata	Pacific	Uncommon
Micropogon altipinnis	Corvina agria	Pacific	Common
Cynoscion jamaicensis	Corvina cola amarilla	Atlantic	Common
Cynoscion virescens	Corvina rayada	Atlantic	Common
Menticirhus martinicensis	Salmonete	Atlantic	Uncommon
Micropogon furnieri	Corvina	Atlantic	Common
Ophioscion venezuelae	Corvina china	Atlantic	Common
Paralonchurus brasiliensis	Corvina	Atlantic	Uncommon
Brotula clarkae	Congrio	Pacific	Uncommon
Brotula emmelas	Congrio	Pacific	Uncommon
Scomberomorus maculatus	Macarela (mackerel)	Pacific-Atlantic	Common
Thunnus albacares	Atún (yellowfin)	Pacific-Atlantic	Abundant
Thunnus obesus	Atún (bigeye)	Pacific-Atlantic	Abundant
Thunnus alalunga	Albacora (Albacore)	Pacific-Atlantic	Abundant
Katsuwonus pelamis	Barrilete (Skipjack)	Pacific-Atlantic	Abundant
Citharichthys platophrys	Lenguado (sole fish)	Pacific	Uncommon

Table IV-7. (Continued)

SCIENTIFIC NAME	COMMON NAME	COAST	ABUNDANCE
Hippoclossina macrops	Lenguado	Pacific	Rare
Monolene maculipinna	Lenguado	Pacific	Rare
Cyclopsetta guerna	Lenguado	Pacific	Common
Symphurus sechurae	Lenguado	Pacific	Uncommon
Citharichthys sp.	Pez hoja (flat fish)	Atlantic	Common
Cyclopsetta chittenderi	Pez hoja	Atlantic	Uncommon
Syacium micrurum	Pez hoja	Atlantic	Common
Penaeus stylirostris	Camarón blanco (white shrimp)	Pacific	Abundant
Penaeus vannamei	Camarón blanco	Pacific	Abundant
Penaeus californiensis	Camarón café (brown shrimp)	Pacific	Abundant
Penaeus occidentalis	Camarón rosado (pink shrimp)	Pacific	Abundant
Penaeus brevirostris	Camarón rosado	Pacific	Abundant
Solenocera agasizii	Camarón fidel	Pacific	Abundant
Heterocarpus vicarius	Camarón camello	Pacific	Abundant
Panulirus japonicus	Langosta (lobsters)	Pacific	Abundant
Panulirus argus	Langosta	Atlantic	Common (seasonal)

Table IV-8. Main mollusc species under exploitation by artisanal fishermen on the Pacific and Caribbean coasts.

SCIENTIFIC NAME	COMMON NAME	COAST	ABUNDANCE
Anadara grandis	Chucheca (mangrove clam)	Pacific	Rare
Anadara tuberculosa	Piangua (mangrove clam)	Pacific	Abundant
Anadara multicostata	Piangua (mangrove clam)	Pacific	Uncommon
Ostrea iridescens	Ostión (oyster)	Pacific	Common
Mitella speciosa	Mejillón (mussels)	Pacific	Common
Mitella guyanensis	Mejillón (mussels)	Pacific	Common
Modiolus capax	Mejillón (mussels)	Pacific	Common
Tagelus peruvianus	Mejillón (mussels)	Pacific	Abundant
Geloina inflata	Miona (mangrove clam)	Pacific	Common
Protothaca asperrima	Almeja (clams)	Pacific	Common
Donax carinatus	Almeja	Pacific	Common
Megapitaria aurantica	Almeja real	Pacific	Common
Crassostrea rhizophorae	Ostión de mangle (oyster)	Atlantic	Uncommon
Strombus gigas	Cambute (crown shell)	Pacific	Common
Vasum muricatum	Cambute (crown shell)	Pacific	Common
Cittarium pica	Cambute (crown shell)	Atlantic	Common
Octopus vulgaris	Pulpo (octopus)	Pacific	Common
Loligo spp.	Calamar (squid)	Pacific	Common

Principal Factors Limiting Development

Probably the most important limiting factor is the absence of an adequate administrative organization. There is no central agency to set the policy nor to execute programs through specialized dependencies. The existing Office of Fisheries Resources and Aquiculture (DRPA) is just one of numerous dependencies of the complex MAG, thus subordinate to the budgetary restrictions and personnel limitations of the government bureaucracy. The sector is complicated by the direct involvement of other government institutions in fisheries activities, causing severe fragmentation of responsibility.

The lack of reliable scientific information on currently exploited resources, as well as those potentially exploitable, is a major limiting factor. Despite efforts by FAO in the mid-60's and more recent agreements with specific fishermen, the country's marine resources have not been adequately evaluated (Fuertes and Araya 1979). Inability to utilize the captures in an integrated process is also an important limitation.

Mariculture

Intensive exploitation of natural fisheries usually results in a decline in captures of the most important commercial species, such as shrimp and filter-feeding molluscs. This has often stimulated public and private efforts to commercially cultivate the most desirable species. Mariculture is a recent activity in the country. Maricultura,

S.A. has the largest operation (405 ha) raising white shrimp *(Penaeus stylirostris* and *P. vannemei)* in Chomes, on the east edge of the Nicoya Gulf. The construction of rearing ponds was at the expense of an appreciable area of mangroves, with considerable technical problems with the ponds including maintenance of the desired pH. The impacts of this project on the Nicoya estuarine ecosystem are unknown.

Another major project near Playas del Coco by Acuicultura, S. A., involves rearing the freshwater crayfish *(Macrobrachyium rosenbergii)* for export. CODESA, the government's development corporation, is a participant in this project to stimulate mariculture and is developing a program for technology transfer and training extension agents. The commercial rearing of shrimp and crayfish requires considerable investment capital, sophisticated technology and highly specialized technical and scientific personnel, that often limit the success and potential of mariculture in developing countries.

The rearing of filter-feeding bivalves has barely begun in the country. The Pacific coast appears to offer excellent possibilities due to the abundance of highly-productive estuaries (K. Gocke, pers. comm.). Again, the lack of scientific information on the behavior of most of the species and their potential for intensive production is a limiting factor to development. Three clam species *(Anadara grandis, A. tuberculosa, A. multicostata)*, two mussels *(Mitella guyanensis, Modiolus capax)* and an oyster *(Ostrea iridescens)* are currently being investigated for commercial potential on the Pacific coast. The mangrove oyster *(Crassostrea rhizophorae)* is being investigated on the Caribbean coast. To use Japanese technology of suspended platforms for rearing local species in Ballena Bay has interesting possibilities. It is important to emphasize that mariculture of filter-feeding molluscs contrasts drastically with shrimp and crayfish; the former does not require great investments and high technology, plus it is within the reach of rural coastal people.

Pisciculture

The commercial rearing of fish is another component of aquiculture that offers major possibilities for protein production. Fish culture tends to be less costly to establish than shrimp mariculture, and is more readily complementary to traditional agriculture, plus it is relatively independent of fossil fuel energy. Despite an abundance of native species potentially suitable for fish culture, tropical countries invariably choose exotic species such as *Tilapia* and carp because of information available, high yields and adaptability. Recommended species for the country include *Tilapia nilotica, T. mossambica, T. honorum, T. aurea;* guapote, *Cichlasoma managuense* and *C. dovii;* large-headed carp, *Aristichthys nobilis;* herbivorous carp, *Ctenopharyngodon idella;* silvery carp, *Hypophthalmichtys molitrix* and the common carp, *Cyprinus carpio* (Nanne 1976). *Tilapia* hybrids are common, too; the red color hybrids from *Tilapia nilotica* males and albino *T. mossambica* females are particularly attractive to consumers (Nanne 1979).

Fish culture uses two well-known systems: the intensive system concentrates large quantities of fish in a relatively small volume of water, e.g., in floating cages; whereas the extensive system uses ponds or tanks. Growth rate and optimum size are somewhat less with the intensive system. Recent research has concentrated on multiple species or polycultures, such as fish + ducks, fish + shrimp, fish + ducks + shrimp, and fish + clams. The combination of species from different trophic levels permits much greater food utilization and lower costs.

The national program in fish culture is administered by MAG's department of aquiculture and operates from a network of experiment stations. Their efforts involve research, fish nurseries, technical training and technology promotion and transfer.

Coastal Zone

In the past few years the coastal zone has received considerable attention due to recent recognition that the coastal environment is intimately related to the nearby living resources. The effects of abusive utilization of coastal resources are now seen as immediate problems with serious consequences for artisan fisheries. Utilization of coastal zones seems to be characterized by chaotic and uncontrolled development that pays little attention to local resource limitations or environmental fragility. The location of tourist complexes, industrial areas, port facilities, etc., have been in response to local interests and pressures. Increased coastal pollution and demands for coastal recreation have resulted in political concern for the conservation and rational development of coastal resources.

The Costa Rican Institute for Tourism (ICT) shares authority over the coastal zones with the respective municipalities; however, centralized plans and programs for zoning and use of coastal zones do not exist. A 1961 modification to the Maritime Law (No. 116, 1948) extends the maritime zone 200 m inland from mean high tide. The Terrestrial Maritime Zone Law (No. 6043, 1977) divides the 200 m strip into equal public and restricted zones. ICT has naturally concentrated on tourism development, while the municipalities control use of the terrestrial maritime zone through leases in the public section and construction permits in the restricted section.

The municipalities are also legally responsible for controlling use of mangroves, but they have consistently ignored this section of the law. Primarily because of municipal disinterest in mangrove protection, MAG promulgated an executive decree (No. 7210-A, 1977) declaring all mangroves to be in the public zone as a National Reserve. Use permits are granted jointly by the DGF and DRP of MAG.

Though MOPT coordinates port development, primary responsibility for administration and regulation is with INCOP on the Pacific coast and JAPDEVA on the Caribbean. Increases in coastal and marine traffic during the past decade prompted the development of modern, expanded port facilities at Caldera (near Puntarenas) and Moín (near Limón). Other minor ports exist on the Pacific coast (Quepos, Golfito) due to export of bananas and vegetable oil. Port facilities for receiving fish catches are inadequate. Two projects at El Carmen and Cuajiniquil are planned to provide integrated receiving and processing facilities.

The extraction of sand from coastal areas is done primarily by municipalities for road maintenance; it is not a serious environmental problem. The mangroves ecosystem is the coastal ecosystem most severely affected by human activities for saltworks, charcoal, firewood, tannin and shrimp ponds. By 1979, 40% of the country's mangrove forests had been destroyed (Madrigal et al. 1979).

Industrial development of coastal zones has been limited severely by the general absence of concentrated mineral resources. The few industries present on the Pacific coast are limited to the FERTICA fertilizer plant and the small processing facilities for fish and shrimp. FERTICA dumps chemical wastes into the Puntarenas estuary. Fish processing plants also dump wastes directly into the estuary. The major industry on the Caribbean coast is the RECOPE refinery at Moín, where oil slicks frequently occur over large areas of the Moín lagoon and have killed the bordering vegetation. Unfortunately, the MAG-JAPDEVA project to rear fish intensively is only 13 km from the Moín refinery.

Recreation centers are usually established by the private sector in areas of great scenic beauty. The developers tend to ignore important aspects such as road access, health facilities and food availability. Only the Culebra Bay project has integrated development plans. The limited development of tourism centers on the coasts has not led to a significant influx of national or foreign tourists; at least in one sense this has contributed to the attractiveness for scientific tourism in Costa Rica.

Institutions Involved With Fisheries

The institutional framework overseeing the utilization and management of fisheries resources is similar to that prevalent in other Latin American countries. The basic institutional structure is associated with MAG, a government agency without power to make decisions or formulate policy, and subject to budgetary restrictions typical of a bureaucratic organization. Too many institutions are involved with fisheries, with consequent absence of coordination and duplication of efforts. Institutions concerned with the fisheries sector include MAG-DRPA, the National Fishing Commission, ICT, INCOP, JAPDEVA, and municipal governments. See Chapter V-C.

Legal Framework

Marine Hunting and Fishing Law

This law dates to the 1948 founding of the second Republic and sets the general character and definitions of marine fisheries. Explicit regulations concern biotic resources in the terrestrial maritime zone and water pollution. A total of 10 other laws and 15 Executive Decrees refer to specific aspects involving the fisheries sector. The legal framework for this sector needs updating and consolidation to include diverse aspects such as fishing, coastal zoning, mariculture, the new international Law of the Sea and occupational guidelines.

Terrestrial Maritime Zone Law

This recent law (Nº 6043, 1977) assigns vigilance of the 200 m strip behind the mean high tide line to the ICT. Similarly, the law charges the municipalities with looking after legal compliance with relation to administration, tenancy, development, exploitation and use of the terrestrial maritime zone. The law was conceived to regulate tourism and recreation development, leaving undefined the many other aspects of coastal zone use, e.g., mariculture. Because municipal governments are political entities, they lack the technical competence to manage coastal resources or protect the local environment. (See Chapter V-B. for a case example).

Regulation and Stimulation of High Seas Fisheries

This 1981 law defines the fishing characteristics and conditions in the 333 km (200 mile) limit, with the basic idea to protect, conserve and exploit in an exclusive form all the natural resources and riches in the water and sea bed. Basically, the law establishes the conditions under which foreign ships can operate in Costa Rican waters, as well as the requirements Costa Rican ships must meet in order to qualify for tax exemptions on imported fishing equipment.

IV-E. SOILS AND LAND USE

Introduction

Agricultural production has traditionally served as the primary source of national economic development. Increasing agricultural productivity, particularly of export crops, is a key component of the new administration's program to economic recovery. Even modest industrial growth will require adequate raw materials such as foodstuffs, fibers and timber. Costa Rica is favored with some excellent agricultural soils in the fertile Central Valley; however, their high productivity, good fertility, low erodibility and resilience to degradation have misled both nationals and foreigners to assume most of the country has good agricultural soils. This widespread attitude and the subtle, often non-visible deterioration of the country's soil resources seriously threaten the possibility of not only increasing, but sustaining agricultural productivity. The limitations and problems of the country's soil resources and their critical role in the national economy are the focus of this chapter on soils and land use.

Soil Resources

There are only two useful maps showing the distribution of soils in Costa Rica. Both are recent, general maps of scant detail and questionable accuracy. The less-pretentious of the two (Vásquez 1979, see Figure IV-8) portrays 18 distinctive site-category subdivisions (Table IV-9) based upon gross physiography, parent material, landforms and surface geology according to U.S. soil taxonomy (Soil Survey Staff 1975). Additional data on bioclimate (Tosi 1969 and Fig. II-1) complements the general distribution of qualitative site features relating to limitations and utilization of the country's soils.

Vásquez' map appears to have been derived either directly or inferentially from data assembled and presented by Pérez et al. (1978) as a preliminary soils map of Costa Rica at 1:200,000 scale. The more detailed Pérez map shows the presumed distribution of soils at the level of Association or Sub-group. It recognizes 82 Sub-groups in 7 Orders, grouped into 55 Associations in Costa Rica.

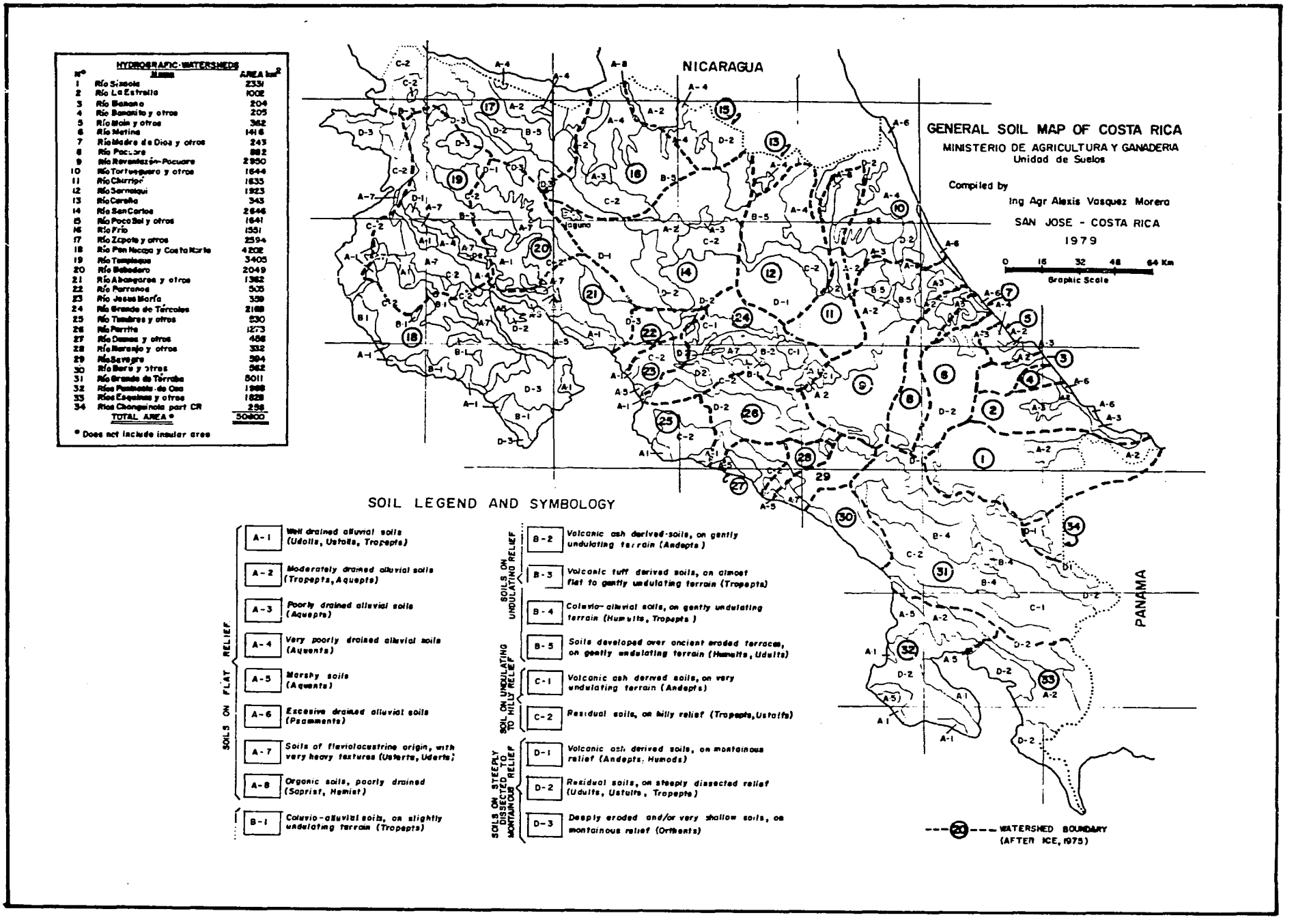

Figure IV-8.—General Soil Map of Costa Rica.

Table IV-9. Areal distribution of Costa Rican soils: Physical site features and sub-orders under the U.S. Soil Taxonomy, after Vásquez (1979).

Map Symbol	Major Site Features	Soil Sub-orders	Area in Km²	Percent
A	SOILS ON FLAT RELIEF		12,076	23.8
A-1	Well-drained alluvial soils	Udolls, Ustalls, Tropepts	2,265	4.5
A-2	Moderately-drained alluvial soils	Tropepts, Aquepts	3,884	7.6
A-3	Poorly-drained alluvial soils	Aquepts	1,021	2.0
A-4	Very poorly-drained alluvial soils	Aquents	2,955	5.8
A-5	Marshy soils	Aquents	519	1.0
A-6	Excessively-drained alluvial soils	Psamments	110	0.2
A-7	Heavy-textured soils of fluvio-lacustrine origin	Uderts, Usterts	1,141	2.2
A-8	Organic soils, poorly-drained	Hemist, Saprists	181	0.4
B	SOILS ON UNDULATING RELIEF		6,835	13.4
B-1	Coluvio-alluvial soils on slightly undulating terrain	Tropepts	586	1.2
B-2	Volcanic ash-derived soils on gently-undulating terrain	Andepts	219	0.4
B-3	Vocanic-tuff-derived soils on gently undulating terrain	Tropepts	1,342	2.6
B-4	Coluvio-alluvial soils on gently-undulating terrain	Ustults, Tropepts	859	1.7
B-5	Soils developed over ancient eroded terraces on gently-undulating terrain	Udults, Humults	3,829	7.5
C	SOILS ON UNDULATING-TO-HILLY RELIEF		10,427	20.5
C-1	Volcanic ash-derived soils on very undulating terrain	Andepts	1,602	3.2
C-2	Residual soils, on hilly relief	Ustalfs, Tropepts	8,825	17.3
D	SOILS ON STEEPLY DISSECTED TO MOUNTAINOUS RELIEF		21,493	42.3
D-1	Volcanic ash-derived soils on mountainous relief	Andepts, Humods	6,413	12.6
D-2	Residual soils on steeply-dissected relief	Humults, Ustults, Tropepts	13,156	25.9
D-3	Deeply eroded and/or shallow soils on mountainous relief	Orthents	1,924	3.8

The work is interpretive, transposing disparate nomenclatures and varying degrees of classificatory detail and map scale into a single composite map. Apparently, many areas were interpolated without field studies. As the authors explicitly recognize, the map is merely the first step in developing a detailed and more accurate national soils map.

Agricultural Soils. A rough estimate of the distribution of Costa Rican soils can be calculated from the Vásquez map (Fig. IV-8) and related empirically to agricultural potential from general edaphic, physiographic, and bioclimatic characters (Table IV-10). Five major land use capability classes are postulated (Tosi 1981), with clean-tillage being the most stringent in its requirements for soil quality, followed by pasture, permanent crops, forestry, and absolute protection in descending order. Higher classes permit lower uses as alternatives but not *vice versa.*

Only 9,437 km² (19%) are of a quality suitable for permanent production of clean-tilled field crops. This is an optimistic figure because no discount has been made for smaller, interspersed areas of poor drainage, or for very high rainfall areas that may limit this use despite favorable topography or high soil fertility. Most of the land in this highest class could be utilized for mechanical cultivation and there is little or no hydric erosion hazard on some 7,290 km² of land in the flat (A) topographic classes. (Wind erosion is another matter.)

The A class lands include those mapped as well- to moderately well-drained alluvial soils, fluvio-lacustrine but heavy-textured soils, coluvio-alluvial volcanic ash-derived soils, and volcanic tuff-derived soils on gently undulating terrain. These lands range climatically from *sub-humid* to *perhumid* and include most of the currently cropped and pastured areas on both the Pacific and Caribbean coastal plains as well as in the Central Valley. The 9,437 km² of class A soils are equivalent to only 0.42 ha per capita of the country's present population: this figure will be halved in approximately 22 years.

Lands in the next lower class have soils and site conditions that under intensive appropriate management will support permanent productive grazing of livestock without unacceptable soil degradation. This amounts to only 4,656 km² (9%); when added to the preceding class, it gives a total of 28% of the national area in the two highest land capability classes. Many of the second-class lands can be productively utilized for permanent crops as an economic alternative to pasture, but they are not suitable for clean tillage due to moderate to high erosion risk or to poor drainage conditions.

Pasture lands (in 1980) occupied close to 19,000 km² (37%) of the national territory (Fig. IV-16), while about 2,250 km² (4%) were devoted to clean-tilled crops, including bananas and sugar cane. Apparently large areas suitable for clean-tillage are currently under-utilized as pasture for livestock. This area may amount to as much as 7,187 km², equivalent to 76% of the best land. The opportunity exists for major increases in crop production simply by converting the pastures on class A lands to crops. Such a conversion may be necessary eventually.

Intermediate quality soils suitable for permanent crops such as coffee, cacao, citrus, macadamia, pejibaye, harvested forage, or timber plantations cover 8,158 km² (16%). These lands tend to be located in areas of high erosion risk due to topography and high precipitation. Other limiting factors may be poor or excessive drainage, low fertility combined with high levels of toxic aluminum, and superhumid climate. Otherwise, these soils have good to excellent physical structure and are capable of good yields from climatically-adapted plant species under careful management. A permanent, undisturbed ground cover providing high levels of surface organic matter is ordinarily requisite to crop management. This soil-conserving requirement excludes all grazing practices or the use of ground-breaking instruments of cultivation. Perhaps half of these lands are marginal for intensive commercial crops; they are best-suited to semi-subsistence, small farm enterprises such as agroforestry. Most of these lands are currently utilized as extensive pasture and include some of the most seriously-eroded soil in the country.

For all agricultural pursuits including grazing and tree plantations, about 22,251 km² (44%) are available. The 19,000 km² of pastures already occupy 85% of these lands, equivalent to slightly less than one hectare per capita of the present population. The total area and productive capacity of many soils are being reduced due to site degradation. Less than one half of this current land area will be available per capita in about 22 years when the nation's population will have doubled.

Forest Soils. Lands suitable only for permanent production of timber and other forest products cover 16,088 km² (32%). A wide range of physical sites is included in this total, ranging from poorly-drained lowlands plains in high rainfall areas to mid and upper plateau and mountain regions. The areas are characterized by soils of low to very low inherent fertility, often of high acidity combined with aluminum toxicity, high to very high rainfall, and moderately-steep to steep slopes. The high erosion risk during and after conversion to other land uses is the most compelling reason for limiting use to natural forests, where timber exploitation requires special techniques to avoid an unacceptable degree of soil erosion and stream sedimentation.

Lands in this class have been extensively deforested for conversion to pasture over the last two decades (Fig. IV-9). Given modern professional forest management these forest lands could make a major and lasting contribution to industrial development in Costa Rica (Tosi 1971). However, this option will soon be lost due to the accelerating loss of natural forests and associated soil qualities needed to sustain forest production. Extensive grazing practices on these lands are particularly destructive to soil and vegetation resources, leading to rapid site degradation. A few years after initial clearing, neither grazing nor forestry is economically possible, while the nation's watersheds continue to be degraded. Public and political awareness of this problem is very weak, while politically strong private and institutional vested-interest groups are opposed to interference with the *status quo.* For such reasons political incentives to take adequate remedial action scarcely exist.

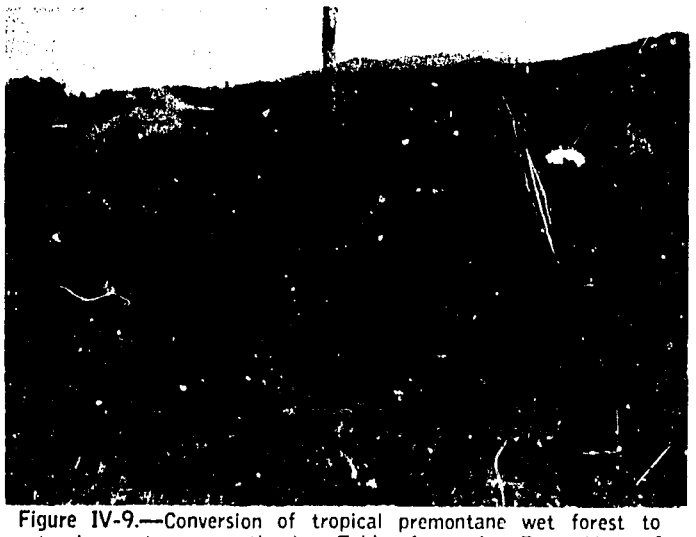

Figure IV-9.—Conversion of tropical premontane wet forest to extensive pasture near the Las Tablas Protection Zone. Most of the timber is burned (note the smoke in distance) during the conversion process. Pasture carrying capacity decreases rapidly during the first few years, often leading to abandonment of the land (photo G. Hartshorn).

Protection Areas. It is often difficult to draw a line between those lands suitable for sustained-yield forestry and those requiring absolute protection. Given the present inadequate public and private concern for soil conservation and watershed management, it is probably better to err on the side of caution. Lands held in reserve from all uses may always be opened to forestry at a later time, if and when higher timber prices make the necessary, but costly, non-destructive extraction techniques economical.

Much of the land in this category has an unacceptably high degree of erosion risk due to steep and often shallow mountain soils in areas of very high rainfall. Most of these lands are in the true *rain forest* life zones; smaller areas represent swampy and marshy lands, rock outcrops, and beach sands. The total area (Table IV-10) in this protection class has probably been underestimated because of scattered units that are too small to have been mapped individually. Even so, the total area is startling: 12,491 km² (24%) of the national territory. This is an area almost equivalent to the land in the two highest agricultural classes.

These protection lands do not ordinarily support a forest of direct economic value due to the adversity of the site for tree growth. Even in those cases where they do —or did as in the case of coastal mangroves— their biological importance for maintenance of other economic or socially-important ecosystems (e.g. marine fisheries, hydroelectric networks, irrigation works, potable water systems) represent an opportunity cost far exceeding any small, short-term economic gains that might be achieved through logging, slash and burn agriculture, or extensive grazing.

Most of these protection lands are still undisturbed or are only beginning to be exploited. Given the imminent exhaustion of native wood supplies from lands in the higher-use classes, there is growing interest in timber exploitation from lower quality areas still in forest, including the forest reserves, biological reserves and even national parks.

Speculators operate within antiquated but still current laws for settlement of the public domain. Political pressure to open up the so-called "unused" lands of the nation are leading to tenure patterns that will make restrictions on exploitation of such lands increasingly difficult to enact or to enforce. Because these lands constitute critical portions of the major catchments, a water and energy crisis is in the offing unless present trends can be reversed.

Land Utilization and Soil Resource Depletion

Under original conditions of undisturbed forest vegetation, Costa Rican soils suffered no significant destruction or unfavorable alterations. Natural catastrophes were repaired by normal biological and chemical processes over time. But natural forests converted to inappropriate land uses can leave some soils totally degraded and therefore unproductive. Although little quantitative data exist to gauge the degree and rate of soil resources depletion, direct evidence is visible in sections of the country (Fig. IV-10). The phenomena are closely-linked to inappropriate land use practices. Some principal classes of depletion and their principal consequences are:

Class I: total loss of the soil body by *mass-wasting* and *landslides* on steeply-sloping land; permanent loss of productive area.

Class II: progressive loss of the soil body by surface *sheet, rill* and *gully erosion*, or by *wind erosion* over all parts of the exposed soil.

Class III: *lateral* or *fluvial erosion* of streambanks and *scouring* and *stream bedload deposition* on adjacent alluvial plains and terraces by overflowing streams and rivers.

Class IV: *elimination of soil* use by urban and suburban encroachment.

In addition to these destructive processes, soils are also degraded physically, biologically, and chemically. Deterioration may take place due to inappropriate land use, e.g., cropping or grazing forest or protection-class soils, or due to improper land use practices, such as exploitative and destructive logging, burning of vegetation and ground litter, over-grazing on too-steep slopes or on saturated soil, operation of heavy machinery on compactable or saturated soils, blade-windrowing of vegetation and topsoil, application of persistent or highly toxic chemicals, soil sterilization, fertilization, or improper irrigation.

Finally, soil development is a naturally slow process that includes a continuing and highly specific interrelationship with complex communities of natural vegetation and associated animal life. Changes in the structure of the biotic community by removal of the diverse life forms and replacement by monoculture can lead to a deterioration in soil quality.

Soil Losses by Destructive Processes. No formal national studies have been undertaken to assess the rate, character, location or quality of soil losses. Arscott (1978) estimates one-third of the country's land surface showed severe soil erosion and another third was undergoing more subtle forms of erosion and increased flooding. The Costa Rica Electricity Institute (ICE) has collected data

Table IV-10. Estimated use-capability and hydric erosion risk for Costa Rican soils based upon general site factors, including bioclimate, after Vásquez (1979) and Tosi (1969, 1972).

Hydric Erosion Risk	MAJOR LAND USE CAPABILITY CLASS										
	Clean-tilled Crops		Pasture		Permanent Crops		Forestry		Protection		All Land
	Soil	Area Km²	Soil	Area Km²	Soil	Area Km²	Soil	Area Km²	Soil	Area Km²	
Nil or Very low	A-1 A-2 A-7	2,265 3,884 1,141	A-3	1,021	A-6	110	A-4	2,955	A-5 A-8	519 181	
Subtotal Very low or Nil		7,290		1,021		110		2,955		700	12,076
Moderate	B-1 B-2 B-3	586 219 1,342	B-4	430	B-4	429	B-5	3,829			
Subtotal Moderate		2,147		430		429		3,829		0	5,835
High to Very high			C-1 D-1	1,602 1,603	C-2 D-1	4,413 3,206	C-2 D-1	4,412 1,603			
Subtotal High to very high		0		3,205		7,619		6,015		0	16,839
Extremely high							D-2	3,289	D-2 D-3	9,867 1,924	
Subtotal Extremely high		0		0		0		3,289		11,791	15,080
Land Use Total		9,437		4,656		8,158		16,088		12,491	50,831

Figure IV-10.—Numerous landslides following deforestation of tropical premontane rain forest in the Río Pacuare watershed. Pasture use of such steep slopes in high rainfall areas greatly accelerates the erosion process (photo J. Tosi).

on stream discharge of sediments into Cachí and Arenal reservoirs and has measured sediment loads in several watersheds important to hydroelectric power development, but these data do not illuminate soil erosion processes. ICE hydrological measurements are faulted for lack of consideration of bedload and of flood-peak sediment loads (see chapter IV-G) and not all eroded soil is deposited in or is moved directly to the surface drainage system.

Studies undertaken for ICE by the Tropical Science Center (1973, 1975, 1977, 1979) estimate erosion rates in the Arenal, Corobicí, and Boruca catchments. Erosion losses under different types of land use and vegetation cover undergoing traditional farming and ranching practices in the Arenal catchment are compared with published field measurements on similar soils in Chinchiná, Colombia; Smithfield, Jamaica; and Turrialba, Costa Rica. It was concluded that Wischmeier and Smith's (1961) Universal Soil Loss Equation (USLE) gives reasonably accurate estimates of soil losses under tropical conditions when USLE-formula values for R, K, C, and P are keyed to the Holdridge Life Zone System (TSC 1980).

The Arenal catchment is predominantly *Premontane wet* and *rain forest* life zones characterized by mostly volcanic Inceptisols (Andepts) that have low to medium erosivity (K-factor = 0.25). Prevalent land uses and soil covers in the Arenal catchment gave the following average annual soil losses in metric tons/ha: undisturbed natural forest—1.4; permanent crops—18.2; improved pasture—109.0; and annual crops—840.0.

These values approximately double if the soil erosivity factor is high (K = 0.57), as it is for many Ultisols and shallow Inceptisols elsewhere in the country, or if the rainfall erosion-intensity index (R factor) doubles, as it does in superhumid *(rain forest)* life zones. If both factors double, soil losses for equivalent degrees of ground cover and land use technology will be as much as four times those stated above. Correspondingly lower values for hydric erosion can be expected in the humid *(moist forest)* and sub-humid *(dry forest)* life zones. However, in the latter, wind tends to become an important erosive agent on non-irrigated, clean-tilled land.

No value has as yet been derived using this formula for unimproved pasture (Fig. IV-11), upon which extensive grazing is traditionally practiced in Costa Rica. This is because the USLE formula makes no provision for the mechanical effects of animals applied directly to the soil,

Figure IV-11.—Extensive gullying in pasture in San Carlos. Even on gentle slopes in high rainfall areas, cattle tracts continue to erode (photo J. Tosi).

as in trailing, slope-climbing and trampling. A conservative estimate for the combined hydric and animal-caused erosion on pasture lands in *wet forest* life zone climatic conditions might be between 400 and 800 metric tons/ha/year.

The preceding figures are for Class II erosion alone (see p. 55). They do not include losses due to Class I erosion, i.e., to mass-wasting and landslides (see Fig. IV-10). Such losses do not occur predictably on an annual basis or on any specific area of land. They are linked in part to the nature of the soil itself, the interface between the soil body and the parent rock beneath, loss of the forest root mat and, especially the degree of slope. Instability may increase over time, to be triggered by an earth tremor (e.g. Garwood et al. 1979), rain storms of long duration with total soil and subsoil saturation (e.g. Hartshorn et al. 1981), cattle movements, or by heavy machinery or blasting operations nearby. While landslides are nature's way of equalizing slope instabilities due to the geological erosion process, injudicious extension of economic activities into areas prone to landslides have precipitated them and magnified their consequences.

Location, Areal Extent, and Relative Severity of Soil Erosion. The loss of soils by hydric erosion has not received appropriate attention by GOCR or private institutions. A provisional estimate of erosion losses has been attempted for the purposes of the present Country Environmental Profile (Table IV-11). Data from Tables IV-9 and IV-2; Figure IV-8; the Watershed Map of Costa Rica (ICE 1974); an unpublished map of Actual Land Use at 1:200,000 scale prepared by SEPSA (1981); IGN topographic maps, aerial photographs and satellite imagery; and recent field observations in many rural areas of the country are the basis for hydric erosion estimates (Table IV-11). The area of soils in each site-soil class was determined for each individual watershed and, in reference to actual land use plus its presumed historical development, assigned on a proportional basis to one of four general classes of erosion severity. The data are then summarized for both Caribbean and Pacific drainages and for the country at large, excluding offshore islands. It is suggested that the regional summaries and the national figures portray the existing situation with a reasonable degree of accuracy.

The four classes of erosion severity are broad ones, each embracing a considerable range of erosion possibilities. They are detailed as a footnote to Table IV-11 but can be generalized as:

A. *No significant erosion* from water but some wind erosion possible in seasonally dry climates on exposed soils;

B. *Light to moderate sheet, rill* and occasional *gully erosion* or *fluvial erosion* in limited areas;

C. *Severe erosion* with surface horizon truncation and frequent or scattered deep gullies and occasional small landslips; or severe *fluvial erosion;*

D. *Extreme erosion* with exposure of subsoil or parent material over large areas; or stream terraces obliterated by *fluvial erosion.*

Table IV-11 shows that 58% of all Costa Rican soils present no significant erosion, 24% have light to moderate erosion, 14% are severely eroded, and 3% are virtually useless economically because of soil destruction by erosive processes. At first glance, these figures suggest that matters may not be too bad after all, but much of the currently uneroded land either consists of flat-lying plains with little or no erosion potential or still remains in primary forest. Of the currently utilized rural land area (about 60% of the country), nearly all that is in steep, hilly areas is eroded to some degree and much of this erosion has occurred in less than 30 years.

A number of general observations can be extracted from Table IV-11 regarding the location, extension, and severity of soil erosion losses in the country.

(1) The most serious and widespread erosion is encountered in the Pacific drainage system, that occupies 27,107 km^2 (53%) of the country. Almost 30% of this area is either severely or extremely eroded, while another 30% is lightly to moderately eroded. On the Caribbean side only 5% of 23,724 km^2 is severely or extremely eroded and 18% lightly to moderately eroded, leaving 77% with no significant erosion, in contrast to only 41% on the Pacific side.

(2) These very significant differences reflect a more widespread, longer and more damaging form of human settlement on the Pacific side of the country, where more erodable soils and more erosive rainfall patterns occur. The Spanish cultural affinity for cattle ranching has been favored by the alternating, seasonally wet-dry Pacific rainfall regime (Parsons 1976). The dry season favors establishment and easy maintenance of grassland by annual burning. Pacific rainfall also has greater

Table IV-11. Estimated degree of hydric erosion of Costa Rican soils, by general soil-site category (Vásquez 1979), in square kilometers and percent of total area affected (Tosi, 1981).

Soil-site Category (b)	DEGREE OF EROSION[a]								
	A		B		C		D		
	Area Km²	%	Area Km²	%	Area Km²	%	Area Km²	%	Total Area Km²
	CARIBBEAN WATERSHEDS								
A-1	—		—	0.0	—	0.0	—	0.0	—
A-2	2,498	95.8	99	3.8	10	0.4	—	0.0	2,607
A-3	1,021	100.0	—	0.0	—	0.0	—	0.0	1,021
A-4	2,379	100.0							2,379
A-5	—		—		—		—		—
A-6	110	100.0							110
A-7	—								—
A-8	181	100.0							181
A-Total	6,189	98.3	99	1.6	10	0.1	—	0.0	6,298
B-1	—		—		—		—		—
B-2	—		—		—		—		—
B-3	221	82.2	43	16.0	5	1.8	—	0.0	269
B-4	—		—		—		—		—
B-5	2,137	55.8	1,371	35.8	310	8.1	11	0.3	3,829
B-Total	2,358	57.6	1,414	34.5	315	7.6	11	0.3	4,098
C-1	39	81.2	6	12.5	3	6.3	—		48
C-2	373	24.8	917	60.9	180	12.0	36	2.3	1,506
C-Total	412	26.5	923	59.4	183	11.8	36	2.3	1,554
D-1	3,024	71.8	952	22.6	181	4.3	55	1.3	4,212
D-2	6,212	82.8	978	13.0	292	3.9	19	0.3	7,501
D-3	61	100.0							61
D-Total	9,297	79.0	1,930	16.4	473	4.0	74	0.6	11,774
Atlantic Total	18,256	77.0	4,366	18.4	981	4.1	121	0.5	23,724
	PACIFIC WATERSHEDS								
A-1	1,937	85.5	267	11.8	61	2.7	—	0.0	2,265
A-2	1,154	90.4	97	7.6	20	1.6	6	0.4	1,277
A-3	—		—		—		—		—
A-4	576	100.0							576
A-5	519	100.0							519
A-6	—		—		—		—		—
A-7	1,095	[illegible]	46	4.0					1,141
A-8	—		—		—		—		—
A-Total	5,281	91.4	410	7.1	81	1.4	6	0.1	5,778

Table IV-11. (Continued)

	Area Km²	%	Area Km²	%	Area Km²	%	Area Km²	%	Total Area Km²
B-1	339	57.8	221	37.7	26	4.5	0	0.0	586
B-2	29	13.2	176	80.4	14	6.4	0	0.0	219
B-3	152	14.2	867	80.8	54	5.0	0	0.0	1,073
B-4	147	17.1	534	62.1	137	15.9	41	4.9	859
B-5	—		—		—		—		—
B-Total	667	24.4	1,798	65.7	231	8.4	41	1.5	2,737
C-1	451	29.0	705	45.4	299	19.2	99	6.4	1,554
C-2	1,084	14.8	2,577	35.2	3,049	41.7	609	8.3	7,319
C-Total	1,535	17.3	3,282	37.0	3,348	37.7	708	8.0	8,873
D-1	1,206	54.8	676	30.7	249	11.3	70	3.2	2,201
D-2	2,056	36.4	1,419	25.1	1,627	28.8	553	9.7	5,655
D-3	435	23.3	454	24.4	784	42.1	190	10.2	1,863
D-Total	3,697	38.0	2,549	26.2	2,660	27.4	813	8.4	9,719
Pacific Total	11,180	41.2	8,039	29.7	6,320	23.3	1,568	5.8	27,107
COSTA RICA — ALL WATERSHEDS-MAINLAND									
A-1	1,937	85.5	267	11.8	61	2.7	0	0.0	2,265
A-2	3,652	94.0	196	5.1	30	0.7	6	0.2	3,884
A-3	1,021	100.0	—		—		—		1,021
A-4	2,955	100.0	—		—		—		2,955
A-5	519	100.0	—		—		—		519
A-6	110	100.0	—		—		—		110
A-7	1,095	96.0	46	4.0	—		—		1,141
A-8	181	100.0	—		—		—		181
A-Total	11,470	95.0	509	4.2	91	0.8	6	-0.1	12,076
B-1	339	57.8	221	37.7	26	4.5	—		586
B-2	29	13.2	176	80.4	14	6.4	—		219
B-3	373	27.8	910	67.8	59	4.4	—		1,342
B-4	147	17.1	534	62.2	137	15.9	41	4.8	859
B-5	2,137	55.8	1,371	35.8	310	8.1	11	0.3	3,829
B-Total	3,025	42.4	3,212	48.6	546	8.2	52	0.8	6,614
C-1	490	30.6	711	44.4	302	18.8	99	6.2	1,602
C-2	1,457	16.5	3,494	39.6	3,229	36.6	645	7.3	8,825
C-Total	1,947	18.7	4,205	40.3	3,531	33.9	744	7.2	10,427
D-1	4,230	66.0	1,628	25.4	430	6.7	125	1.9	6,413
D-2	8,268	62.8	2,397	18.2	1,919	14.6	572	4.4	13,156
D-3	496	25.8	454	23.6	784	40.7	190	9.9	1,924
D-Total	12,994	60.4	4,479	20.8	3,133	14.6	887	4.1	21,493
Costa Rica Total	29,436	57.9	12,405	24.4	7,301	14.4	1,689	3.3	50,831

[a]A: No significant erosion from running water (wind erosion possible in some cases).

B: Light to moderate erosion: symptoms of sheet and rill erosion visible, gullies absent or scarce.

C: Severe erosion: abundant small gullies and deep tracks in pastured land, small landslips and occasional gullies, B-horizon exposed.

D: Soils nearly destroyed or deeply truncated with exposure of subsoil in many places, abundant deep gullies, landslips, and occassional massive landslides.

[b] After Figure IV-8 and Tables IV-9 and IV-10.

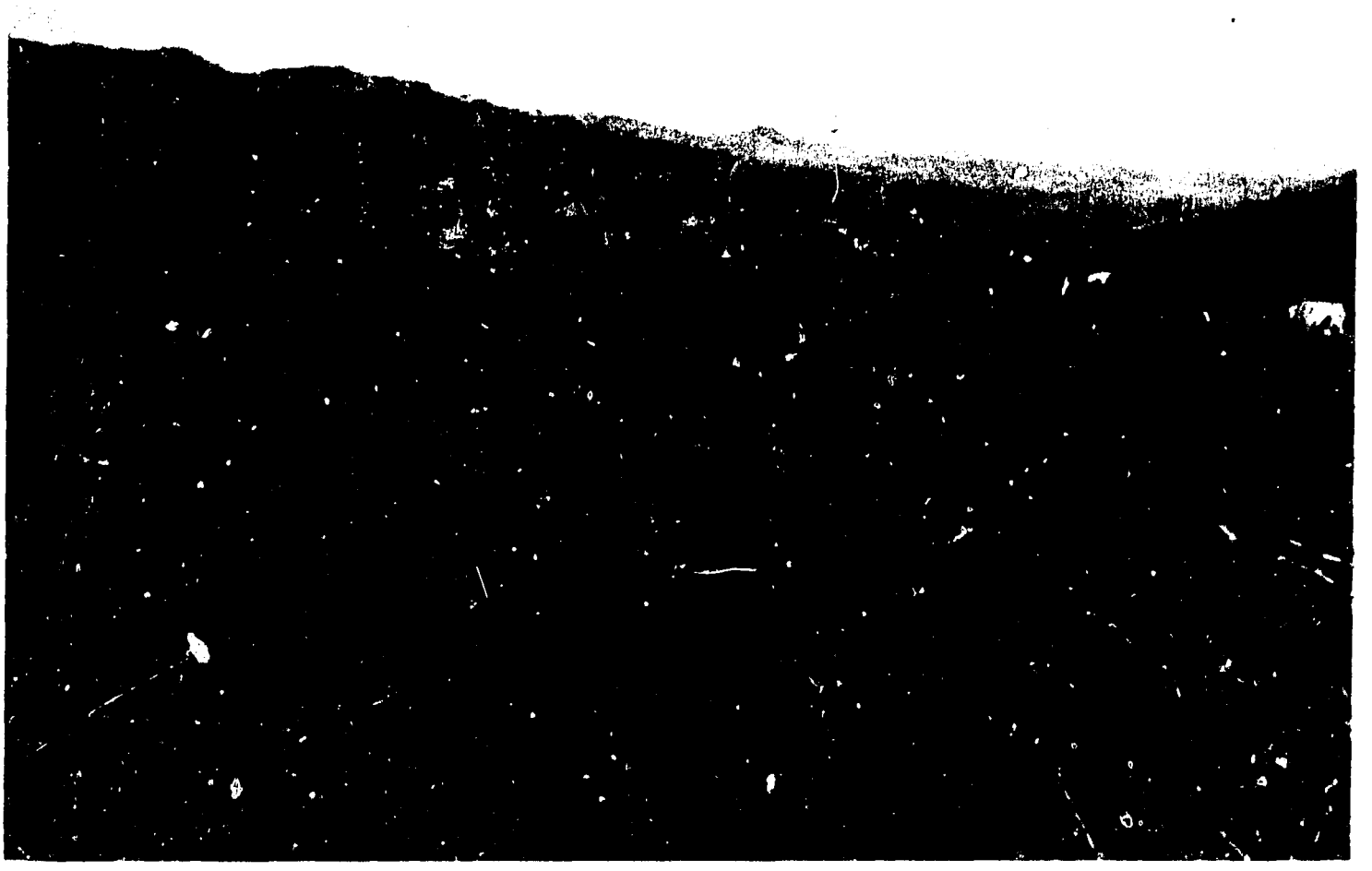

Figure IV-12.—Completely deforested Pacific slopes of the Cordillera de Tilarán. Extensive grazing of slopes exceeding 100% degrades the land making it unsuitable for economic reforestation (photo J. Tosi).

erosive potential, being concentrated in a shorter period of the year. Soils of the Pacific region are mostly mature to over-mature residual clays with low permeability and absorbancy. They are not particularly deep and tend to have high erosivity indices.

(3) The Caribbean region without a pronounced dry season has been less attractive historically to settlement, especially in its superhumid mountain areas (see III-A Cultural Aspects). An appreciable proportion of these lands remain even today in undisturbed forest: 79% of the soils in Vásquez' mountainous relief class (D) are still uneroded. On the somewhat less humid, lower-lying hills and plains, where pastures are now being established, year-round moisture fosters exuberant grass growth and inhibits fire. In the well-tended pastures of the plains and low hills, undergrazing of the grass developed under the year-round rainfall defies burning and insures retention and protection of organic matter. Pasturing of steep mountain slopes causes soil compaction and increased runoff.

(4) Slope-grazing in the Pacific region is the rule rather than the exception (Fig. IV-12). Demand for pasture is high due to the scarcity of flat-lying and low-slope land (31% on the Pacific as opposed to 44% on the Caribbean). Over-grazing and unrestricted ranging of animals is common practice, contributing to high rates of erosion, landslides, and other forms of soil damage including compaction. The strongly-held, traditional practice of dry season burning conveniently eliminates non-palatable woody stems from the previous wet season regrowth. It also removes the soil-nourishing organic matter and the ash is blown away by the dry season winds or is washed downhill in the first heavy downpours of the next rainy season. Early, seasonal rains may be particularly damaging to mineral soils exposed between bunchgrass pedestals before new grass growth can extend a partially-protective cover.

Table IV-11 indicates the severity of the present situation in the Pacific region: 75% of all low slope (class B) land is eroded to some degree, 10% is severely or worse; 83% of all hilly land (class C) is eroded to some degree, with 38% severely eroded and 8% extremely eroded; mountainous relief (class D) areas do not appear to be so bad as C class. An appreciable area of primary forest still exists in large national parks and forest reserves and on inaccessible upper slopes and ridges.

(5) Not even the flat-lying (class A) lands have been immune to erosive processes in the Pacific region: 9% of these lands have suffered some degree of soil erosion,

much of it in Class III *(Lateral fluvial erosion)*. The flat-lying well-drained (A-1) and the moderately-drained (A-2) alluvial soils seem susceptible to wind erosion. Dry season winds carry soil on clean-tilled fields, particularly in the *Tropical dry* and *moist forest* life zones of Puntarenas and Guanacaste provinces. Lateral erosion, scouring, and bedload deposition are due to overflowing rivers: Tempisque, Barranca, Bebedero, and Abangares plus several smaller rivers on the Nicoya Peninsula. In 1971 the Barranca river overflowed causing bedload movements plus over 500 landslides, as well as destruction of the ICE hydroelectric power station at Nagatac that has never been replaced.

The Bebedero river system includes the major part of the proposed "Moracia" irrigation project in Guanacaste. Project planners and developers have inadequately considered the potential sedimentation and major economic losses that will result if the Arenal watershed continues to be degraded.

The coluvio-alluvial soils on gently undulating terrain (B-4), principally in the El General valley used for extensive grazing, are already highly eroded. Land use capability classification would place these lands in intensive (improved, rotation) pasture use at best, or preferably in permanent crops. Lands in the B-5 class (principally Ultisols) have been in grazing use for less than 30 years but are potentially as erodable as those in the B-4 class. Both classes will contribute enormous sediment loads to the proposed Boruca reservoir unless land use will be controlled.

The most serious soil erosion is encountered on lands in the C class, those with undulating to hilly relief; these 10,427 km² (21%) are largely concentrated in the Pacific region. Only 19% of these lands is currently free of significant erosion, while 41% (4,275 km²) is either severely or extremely eroded. Pastures continue to expand at the expense of natural forest in precisely these areas. Especially affected are the C-2 residual clay soils on mostly steep, hilly relief. These soils are widespread throughout the Pacific region and occur mostly in perhumid *(wet forest)* life zones with alternating wet and dry seasons. Though rated as suitable only for permanent crops or forestry (Table IV-10), nearly all are over-utilized as extensive pastures. Soil conservation programs should be oriented to harmonizing actual with recommended land use in this class (Fig. IV-8).

Lands with mountainous relief (class D) have been subjected to less interference, but they are under increasing pressure from small farmers and the cattle industry. The present balance between non-eroded (60%, 12,994 km²) and eroded (40%, 8,499 km²) land reflects the actual ratio of forested to deforested area. Virtually all the land deforested in this class is in pasture, but a sizeable part of the pastured area is utilized by the dairy industry in cooler, upper-mountain climates. Erosion is less severe with the dairy industry in spite of high rainfall and generally steep slopes. Nevertheless, 19% of the land in this class is severely eroded and threatens water resources. Most of the serious erosion is again located in Pacific watersheds.

Soils Losses by Elimination. Obviously, the preceding data tend to overestimate losses due to erosion in the sense that total area figures fail to discount water bodies,

Figure IV-13—Conversion of the country's finest agricultural soils to residential units in the Central Valley (photo M. T. Saborío).

urban, farm, and industrial and highway infrastructure. Since about 1960 the Central Valley has become a major focal point for rural-urban migration. Between Paraiso on the east and Atenas on the west, a major transformation of landscape is now under way. Predictions are that this will become an unbroken urban metropolis housing as many as 1.8 million people by the year 2000. The growing "megalopolis" (677 km²) covers some of the country's richest volcanic soils on low relief terrain (Fig. IV-13). These deep, fertile, well-drained soils are combined with the country's principal areas of *Tropical Premontane* and *Lower Montane moist forest* life zones and constitute the heartland of its agricultural economy. There are virtually no qualitatively equivalent soils and climates found outside this area. Many essential food products can only be grown successfully in the Central Valley. High rural population densities, old and prosperous farms, and the location of the capital city attest to these superior environmental qualities. While much of the area still in agriculture is currently planted to coffee, these lands also have the unique qualities suitable for temperate zone horticultural crops, such as onions, potatoes, cabbage and many other fresh vegetables. These lands disappearing under urban sprawl also have the highest potential for irrigation.

MAG and OFIPLAN recently recognized this area as the "Greater Metropolitan Area", but planning and zoning appear to be strictly *post facto*. Of the 67,700 ha area, 23,700 ha are identified as of the highest quality for agriculture, but 15,500 ha are already in residential use; 14,000 ha are occupied by industry, parks and airports; and 11,000 ha have been officially designated as priority areas for urbanization because "the necessary infrastructure already exists and there is a pronounced trend for urban development to take place spontaneously".

The report cites problems of under-utilization, over-utilization and destructive utilization of land. Though the remaining area includes some dairy farms, the major San José milkshed lies in the higher hills of the cool, *Lower Montane* altitudinal belt just to the north and south of the main valley floor. Enchoaching suburban residences with

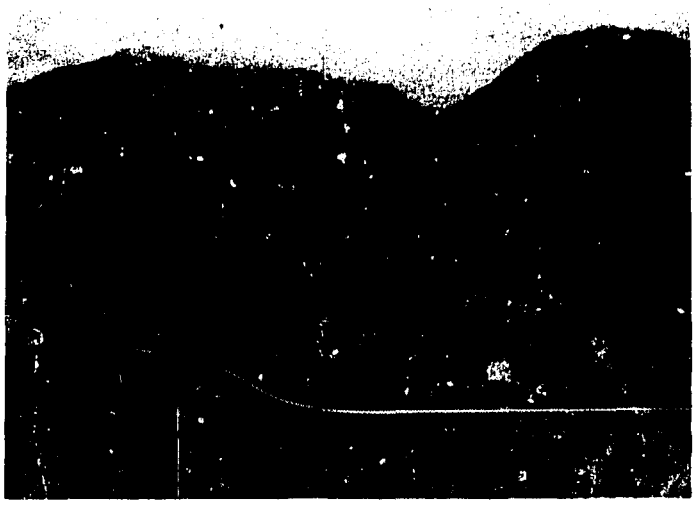

Figure IV-14.—Construction of the San José-Guápiles highway through the rugged Cordillera Central. Strong conservation opposition to this highway prompted the creation of Braulio Carrillo National Park. Nevertheless, construction has stripped the forest from steep slopes and choked the Hondura (shown here) and Patria rivers with sediments (photo G. Hartshorn).

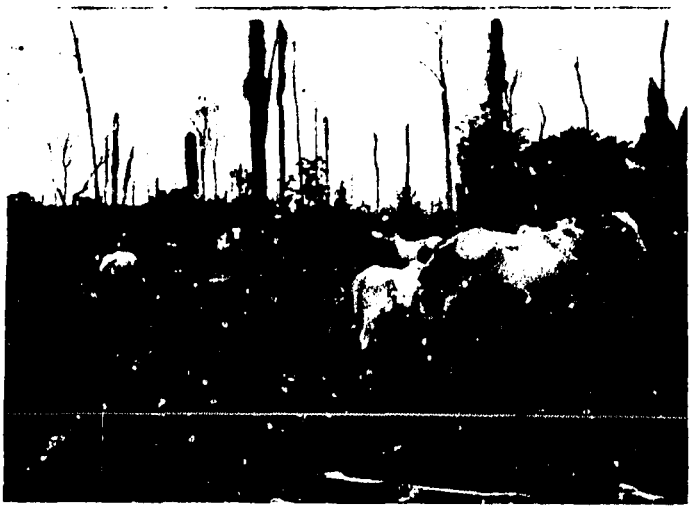

Figure IV-15.—Conversion of tropical wet forest to cattle pasture on the Osa Peninsula. Note the absence of grass in this one-year-old "pasture" (photo T. J. Lewis).

prized panoramas have substantially reduced milk production from these quality pastures; e.g., in the San Ramón de Tres Ríos area daily milk production has dropped from 18,000 bottles 20 years ago to less than 1,000 bottles today. It is paradoxical, of course, that while national milk demand is increasing, production is actually declining, adding to the basic food costs.

The uncontrolled and disorganized expansion of the metropolitan area not only removes excellent soil from crop production, but often results in idle land as speculators await the inevitable urbanization (Fournier 1976). The numerous vacant lots and idle farms in the greater metropolitan area could produce considerable quantities of basic foodstuffs. The demise of small farms in the metropolitan area often sends the small farmers higher on the flanks of the Central Valley where the soils are usually less suitable for intensive agriculture.

INVU is completing a study of urban growth projected to the year 2000. An INVU recommendation will allow up to 40% of the coffee producing land north of San José for unrestricted urban expansion. Because of excellent climate and soils this area produces about 60% of the highest grade coffee. MAG does not appear to be concerned about the probable loss of prime coffee land, claiming substitute areas can be developed elsewhere. Central Valley zoning should be approached from a multidisciplinary perspective rather than solely from the need for housing. The INVU proposals should be reviewed by independent specialists in agriculture, water, health and transport.

Several infrastructure and mining projects that will have major impacts on the area of agricultural soils are either underway or planned. Among the more outstanding of these are: (1) the proposed bauxite strip-mining operation on 20,000 ha in the San Isidro de El General area (TSC 1975); (2) proposed coal-mining in the Talamanca region; (3) the proposed Boruca Dam project in the Térraba-El General Valley that will inundate 19,800 ha (TSC 1982); and (5) extensions of the national highway system, including re-routing the Inter-American Highway in the southeast.

Highway construction can be particularly damaging to soil resources because planning and construction normally do not include adequate environmental restraints and safeguards. Road projections are sometimes influenced by speculative land interests or wildlands areas are violated due to pressure from lumber or cattle interest groups. Public institutions entrusted with planning and execution of road building (MOPT) lack perception of the possible undesirable consequences of such road penetration. Transport engineers trained in Costa Rica should receive comprehensive education that would include ecological factors and responsibilities in their profession.

New highways are often proposed and sometimes constructed in watersheds that should be protected. The trunk highway between San José and Guápiles (Fig. IV-14) now under construction with World Bank financing is a classical case. This highway was bitterly opposed by conservation groups for it cuts directly through a major wildland protecting important watershed and other natural resources. Although a compromise was reached in which a national park was declared to protect the critical high rainfall, steep mountain section from invasion following the opening of the highway, the road construction has been far more costly and time consuming than originally predicted. Enormous construction damage to virgin forest leaving great unvegetated spoil-banks for further erosion and sediment-loading of the Patria and Hondura rivers has resulted.

The national highway development plan includes the road to Los Chiles from San Carlos on the Caribbean plains and the Golfito-Puerto Jiménez road on the Osa Peninsula. Soon, the last remaining areas of high quality, natural hardwood forest and forest quality soils will be open to speculation and agricultural colonization, even though these lands are generally not suitable for agriculture or pasture. The area around Los Chiles (subclass B-5) was studied and proposed for reservation to industrial forestry on a sustained yield basis (TSC 1968). This very attractive economic development option would provide for permanent and high level timber production and employment. In a few years cattle production may be expected

to decline, but by then soils will be too degraded and old-growth natural forest areas too scarce for any return to industrial forestry as an economic alternative.

The Osa Peninsula also has soils of low potential for agriculture and, despite the presence of both a national park (Corcovado) and a forest reserve (Golfo Dulce), road construction is rapidly opening these lands to deforestation and cattle ranching (Fig. IV-15). The conversion to pasture in such a high rainfall area can only cause concomitantly rapid soil deterioration.

Soil Degradation. In addition to absolute losses of soil by hydric, fluvial and wind erosion, plus elimination for settlement, other soil degradation causes include compaction, chemical toxification, repeated burning, biological contamination with inadvertently introduced plant disease organisms, and blocking of drainage by unculverted highway fills. Soil compaction and chemical toxification are the most harmful; see chapter V-A for a discussion of the latter.

Compacted soils have lower porosity and higher erosion potential than they had originally. The effects of compacted soils are particularly deleterious in critical watersheds where increased surface runoff and concomitant erosion increases stream sediment loads and peak flows, while lessening dry season discharge. Rehabilitation can be brought about by complete abandonment for several years to natural forest regrowth, followed by ecologically adaptive crop or grazing systems of an intensively managed type.

Problems and Status of Soils Management

According to Duisberg and Newton (1978) "Costa Rican soil science has produced more advanced and sophisticated soil research than any other country in Central America. On the other hand, it has lagged behind in coordinating its efforts and in obtaining some of the simpler and more basic information needed for classifying soils and making fertilizer recommendations". They also note that a larger cadre of soil scientists is needed, although the caliber and interest of agronomy students is high and the university training (in this field) adequate. According to the same authors, a particularly glaring weakness in this discipline is soils classification and mapping.

Technological Capabilities. From the discussion of the existing soils maps (see p. 51) it should be apparent that the lack of a reasonably detailed map at the national level is a major obstacle to land capability classification. Planning and execution of government programs for agrarian development, colonization, and agricultural extension, including conservation are therefore limited.

The report by Duisberg and Newton (1978) includes a table listing all soils agencies in Costa Rica, their major soils emphasis, budget, field and laboratory facilities, major outputs, and the principal users of their services or information. Four government agencies, including the University of Costa Rica, plus two private institutions are included in the listing. Virtually all soils activity, except for limited soil classification and mapping efforts, corresponds to soil and plant chemistry research, with a major emphasis on soil fertility and plant nutrition via chemical fertilization. Fertility trials are the only soils work being undertaken by the agricultural extension service. At the time of their report, no public or private agency had a significant program in soil conservation at either the research or the applied level.

Research on quantifying soil loss is badly needed. While at CATIE, Dr. W. Forsythe (1976) devised simple equipment for field measurement of soil erosion, but this work was discontinued after his departure.

Wischmeier and Smith (1961) introduced an empirical formula for estimating soil losses (Universal Soil Loss Equation, USLE) in the United States from measurements of rainfall volumes and intensity, slope, soil erosivity, vegetation cover, and land use practices. As mentioned previously, Tosi (1972) correlated the USLE formula with the Holdridge Life Zone System to provide a method for estimating soil losses in the tropics wherever specific soil and climatic parameters are known. The methodology was tested in the Arenal watershed (TSC 1980) as well as against measured data for some other tropical countries with conditions similar to Costa Rica. Results indicate that the method provides a practical and inexpensive means of predicting soil losses caused by Class II (hydric) erosion, being adequately similar to those derived from direct field measurements. Because this method is inexpensive, rapid, and requires only data on life zones and soils such as are already available for most parts of the country, it may be recommended for obtaining first-approximation estimates in specific watersheds as prerequisite to planning for soil management and soil conservation.

By applying data from Table IV-11 and the section on Soil Losses by Destructive Forces (p. 55), crude estimates of annual losses can be made. In 1981, approximately 38% of the national territory (19,000 km^2) was in pasture (Fig. IV-16) and, at the most, another 11% in crops. If we assume that 50% of all land in pasture occupies hilly to very steep land, and an average of 600 tons of soil/ha/year are lost in these areas, then annual soil loss from these lands alone amounts to 570 million tons. Assume one-tenth of this for low-slope lands in pastures or 57 million tons more. If 25% (2,250 ha) of all clean-tilled land suffers serious erosion due to location on hilly to steep locations, that adds another 47 million tons. Lesser amounts can be assumed to be lost from lands in permanent crops, most of which occupy hilly to steep locations. If roughly 18 tons/ha are lost under permanent crops, this adds another 6 million tons. The grand total may be 680 million tons/year, with grazing areas contributing 84%.

The rate of soil formation is sufficiently slow that topsoil is essentially a non-renewable resource, hence the annual loss of several hundred million tons of soil should be alarming. Even though it is impossible to calculate the value of a ton of topsoil, the crudely estimated magnitude of soil loss in the country is sobering. Accelerating erosion of soil threatens not only the country's agricultural prosperity, but the economic viability of hydroelectric, potable water, irrigation and forestry projects as well. Costa Rica must recognize the severity and consequences of soil erosion and address the causes of such unacceptable losses. National programs to classify land capability, to plan and zone use, and to coordinate and reform land tenure can appreciably lessen soil losses and initiate recovery of eroded soils.

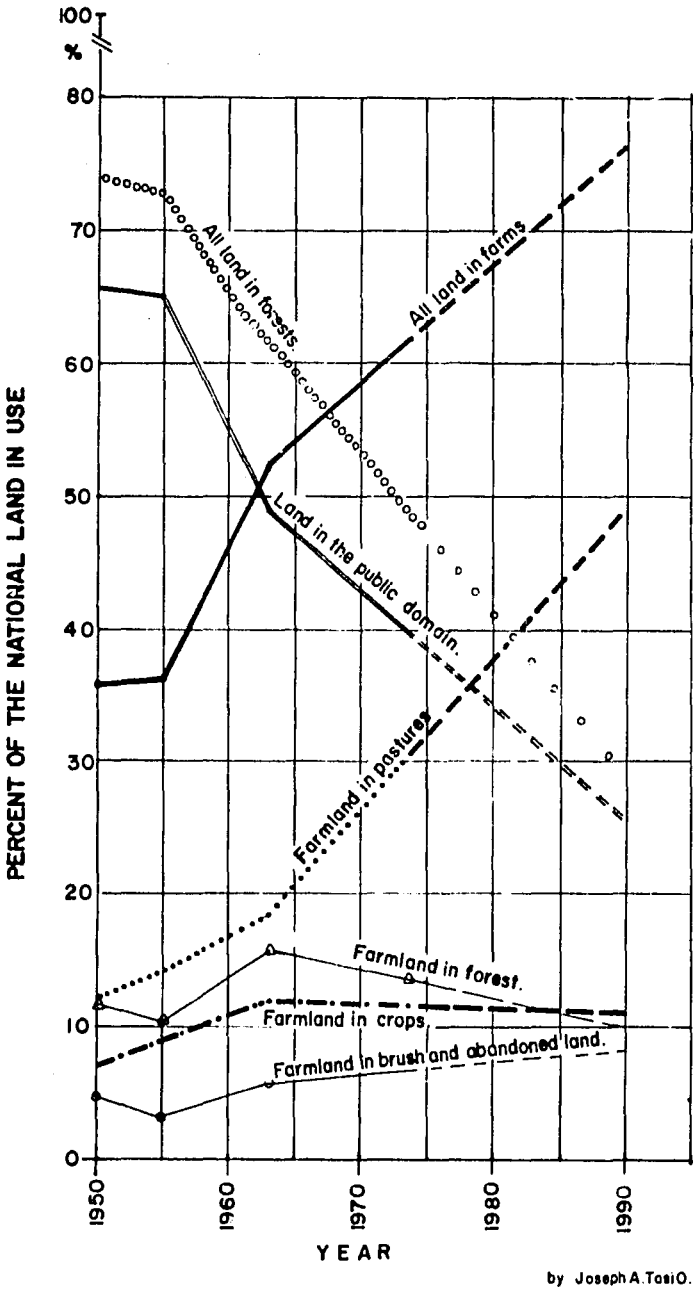

Figure IV-16.—National Land Use for the years 1950-1990.

IV-F. AGRICULTURE & CATTLE

Agricultural Perspectives

Costa Rica is at a crossroads concerning its agricultural and national development policies. The current economic situation has deteriorated rapidly and is unlikely to improve drastically in the near future. Due to regional political instability, inflation, and rising prices of petroleum, the time has arrived when Costa Rica has to make fundamental changes in its development strategies. New and efficient methods to increase exports and reduce imports must be found. Alternative energy sources need to be developed. Natural resource destruction has to stop. External borrowing has to be reduced. The government sector has to be more efficient and cannot be expected to absorb more employees. The agricultural sector will play a key role in the success of any development strategies that might be encouraged.

Indicators

Agriculture is the largest sectoral employer, accounting for 28% total employment. The agricultural sector accounts for approximately 19% of the Gross National Product. Agricultural exports accounted for 74% of the total value of exports in 1979 (Table IV-12). The principal agricultural export products in 1979 were coffee ($252 million), bananas ($169 million), beef ($65 million), sugar ($37 million) and cacao ($7 million). While Costa Rica produces basic grains such as rice, corn, beans and sorghum, only rice is currently being exported. Food grains (especially wheat) account for 32% of agricultural imports. Many varieties of fruits and vegetables are produced on a small scale, but not sufficiently to supply local demand. Consequently, fruits and vegetables are imported (16% of total agricultural imports) from neighboring Central American countries. Dairy products and animal feed concentrates account for the remainder of the $90 million in total agricultural imports.

With respect to land distribution, approximately 35% of the farms are less than five hectares; however, they only account for two percent of the area under cultivation. Approximately three-quarters of the agricultural land is held by only 10% of the largest farms. Average farm size is 38 ha, equivalent to 8 ha per farm worker. Average fertilizer consumption is 163 kg/ha. Population density just based on agricultural land is 215/km^2, but only 5% of the agricultural land is irrigated. At the other extreme, large farms of 200 ha or more account for three percent of the total farms, but they occupy 54% of the land.

Permanent crops such as coffee, cacao and fruit trees, as well as corn, beans and various root crops (yuca, malanga, tiquisque) are the principal source of income for small farmers. Coffee production is remarkably evenly distributed among farms of differing size (Table IV-13). Large farms are generally dedicated to beef cattle, bananas, sugar cane, coffee, cacao or rice.

Production

Costa Rica has the potential to produce all of its requirements for basic grains, vegetable oil, fruits and vegetables. However, many foodstuffs are imported due to crop preferences, low yields and high costs that make it cheaper to import certain basic foods. Export products are officially encouraged to moderate the enormous national balance of payments deficit, yet productivity remains low due to inefficient transfer of technology coupled with poor husbandry of soil resources. Even though labor is cheap, the costs of imported fertilizers and pesticides are sky-rocketing; thus government-set prices for basic foodstuffs combine with higher production costs to significantly reduce the margin for farmers. This trend has been countered somewhat for Central Valley farmers by the popular development of weekend farmer's markets, where direct purchasing of high-quality fruits and vegetables excludes the middleman.

Table IV-12. Agricultural Imports and Exports for Fiscal Year 1979.

Description	IMPORTS Value US$	IMPORTS % Total Ag Imports	EXPORTS Value US$	EXPORTS % Total Ag Exports
Live Animals	3,004,553	3.3	851,912	0.1
Meat & Meat Products	6,723,147	7.4	84,729,637	12.3
Dairy Products, Eggs	11,375,325	12.6	855,644	0.1
Seafood Products	1,695,158	1.8	11,326,428	1.6
Grains	29,124,051	32.3	17,247,692	2.5
Fruits & Vegetables	14,471,943	16.1	206,341,479	30.1
Sugar	2,903,353	3.2	18,738,615	2.7
Coffee, Tea, Cocoa, Spices	1,686,758	1.9	338,650,290	49.4
Animal Feed (except unmilled grains)	14,443,544	16.0	576,549	0.1
Miscellaneous Food Products	4,580,480	5.4	7,735,751	1.1
Total Ag Imports/Exports	90,008,312	100.0	687,053,997	100.0
Total Country Imports/Exports	1,449,131,692		934,391,357	
Ag Imports/Exports as % of Total	6.2%		73.5%	

Table IV-13. Relative production of selected agricultural products by size of holding (in ha).

Size of Holding	Rice	Corn	Beans	Cacao	Beef	Sugar	Coffee	Bananas
<1	0.3	2.0	1.9	0.1	0.5	0.5	2.6	0
1-5	2.9	14.1	13.6	5.2	2.1	5.2	15.4	0.3
5-10	2.8	10.0	9.9	8.8	2.6	5.8	12.5	0.4
10-20	4.5	12.9	13.9	13.7	4.5	6.6	12.8	0.7
20-50	12.5	25.9	29.9	21.0	13.1	9.3	18.1	2.0
50-100	9.4	14.9	18.8	10.4	14.1	8.3	12.7	2.2
100-200	8.4	7.7	8.0	16.3	13.7	9.3	9.0	6.2
200-1000	30.4	8.0	3.8	18.8	30.8	26.8	13.7	66.6
>1000	28.8	4.5	0.2	5.7	18.6	28.2	3.2	21.6
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

According to the Agricultural Sector Planning Office (OPSA 1979) increases in agricultural production over the past decade were due primarily to increases in area under production rather than increased yields (Table IV-14).

Coffee production is still a way of life with Costa Ricans. Even though it is the number one export crop, low world prices do not help the current economic situation. In 1978 one 60 kg bag of coffee purchased 15 barrels of petroleum, while in 1981 one bag purchased only 4.3 barrels. The cost of imported petroleum now slightly exceeds the earnings from exported coffee. Production level for 1980-81 (2,038,043 bags) is a record due to good weather conditions and management practices. Coffee rust continues to be a long-term threat.

Although Costa Rica currently exports 50 million boxes of bananas per year with an export value of US$169 million, the area in bananas is not expected to expand beyond 28,000 ha due to the high $1/box tax levied by the government (ASBANA 1981). United Brands and Standard Fruit Company account for about 35% each of the total banana export and BANDECO, a subsidiary of Del Monte, accounts for 30%. Average yields are 1800-2000 boxes/ha/year, with a couple of well-managed farms reaching 3,000 boxes/ha/year. In 1976 it took 5.6 boxes to purchase one barrel of petroleum, whereas last year 10 boxes were equivalent to one barrel. Black Sigatoka disease and continued labor unrest tend to be major limitations to production. Due to a relatively even distribution of rainfall in the banana

growing areas in the Caribbean lowlands, irrigation is not used, while in the Pacific lowlands, bananas are irrigated during the dry season.

Table IV-14. Estimated areas and yields of selected crops, 1980. Source: AID Ag. Attache Reports and La Nación, Nov. 1981.

CROP	Area Planted (1000 Has)	Estimated Yield (tons/ha)
Coffee	81	1.4
Rice	70	1.5
Sugar Cane	48	55.2
Corn	32	1.5
Bananas	28	37.5
Cacao	20	0.3
Beans	20	0.5
Sorghum	20	1.7
Cotton	2.3	0.5
Tobacco	1.2	1.3
Root Crops	?	?
Plantains	?	?
TOTAL	322.5	

Basic grains such as beans, corn, and sorghum all compete for the same land in appropriate areas (Guanacaste) because they require a dry season for harvest. Grain production for 1981 had a 32% decrease from the previous year due to heavy rains that prevented land preparation and therefore resulted in reduced area planted. Lack of credit due to the deteriorating economic situation also served as a limitation to increased production (Agr. Attache 1981).

Rice production will meet local demands and surpluses are being exported. Corn, beans, and sorghum will continue to be imported since high costs of production and low yields make imports cheaper than locally produced grains. Corn is a traditional small farmer crop but if animal feed concentrates are going to be used for beef, dairy, swine and poultry production, then large quantities of corn and other feed grains will have to be imported. Currently the feed situation is one of high prices, frequent shortages and questionable quality.

Cacao has been grown in the Caribbean lowlands as an export crop for several centuries. It represents the principal source of income for a large number of small farmers in the area. The factor most severely limiting production is the presence of two very serious fungal diseases: Black Pod *(Phytophthora palmivora)* and Monilia Pod Rot *(Monilia rorevi)*. Interestingly, monilia is being kept under control in well-tended plantations.

All of Costa Rica's vegetable oil requirement is met through importation, except for margarine, mayonnaise, and shortening produced from African oil palm. The United Brands processing plant at Quepos supplies practically 100% of these oil palm products for the local market. In the last 10 years there has been a serious attempt to produce oilseed crops necessary to supply cooking oils. Cotton, sesame, and peanuts were considered priority crops since their annual production cycle is shorter than for oil palms; however, they have not been successful.

Cotton is produced basically to utilize the seed for oil and the cotton seed meal for animal feed. The fiber that is produced is generally exported since the local industry cannot absorb the national production.

Soybeans, in addition to oil products, have other uses as high protein meal and human food. Peanuts are grown for oil but they require dry, sandy soil. To attempt to grow soybeans or peanuts on a commercial scale in any part of Costa Rica other than Guanacaste is not practical; these crops require good soils for high yield and a dry season for harvest.

To date, the trend has been large scale plantings of African oil palm financed by foreign capital, such as the United Brands 14,000 ha plantation near Quepos. There is no reason to believe this trend is going to change. ITCO has 60 ha of oil palm in production near Coto Sur and has proposals for larger plantings although it will take three to seven years before production starts. Ecological conditions are appropriate for increased plantings on the Caribbean coast, but it is doubtful whether small farmers can be successfully incorporated into production schemes. Small to medium size farms could produce soybeans and peanuts in Guanacaste, but economics of crop substitution dictate that those lands should probably be planted to higher value crops.

Financing

Commercial banking in Costa Rica is provided only through government controlled institutions grouped in the National Banking System (SBN) under the control and direction of the Central Bank. There is no agricultural bank to offer long-term financing at reasonable rates of interest for agricultural production or diversification. The Banco Nacional de Costa Rica (BNCR) consistently disburses more agricultural credit than all other SBN banks combined. The BNCR rural credit department consists of over 40 regional offices and 60 rural credit boards, with each regional office manager usually having a background in agronomy and living in the area. Small loans can be approved by the manager of a regional office and loans up to US$ 35,000 can be approved by the local credit board. High interest rates and scarcity of funds make it difficult for farmers to obtain credit. Problems with long-term agricultural credit will only become more difficult with the current economic stagnation and have potentially serious repercussions on agricultural productivity.

Irrigation

In 1973 there were 66,400 ha under irrigation in Costa Rica. There is a rough estimate that 250,000 ha

Figure IV-17.—Pejibaye plantation at the La Selva Biological Station. Commercial plantations of pejibaye are the principal source of heart of palm, a rapidly expanding export commodity of Costa Rica (photo D. Pool).

have irrigation potential of which two projects, Itiquis and Moracia are the most important (OPSA 1979). Itiquis is a vegetable growing area in the Central Valley with an estimated 1,500 ha under irrigation. The irrigation of the lower Tempisque basin will utilize water from Arenal to incorporate approximately 200,000 ha into agricultural production. Proposed crops include pasture and hay, grains, sugar cane, fruit tree crops, vegetables and rice (Bookman-Edmonston 1979).

Technically, the Moracia project is feasible since no problems with engineering or construction are anticipated. Some of the primary canals have been constructed, but secondary distribution canals to individual farms have not. The project is important socially and economically as well as ecologically since this is the first large scale investment in irrigation in Costa Rica. Considering the large investment and soil and water resources committed to the Moracia project, it is important to investigate on-farm water management, including design and operation of irrigation water, drainage and management of heavy-textured, poorly-drained soils. Since there is little previous experience in actual management of irrigation and drainage systems in Costa Rica it is recommended to cautiously approach the implementation stage in order to minimize costs to both the public and private sector and avoid irreversible processes such as saline soils, flooding of agricultural lands, and overall low productivity based on inexperienced management.

Diversification Possibilities

Agricultural diversification is technically feasible, as shown by successes with macadamia, pejibaye, (Fig IV-17), coconut and black pepper. Much more can be done and needs to be done if agricultural exports are to increase. Most of the crop possibilities already exist in the country, thus what is needed for successful diversification are marketing outlets, technical and financial assistance and a supportive commitment from government. Several other interesting possibilities merit commercial development such as using discarded bananas for animal feed, conversion of biomass to alcohol and agroindustrial food processing in the industrial parks.

BEEF CATTLE PRODUCTION

Production and Supply

For the 1963-1978 period cattle production experienced an average growth rate of 4% per year, but considering the years 1974-1978, that growth rate was only 1% per year. Nevertheless, total production grew from 191.5 to 341.5 thousand cattle from 1963 to 1978. During the same period the supply of cattle grew at approximately 7% per year, from 149.4 to 406.5 thousand (DGEC 1964, 1974). Supply outpaced production, and the data strongly suggest a reduction in the stock of cattle. It has been estimated that the reduction in stock of cattle began in 1974 and continued through 1978.

A more detailed inquiry into this matter (Solera 1981) established that the officially reported supply of cattle, by the Census Bureau (DGEC 1978), contained and/or subestimated a foreign component in that data. In accord with this inquiry and from the viewpoint of nationally produced cattle, such reports have consistently under or over-reported such cattle.

The national stock of cattle and an additional amount for officially unrecorded imported cattle awaiting processing for meat exports confuses the issue of actual pasture land expansion. Due to the nature of that cattle trade, additional pressures were created on land resources with forest lands converted to pastures. If such officially unrecorded cattle trade did not continue, excesses of pasture lands would be evident and repayment of loans for establishing new pastures would become difficult.

Pasture Lands

Total farmland increased 72% from 1950 to 1973 (last agricultural census), during which 1.3 million ha were incorporated into agricultural production (Table IV-15). Land allocated to pastures was the only important land use that grew at higher than the average growth rate by the 1973 census year. All agricultural uses except pastures have lost their relative positions. By 1973 pasture lands represented 50% of all farmland (up from 34.8% in 1950). Close to 71% of all new farmland by 1973 (from 1950) was allocated to pastures, 16% left in forest, and only 13% into all other uses. This clearly documents the considerable transformation of forest to pastures (also

see chapter IV-E). It is known (Aguirre 1970a, b) that there is usually an intermediate and transitory step between forest and pastures--i.e., the production of grain (rice, beans, sorghum or corn) for one or two years to pay for the cost of clearing the forest land.

Table IV-15. Agricultural land (in thousand ha) for census years 1950, 1955, 1963, 1973. Source: Table B9 National Development Plan 1979-1982 for beef cattle in Costa Rica (OFIPLAN 1979).

Census Years		Census Total	Annual Crops	Perennial Crops	Pasture Land	Forest Land	Other Land
		FARMLAND IN					
1950	ha	1,812.7	217.7	132.4	630.8	790.5	41.3
	%	100	12.0	7.3	34.8	43.6	2.3
1955	ha	1,852.0	281.6	155.4	722.7	676.8	15.5
	%	100	15.2	8.4	39.0	36.5	0.8
1963	ha	2,668.1	387.5	200.5	957.7	1,097.1	25.3
	%	100	14.5	7.5	35.9	41.1	1.0
1973	ha	3,122.5	283.3	207.2	1,558.1	1,000.1	73.8
	%	100	9.1	6.6	49.9	32.0	2.4

Features of Cattle Farming

A very interesting feature of cattle farming is that production is not fully specialized in either beef or milk, but other production as well. In 1973, according to the Agricultural Census (DGEC 1974, Solera 1981), 84% of all farmland was in cattle farms. With the exception of perennial crops, cattle farmers had full control particularly of grain production; in recent years beef cattle farms have combined cattle, rice, and sorghum.

Production of forage is crucial for beef cattle production when grasses are the only cattle food, as is the case in Costa Rica. It was found (Solera 1981) that owners of mini-farms (less than 20 ha) were capable of producing larger amounts of grass cattle rations per unit of land than owners of farms of family size (20 to 200 ha) or large farm owners (over 200 ha). The rotation and cattle load systems were commonly practiced on the mini-farms; subdivisions in pasture lands were used more frequently during the year, and the cattle load (cattle/land) was higher than in the other size farms. Mini-farms were able to supply an average of 383 kg, live weight equivalent, of cattle per hectare of pasture per year; family size farms produced 122.3 kg; and the large farms produced 161.7 kg. Under family labor surplus conditions and cattle production stages, the difference was accomplished especially due to the characteristics of these farm sizes: calf-cropping (yearling production) for mini-farms; developing (intermediate growth stages) for family size farms; and finishing (fattening) for large farms. Equivalent results were also found in other parts of the world, with no consideration given to farm size or to production stage, but to the rotation system (Santhirasegaram 1974).

Although farmers have adopted an ad hoc land classification for the purpose of allocating land into different farm uses, many are willing to sacrifice income in order to continue with cattle production due to income flow security. An income penalty for small farmers amounted to over 25% of their actual net income, which is a very high insurance premium to pay for such expressed desire (Solera 1981). This sense of security through cattle farming spills over the traditional farmers' community, and attracts investors from other economic endeavors, as witnessed by the number of absentee owners (DGEC 1974). These farmers are even more willing to sacrifice income from other agricultural production that might require more knowledge and production attention.

Mini-farms seldom use outside help, except for contractual mechanical land preparation and the family supplies all the required labor. Most family and large size farms keep to a minimum the number of hired hands, and the majority of farm chores are done under job contract. Permanent labor is kept to a minimum due to the 50% fringe benefits due over the basic wages.

Well-organized farms, called a technological oasis above, have a relatively large group of workers hired on a more permanent basis. For such large farms, cattle production can be pursued with more labor intensive techniques (Solera 1981).

In general, however, given the technological matrix in the beef cattle industry, traditional cattle farming is not capable of absorbing the growing labor force emerging from the rural areas.

Resource Allocation in Beef Cattle Farming

Economic efficiency is the equality between the marginal value productivity, MVP, or shadow price, and the marginal factor or input cost, MFC. Farms located in the San Carlos area, both beef and dairy, were examined for economic efficiency and it was reported (Aguirre 1970a, b) that technology can contribute to farm income. Shadow prices of feeds, fertilizers, veterinary medicines and the like, are higher than the actual costs, and there is economic inefficiency in beef and milk production. A more recent study (Solera 1981) utilized a linear programming technique for Guanacaste farms and reached the same conclusions. The shadow prices of technology, labor and credit were severalfold larger than the actual costs.

Therefore, a more intensive use of the inputs and labor would increase production in the pasture lands actually allocated to cattle production, reducing the pressure of the demand for land elsewhere, i.e., reducing the demand for forest lands. It was also found that improving the vegetative composition of pasture lands and adopting improved rotation systems would do more for beef cattle production than many other incentives proposed by the National Development Plan (OFIPLAN 1979) for fostering beef cattle production.

Furthermore, due to the mutual effect of the use of technological inputs and rotation systems, it would be

Table IV-16. General description of watersheds in Costa Rica and major uses of the water resources. Sources: OFIPLAN 1979, ICE 1977, and observation C. Quesada. KEY: a=not studied; b=not irrigated; c=irrigated in banana plantation; d=small irrigation system, Orosi Valley; e=Irrigation in Guanacaste from Arenal; f=small fincas; g=no data or doesn't exist; h=not possible; I=boats; i=small boats; j=only at river mouth; T=Tortuguero canals.

WATERSHED						HYDROELECTRIC ENERGY					
Nº	River	Area km²	Mean Annual Rainfall (mm)	Mean (mm)	Outflow l/s/km²	Projects	Potential Mw	Energy Gwh	Irrigation	Navigation	Potable Water
1	Sixaloa	2,330.0	4,790	3,905	123.8	9	1,385	6,104	a,b	i, j	a
2	La Estrella	1,002.1	2,877	2,125	67.4	—	—	—	c	i, j	a, use of small streams and wells
3	Banano	204.3	4,379	3,722	118.0	—	—	—	b	g	ICAA has a project for Limón
4	Bananito & others	205.3	2,951	2,444	77.5	—	—	—	b	g	a
5	Moín & others	361.6	3,956	2,582	81.9	—	—	—	[illegible]	T	Small springs
6	Matina	1,415.6	3,626	3,086	97.9	2	600	2,600	b	T,j	a, Small springs, wells
7	Madre de Dios & others	443.1	3,402	1,888	59.9	—	—	—	b	T	a
8	Pacuare	802.4	4,021	3,032	96.1	2	764	2,992	b	T	Small springs
9	Reventazón & Parismina	2,950.3	3,777	2,646	83.9	5	686	3,053	d	T	Small springs, ICAA project 1,800 lps
10	Tortuguero & others	1,644.3	3,887	2,486	78.8	—	—	—	b	T	Springs
11	Chirripó Atlántico	1,635.1	4,326	3,671	116.4	3	365	1,768	b	i	a, Small springs
12	Sarapiquí	1,923.3	5,156	3,987	126.4	3	256	1,147	b	i	Small springs
13	Cureña	342.8	4,100	2,918	92.5	—	—	—	b	i, j	a
14	San Carlos & Nº 20	2,646.3	3,961	3,143	99.7	5	967	2,631	e	i	Small springs and others

Table IV-16. (Continued)

WATERSHED						HYDROELECTRIC ENERGY					
Nº	River	Area km²	Mean Annual Rainfall (mm)	Mean (mm)	Outflow l/s/km²	Projects	Potential Mw	Energy Gwh	Irrigation	Navigation	Potable Water
15	Pocosol & others	1,641.1	2,516	1,358	43.11	—	—	—	a,b,	I,j	a
16	Frío	1,551.4	4,196	2,174	8.9	—	—	—	a,b,	i	a
17	Zapote & others	2,593.8	2,858	1,643	52.1	—	—	—	a,b,	i,j	a
18	Nicoya Peninsula & North Coast	4,202.0	2,043	936		—	—	—	f, ha 7,851	i	Small springs, wells
19	Tempisque	3,405.0	2,040	768	24.35	—	—	—	f, ha 1,396	i	Small springs, wells
20	Bebedero see Nº 14	2,050.0	2,118	865	27.42	—	—	—	f	g	Small springs, wells
21	Abangares & others	1,362 5	2,382	1,240	39.3	—	—	—	g	g	Contaminated river
22	Barranca	504.5	3,750	1,999	63.4	1	50	195	g	g	Small springs, wells
23	Jesús María	358.5	2,593	1,322	41.9	—	—	—	f	g	Small springs, wells
24	Grande de Tárcoles	2,168.5	2,456	1,520	48.2	3	350	1,720	a	g	Small springs, wells
25	Tusubres & others	830.1	2,947	1,152	36.5	—	—	—	a	g	Pirris project, Metropolitan aqueduct
26	Parrita	1,272.5	3,254	1,988	63.0	5	460	1,947	g	g	Small springs, wells
27	Damas & others	458.2	4,407	1,864	59.1	—	—	—	g	h	Small springs, wells
28	Naranjo	332.2	6,387	3,973	126.0	2	195	820	g	h	Springs
29	Savegre	593.2	5,090	3,557	112.8	3	650	2,652	g	h	Springs
30	Barú & others	561.1	3,351	2,121	67.3	—	—	—	c	i	Springs, wells
31	Grande de Térraba	5,075.8	3,358	2,198	69.7	7	2,065	8,233	g	h	Springs
32	Osa Peninsula	1,968.1	4,408	2,830	69.7	—	—	—	g	h	Springs, wells
33	Esquinas & others	1,827.6	3,886	2,699	85.6	—	—	—	g	h	a
34	Changuinola, Costa Rican part	255.5	3,800	2,690	85.3	—	—	—			

necessary to determine the most advisable combination to bring about optimum production at farm or regional level. To make this empirical determination successful, cattle and grain farmers from all farm sizes should be brought together to share their knowledge.

Sacrificed income is not the only type of production constraint in beef cattle farms. Adherence to cattle breeds that do not adapt to given climatological conditions--dairy cattle in areas with average temperatures around 40°C; *ad hoc* land classification with no regard for pasture production, soil and fertility requirements; maximum amount of cattle the owner could handle without outside help; and the like, explain inefficiencies in resource allocation in cattle farms, at least to some extent. Another limitation is the size of the farm--small cattle farms being inefficient for the most part, even though an adequate income may be realized.

Behind the setting of psychological constraints to beef cattle production is the ability of farmers to better allocate available resources: the avoidance of hiring workers when the shadow price of labor is severalfold the actual cost; he is ignorant of opportunities that increase the farm's net income. Farmers sacrifice noticeable amounts of cattle and grain production as well as income.

Destruction of the land resource--especially soil deterioration through compaction, wind and water erosion, and mineral depletion--can be irreparable when danger signs are not noticed and obeyed. An obvious reaction to a farmer's land being beyond repair is for him to move up the hillside to further remove forest cover to raise his cattle.

The Beef Cattle Program of the National Development Plan

The beef cattle production goal was set by the National Development Plan (OFIPLAN 1979) at 91,600 tons of meat by 1982. This amount of meat would correspond to a production of 485,900 cattle. Out of this production 230,100 would have to be processed for beef exports. To produce 485,900 cattle by 1982, the stock of cattle would have to be close to 2.3 million (Solera 1981 Table A-3). Cattle supply for the years 1979 (393,900) and 1980 (343,100) suggest very strongly that such a production goal would not be attained in 1982.

Productivity goals for the beef cattle industry, as stated by the National Development Plan (OFIPLAN 1979), are yet to be fulfilled. It is legimitate to estimate the amount of land required for such stock of cattle, using the 1973 cattle/land ratio: a total of 520,000 ha *more* than the amount allocated to pastures in 1973 (DGEC 1974) would be necessary.

The National Development Plan (OFIPLAN 1979) estimated that there were only 584,000 ha of agricultural land available for agricultural production expansion. If the production and export goals were to be filled in 1982, there would be only 64,000 ha available from 1979-1982 for all other agriculture, or cattle production would be demanding more forest land for transformation into pasture. The Plan implicitly endangers forests and ignores soil capability.

IV-G. WATER RESOURCES

Introduction

Water resources constitute probably the most viable option for sustained development in Costa Rica. The combination of very broken topography and high rainfall over a relatively small geographic area make the country one of the world's richest in water resources. The country abounds with excellent dam sites and strong-flowing rivers that carry much more water than suggested by watershed size. Topographic features favor the capture of surface waters and gravity distribution for irrigation, human and industrial use.

The rational exploitation of water resources is contingent upon the protection of watersheds, especially the native forests that cloak the steep mountain slopes. Under conditions of steep topography and high rainfall, it is well known that drastic changes in land use, such as deforestation, urbanization, highway construction and open pit mining, cause substantial changes in water and sediment regimes that have a negative effect on the development of water resources. Exploitation of water resources traditionally involves engineering the capture, storage, conduction and use of water, but the concept of the watershed must become an integral part of the development and management of water resources. According to physical (topography, climate, geology, soils, etc.), biological (principally vegetation cover) and cultural (land use) conditions, the watershed transforms rainfall inputs into outflows of variable water quality and quantity over time and space.

Costa Rica is a tiny country favored with excellent natural resources of soil and water that provide daily subsistance, major portion of income, electricity and potable and industrial water, plus considerable potential for irrigation. It is imperative that these vital, irreplaceable resources be used rationally. Protected watersheds are the best guarantee that present and future generations will have potable water, hydroelectricity, food, energy, plus many other uses and opportunities indispensible to our survival and quality of life.

Status of Water Resources

Hydrographic Units

ICE has subdivided the country into 34 watersheds or groups of watersheds (see Fig. IV-8). The general orientation of mountain ranges along the longitudinal axis of the country contributes to the high number of watersheds that are generally drained by relatively short rivers with steep gradients. Heavy rains turn these rivers into raging torrents with awesome erosive power. River flow rates are monitored by ICE. Both ICE and IMN take rainfall data (e.g., ICE-IMN 1975). A few other groups (e.g., ICAA, banana companies) take hydrometeorological data. On a national level, the network for taking hydrometeorologic data is deficient, particularly in the north and in the Cordillera de Talamanca. The most important rivers for potential hydroelectric exploitation are the Sixaola, Chirripó Atlántico, Reventazón, San Carlos, Tempisque, Grande de Tárcoles and Grande de Térraba (Table IV-16, previous pages).

Table IV-17. General information on ground water and for major watersheds in Costa Rica. Adapted from OFIPLAN 1979.

WATERSHED		QUANTITY OF GROUND WATER							WATERSHED AREA			
Number	Major River	Zones	High	Moderately High	Moderate	Moderately Low	Low	Scarce	Upper	Middle	Lower	Coast
1	Sixaola	a		x							x	
		b					x		x	x		
2	Estrella	a		x							x	
		b					x		x	x		
3	Banano	a		x							x	
		b					x		x			
4	Bananito & others			x							x	
5	Moín & others	a			x					x	x	
		b						x				x
6	Matina	a	x								x	
		b				x			x	x		
		c						x				x
7	Madre de Dios & others	a		x							x	
		b					x		x			
		c						x				x
8	Pacuare	a		x							x	
		b				x			x			
		c						x				x
9	Reventazón & Parismina	a					x		x	x		
		b			x						x	
		c						x				x
10	Tortuguero & others				x					x	x	
11	Chirripó Atlántico	a		x							x	
		b					x		x			
		c						x				x
12	Sarapiquí	a		x						x	x	
		b					x		x			
13	Cureña	a					x		x			
		b	x								x	
14	San Carlos	a		x						x	x	
		b					x		x			
15	Pocosol & others	a					x		x			
		b			x						x	

Table IV-17. (Continued)

WATERSHED		QUANTITY OF GROUND WATER							WATERSHED AREA			
Number	Major River	Zones	High	Moderately High	Moderate	Moderately Low	Low	Scarce	Upper	Middle	Lower	Coast
16	Frío	a b		x			 x		x x	x		
17	Zapote & others	a b	 x		x					x	 x	
18	Nicoya Peninsula & North Coast	Important Rivers Associated with ground water sources: Las Cañas; Andamojo; Nosara; Bejuco; Jabillo y Bongo; Jicaral-Santa Rita										
19	Tempisque	a b c	 x			x		 x	x	 x	 x With salinity problems	
20	Bebedero	a b c	 x			x		 x	x	x	 x	 x
21	Abangares & others		NO DATA									
22	Barranca				Industrial; Conservation important							
23	Jesús María		NO DATA									
24	Grande de Tárcoles		x Available for high consumption; danger of contamination							x		
25	Tusubres & others				x							x
26	Parrita			x								x
27	Damas & others			x								x
28	Naranjo			x								x
29	Savegre			x								x
30	Barú & others			Few possibilities of significant quantities								
31	Grande de Térraba	a b		x	 x					 x	x	
32	Osa Peninsula			x						x		
33	Esquinas & Others			x						x	x	
34	Changuinola		NO DATA									

The country also has appreciable ground water resources, with an estimated potential of 350 m^3/second sustained flow (R. A. Moya, pers. comm.). SENAS has data on several well-studied aquifers, plus yield data from a large number of wells throughout the country. Table IV-17 provides a general and brief review of the country's ground water resources.

Hydroelectric Development

Costa Rica's lengthy history of hydroelectric development began in 1884 with installation of a tiny plant in Aranjuéz to illuminate 25 street lamps in San José. In 1899 a 600 Kw plant was installed at Los Anonos to supply the streetcars that served San José until 1950 (CNFL 1971). The modern era of the country's hydroelectric development began with the 1949 creation of ICE. Since 1950, when total installed power was less than 50,000 Kw, ICE has installed 404,000 Kw of hydroelectric power (Table IV-18) and is now satisfying 99% of the demand with a production of 2,200 Gwh in 1980. A modest amount of additional electric power is generated by the seven CNFL plants (totalling 30,000 Kw) and a few municipal small generators (about 12,000 Kw) (A. Rodríguez, pers. comm.).

ICE's development program projects a tripling of installed power by 1990 (Figure IV-18); however, the drastic deterioration of the country's economy in 1981 makes it unlikely that both demand and construction projections will be realized as scheduled. For example, due to financing difficulties, the government has temporarily suspended plans to construct the Boruca dam.

Electricity consumption by sectors in 1979 was 45% residential, 33% industrial, 19% commercial and 3% others. Per capita consumption was 760 Kwh in 1978 compared to 720 in Panamá, 346 in Nicaragua, 295 in El Salvador, 187 in Honduras, and 168 in Guatemala. Costa Rica's great advantage is that 99% of the electricity needs are provided by hydropower, whereas, other Central American countries are heavily dependent on fossil fuels for their electric generation. Costa Rica has plans to export excess electricity to its neighbors in the near future.

In contrast to a 9% annual growth in electricity demand during the 1970's, growth dropped to a 6.5% increase in 1981. According to an ICE official, 1,500 persons in the metropolitan area had stopped paying for electricity by August 1981. Further rate increases planned for early 1983 may lower the demand increase even more. Due to the higher cost of electricity, low income homes are probably switching to firewood for cooking. Dramatic increases in the demand for firewood and charcoal could induce uncontrolled deforestation. Alternatively, the opportunity for energy plantations could lead to reforestation of degraded lands.

Costa Rica will have to capitalize on its hydroelectric resources to overcome the current economic difficulties and base future development plans on its vast hydroelectric potential. Evaluation of some 75 possible hydroelectric projects puts the country's potential hydroelectric capacity close to 9 million Kw (Lara 1980).

In the past 20 years rural electrification projects have received broad support. ICE constructed 1,660 km of primary and secondary grids in 1980 alone, bringing electricity to 70% of the country's populations (Figure IV-19).

ICE's legal mandate (Law N° 449, 1949) explicitly directs ICE to conserve and defend the country's hydraulic resources and to protect watersheds, springs and river channels. ICE has complied partially with its mandate by protecting a few watersheds where it has substantial investments, such as the Río Macho reserve. ICE now includes specific environmental studies as part of any hydroelectric projects, e.g., Palomo, or in some cases, contracts integrated ecological studies such as for Arenal (TSC 1980). Nevertheless, these efforts do not fulfill ICE's legal mandate to protect watersheds.

Virtually every major watershed in the country is being degraded by deforestation and inappropriate land

Table IV-18. Thermal and hydroelectrical generators built by ICE. Only thermal generators in the National Interconnected System are included. Source: ICE 1980.

Generator	Type	Year Operation Inaugurated	Initial Installed Power Kw	Year Addition Completed	Final Installed Power Kw
Colima	Thermal	1956	8,000	1962	19,400
La Garita	Hydro	1958	30,000		30,000
Río Macho	Hydro	1963	30,000	1978	120,000
Cachí	Hydro	1966	64,000	1978	100,800
S. Antonio	Thermal	1973	38,100		38,100
Barranca	Thermal	1974	41,600		41,600
Moín	Thermal	1977	32,000		32,000
Arenal	Hydro	1979	153,000		153,000
TOTAL					534,900

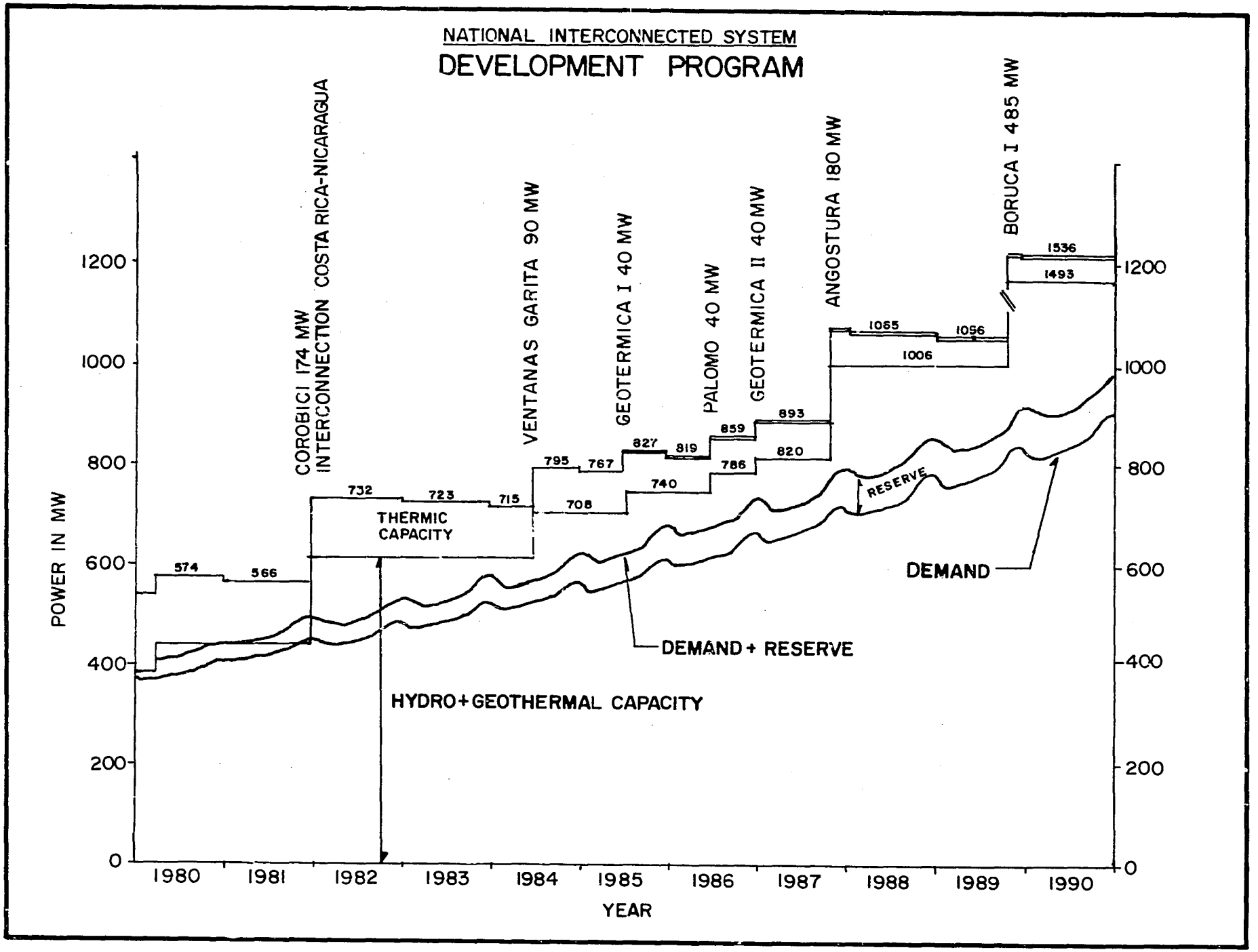

Figure IV-18.—Program development of ICE's National Interconnected System. (Source: ICE 1980)

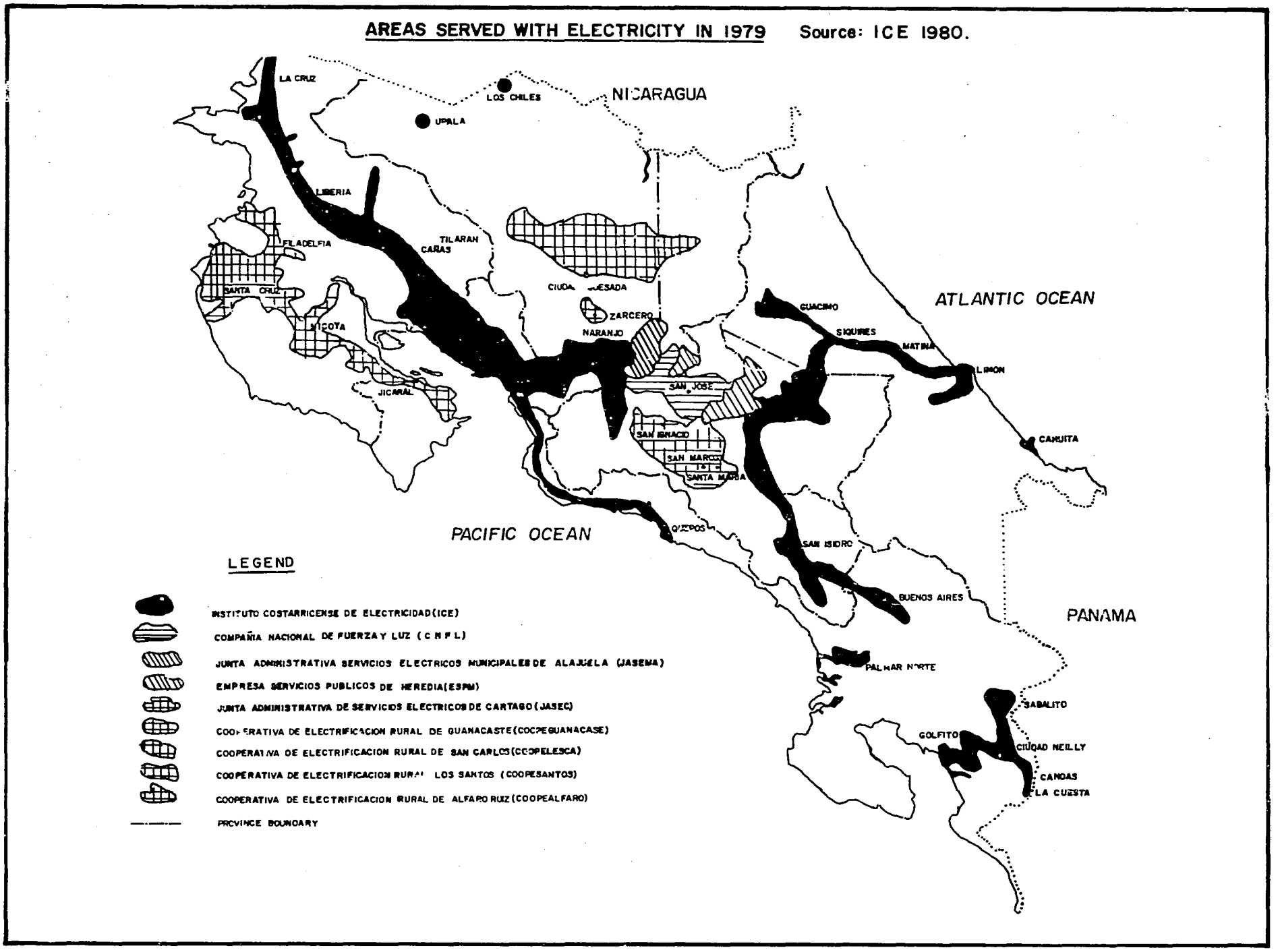

Figure IV-19.—Areas served with electricity in 1979.

use (see the separate sections on these topics). ICE should be protecting critical watersheds even before the start of a hydroelectric project, rather than after construction is completed. Land invasion and speculation by professional squatters not only increases the cost of expropriation, but degrades water quality, thereby threatening the economic viability of the project.

Potable Water

Costa Rica has been exceptionally successful in supplying water to its citizens. Of the 82% of the population served by aqueduct in 1980, coverage is 98% in urban areas and 62% in rural areas; these exceed the decade goals for 1980 of 80% urban and 50% rural coverage (ICAA, unpublished data) (see Table V-1); The ICAA system of aqueducts supplies 87% of the urban coverage and 6% of the rural.

Historically, the country was more concerned with supply than quality in urban centers, particularly in the metropolitan area. Although ICAA administers few rural aqueducts, it advises municipalities on design, supervision, construction, tariff design, and administrative structure.

The metropolitan area's current demand of 2,200 l/s is met by both surface and ground water sources, the latter largely from aquifers near Heredia. Potable water demand is expected to exceed supply in the late 1980's (Figure IV-20), even if projects can be completed as planned.

The aqueducts serving other urban centers such as Heredia, Alajuela, Cartago, etc., are usually controlled by local agencies. Cartago appears to be near crisis stage for both water supply and quality.

With important foreign funds over the past few years, ICAA has carried out a series of interesting studies on the evaluation and exploitation of water resources, e.g., Ramírez 1981; Lucke & Ramírez 1980; Solano 1981; Mora 1981. These and other reports are indicative of the competence and professionalism in ICAA's Department of Studies & Projects.

ICAA's principal problem is the lack of realistic means (but not legal) of complying with several articles of its legal charter. The failure to protect water sources is due to the mistaken concept that other institutions such as DGF or MS are responsible for watershed protection or controlling water pollution.

Irrigation

Available information on the area of irrigated land is inexact and incomplete, perhaps due to the absence of a government agency responsible for irrigation. The 1973 agricultural census reports 66,362 ha of irrigated land, of which 13,000 ha was in banana plantations. A slightly later report (CNHM 1976) lists 40,000 ha of irrigated bananas out of a total of 65,525 ha of irrigated land. Although the same CNHM report puts the potential area of irrigated land at 350,000 ha, a more accurate estimate is 250,000 ha (A. Vásquez, pers. comm.).

The development of the Itiquís and lower Tempisque irrigation projects has been plagued by a series of financial and administrative difficulties. The lower Tempisque irrigation project is way behind the master plan's schedule (BEL 1978); only 245 ha are now being irrigated. Completion of the southern canal and the Magdalena dam will permit irrigation of 8,360 ha by 1985 in the zone between the Corobicí, Tenorio, Bebedero and Cañas rivers (L. Miranda, pers. comm.). After 1985, the goal is to add 5,000 ha per year to a total of 120,000 ha of irrigated land, but will be almost entirely dependent upon the availability of foreign financing.

The lower Tempisque irrigation water will come from the Arenal hydroelectric project; however, the monthly flows will not entirely satisfy the projected irrigation demand during the dry season. An additional 192 million m^3 of reservoir capacity will be needed for irrigation. Due to its size and potential impact, the lower Tempisque irrigation project could provide a tremendous technological boost to agricultural production. Nevertheless, the environmental and socio-economic implications of the project must be taken into consideration if the project is to truly contribute to development of the country.

The well-publicized Itiquís irrigation project still has not been formally inaugurated, and only the experimental plots are being irrigated. Some 500 ha were irrigated in 1982 and project officials hope for a political decision to add another 5,000-7,000 ha (C. Chávez, pers. comm.). The Central Valley has about 15,000 ha of fertile land requiring irrigation, mostly in the western part of the valley. If these productive lands are to be the "breadbasket" for the metropolitan area, political decisions must be taken soon to ensure their agricultural use, otherwise they will continue to be urbanized. Irrigation waters in the Central Valley are threatened by serious water pollution (see section V-A), plus the demand for water is increasingly competitive.

A few other areas of the country have some additional 50,000 ha suitable for irrigation: Parrita valley; El General valley; Lagarto and Guacimal valleys; central Pacific; and small intermountain valleys on the Nicoya peninsula (A. Vásquez, pers. comm.).

Navigation

River navigation with medium and deep draft boats does not occur due to the steep gradients and shortness of the country's rivers. There are only about 600 km of navigable rivers in the country and these can only be used by small boats (CNHM 1976). The only area where river transport is important is in the northeast on the Tortuguero canals and the San Carlos, Sarapiquí and San Juan Rivers. The massive deterioration of the country's watersheds strongly affects the hydrologic regime that in turn will lessen the navigability of rivers. The uncontrolled increase in sediments generally causes a reduction in channel depth and increased channel width. The more rapid hydrologic response in altered watersheds produces greater floods in the rainy season and less base-flow in the dry season.

Recreation

The principal recreation demand for potable water occurs on the coasts during the dry season. The uncontrolled development of some coastal tourist attractions was

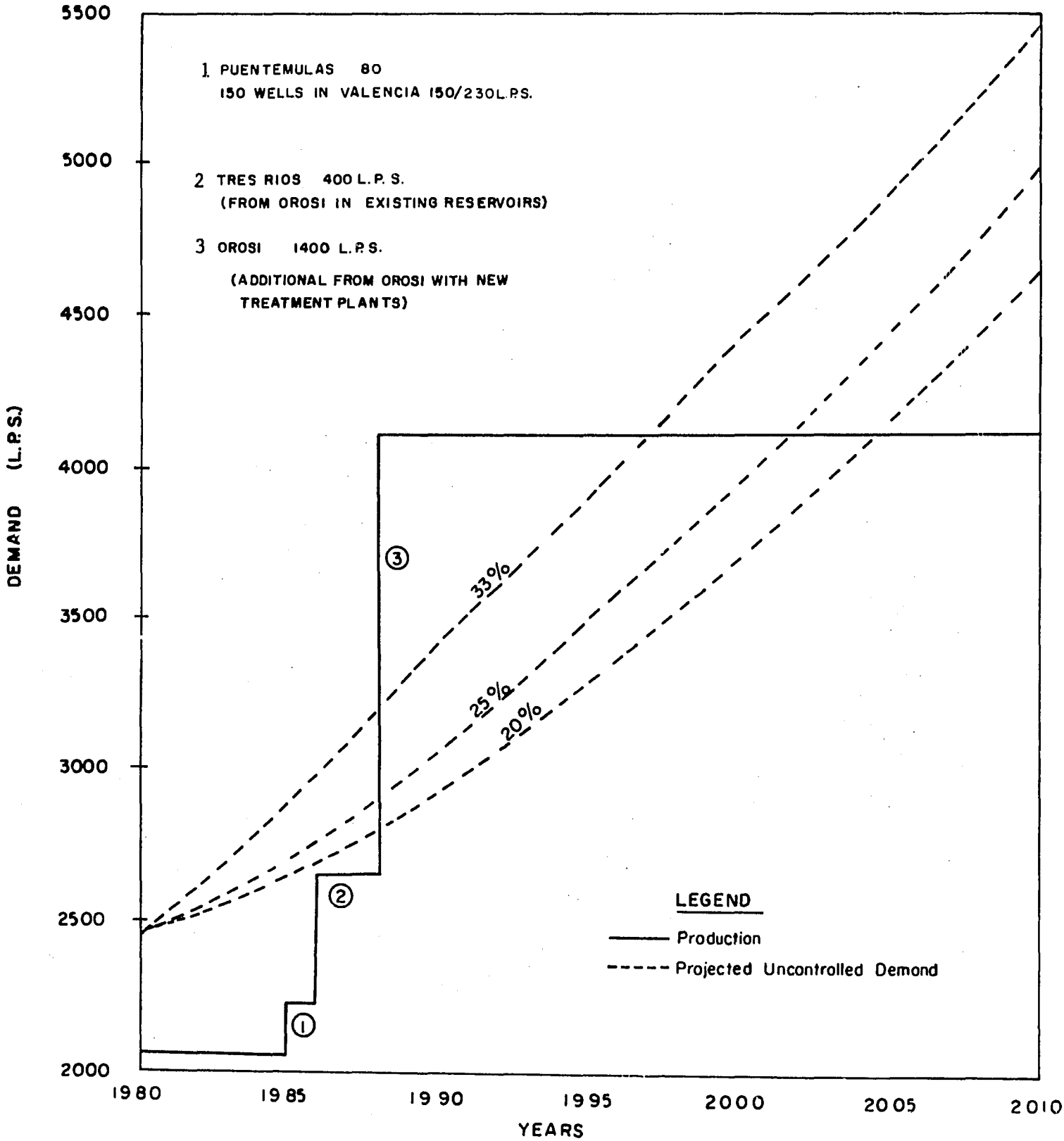

Figure IV-20.—Potable water production and demand in the San José metropolitan area.

Figure IV-21.—Sarapiquí river flooding the gas station in the town of Puerto Viejo de Sarapiquí. The high rainfall, topography and uncontrolled deforestation are increasing the flood risks to many towns and major agricultural areas of Costa Rica (photo G. Hartshorn, December 1974).

done without considering source and demand of potable water. The supply is usually pumped from wells that are easily contaminated by pollutants or salt-water intrusion (Figure V-1), such as is ocurring at Tamarindo, El Coco, Cahuita and Puntarenas (D. Mora, pers. comm.). The adequate supply of potable water is critical to the success of tourist development on the coasts. Some wells have reached critical drawdowns, causing salinization late in the dry season, usually coincident with the traditional tourist peak during Holy Week.

Floods

The problems caused by flooding have been increasing recently, both in rural and urban areas, due to the increasing use of natural flood plains for economic activities and human settlements. Although anecdotal sources suggest higher floods are occurring more frequently, the absence of flood-risk zoning and the political decisions to prohibit flood plain construction have contributed to increase annual damage caused by floods. The potential for disastrous floods is greatest in the Caribbean lowlands (see Table IV-16), particularly in the towns located at the base of the mountains, e.g., Pocora, Guácimo, Guápiles, Puerto Viejo de Sarapiquí (Fig. IV-21). Many of these towns are situated on the outwash cones formed by major rivers of the Cordillera Volcánica Central. Course changes such as have recently happened to the Toro Amarillo, Blanco, Costa Rica and Chirripó rivers are vivid demonstrations of the awesome power of floodwaters. Relatively small rivers (e.g., La Vieja, Cañito) are capable of moving huge boulders during the flood stage (Quesada 1978).

The rampant deforestation and widespread destruction of watersheds in the Caño Seco and Corredores rivers make Ciudad Neilly probably the most poorly located urban center in the country. Flooding of the Caño Seco and Corredores rivers annually threatens to sweep away the town. The threat of landslides temporarily damming a stream, then breaking during a severe storm, is real and a potential for devastation. The famous flood of the Río Sombrero on 23 June 1975 is an example of the incredible

Figure IV-22.—High sediment loads increase the cost of treatment of potable water as shown here by the muddy water entering the ICAA treatment facility at Ipís (photo A. Mata).

damages caused by deforestation of a critical watershed (Quesada and Rodríguez 1975).

Uncontrolled urban expansion has permitted the proliferation of slums on the flood plains of the rivers in the metropolitan area (Tiribí, María Aguilar, Torres, Ocloro rivers). In a few cases more economically solvent neighborhoods are affected, e.g., Barrio Vásquez Dent where the Los Negritos creek annually overflows. Failure to consider the changes in ruoff caused by upstream urbanization is why the Los Negritos creek often exceeds the inadequate storm drains. More detailed information on urban flood control is available in the excellent DRENACA study (IFAM 1979).

Principal Environmental Problems

Water Resource Development and Watershed Protection

A reservoir site, at a specific geographic location is a non-substitutable option because of a set of hydrologic, topographic, physiographic and geologic conditions. Whether for energy, potable water, irrigation or recreation, the costs of developing water resources are very high and dependent on the quality of the resource as well as its spatial and temporal distribution. Water quality, which is dependent on sediment load (Fig. IV-22)

and the nature and concentration of contaminants, can easily affect not only construction costs but technical feasibility and useful life as well.

Sedimentation in irrigation and drainage canals, premature silting of reservoirs, and increased treatment costs of potable water are some of the results associated with the degree of watershed protection. These same results also have important secondary effects, such as: (a) a decrease in hydraulic efficiency of irrigation canals can cause time lags in irrigation that could affect crop yields or area irrigated; (b) a decrease in reservoir capacity reduces water storage volume and hydroelectric generating potential; (c) increased water pollution involves greater treatment at higher costs; (d) a significant decrease in base flow may require water rationing during low water periods.

More detailed information on the deterioration of the country's natural resources and the socio-economic consequences can be found in symposia on natural resources (First National Congress on Conservation of Renewable Resources 1974; International Symposium on the Ecology of Conservation and Development in Central America 1976). Specific ecological studies of Arenal (TSC 1980) and Boruca (Tosi and Zadroga 1975; TSC 1981) clearly document environmental deterioration, particularly on water resources.

The principal problem of watershed degradation is that, outside of national parks and equivalent reserves, wholesale changes in land use are occurring rapidly due to forest exploitation, agricultural activities, land tenancy pressures and lack of legal mandate based on land use potential. During the past decade several developmental projects have been proposed and pushed by politicians and special interest groups without mention of environmental constraints, e.g., an interocean oil pipeline traversing the Talamancas, pulp and paper mill, or open pit copper mining.

Urban watersheds are severely degraded, with attendant problems of water quality and flooding. Both of these serious problems require urgent attention in the metropolitan area. It appears that the official estimates of reservoir sedimentation may be too low, as mentioned in TSC (1980) and Tosi and Zadroga (1975), thus the projected useful life may be appreciably less than the figures used in the feasibility studies. If critical watersheds continue to be unprotected, sedimentation rates will continue to increase, with drastic consequences and setbacks to water resources developments.

The degradation and changes to the lower Tempisque irrigation project have been only superficially considered. Considering the total absence of experience and tradition with irrigation, numerous possible results can easily occur: (a) excessive application of water leaches nutrients, which can cause high levels of nitrates in the water; (b) lack of or poor canal maintenance permits weed growth and sediment accumulation, that in turn reduce canal efficiency. The combination of obstructed canals and excessive application of water can cause major drainage problems in low-lying areas; (c) uncontrolled use of pesticides could provoke serious water pollution. Pesticide spills or dumping of excess are the principal hazards; (d) the dry-season working of farmland could cause severe wind erosion of soil due to the strong tradewinds. Windbreaks should be a prerequisite to irrigation; and (e) lack of irrigation experience generally produces a carelessness in the use of small siphons, causing serious local erosion and sedimentation in the irrigation furrows.

Road Construction

The slight emphasis on drainage in the design and construction of roads produces serious drainage problems that are often detrimental to the road. Unpaved rural roads frequently lack transverse and longitudinal drains, causing severe surface runoff that sometimes turns the road into a drainage way. Absence of adequate drainage causes the road sub-base to be saturated during the rainy season, thus reducing the road's capacity to support heavy vehicles. The consequent subsidence and cracking of the road quickly leads to the famous holes in the country's roads.

Unpaved roads in areas of high precipitation and long rainy periods probably contribute considerable local erosion due to their steep grades. Concentrated water flows in non-reinforced or non-lined drainage ditches erode the road edge before flowing down slope to a stream, often carving out impressive gullies. Rapidly advancing gullies produce huge sediment erosion and threaten the road with gully-induced landslides.

The frequency of landslides is accentuated by road construction, especially where there are severe topographic, geologic and hydrologic restrictions that prompt appreciable cut-and-fill sections of the road (Fig. IV-23). The disruption of the natural stability of slopes by road construction may continue to plague the road with landslides for many years, such as along the Interamerican Highway between El Tejar and San Isidro de El General or on the railway line at Piedras de Fuego. The environmental impacts of the Guápiles highway construction are well-documented (TSC 1975).

The most serious environmental problems of a transisthmian oil pipeline would come from opening the

Figure IV-23—San José-Guápiles highway under constuction through the rugged Cordillera Central. Extensive cutting into steep slopes often plagues the highway for years with massive landslides (photo G. Hartshorn).

right-of-way and the actual construction. Earth-moving, landslides, access and maintenance roads for the pipeline and pumping stations would all threaten the hydroelectric potential of the Talamancas. Uncontrolled construction of the secondary roads and timber extraction would accentuate slope instability and the production of sediments.

Open-pit mining of copper in the Talamancas would result in serious environmental degradation due to the movement of millions of tons of earth and the road network in very steep terrain with high rainfall.

Irreversible or Irreparable Losses of Resources and Development Opportunities

Due to the prohibitive cost, extremely long recovery time, or irreversible consequences, the following aspects of water resource utilization can be considered as irreversible losses:

a) Aquifer salinization

b) Urbanization of potentially irrigated land

c) Sedimentation of reservoirs

d) Watershed deterioration to a critical point where accelerated erosion continues for several years, making reforestation or erosion control uneconomical

e) Loss of life and property damage due to floods

f) Soils flooded by filling of reservoirs

The urbanization of irrigable land in the western Central Valley will soon be a lost development opportunity unchangeable in the short-term. These farmlands offer excellent agricultural opportunities because of the absence of land tenure problems, existing infrastructure and social services, the benefits of born farmers already there and easy access to distribution centers. Irrigation would permit profitable vegetable farming and would maintain green belts in the sea of uncontrolled urban sprawl.

The tremendous hydroelectric potential presents great development opportunities that are diminishing in the absence of watershed protection. Costa Rica could use its hydroelectric potential as a catalyst to establish industrial centers requiring abundant hydroelectricity. Joint ventures with friendly governments or international investment consortia could finance the construction with no cost for the Costa Rican government and then discount their investments in manners that do not infringe on national sovereignty. Stimulating international investments in a renewable natural resource actually lost to the oceans with no benefit, would be a great economic benefit to the country.

Some rivers and watersheds are of such extraordinary beauty and biological richness that they could be exploited for recreational and scientific tourism. Deforestation and erosion will forever spoil their multiple potential. Particularly severe erosion is evident in the following watersheds:

Watershed	Area km²	Condition % Eroded	Condition % Severely Eroded
Tusubres	830	86.4	59.8
Parrita	1,265	85.9	56.7
Península de Nicoya	4,202	65.7	42.2
Barranca	505	67.3	37.0
Abangares	1,362	60.5	37.3
Bebedero	2,050	63.7	29.1
Grande de Térraba	5,075	62.8	28.7
Grande de Tárcoles	2,168	68.0	26.7

Obviously, the matter of forest invasion and destruction is serious, and the results to the watersheds cannot be considered less than threatening.

Major Limitations to Progress

These can be succinctly stated as follows:

1) Lack of political will to effectively protect watersheds and to clearly define acceptable land use based on specific technical criteria.

2) Lack of inter-institutional coordination and cooperation.

3) Lack of financial resources to complete essential projects, e.g., DRENACA, due to current economic crisis.

4) Rigidity of government institutions to adopting new programs.

5) Unwillingness of competent scientists and technicians to influence the political decision-making process concerning water resources.

6) Insufficient representation of competent scientists and technicians on the boards of directors of autonomous institutions.

Conclusions

General

A coordination problem exists among the institutions involved in the administration, control, production and distribution of water resources. Each institution independently carries out its programs, that tend not to be part of an integrated resource development policy. The lack of coordination and integrated planning in the development of water resources could create future conflicts as water utilization becomes more competitive, while water quality diminishes.

Despite legal mandates that obligate user institutions to protect their watershed, institutions show little concern because they are not doing anything to effectively protect their natural resources. Lack of norms and policies for land-use planning is causing accelerated deterioration of watersheds. The DGF has major responsibility for watershed protection, but it is hampered by technical and financial limitations and limited political power.

Although considerable progress has been made in obtaining baseline data on water resources, hydroelectric

and meteorologic information is still incomplete, particularly in the very remote and wet regions. In addition to the basic network of meteorological stations, the principal user institutions place specific equipment in the field to complement the basic meteorologic data.

Irrigation

Approximately 5-7% of the country is suitable for irrigation; however, no integrated policy exists, nor is a single institution in charge of irrigation. There is a serious lack of technical expertise with irrigation and drainage, which may complicate the initial phases of irrigation projects. The complicated land tenancy structure in the major irrigation zones is a serious obstacle to stable and equitable agricultural development. The lower Tempisque master plan addresses the environmental and socio-cultural aspects of the irrigation project in a very superficial manner.

The Central Valley has some 20,000 ha suitable for irrigation that are in imminent danger of being lost to uncontrolled urban sprawl. These fertile lands are excellent for vegetable farming and have the necessary infrastructure, plus they would serve as a green belt for the developing megalopolis.

Hydroelectricity

ICE has fulfilled its mandate to supply electricity to the country thanks to precise policies. The National Interconnected System (SNI) and programmed development of hydroelectric projects now permits 99% of electricity generation to come from hydroelectric power. Although ICE is concerned about environmental problems and is actively searching for new energy sources, there is no institutional commitment to impede the destruction of watersheds.

Preliminary evaluations of the country's hydroelectric potential indicate about 9 million Kw; however, these were based on a minimum unit potenial of 40,000 Kw. Given the rapidly escalating cost of fossil fuels and the current economic situation, it is necessary to reevaluate the minimum size for an economically-viable hydroelectric project. Small or intermediate size hydropower projects may be a more economical option than building long, high tension lines to supplying electricity to some remote communities such as Puerto Jiménez.

ICE has developed projects to meet expected electric demands, rather than using hydroelectric potential as a stimulus or incentive for energy-demanding industry. The excellent hydroelectric potential could be used to attract energy-intensive industry to finance the necessary hydroelectric development.

ICE needs more accurate data on rates of erosion and sedimentation under different land use systems if it is to accurately evaluate existing and future hydroelectric projects and sedimentation rates. Technicians appear to be underestimating erosion rates and sediment accumulations.

Potable Water

Although ICAA has made considerable progress in improving the supply and quality of potable water to urban centers, numerous smaller municipalities resist being administered by ICAA. Many aqueducts, primarily rural but with a few urban exceptions such as Cartago, are inadequate due to age, technical deficiencies, poor administration and unrealistic rates. Technical and organizational assistance from ICAA to rural municipalities is helping local groups significantly upgrade their potable water services. In the metropolitan area ICAA has had appreciable success reducing water losses to leaks, breaks, etc.

One of ICAA's major problems is the technical impossibility of supplying potable water to the poor settlements located in places completely unsuited for social (IMAS) services. Social pressures on institutions like INVU force them to accept spontaneous urban developments in upper watersheds where service is difficult and contamination is rife. Pumping water to these poorly-located developments, seriously strains the ICAA budgets.

Navigation

Great changes are not likely in navigation due to the limited possibilities of expansion or substitution.

Flooding

Flooding is a serious problem in certain low-lying areas where important economic activities are concentrated, such as bananas. Deterioration of watersheds through changes in land-use will increase the severity and frequency of floods, occasionally with disastrous consequences. The problem of urban flooding is accentuated by urban sprawl, which decreases soil permeability and hastens runoff. Frequent spontaneous invasions of the narrow floodplains in the metropolitan area for slum housing could lead to a great tragedy if a major flood occurs. The DRENACA study is an excellent effort to lessen the flooding problems in the metropolitan area; even though the costs are prohibitive, the most urgent and economically feasible corrective actions should be given highest priority.

Water Law

The Water Law is functional, but needs some reforms concerning policy of land distribution to holders expecting irrigation water supplied by the government. A "partial quota" concept may resolve the land tenure problem in irrigated lands. The Water Law does not contain any clauses regulating the activities of mining operators and potential contamination of water resources. Although the Water Law gives guidelines restricting a few concessions, no mechanisms exist for forcing compliance. Thus solid wastes continue to be dumped into streams, and rock, gravel and sand extraction is unrestricted.

Recommendations

In order to obtain the maximum utilization of water resources according to the changing needs of society, a national water resources plan needs to be developed by a technically qualified executive secretariat that should coordinate the execution of different activities and projects among the various institutional users. Such a secretariat should avoid possible use conflicts that could develop from increasingly competing demands for scarce resources.

The user institutions should unify forces in order to exert more political pressure for conservation of water resources and watershed protection. This includes support of the DGF's watershed department and the MS's environmental protection office by the larger institutions.

To avoid accelerated deterioration of watersheds, each user institution should define by technical criteria the critical zones that must be protected. These essential areas should be classified as inalienable hydrologic reserves whose absolute protection is the responsibility of the water resources executive secretariat. The costs of protection should be an integral component of the hydroelectric projects or other water resources development projects.

The hydrologic data base needs strengthening in some sites of high potential in order to increase ICE's predictive capacity.

Financing is needed to carry out studies on the possible sources and quantities of sediments eroded under different land-use practices. These studies need to be done in representative watersheds so that accurate projections of sedimentation rates can be obtained. Traditional hydrologic procedures tend to underestimate erosion rates in mountainous tropical watersheds where strong rains, landslides and changes in land-use contribute enormous quantities of sediments to streams and reservoirs. One alternative would be for CONICIT to support appropriate research on small experimental watersheds.

Ground water resources should be evaluated systematically in coastal zones where there is potential for tourist development. Guidelines and information are needed on minimum yields, location of wells and prevention of salinization of the aquifer.

The government should solicit on a world-wide basis for intergovernmental cooperation to participate in major hydroelectric development projects where the governments would finance construction costs in return for priority usage of electricity to be paid back by depreciation throughout the economic life of the project. The country's enormous hydroelectric potential should be very attractive to energy-intensive industries. International participation in hydroelectric development would avoid further local indebtedness, would attract foreign capital, and would generate more industrial employment.

ICAA's rotating fund for technical assistance to municipalities needs to be increased so that ICAA can supply desperately needed assistance to urban and rural centers with potable water supply and quality problems.

Well-established regulations and lines of communication are needed between ICAA and the various institutions that carry out housing programs so as to avoid human settlements in areas where it is difficult to provide potable water, or where settlement would result in loss of water or land quality.

In order to avoid greater deterioration in urban watersheds that supply potable water, settlement must be prohibited in inappropriate locations. INVU should promote a law controlling urban development that protects urban watersheds and rigorously brings order to the currently chaotic urbanization process.

Programs involving conservation of potable water need to be strengthened and expanded, e.g., meters and leak-control particularly in those areas where water treatment is very costly.

The problems of urban flooding must be given much more serious attention, including implementation of effective zoning policies in critical areas. It is cheaper in money and in lives to address the problem before a major flood rather than provide disaster relief. Given the potential magnitude of urban flooding problems, the preventative efforts should be centralized in one responsible institution.

An integrated irrigation policy should be defined under the responsibility of one competent institution that is given the financial and human resources to meet the difficult challenge of developing major irrigation projects. The Central Valley should be evaluated for lands appropriate for irrigation and immediate action should be taken to inhibit loss of these lands to urbanization. A detailed environmental and socio-cultural study of the lower Tempisque irrigation project is needed. Specific attention should be given to irrigation-drainage relations and the potential for wind erosion. Training programs in irrigation technology are urgently needed to maximize the benefits and avoid costly mistakes. The integrated irrigation policy needs to be redefined to include the relevant socio-economic perspectives, because the enormous costs of government-financed irrigation projects should not benefit only a few large landholders. A "partial quota" system used in other developing countries, such as the Dominican Republic, would more equitably distribute the benefits of increased land values and productivity. The partial quota is a kind of tax, paid with land for the increased value and productivity of land because of irrigation.

An independent environmental analysis should be required for any major project proposed in watersheds or whose development might affect the water resources.

IV-H. RENEWABLE AND NON-RENEWABLE ENERGY RESOURCES

This chapter reviews the development patterns of the production, import, and consumption of energy in Costa Rica based on National Energy Balances for the decade 1970-1979. After a brief diagnostic overview of the behavior of the national energy system, projections of demand and national sources are offered to the year 2000. The fundamental options for supplying national demand form the basis of alternative scenarios that will require critical decisions by the GOCR in formulating a national energy strategy. Long-, mid-, and short-term projects are evaluated. Key national institutions and the international context of Costa Rica's energy situation are discussed in Section V-C.

Characteristics and Trends

Costa Rica's dependence on imported energy increased dramatically in the past decade to where 80%

of the commercial energy consumed is imported. The increase in demand for commercial energy averaged 8.4% per year for the past decade (Table IV-19). On a per capita basis, Costa Rica uses twice as much commercial energy as the rest of Central America. RECOPE's petroleum distillery in Moin supplies only about one-half the national demand: it produces all the kerosene, jet fuel, asphalt and bunker (fuel oil) needed, but about 70% of the liquid gas (gasoline) and diesel are imported directly. In 1979 petroleum accounted for 13% of the country's total imports.

Hydroelectric power accounts for 19% of the country's primary energy supply (Table IV-20). If only electric power is considered, 99% came from hydroelectricity in 1980. Use of diesel or bunker fuel to generate electricity was often needed late in the dry season, but the new Arenal reservoir and power plant now easily cover the dry season electrical demands. A few rural electric cooperatives (e.g. CoopeAlesca in San Carlos) are not connected in the national grid; they still use diesel power plants to generate electricity.

The consumption trends over the past decade are detailed in Table IV-20. A key trend is the strong substitution of renewable energy (firewood) by non-renewable energy (petroleum derivatives). In relative figures, firewood decreased from 60% of final energy consumption in 1965 to 30% in 1979, largely due to conversion to liquid gas (propane) for cooking. Some 92-96% of firewood is used for household cooking.

The transport sector increased final energy consumption much more rapidly than either the residential-commercial-public or industrial-agricultural sectors (Table IV-20). The sector analysis indicates that the transport

Table IV-19. Energy consumption in Costa Rica 1970 and 1979. Annual commercial use increment is 8.36% for the decade.

	1970	1979
Total Energy Consumed (TEP*x 10^3)	1,185	1,660
Commercial energy (TEP x 10^3)	406	836
Non-commercial energy (TEP x 10^3)	556	571
Per capita consumption (TEP)		0.76
Per capita commercial consumption (TEP)		0.39

* Tons Equivalent of Petroleum; 1 TEP = 7 barrels of petroleum; 1 TEP = 10^{10} Calories.

Table IV-20. Energy consumption and sources by major population sectors for 1970, 1974, and 1979.

SECTOR	1970 TEPx10^3	1970 %	1974 TEPx10^3	1974 %	1979 TEPx10^3	1979 %	Decade % Increase
Residential, Commercial and Public	505	100	528	100	555	100	
Firewood	423	83.8	420	79.5	416	75.	- 2
Electricity	51	10.1	72	13.6	89	16.	75
Kerosene, etc.	19	3.8	19	3.6	20	3.6	5
Others	12	2.4	17	3.2	30	5.4	233
Transportation	227	100	310	100	463	100	
Diesel & Gas oil	121	53.3	171	55.2	286	61.8	136
Gasoline	98	43.2	128	41.3	154	33.3	57
Kerosene	7	3.1	10	3.2	22	4.8	214
Electricity	1	0.4	1	0.3	1	0.2	0
Industry & Agriculture	228	100	275	100	385	100	
Animal & Vegetable Combo	102	44.7	107	38.9	136	35.3	33
Heavy oils	57	25.	73	26.5	124	32.2	118
Firewood	31	13.6	35	12.7	19	4.9	-39
Others	38	16.7	60	21.8	106	27.5	179
Other Sectors	2	100	2	100	4	100	
Electricity	2	100	2	100	4	100	100
TOTAL	962		1,115		1,407		
SOURCE							
Petroleum Importation	309	25.3	399	33.	404	32.8	
Firewood Production	474	38.9	475	39.3	458	37.2	
Hydroelectricity Production	332	27.2	225	18.6	229	18.6	
Others/Animal & Vegetable	105	8.6	109	9.	139	11.3	
TOTAL	1,220	100	1,208	100	1,230	100	
National Production	911	74.7	809	67.	826	67.2	

sector growth was fueled more by diesel than gasoline, no doubt related to the GOCR-subsidized price of diesel. The national energy flow in 1979 is illustrated in Figure IV-24.

Resources

Knowledge about national energy resources is incomplete, with competent estimates available only for hydroelectric energy. OLADE (1981) estimates national hydroelectric potential at 8,900 MW, equivalent to 639 million TEP. Although ICE is actively developing a geothermal plant on Volcán Miravalles, accurate estimates of total geothermal potential are unavailable. OLADE guesses Costa Rica's geothermal potential could be 10-50 million TEP. Detailed energy studies of biomass potential (firewood, charcoal, alcohol) do not exist Firewood alone could produce 50 million TEP. With technical assistance from México, Costa Rica has an active petroleum exploration project on the Caribbean slopes of the Talamancas. Although the petroleum deposits may be commercially exploitable, the national petroleum potential is thought to be small; the petroleum deposits appear to be difficult and costly to extract. The small petroleum deposits are expected to have a potential of 10-20 million TEP. Preliminary studies indicate coal reserves are of the order of 30 millions tons (=21 million TEP).

It is obvious that the principal energy resources are hydroelectricity and biomass--both renewable resources and directly dependent on the rational utilization and protection of the environment.

Estimating Future Demand Trends

Estimation of future trends in energy demands is a complex task requiring detailed analyses of multiple factors; detailed analyses are beyond the scope of this environmental profile. Dynamic factors such as economic and demographic growth, technological progress, price levels, and political changes must be included in elaborating future energy projections. Nevertheless, historic patterns of energy demands and their relation with other economic indicators permit estimation of probable ranges for future energy demands.

While Costa Rica's economy grew at an average annual rate of 6.0% during the 1970's, petroleum imports increased annually at an average of 8.5%. Short- and medium-term maintenance of the same economic growth rate is only possible by increasing consumption of commercial energy, which translates directly into increases in petroleum imports just to maintain the same rate of economic growth.

OLADE (1981) has estimated future energy demand and consumption correlated with three rates of growth in GNP: 3.5% (low); 5.7% (regional average for the 1970's); and 7.0% (used by CEPAL). The historical correlations between energy consumption and growth of GNP permit estimation of the proportional change in energy consumption that accompanies a proportional variation in GNP. The OLADE projections (Table IV-21) show that with a low GNP growth rate (3.5%) and a constant price of petroleum ($35/barrel), the minimum cost of Costa Rica's petroleum imports will more than double by the year 2000. GOCR economic planners will undoubtedly strive for a higher GNP growth rate and it is equally probable that the price of petroleum will continue to rise, thus the cost of imported petroleum could be several times more expensive than shown in the minimum projections of OLADE. For example, if the price of imported petroleum reaches $ 60/barrel by 1985, the minimum cost would jump to $ 450 million, while an average GNP growth rate of 5.7% would require $ 550 million for petroleum imports in 1985.

Table IV-21 OLADE projection for demand of imported petroleum and its derivatives (TEP x 10^3) estimated for three GNP growth rates for Costa Rica.

GNP Growth Rate/	1979	1985	1990	1995	2000
3.5%	882	1,016	1,407	1,791	2,278
5.7%	882	1,320	1,946	2,869	4,229
7.0%	882	1,463	2,349	3,772	6,058
Minimum cost* of imports (US $ millions as of 1981)		271	345	439	558

* Based on GNP of 3.5% with petroleum cost of US$ 35.

Fundamental Options

The exploration for petroleum in Costa Rica is receiving ample publicity locally and raising national hopes. The presence or absence of commercially exploitable petroleum deposits will have a major impact on national energy planning. Independent of the presence or absence of oil strikes, the country must plan transition to an energy system in which the consumption trends approximate the national resources. Petroleum deposits could have considerable economic impact, but will only postpone the necessary transition by a few years. Additional factors influencing the need for planning a national strategy without considering the possible role of local petroleum are: (1) if commercially exploitable petroleum deposits exist, they are probably small and costly to exploit (both energetically and economically); (2) even if commercial exploitable petroleum deposits exist, it is unlikely production could begin before 1985; (3) for the short-term the country will continue to import all the petroleum needed and demand is projected at 21,000 barrels per day in 1985 just to maintain a modest 3.5% rate of economic growth. RECOPE (1982) reports that 15,000 barrels/day are needed at the present to serve the country.

The above considerations lead to the inescapable conclusion that the fundamental options for the country are:

(1) Diversify sources of energy, by increasing the contribution of hydroelectric, biomass, and geothermal reresources.

(2) Restructure consumption patterns to lessen the need for and reliance on imported petroleum.

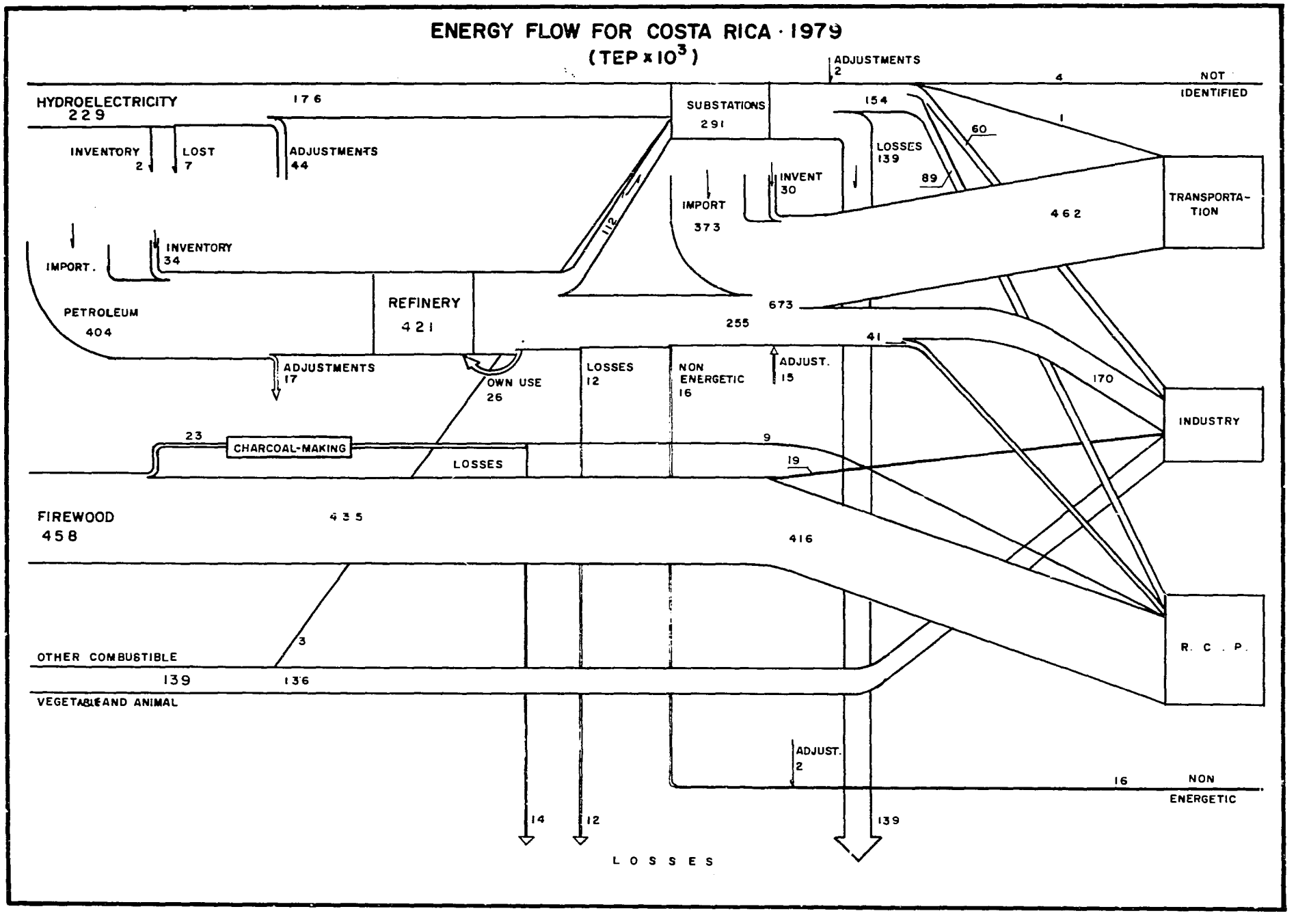

Figure IV-24.—Energy flow for Costa Rica 1979.

(3) Rationalize energy production and consumption, with emphasis on utilizing hydroelectric excess, efficient alcohol production, and fuel rationing for non-commercial uses.

(4) The most serious efforts must be concentrated in rationalizing fuel consumption in the transport sector, which is completely dependent on imported petroleum.

Before considering the perspectives of energy resource diversification, it is essential that the degree of flexibility of each user sector be taken into account. The residential-commercial-public sector draws its energy almost exclusively from local sources (75% firewood, 16% hydroelectric) (Table IV-20). Replacement of kerosene and liquid gas (propane) with local resources could save 40,000 TEP annually. The transport sector is not only completely dependent on petroleum imports, it is also the least flexible sector due to the national transport system and the useful life of the automotive fleet. The dominance of diesel (62%) is indicative of its role in public and cargo transport, private transport and agriculture. In the short-term, diesel consumption is inflexible and cannot be replaced with national resources. The only medium-term substitution possibilities are electrification of public transport and the development of local substitutes such as vegetable oils.

Gasoline shows a greater degree of flexibility than diesel because of the possibility of substitution by alcohol. All the scenarios of the country's energy future have as a focal point the transport sector and the possibilities of substituting electricity and alcohol for petroleum derivatives.

The industrial-agricultural sector is partially dependent upon petroleum imports, particularly the heavy derivatives. These can be replaced with hydroelectricity to a considerable degree on the medium-term time frame.

With the critical situation caused by the distortion between the consumption trends and local energy resources, a national policy is urgently needed to diversify energy resources and reduce the country's dependence on petroleum imports. Costa Rica's principal renewable energy resources include electricity (hydroelectric and geothermal) and biomass (firewood, combustible vegetable oils and alcohol).

The fundamental diversification problem is that liquid fuels in the transport sector are not easily replaced by electricity--the most abundant potential resource. This implies that a diversification policy must necessarily include structural changes in the national economy including the development of a transport system based on national energy resources such as alcohol and electricity.

The economic shocks of 1981 (e.g., devaluation, accelerating inflation) demonstrate that the national economy is not capable of sustaining the burdens of servicing the foreign debt and importing petroleum.

The San José Municipal Government has about 20 suggested plans to reduce solid waste economically. One of them is a plan to burn solid waste for electricity at a cost of about $ 0.40/Kwh. ICE produced electricity in 1980 at a cost of $ 0.33/Kwh and thermoelectricity a $ 0.35/Kwh. With increased costs in electricity, it i probably economically reasonable to produce energy fror solid wastes. A generator taking 500 tons/day of soli waste would produce 52,000 Mwh per year. Placing th generator away from major population centers would b advisable. Financing is available and favorable and th feasibility studies have been completed. It will be impor tant to oversee the new technology to prevent hazardou contamination of the environment. Another plan to re duce solid waste and provide another form of energy i the production of methane from solid and fecal wastes The Director of SINAPROMA, Dr. Ortiz (1981), state that methane is derived from sanitary landfills in Río d Janeiro. The Río Azul sanitary landfill is producin methane but it isn't being harvested for use. By recyclin wastes, the unsightly garbage dumps of empty lots, river and roadsides will disappear to be reused for the benefi of energy production.

Reaction to Energy Crisis

A national plan for energy production does not exist Obviously the institutions involved with energy are no coordinating plans and activities nor do they exhibi leadership in order to fulfill national goals. It is ap propriate to briefly review the recent history of the energy sector in order to understand the origins of the complete lack of an integrated plan for national energy development.

Few countries had a national energy plan prior to the 1973 energy crisis, as a result of the tremendous increases in petroleum costs, but many governments responded rapidly to avoid disaster. Through effective policies of price controls and energy conservation, several developed countries appreciably lessened energy consumption. Developing countries responded much more slowly, and in a few cases, adopted solutions that were counterproductive.

Costa Rica is a perfect example of the latter case, whose response was late and wrong, with very severe consequences. Although the country initially made significant reductions in petroleum imports, by 1976 petroleum consumption began a dramatic increase that has continued to the present. The phenomenon was due, in part, to government subsidy of diesel fuel and a fiscal policy that heavily favored import of diesel vehicles. These factors obviously stimulated a tremendous increase in the consumption of diesel--more than 50% between 1974 and 1979. During the same period the direct import of diesel fuel increased by 600%.

During the 1974-1979 period no concrete action was taken to coordinate the different components of the energy system, nor to study the impact fiscal policies and prices could have in the near future. The National Energy Commission was created in 1979, but it contributed little to understanding or solving the country's energy problems The GOCR then proceeded to put into practice a system of sectorial planning that included an Energy Minister (without portfolio) and a coordinating secretariat. In theory, this organizational system permits the Minister to coordinate national energy policy in a flexible and effective form; however, the results have been very different. Integrated energy plans with clear goals still do not exist.

Short-, medium-, and long-term problems and solutions have not been identified. This requires policy definitions with clear goals and legitimate and effective interinstitutional coordination. Indispensible to this process are knowledgeable politicians who understand the national energy problems and are willing to make hard or unpopular decisions in the national interest.

Analyses of principal institutions in the energy sector emphasize the future role of each institution within an integrated planning system (see Section V-C).

Recommendations

The basic options for Costa Rica are:

(1) Acelerate development of hydroelectricity for export, electro-intensive industry, fertilizer production (ammonia and urea), electrified transport, and rational use of installed capacity (See Section IV-G).

(2) Rationalize the consumption of petroleum derivatives, with special emphasis on diesel, by restricting the import, reducing the subsidized differential between diesel and gasoline prices, restricting the import of diesel vehicles, and substituting electricity for diesel in the transport sector, especially the urban transport of passengers and cargo.

(3) Continue and expand the petroleum exploration program.

(4) Produce combustible alcohol from sugar cane and plantation forests by utilizing the installed capacity of distilleries exceeding 30,000 TEP/year, plus small-scale production using local, existing technology.

(5) Rationalize utilization of biomass resources for renewable energy exploitation by the efficient utilization of firewood; expansion to the industrial sector; production of vegetable substitutes for petroleum products; energy plantations.

(6) Expand the geothermal program to 40 MW by 1984 and explore for new resources, including feasibility to produce methane and electricity from solid waste.

V.

Environmental Relations

V-A. PATTERNS AND TRENDS IN ENVIRONMENTAL CONTAMINATION

The exceptional social, economic and demographic changes of the past 40 years have had profound effects upon the environment, principally because modern consumption patterns require ever greater transformation of raw materials and the concomitant urban production of wastes. Consumerism, lack of conservation education and the absence of an environmental consciousness contribute synergistically to pollution problems.

Foreign technological advances are established rapidly in Costa Rica, but implementation of environmental control mechanisms has not kept pace. For example, construction of modern highways and the import of overpowered cars have occurred in the past 20 years; however, education of pedestrians and drivers, use of highway signs and imposition of traffic and transit control have been insufficient such that it has been impossible to lower traffic accident statistics. Due to an absence of appropriate health regulations, imported industrial technolcgy has not had parallel development of environmental protection measures.

Locally developed technology is also a major contributor to environmental pollution. Coffee beneficios (processing plants for the de-pulping and drying the beans), sugar mills and other agroindustrial plants contaminate rivers–the most serious national pollution problem. Uncontrolled and unplanned urbanization in the Central Valley results in the dumping of tons of sediments daily into the Virilla River watershed.

Principal Pollution Problems

Water

The humid, marine climate of Costa Rica generally ensures sufficient rainwater for national needs; thus storage, distribution and quality are primary concerns. In the 1960's there were major advances in the aqueduct systems with the creation of SNAA, later changed to ICAA (also known as A y A). ICAA's potable water systems are considered to provide excellent water from urban treatment plants whose average efficiency is above 90% in eliminating bacteria. Only 50% of the rural water systems under ICAA control provide potable water. The situation is far worse where the water system is controlled by the local municipality. Problems include discontinuous service, insufficient pressure and poor quality water, often due to age of the system, incorrect operation, lack of maintenance, no plans for improvement of quality control, no access to laboratory analyses, as well as shortage of funds for personnel and system improvements.

The Health Law (Ley General de Salud) states that the Ministry of Health (MS) has responsibility to supervise the control of water quality; however, the MS does not have the physical capability to exercise control. Water samples have been taken and analyzed only in a few cases of health epidemics; the MS does not exercise systematic bacteriological control of the municipal aqueducts. In the opinion of Dr. E. Ortiz, director of the ICAA water control laboratory in Tres Ríos, contaminant problems of ICAA aqueducts are sporadic and insignificant to the general public health due to rapid detection and correction. The Tres Ríos laboratory staff is one of the most competent in the country and is responsible for the successful control of physical, chemical and bacteriological contamination of ICAA potable water. Although Costa Rica has improved its potable water systems and sewage systems to levels above the goals for Latin America (Table V-1), there is still much to do. Priorities include maintenance of deteriorating aqueducts, incorporation of municipal systems under ICAA control, and complying with the objectives of PRONASA (DSA/MS 1976). It is illustrative of the excellent potable water system in Costa Rica that only 10% of the sanitary deficiencies found by MS inspectors were due to a lack of potable water (MS 1978).

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Table V-1. Potable water and sewage systems in Costa Rica in 1980. Source: ICAA, Planning Office 1981.

	POPULATION WITH WATER SUPPLY				POPULATION WITH SEWAGE REMOVAL			
Population	Water Service Connection	%	+Water Service Not connected	%	Sewer Service Connected	%	+Some System Not connected	%
Urban 1,095,941	1,074,022	98	1,095,941	100	471,255	43	1,052,103	96
		80*						70*
Rural 1,117,422	692,802	62	726,324	65	—	—	972,157	87
		50*						50*
TOTAL 2,213,363	1,766,824	69	1,822,265	82	471,255	43	2,024,260	91

* International Goal for Latin America, fixed by the 10 year health plan for 1980. WHO 1976.

National preoccupation with water pollution dates to the turn of the century when Jiménez (1902) sought ways to eliminate contamination caused by coffee pulp being dumped into rivers. The discharge of organic matter from coffee processing, industrial effluents and domestic use is still the principal source of contamination of the country's rivers. Contaminant loads in the nation's rivers are equivalent to a population of 5,100,000--more than double the actual number of inhabitants. The Virilla and Tárcoles river systems receive 70% of the contaminant load (Table V-2) mostly between November and February.

Principally with IDB funding during the past decade, ICAA steadily advanced sewage systems to cover approximately 60% of the metropolitan area (ICAA 1981). A third phase is now being planned that will further increase coverage. Nevertheless, complete sewer system coverage would not solve all the stream pollution problems because of the large quantities of solid wastes traditionally dumped into streams.

Detergents form a critical part of the domestic effluents in densely populated areas where they are easily seen on the Virilla, Bermúdez, Alajuela, Toyogres and María Aguilar rivers (Fig. V-1). These rivers are highly contaminated with anionic detergents (Table V-3) that are only slightly biodegradable. Fish cannot survive concentrations above 3 ppm. International guidelines indicate 0.5 ppm as the upper limit for human consumption. As seen in Table V-3, the María Aguilar, Ocloro, and Toyogres rivers exceed the limit for potability, while the Virilla, Torres and San Nicolás rivers are close to the acceptable limit. Given the continued growth of the metropolitan area, it is logical to expect continued increase in the use of detergents with its consequent increase in stream pollution. The only viable solution for the near future is to restrict the import of hard, non-biodegradable detergents and replace them with soft, biodegradable detergents that are much less damaging to the environment.

Figure V-1.—Virilla river polluted with detergents (note the foam in the left-center). Most of the Central Valley rivers have high detergent loads (photo J. Tosi).

Table V-2. Principal watersheds affected by organic waste disposal. Source: DSA/MS-OPS Program for Control of Water Contamination, First Phase, PRONASA 1981. (Recalculation).

Watershed	ORGANIC CONTAMINATION LOAD KG/DAY Domestic	Industrial	Coffee Beneficio	TOTAL	
Tárcoles	31,660.7	75,633.6	192,500.0	299,794.3	69.5
Reventazón	3,957.3	16,207.2	26,100.0	46,264.5	10.7
G. de Térraba	1,599.0	*	31,300.0	32,899.0	7.6
Other 31 Watersheds	10,113.5	16,207.2	26,100.0	52,420.7	12.2
TOTAL	47,330.5	108,048.0	276,000.0	431,378.5	100.0

* Insignificant

Table V-3. Amounts (ppm) of detergent found in principal rivers of the Central Valley, Costa Rica. Sources: aA. Mata and B. Chacón 1978; bM. Garro, A. Mata, B. Chacón, A. Rodríguez; CICA, unpublished MS 1981.

River	Maximum value ppm	Minimum value ppm
Central Valley-San José [a]		
Virilla	0.67	0.42
Torres	1.60	0.40
María Aguilar	2.50	0.70
Ocloro	7.40	2.70
Tiribí	1.20	0.15
Grande de Tárcoles [b]	1.44	0.12 (Mouth)
Guarco Valley [b]		
San Nicolás	6.50	0.50
Toyogres	10.00	2.20
Tarás	0.35	0.20

If ICAA constructs urban waste treatment plants with mechanical aerators, it is probable the detergents will form undesirable foam that impedes transfer of oxygen to the degradation process. Detergent foams also reduce the effectivenses of trickle filters and aeration ponds (Mata and Chacón 1979). Failure to construct treatment plants would not only waste the investment in collection networks, but would bypass the natural absorptive capacity of some 260 km of rivers and creeks in the Central Valley. Dissolved oxygen and natural aeration in the streams combine to oxidize considerable quantities of urban effluents. Natural degradation of organic wastes occurs principally in the upper Tárcoles river system, where the streams are sinuous and the vertical drop is great (DSA 1981; Ortiz 1981). If untreated or treated effluents enter the Tárcoles river downstream of the area of high natural degradation capacity or if the upper river's capacity is saturated, the rest of the river may be easily and rapidly polluted.

Industrial contamination of water is largely due to the processing of foods (Table V-4). Despite explicit regulations requiring industrial waste treatment (Health Law, Article 300), 95% of industries lack any type of waste treatment. Some 100 coffee beneficios produce more than double the combined amount of organic wastes that homes and industries produce (Table V-2). The Coffee Office's research center has developed a process to convert coffee pulp into a component of cattle feed and one operating plant has the capacity to use 25% of the national production.

Table V-4. Number of industries and their share of contamination activities by percent. Sources: aFourth Manufacturing Census 1975, Vol. II, MEIC, April 1978; bDSA/MS-OPS Program for Control of Water Contamination, First Phase, PRONASA 1981.

Type of Industry	Industries [a] Number	%	Organic Load [b] Kg/day
Food Products	770	26.8	70,959
Tobacco and Beverages	36	1.3	5,882
Textiles	84	2.9	13,115
Garments	476	16.6	
Leather & Shoes/ Tanning	174	6.1	4,049
Wood	587	20.5	
Paper & Printing	113	3.9	[illegible],187
Chemical Substances & Products	115	4.0	3,856
Mineral & Non-mineral Products	160	5.6	
Basic Metals	18	0.6	
Machinery & Equipment	301	10.5	
Others	36	1.2	
TOTAL	2,870	100.0	108,048

Toxic contamination of heavy metals, (e.g., chromium, copper, cadmium, lead and mercury) has not been detected in quantities approaching internationally-set limits; however, isolated sources such as the Tilarán and Esparza gold mines have not been checked. With respect to chromium pollution from the tanning industry, Brenes (1980) developed a recycling system for the liquid tanning chemicals that cuts the amount of chromium used to one-half, while reducing toxicity equivalent by 80%. Nevertheless, the effluent still exceeds the EPA limit of 0.5 ppm. The Costa Rican tanning industry annually processes 200,000 hides and discharges 100,000 m^3 of effluent daily; thus it is a major source of stream pollution (Sánchez 1980).

Contaminated river water is often used to irrigate vegetable crops in the Central Valley. The high content of salts in the Río Bermúdez damages young plants (Cordero and Chacón 1979). Tomatoes weigh less, are smaller and fewer when irrigated from the Río Alajuela (Salas et al. 1980). Salas et al. (1981) obtained similar results irrigating string beans from the Quebrada Seca (Heredia). Contaminated irrigation water not only reduces yields but may adversely affect consumer health. There is a high incidence of bacteriologically contaminated vegetables sold in the Cartago area, presumably due to irrigation from the highly polluted Toyogres and San Nicolás rivers.

Ground waters are usually viewed as an uncontaminated source of potable water, yet some of the Central Valley aquifers are already contaminated. The metropolitan area's key aquifers are north of the Río Virilla. Both ICAA and SENAS are preoccupied with protecting the Lower Colima aquifer by limiting garbage dumps in the area. According to Mora (1980), poor agricultural practices in the application of fertilizers and pesticides, absence of sewer systems, use of septic tanks and latrines, and presence of garbage dumps, are continuing to contaminate the metropolitan aquifers. The Santa Rosa garbage dump, south of Santo Domingo de Heredia, is in the protection zone of the La Libertad spring.

Contamination of aquifers is also occurring in rural areas, primarily due to indiscriminant use of fertilizers on agricultural crops. Chacón (1981) reports nitrate contamination of the aquifer in the upper Río Cañas watershed (Guanacaste) probably due to use of fertilizers in proximity to wells. The Moín aquifer, which supplies part of Limon's potable water, is in imminent danger of contamination from housing developments and livestock corrals and barns because of the lack of a sewage system to carry wastes out of the critical zone (ICAA 1980). In other areas, e.g., Río Blanco aqueduct, lack of interinstitutional coordination threatens the integrity and quality of water entering the supply system.

Numerous examples of overexploitation of wells occur in the coastal regions. Coastal aquifers are especially susceptible to contamination by organic matter, agro-chemicals and salt water intrusion (Figure V-2), e.g., Playas del Coco (SENAS 1978), Barranca and El Roble (Rojas 1979). Even the new port of Caldera has potable water supply problems, due to lack of vigilance, institutional coordination and detailed studies. A recent study (ICAA 1981) indicates actual demand is more than 100% greater than the supply capacity from wells along the Río Jesús María. However, Mora (1981) states that Caldera's problems are caused by a poor quality aquifer that was incorrectly selected to supply potable water.

The numerous reports of SENAS and ICAA clearly indicate that the country has the technical capability to diagnose and evaluate ground water resources. Better interinstitutional coordination is needed, as are more financial resource in order to accomplish greater coverage of prediction and control of quality water sources.

Pesticides

Pesticides (insecticides, herbicides, fungicides, rodenticides, etc.) are widely used in the home, in agriculture and in the storage of foodstuffs. The massive use of pesticides, their indiscriminant application and the established criteria for economic yields means that they get into surface and ground waters, to the coasts and estuaries, into the air, soil and agricultural products, and into the people who apply them. Pesticides cause occasional massacres of fish, birds and beneficial insects; they accumulate in food chains; they produce occupational diseases, poisonings, anemias, sterility, and unknown genetic disorders.

According to Dr. Ortiz, executive director of SINAPROMA, pesticides are perhaps the most important national environmental contamination problem. Although pesticide benefits are known, the environmental costs are not nearly so well known, nor do we know the long-term effects on human health. We don't know what degree of environmental disequilibrium we are producing by our increasing dependency on and use of pesticides.

With respect to rational use of pesticides, the GOCR has successfully restricted the use of organochlorines, whose use on cotton has been replaced by organophosphates and pyrethrins. The substitutes are used in lesser concentrations and are not as persistent as organochlorines; also, much less cotton is grown today than before.

Natural breakdown of pesticides is much more rapid in the tropics than in temperate climates (M. Constenla, pers. comm.). Pesticide half-life is generally less than six months in tropical soils; hence leaching of pesticide chemicals may not be an important contributor to stream pollution. Constenla and Fuentes (1981) report that the principal sources of pesticides in streams are (1) washing of application equipment directly or indirectly in streams; and (2) aerial spraying, particularly when the pilot is paid by volume applied. Little or no education about pesticide hazard among farm laborers and the general public also plays an important role in the prevalence of pesticide contamination.

Agrochemicals are most extensively used to control pests on coffee, rice, bananas, sugar cane and corn. In coffee plantations paraquat-type compounds continue to be the principal herbicide used; these are inactivated in the soil by organic matter and clays. The traditional use of arsenic on coffee plants to control leaf-spot disease, has been replaced with less noxious carbamates and phosphates. Bananas are treated with maneb-type fungicides, which have low solubility in water and do not leave residues in the fruit; the short life of some 10 days means that very little chemical contamination reaches streams.

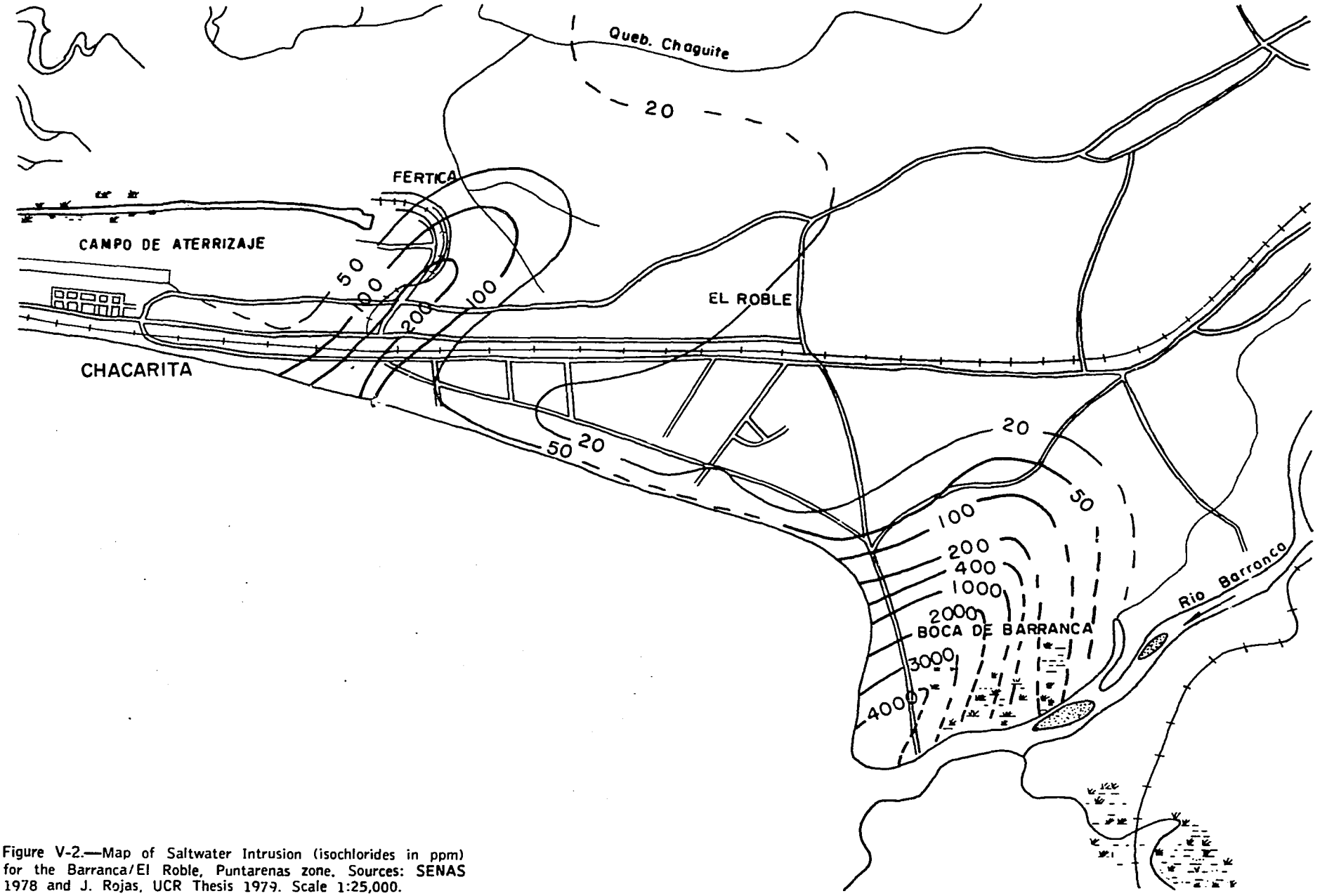

Figure V-2.—Map of Saltwater Intrusion (isochlorides in ppm) for the Barranca/El Roble, Puntarenas zone. Sources: SENAS 1978 and J. Rojas, UCR Thesis 1979. Scale 1:25,000.

Figure V-3.—Garbage thrown along a road in Paso Hondo. Solid wastes are a major environmental problem throughout the country (photo A. Mata).

However, other pesticides such as the iso-phtalonitric polychlorates are toxic to aquatic organisms when sprayed aerially. Carbamates are commonly used as nematicides and insecticides on a variety of crops; application is usually local and seldom has a serious negative impact on the aquatic environment.

Little attention is paid to pest species other than those to be controlled. Indiscriminant and excessive use of pesticides frequently kills beneficial insects, birds and bees; unfortunately, such cases are not well-documented. Most pesticide applications are done on a routine basis rather than as a reaction to specific pest infestations. Lack of sanitary controls permit a variety of vegetables to arrive at markets bearing toxic residues of recent pesticide sprayings, e.g., arsenicals or lead (Carazo et al. 1976).

The legacy of past pest control programs can persist for years. Copper, for example, is essential to plants in very low concentrations, but toxic at higher levels. Normal copper levels in soils are roughly 20 ppm, yet Cordero (1970) reports levels ranging from 20 to 3,900 ppm over some 50,000 ha in southern Costa Rica. These exceptionally high levels of copper are the consequence of the intensive use of "caldo bordolés" to control fungus in banana plantations. Approximately 100 kg/ha of copper compounds were applied annually between 1930 and 1950 and still persist in toxic levels so that the soil is useless agriculturally. Nevertheless, MAG stated that this same area could produce all the rice needed for national consumption. Some of these lands purchased by the GOCR for agricultural cooperatives have yet to produce a single crop. The continued persistence of toxic levels of copper make it unlikely that these alluvial soils will be productive in this century.

In an analogous but less severe case, León et al. (1978) found significant residues of the herbicide amethrine in Guanacaste sugar cane fields. The herbicide is used for weed control in young sugar cane fields. Amethrine residues cause serious damage to other crops such as rice, sorghum or cotton, that replace sugar cane.

In summary, little is known about the role and persistence of pesticides in crops, soils, food-chains, agroecosystems or natural ecosystems. Yet agrochemicals must play a key role in the country's urgent need to boost agricultural productivity (Vega 1981). More judicious and ecologically sound use of pesticides must occur in the fields in order to produce quality foodstuffs suitable for local consumption and export.

Solid Wastes

Solid wastes, one of the grave pollution problems throughout the country, are the responsibility of all the citizens. If the solid waste problems could be satisfactorily resolved, then the rest of the pollution problems could be handled promptly. Wherever there is human settlement, no matter how small, there is a garbarge dump (Fig. V-3). Except for the sanitary landfills serving the metropolitan area, Heredia, Cartago (intermittently), San Isidro de El General, and Limón, the rest of the cities and towns dispose of untreated garbage in open air dumps, in streams (e.g., Naranjo and Turrialba) or to the sea. This indiscriminant and inadequate disposal creates problems of strong odors, insects, smoke, rodents, scenic impoverishment, ecological damages as well as public health hazards.

The country is probably producing about 1,500 tons/day of trash, with most of it coming from the metropolitan area. Solid waste production in San José is estimated at 0.86 kg/day/person. Daily input into the Río Azul landfill is 494 tons/day at a cost of US$16/ton. Solid waste collection and disposal in the San José metropolitan area is efficiently organized under the Intermunicipal Cooperative Agreement (COIM), that serves 10 districts in the metropolitan area.

Other urban centers such as Heredia, San Pablo, Santo Domingo, San Rafael, San Isidro, San Joaquín, Barba, Santa Rosa, Santa Bárbara, Villa Colón, Santa Ana, Escazú, etc., are not in the COIM and have problems with solid waste management. Many of these towns are in key protection areas for ground waters. The contrast clearly indicates that it is unwise to permit municipalities to independently and individually manage their solid wastes. One of the most pathetic cases is the Puntarenas dump located in a densely populated area; the dump receives even hospital wastes that should be properly incinerated at the hospital.

Though the metropolitan sanitary landfill functions effectively and economically, the timing is propitious to reorient thinking to more ecologically sound approaches such as recycling and energy sources. Costs are rising not only for solid waste collection and disposal, but also of the raw materials thrown away. The country isn't self-sufficient in many raw materials or products such as paper and metals, yet large quantities of aluminum, copper, bronze, white glass and paper trash are buried daily in the Río Azul landfill. Some recycling of glass and paper occurs, but it is minor. Simple sorting of trash in the home would facilitate much more recycling. Dry paper products can provide energy. Food and other organic wastes can be composted to fertilizers or provide methane gas. The potential is enormous. Perhaps the re-utilization

of trash for attractive economic returns will be one of the few positive consequences of the current economic crisis.

Air

The principal sources of air pollution are automotive vehicle exhaust and certain industries. While air pollution problems are largely concentrated in the metropolitan area, a few major contaminators are located away from the cities. Dry-season burning of fields and forest clearings often adds large volumes of particulate matter, but the prevailing trade winds easily disperse the contaminants. Occasional temperature inversions over the Central Valley do create brief periods of stagnant, polluted air. Microclimatic pollution is more acute and pervasive especially in San Jose's narrow and congested streets and near bus stops.

Industrial emissions are insignificant in the metropolitan area, making up roughly 10% of total emissions (Rodríguez 1981). Automotive vehicles generate the bulk of the area's air pollution. According to DSA (1980) the metropolitan area has 41% of the country's vehicles (87% gasoline, 14% diesel), 51% of the industrial establishments, but only 27% of the population. Total vehicular emissions calculated at 67,860 tons in 1979, included 80% carbon monoxide, 10% hydrocarbons, 6.3% nitrogenous oxides, 3% anhydrous sulfur and 0.8% particulates; partial oxidation products of hydrocarbons were not named. These estimates were made on the basis of well-tuned motors. Correcting for the widespread conditions of poorly adjusted motors, the quantity of carbon monoxide increases by 50% and the emission of particulate matter triples.

The high sulfur content of imported fuels is largely responsible for the corrosivity of the fuels, as well as acid rain. Unfortunately, the sulfur limits of 0.32% in gasoline and 0.2% in diesel used by many countries are not used by Costa Rica. Diesel imports average 1.0% sulfur; thus, despite gasoline vehicles producing 88% of the emissions, diesel vehicles produce 55% of the anhydrous sulfur and 31% of the particulates. Although these are theoretical calculations based on internationally accepted models, they present a good idea of the levels and sources of air pollution in the Central Valley. Sporadic measurements taken on Avenida Central in San José show that carbon monoxide levels exceed U.S. EPA limits.

Preliminary studies by DSA indicate abnormal levels of acid rain in downtown San José, plus high levels of particulates (150-220 ug/m^3/24 hours); the latter is 55-80% of DSA's acceptable limit. Considering future growth patterns and vehicle deterioration, DSA concludes that the level of carbon monoxide in the metropolitan area will reach maximum permissible values within 10 years and anhydrous sulfur emissions within three years. The inclusion of industrial emissions would considerably shorten the periods.

The most important recommendation is to reduce the sulfur content of fuels, but the economic situation of the country makes it difficult to pay premium prices for low sulfur petroleum, plus the country does not possess modern methods for sulfur removal. DSA (1981) has recommended a broad and complete program to control air pollution, including emissions regulations, technical aspects of vehicle function, periodic inspections of emissions controls, etc.

Although industrial sources of air pollution are minor, there are some important hazards worth mentioning. With 80% of the country's industries located in the Central Valley, INVU (1980) is trying to create industrial zones to avoid spatial anarchy, environmental disorders, etc. INVU has zones near San José for consolidated industries, allowing continued location of industries; however, DSA technicians want to prohibit industrial development to limit air pollution in the metropolitan area.

Though few in number, the largest industries are generally in coastal zones, e.g., sugar mills, fertilizer plant, petroleum distillery, cement factories and vegetable oil plants. The fertilizer industry in Puntarenas is a special situation because at the time of installation the surrounding area was not urbanized. Over the years, government authorities have acquiesced to demographic pressures, such that the plant now sits in a fully urban area. Other industries tend to be located in unpopulated areas or produce few emissions. Heavy metal-based industries are of more concern from the standpoint of occupational health (see separate section on this topic).

Noise

Noise pollution originates principally from automotive vehicles--motor-cycles, buses and trucks. Industries contribute in a minor way, and some have occupational health problems as well. With the preponderance of vehicles in the metropolitan area, noise pollution is most bothersome on the narrow, heavily-used main thorofares. The few studies of noise intensity in San José report peak hour averages of 80 dB (DSA 1981) and 82 dB (Mata 1978), with maximum values exceeding 90 dB. The former study found noise levels to be significantly less on wide streets and adjoining parks.

In commercial districts loudspeaker announcements are permitted at uncomfortable intensities. Most discotecs have noise levels around 100 dB. The spontaneous and disorganized growth of the metropolitan area has industrial plants scattered through residential areas. Only 33% of industrial laborers work with background noise less than the normal limit of 70 dB. The illegal conversion of warehouses to industrial plants is a serious occupational health hazard.

Noise is particularly concentrated at bus stops and on the heavily trafficked narrow streets, especially Avenues 3, 5, and Central, and Streets 4, 6, and 8, where levels often exceed 70 dB, the normal noise level on streets. Bus passengers are also assailed by very noisy motors, due to lack of maintenance and poor noise insulation. Inadequate exhaust and muffler systems also contribute to excessive noise levels, such as on the Heredia and Alajuela bus lines.

Occupational Health and Industrial Hygiene

In 1976 INS initiated annual publication of statistics on work-related accidents, but the reports do not include information on risks or the types of occupational diseases.

As a reference base, the 1977 statistics suggest there is an enormous amount of occupational stress: in a labor force of some 600,000 there were 80,184 accidents reported, of which 3,500 were serious. Insurance claims totaled $7.3 million, equivalent to $ 31 per insured worker (only 236,000 laborers were insured). INS projections for 1981 were a quadrupling of amount claimed from a total force of some 720,000. Recent studies by DSA indicate only 10-15% of the laborers use protective hats, eye screens, gloves, masks, clothing or shoes.

Poisoning is a serious problem in banana plantations and in the pesticide industry. Of 2,150 cases during three months of 1979 handled by the INS office in Limón, 223 involved chemical poisoning, of which 90 required hospitalization (Chediak 1980). Most of the acute cases were caused by organophosphate pesticides. According to DSA and the Poison Control Department of the National Children's Hospital, the incidence of pesticide poisoning could be lessened appreciably by using adequate personal protection, training in correct application of pesticides, creating hygiene and security committees in industry, correctly handling and storing toxic substances, improving hygienic and living conditions of workers, as well as upgrading the general educational level. Industrial diseases and accidents appear to be more related to problems of security rather than hygiene.

Foodstuffs

Quality control for foods--including agroindustry and preparation to storage--is almost entirely ignored in Costa Rica. DSA (1976) estimated 14,846 locales of food preparation or sale, of which only 3% were properly registered with the MS. The 1975 industrial census listed 770 factories processing food products. Deficiencies in material resources and personnel in the MS's Food Control Department in combination with inadequate technical and administrative resources, result in an almost total ineffectiveness of the control and protection programs for foodstuffs. For example, the only food control laboratory has functioned for 30 years with essentially the same resources and physical plant. The laboratories are contaminated, overcrowded, with technical difficulties that preclude even approaching satisfying present necessities. A decade ago only about 20% of commercial foods were sampled for contaminants (DSA 1971); some DSA technicians are of the opinion that 20% may be too optimistic an estimate of current sampling. Imported foods are largely ignored, so there is minimal protection against adulteration, mislabeling, additives, coloratives, etc. No attempt is made to monitor the presence of heavy metals, pesticides or other pollutants.

The DSA's Food Control Department has developed a good program to upgrade the inspection and control of foodstuffs. With the assistance of international and national institutions like WHO and CITA/UCR, the program will begin to address the most serious risks or threats. The program will include food inspection of retail outlets as well, for it is estimated that some 70% of the local bars fail to meet minimum hygienic conditions.

Major Industrial Influence on Pollution Problems

1. *Organic Matter (BOD)*

Coffee beneficios produce 66% of stream contaminants, versus 25% from other industries. Despite the local design of two treatment systems for coffee processing wastes, the high costs and waste volume have kept them on paper. A major constraint is the economical separation of the pulp from the bean; so far only 20% of the pulp is being used. For over a century, coffee pulp has traditionally been thrown into streams, where it is broken down naturally. The total industrialization of coffee pulp, the recycling of liquids, together with primary treatment of wastes adapted to local geomorphology and tropical conditions, would greatly reduce the contamination from coffee wastes and processing.

The solution to organic pollution of streams by industries consists of obligatory treatment as indicated by the General Health Law, beginning with the major source industries. A system to permit and control pollution activities should be established as described and outlined by the MS. Of the 171 industries considered as significant polluters by the MS, the sugar mills are the most serious sources of environmental contamination. A particular case is the Ingenio El Palmar in Puntarenas, that throws wine dregs that give off a very disagreeable odor, into a branch of the Puntarenas estuary that reaches several kilometers into the mangroves. During the sugar cane harvest, the estuary canals are so contaminated that they produce a tremendous amount of hydrogen sulfide and other substances that totally degrade the water. The contamination of the estuary causes high mortality of local marine fauna.

The potentially massive production of ethanol by molasses fermentation will cause much more serious contamination of streams and estuaries, thus serious control mechanisms will be needed.

2. *Oils*

An example of government-condoned contamination is the oil residues that RECOPE discharges into the Moín Canal. The RECOPE oil-water separator operates with low efficiency, plus dissolved and emulsified oils are not separated. The DVS has denounced the pollution and RECOPE has the technical capability to resolve the problem but has failed to do so. Contamination from vegetable oil extraction plants in Quepos, Parrita and Corredores has not been studied.

3. *Inorganic Substances*

Fertica's fertilizer plant in Puntarenas has a large production volume. In spite of recycling systems for gases in the newest installations (e.g., nitric acid unit), it continues to emit nitrogenous oxides that cause acid rain. If the plant were located in an unpopulated area the acid rain would be a fertilizer, but the potential danger to the nearby population is high. Occasional emissions of pollutants occur that cause alarm among the neighbors, e.g., the corrosive smoke emitted from the ammonium nitrate spheroidization tower. In the past few years Fertica has agreed to install and operate air monitoring stations as well as improving the functioning of the sulfuric acid plant.

Conclusions and Recommendations

1. Various government institutions have parallel or duplicate functions concerning environmental sanitation, as well as statutory obligations to conserve resources. Some of these obligations have been forgotten or ignored; other agencies function without any coordination with other involved institutions. Two years ago an unsuccessful attempt was made to form a technical commission for coordinating the efforts of SENAS, MAG and ICAA. In March 1981, a National Coordinating Committee was formed in the MS to advise on water pollution, with representatives from OFIPLAN, SINAPROMA, ICAA, SENAS, SNE, MAG, ICE, MEIC and IFAM. Also through the technical commissions of SINAPROMA, efforts are being made to coordinate inter-institutional efforts in environmental sanitation.

It is essential that there be effective coordination of efforts and responsibilities among the numerous government agencies concerned with the environment. Specific recommendations include (a) facilitate the efforts of the National Coordinating Committee on water pollution; (b) facilitate the coordinating efforts of SINAPROMA's technical commissions; and (c) systematize the control activities, planning and interchange of basic information of the specific institutions.

2. Very few data exist (and those are largely unpublished) on the effects of environmental contamination on occupational health. Some suspected effects are aplastic anemia, low sperm count, and high blood levels of lead due to poor ventilation, inadequate worker protection, and deficient knowledge or supervision.

High mortality of aquatic organisms has occurred in the Gulf to Nicoya estuaries and in large rivers, presumably due to incorrect use of pesticides or the decomposition of coffee and sugar processing wastes. There is an almost complete lack of environmental impact studies for fragile tropical ecosystems such as estuaries, coral reefs, coastal lagoons, etc. There is no classification of the country's aquatic resources according to actual and potential uses so that optimum utilization or protection strategies can be adopted.

It is imperative that a substantial increase occur in the coordination of research by both public and private institutions that evaluate the real and potential results of contaminants on man and ecosystems in order to control the environmental hazards and to determine rational use of the natural resources. Specific recommendations include (a) make operative the PRONASA programs of Hygiene and Worker Safety, and Food Protection; (b) classify aquatic resources according to actual and potential uses, as well as determine optimum utilization, natural recuperation or total protection of the resources; (c) coordinate research to evaluate real and potential environmental impacts of pollution on man and ecosystems.

3. The country lacks technology to exploit waste products and has generally failed to adapt technology to local conditions. Even though methods exist for using coffee pulp, studies are needed on means of improving water use so as to concentrate the organic residues available. Research is needed on the transfer of technology according to national economic and environmental conditions.

4. In order to effectively carry out environmental protection programs, it is necessary that the different institutions involved, but especially the DSA, take more efficient and technical actions in complying with statutory obligations. Information flow from the technical level must reach the decision-making levels, while the latter must be open to technical coordination. Most actions are responses to urgent public demands, projects to be implemented, or arbitrary personal decisions rather than a national environmental protection policy. Government agencies, particularly the DSA, require some organizational restructuring plus adequate human and fiscal resources to make environmental protection a reality.

5. Many legal means exist that permit immediate action in environmental improvement and conservation, but are seldom applied or enforced. The existing laws and decrees should be reviewed so as to harmonize them, eliminating contradictions and facilitate interinstitutional cooperation in environmental protection.

Specific recommendations include (a) effective application of existing laws and decrees; (b) harmonization of disparate laws in order to increase their collective effectiveness; (c) publish a compendium of environmental legislation including judicial relations and interpretations so that the public may be better informed on environmental protection and conservation; (d) strengthen the Health Law with comprehensive regulations concerning industrial and automotive contamination; and (e) include an article in the constitution of Costa Rica on the environmental rights and obligations of both the citizen and the State.

6. None of the above recommendations is feasible without the political leadership throughout the institutional hierarchy to defend, husband, and preserve the national resources indispensable to human survival and well-being. Since political decisions are influenced by public opinion it is extremely important that an environmental consciousness be fostered in the citizenry through environmental education programs. Although these programs must reach all social levels, they are most effective when incorporated into primary education. Environmental education programs must overcome the deeply ingrained cultural patterns of the use and waste of the country's natural resources.

Specific recommendations include (a) legislation to improve and conserve the country's natural resources; (b) create environmental education programs to reach all social levels, stressing the cultural patterns to be changed and the intimate relationships between man and the environment; (c) actively implement decisions made at the technical level even though they don't reach the upper levels of political decision-making.

7. The following list of technical recommendations is directed to short-term amelioration of the country's most serious pollution problems: (a) Conduct an inventory of the principal sources of serious pollution and initiate control programs on a priority basis; (b) Initiate

a monitoring program of contamination of air and principal rivers in the metropolitan area; (c) Strive for total use of coffee pulp; (d) Create a department of soil conservation with the appropriate government institution; (e) Initiate a national program to eliminate or recycle solid wastes; (f) Initiate studies to quantify the residues and metabolites of pesticides present in natural ecosystems; (g) Strive to lower the amount of sulfur in fossil fuels to acceptable levels; and (h) Coordinate all efforts in urban planning and industrial zoning to harmonize municipal and national government decisions about orderly urban growth.

V-B. ENVIRONMENTAL LAW

Introduction

The objective of this chapter is to describe briefly the existing legal framework in Costa Rica as it relates to environmental law, to assess its capability to deal with problems related to the environment, and finally, to make suggestions or recommendations that would improve the legal system's ability to protect the environment. This chapter, due to limits of time, space, and economic support, does not purport to be a summary of legislation or a definitive statement, but rather a modest and preliminary beginning toward developing an outline for action to use law as a tool to allow development without environmental destruction and at the same time insure environmental quality for future generations.

Despite the impressive advances made in conservation, Costa Rica continues to suffer from numerous environmental problems. This profile presents and discusses many of them. If strong Constitutional and/or legal norms were enacted or/if an Environmental Protection Agency with significant powers over the public and private sectors were approved, further advances in protection of the environment would probably be hastened. However, by working *now* with legal tools currently in existence, a great deal more could be achieved to protect our environment for future generations.

There will probably never be a perfect State where all citizens live in perfect balance with the environment. There will always be shortsighted leaders and citizens whether capitalistic, socialistic, or communistic, who favor production and development at the expense of the environment. Others, focusing on the needs of future generations and the laws of nature, will give higher priorities to protection of the environment. The legal field will be one more battleground where adversary forces debate and resolve questions related to the environment.

Status of Environmental Law

A unified recognized center for information on environmental law simply does not exist. What does exist regarding the environmental law are the following:

A. Institutions

1. ASCONA is a civic public association with 2,000 members and an administrative staff of 20. Although it has no legal department, ASCONA used private attorneys to file suit against the State to annul MAG resolution 12765-A to reduce the Palo Verde National Park to approximately one quarter of its original area. Within that suit, which at the time of writing is still in process, a Prima Facie temporary restraining order suspending the effect of Decree 12765-A was granted by the court to avoid grave and irreparable ecological, international and economic damage. ASCONA's lawsuit is one of the first attempts by a civic organization to challange environmental problems of public concern in the forum of the courts. The preliminarily favorable results obtained suggest that lawsuits may be a major non-political tool for demanding enforcement of environmental legislation or restraining anti-environmental action in the future.

2. Institute of Legal Research, Faculty of Law, University of Costa Rica, is conducting a general analysis of environmental legislation under the direction of professor Anabelle Porras Zúñiga. The results of the first investigation entitled, "The Legal Causes of Deforestation in Costa Rica," have been preliminarily published. The Institute will soon be presenting a study on the problems of water, and is projecting other studies on noise, contamination, fish and wildlife, and international treaties ratified by Costa Rica. The main problem of the Institute, and especially the division on Environmental Studies, appears to be economic--lack of money for research assistants and publishing.

3. SINAPRONA, the National System for Protection and Improvement of the Environment was created by Executive Decree 12194-0P in 1981.

4. Legal or quasi-legal departments of various institutions, e.g., MAG, DGF, SPN, ICT, etc.

B. Individuals

1. Besides previously mentioned professor Anabelle Porras, there are a limited number of other attorneys or law professors who are known in legal circles to be either interested in and/or working in the field of environmental law.

2. Lic. Rafael González Baller has published an article in the Law Journal of Costa Rica entitled, "Reflections on the Law for the Protection of Nature and the Struggle Against Contamination of the Environment in Costa Rica". He was also one of the two lawyers contracted by ASCONA in the Palo Verde case.

3. Dr. Rodrigo Barahona, professor of agrarian law at the University of Costa Rica, and moderator of and speaker at the recent seminar on The Environment in Costa Rica, is presently compiling a list of legislation affecting the environment together with a descriptive summary of the treaties, laws, executive decrees and regulations appearing on the list.

4. Lic. David González, currently a penal judge, one of the speakers at the Environment seminar, and soon will be publishing a paper entitled, "Protection of the Atmosphere in European Law".

There are certainly other legal professionals interested or working in the field of environmental law, but again the lack of a catalizing association or institution makes it difficult to know or find out who these people are and what they have done.

C. *Research Facilities*

There are two major legal libraries in Costa Rica--that of the Law Faculty of the University of Costa Rica, and the library located in the Supreme Court. The law library of UCR consists of 27,000 volumes classified into 68 headings of law, but the classification system includes only traditional topics of the civil system. Nowhere can one find topics such as environment, natural resources, contamination, conservation, etc., common to the field of environmental law. Categories such as trespass, nuisance, water, health, temporary restraining orders, etc., must be researched completely to see if there are any materials dealing with those subjects as they pertain to the environment. Since the subject is relatively unknown, and is not traditional, the materials available are few.

The other library, located in the Supreme Court, has approximately 10,000 volumes classified according to approximately 100 traditional subjects. Once again, most topics of environmental law are absent.

D. *Jurisprudence (Judicial Decisions)*

Judicial decisions are available, but once again, on a limited basis and difficult to encounter because the classification system used is not geared to the new subject of environmental law. There are three principal sources: The Legal Journal of the Supreme Court edited by Dr. Víctor Pérez; the digest of jurisprudence of the court; and by consulting with judges on an individuals basis.

The best of the sources for the researcher is the Law Journal of the Supreme Court, basically because of its availability and its continuity. Financed by the independent budget of the Judicial Power, it began in 1975 and offers a non-consecutively numbered description of each case of the Full Supreme Court (constitutional questions), the penal and civil courts of cassation (highest level appeals courts), and the penal and civil superior courts (first level appeals courts). Also, it offers both a detailed topical index according to Code, Law or Decree with reference to the article of the legislation in controversy. Unfortunately, if one is looking for the case decisions on a specific topic of environmental law, there are almost no topics of environmental law listed in the classification system, and one has to review each of the 21 issues since the classification system varies with each publication in accord with the content of the cases published in that issue. The same is true if a researcher wishes to research the cases that have been tried regarding a specific article of a specific piece of legislation. He must review each of the 21 volumes for the law and its articles to see if there is a reference to a case. The third way it to read all the descriptions of all the cases to see if there is a reference to anything that has bearing upon the environment. Finally, if a prospective environmental case is found the researcher must go to the respective court and obtain the original files since description is too brief to be of practical use.

The digest of jurisprudence, located on the second floor of the "Tribunal Building" (Los Tribunales) is classified into 94 categories of traditional civil law topics, none of which has any specific relation to the environment. A few of the topics are related in a general way to the environment (such as food, property, expropriation, possession, public health, and usurpation). The digest contains brief references to cases from 1938 to 1978, but a person must review each card under a given topic to see if there is a precedent for or against environmental law. The office is approximately three years behind in the digesting of cases.

Finally, consulting with individual judges and fellow lawyers is probably the most widely used method--and the best. Most high level judges have been in the judicial system for a long time and can remember most of the cases they have worked on. The problems, however, are obvious. The younger the judge, the fewer references he has, and conversely, when an elderly judge dies, all those accumulated references die with him. Then, not every judge works on the same case, so many must be consulted to obtain extensive, though incomplete, references, and only persons who have access to the friendship of old or middle-aged judges can use this source. Therefore, most young law students, researchers, or recently graduated attorneys are excluded from this source.

Having said all the above regarding jurisprudence, the question arises, "Why mention it at all?" The courts in Costa Rica are not bound to follow the precedent established in previous cases. There are a number of answers. First, whereas the courts are not bound to follow former decisions, they do create weight, if not precedent for interpretation or application of the laws. And even though the former case is not binding, most judges and attorneys feel that arguments are strengthened if they have the backing of jurisprudence, especially if the reference is a decision of the courts of appeal. Finally, and most important, the careful review of the court records of individual cases is often illustrative of the technical failures most common in the actual trial of cases. Cases are often won and lost not on substantive question of law (e.g. is there really contamination or deforestation?), but rather on procedural and technical questions (e.g. is the proper party being sued, is there enough of the right kind of proof, was the case presented within the allowed time limits and in the proper court of law? etc.). Often jurisprudence can show where and why previous attempts have failed, so that the pleading of future cases can be corrected.

E. *Past Legislative Efforts*

It would be impossible and of little use for this chapter to go into the past legislation of Costa Rica. Suffice it to say that concern for the environment has a long legal history in Costa Rica, though the legislation making up that history has often not been enforced. Two projects, however, are especially noteworthy. First, in 1976 a consulting commission was formed to deal with the subject of Natural Resources and the Environment. That commission drafted a law known as INDERENA (Instituto de Recursos Naturales) that proposed to create an institute charged with the protection and conservation of natural resources. There was a great deal of discussion regarding structure of the institution and its powers, and although the proposed legislation was never approved, it marked the first time widespread environmental concern was crystalized in the form of a strongly debated legisla-

tive bill. A second but less ambitious proposal was the "Law for the Protection of the Environment" that proposed to create a Center of the Protection of the Environment staffed by high level technicians with a wide range of powers. This second attempt to create an Environmental Protection Agency was not approved, but the proposed bills are available for study and the persons who participated in the commissions and discussions are available for the purpose of using their expertise and experience for future attempts.

F. Existing Legislation

> "Until now, the environmental legislation in force in Costa Rica (as is the origin in most all countries), is represented by a number of varied and dispersed juridical norms referred to as use, conservation, protection, improvement and control of the natural resources and of the environment, as well as the ecological aspect (which is tied to contamination and to the alteration of the biological equilibrium). These juridical norms appear related (in Costa Rica) with renewable and non-renewable natural resources, and they are found in special laws relating to the special sectors of soils, mines, water, forests, groundwater, marine life, wildlife, and others. These laws do not have any interconnection, which in turn, reflects the sectorialization or the absence of a national program which integrates the elements of Nature within the National Development Plan of the country". — Porras Zúñiga (1981).

The above quotation describes only partially the legislative branch of environmental law in Costa Rica. Professor Porras refers to what might be termed "specific substantive legislation" but does not mention other legislation, norms or principles of a more general or non-environmental nature, but which nonetheless, have a significant impact on the environment, and consequently form an important part of environmental law. A few examples of these general, non-environmental laws and principles are (1) the land titling law and its inadequacies; (2) Article 3 of the penal code that states that the general provisions of the code will be applied to punishable acts described in special laws, as long as those laws do not provide otherwise; (3) Article 330 of the penal code that states that the public official who illegally omits, refuses to or delays in doing an act required of his position will be fined 20 to 60 days; (4) The principle of legality stated in Article 49 of the Constitution requiring that the acts of public administration must be in accord with the law; (5) Article 7 of the Constitution which provides that international treaties duly approved by the Legislative Assembly have authority superior to the laws of the Republic; and (6) All the procedural law that bears upon whether an act or omission that negatively affects the environment can be challenged in a court of law.

The above are only a few illustrative examples of the general laws, norms, and principles that should be taken into account in the analysis of environmental law and legislation and in any proposal for future reform.

To attempt to summarize the existing specific and general legislation having a direct or indirect bearing on environmental law would be impossible and it would represent a duplication of effort. Dr. Rodrigo Barahona has prepared an eight page list of legislation specifically or directly affecting the environment. The interested reader can refer to that list (office of Dr. Rodrigo Barahona).

A compilation of the treaties, laws, and regulations contained in Dr. Barahona's list would represent literally thousands of pages of environmental legislation, that in turn, require numerous actions and establish sanctions for disobedience. Many persons ask, "Why are those laws not applied?" Answering that question opens the barn door to environmental law in Costa Rica and the focus for the remainder of this chapter.

First, we must ask ourselves, "Is it true that the laws are not applied?" For example, the Law of the Maritime or Coastal Zone (N. 6043) describes a 200 meter wide strip on the Caribbean and Pacific coasts. The first 50 meters of the strip is a public zone and cannot be legally occupied under any title of ownership. Exploitation or construction, without legal authorization, is also prohibited. Referring back to the original question, some persons would point to numerous violations of the law alleging that it is not being applied. Others, such as ICT personnel, would point to the fact that the legislature reserved more than 95% of Costa Rica's coastline for use by future generations, and most of the development that takes place in the future will be in accord with sound development principles. In summary, the Law of the Maritime Zone represents just one of many major advances for environmentalists and a major contribution to environmental law. Mereover, it and many other environmental laws are being complied with and are producing exceptional results.

However, there are, and will continue to be, numerous violations of the law. Therefore, a substantial part of the work of environmentalists, technicians, lawyers, politicians, and the public at large, should be encouraging active enforcement of existing laws. Unfortunately, this has been largely left to the overworked public sector--attorney general's office, prosecuting attorneys, ICT, municipalities, etc. Analysis of environmental law must, therefore, include the efforts that might be made, possible and likely obstacles to these efforts, and how those obstacles might be overcome. Environmentalists will not win all the legal battles, but ground will be gained in the protection of the environment if each case is fought and analyzed to discover more effective ways to litigate in the future.

Returning to the question, "Why are not those thousands of pages of environmental legislation being applied?" We might better phrase the question, "Why are there so many obvious cases of pollution--air, noise, and water; deforestation; turtle slaughter; if there are laws to protect and control these activities?" A second and related question is, "Why are the offenders not immediately punished?" These questions take us to the heart of the Costa Rican Legal System--its laws of organization, substance, and procedure. The following sections will only touch upon those laws that have significant environmental relevance.

Organizational and Substantive Law

The cornerstone of the Costa Rican legal system is the Constitution, containing principles of both an organizational and substantive nature. In terms of organization, Article 9 establishes three main branches of government--the Legislative, the Judiciary, and the Executive--with each branch being distinct and INDEPENDENT from the other. The matter of independence is very important to environmental law and will be dealt with later in this chapter.

The Legislative Branch is unicameral with 57 congressmen. Its only organs are administrative, with the exception of the Comptroller's Office (Contraloría) that is responsible directly to the Legislature.

The Judicial Branch includes both the court system and the Public Ministry (Ministerio Público). The court system is headed by the Supreme Court composed of 17 magistrates. The Supreme Court is divided into three sections: The Tribunal of Penal Cassation, the Tribunal of Civil Cassation, and the Full Court that meets for special cases and functions. The Public Ministry is under the control of the Full Court.

The name of the organ, Public Ministry, is deceptive since it would lead one to believe that it is like any other Ministry and forms a part of the Executive Branch. Formerly a part of the State Attorney General's Office (Procuraduría) that is responsible to the Executive Branch, certain functions of that office were passed to the Judicial Branch to make them more objective and scientific, and less political. The Public Ministry has two main organs: the Organization of Judicial Investigation (OIJ) and what would roughly correspond to the functions of the offices of the prosecuting attorney and the district attorney (Fiscales de Juicio y Agencias Fiscales).

The OIJ has judicial police, detectives, scientific laboratories, etc., and can receive reports of illicit activities as well as investigate them.

The Prosecuting Attorneys try cases involving criminal activities--whether committed by private individuals or government officials. The district attorneys' offices are located in most of the county seats, and are for the purpose of receiving and investigating complaints of criminal activities. The district attorneys can decide (1) to take no action if they feel the matter does not warrant it; (2) turn it over to a minor court (Alcaldía) if it is a misdemeanor; or, (3) proceed with the case by either investigating further, calling in the services of the OIJ, or turning it over to the investigative penal judge (Juez de Instrucción).

The Executive Branch, headed by the President of the Republic, is by far the largest and most visible to the public. All the ministries, municipalities, and autonomous institutions are under the control of the Executive Branch, as well as the Attorney General's Office (Procuraduría). The function of the Attorney General's Office is to advise the Executive Branch as to the legality of its actions and to represent the State in litigation.

From the brief organization summary of the principal government powers, it should be apparent to the environmental lawyer that in cases involving penal activity or omission by the State, the Judiciary's Public Ministry would be the agency most indicated to handle the matter. In cases involving penal activity or omission by private companies or individuals, a decision has to be made to solicit intervention of the Judicial Power or the Executive Branch.

In terms of substantive legal principles, there are two great divisions of law: (1) Private Law (Derecho Privado) which is that area of law governing the rights and obligations of citizens in their relations with one another. It includes the commercial code, the family code, and the civil code which in turn includes the law of persons, property obligations and non-commercial contracts. (2) Public Law (Derecho Público) which includes Constitutional Law, Administrative Law, Penal Law, Tax Law and Civil Penal Procedure. Within these two great division of law, the Constitution establishes a hierachy of legal norms with the following ranking of power: international treaties; laws approved by the legislative assembly; executive decrees; regulations; and administrative resolutions and agreements.

Private Law played a much more significant role than Public Law until recently; however, in the past 12 years the role of the public sector has grown tremendously. Many activities and services formerly carried out by private individuals or companies, have been taken over by the State or its autonomous institutions. The State is currently involved in the production and distribution of food, oil and petroleum products, banking and finance, transportation systems, and cement production to mention only a few.

The expansion of the public sector's activities is important to the environmentalist for a number of reasons. First, the public sector is controlled first and foremost by political forces, that are primarily concerned with the resolution of social problems--agriculture, housing, transportation, health, development, etc. The environmentalist will often find that it is not only the stereotyped private entrepreneur but also the government itself, through its agencies, public companies, services, and social programs that are contributing significantly to environmental problems. And as the public sector continues to expand, a short-sighted, development-minded, progressive voter-oriented government could easily become the single greatest threat to the environment.

Second, environmental complaints to politically influenced executive organs such as the Attorney General, ICT, municipalities, Ministry of Public Health, Ministry of Public Security, etc., will become less effective as legal questions become subserviant to political goals and interests. Third, the *independent* power of the Judicial Branch must be strengthened and depended upon more as a check and a balance to the growing power of the public sector dominated by the Executive Branch. The previously mentioned case of the Palo Verde National Park is an excellent example of the Judicial Branch, at least temporarily, restraining the activities and interests of the Executive Branch.

Procedural Law

In addition to organizational and substantive considerations facing the environmental lawyer, there are also questions of procedure (How to enforce the rights or obligations thought to be owed?). What court or agency has jurisdiction? Is the judge competent to handle the issues? Does the law require personal damages to the party bringing the case? Has the problem disappeared? Is there an identifiable party to be accused? Is there sufficient proof?

Of particular interest are the causes of action, both civil and penal, available to the environmentalist. These are defense appeal; edicts; restraining order of an administrative act, the effects of an administrative act, or the execution of an administrative act; and accusations before the Public Ministry, administrative authority, transit tribunal or for misdemeanors.

Defense Appeal (Recurso de Amparo)

Public officials must always act from a legal base. If a public functionary acts without a legal base and violates a constitutional norm, a defense appeal is appropriate to either impede his action or to obligate him to act in the case of omission. A defense appeal can quickly impede an act contrary to constitutional principles, with the advantage that third parties can intervene once the simple appeal is made before a judge or tribunal. The defense appeal will be heard by the Full Court if the act or omission which violates or threatens to violate the law and the appeal comes from the President, a Minister, provincial governor, a guard commander or the director of the Civil Guard. All other appeals are heard by a penal judge.

When the violation could cause grave or irreparable damage, the judge or tribunal has the power to order immediate suspension of the contested order or act. The appeal must refer specifically to the constitutional principle being violated or threatened; in the environmental context it is usually Article 89 "to protect natural beauties". According to the law the appeal can be brought only by the person victimized by the act or omission.

Edicts (Interdictos)

Edicts are summary proceedings tending to reestablish certain factual situations so as to avoid damages during the slow legal process. There are five types of edicts: possessional appeal; restitution; replacement of landmarks; demolition; and suspension of work. Only the latter two types of edicts are environmentally important. Demolition orders are frequently given for large trees in urban areas, regardless of the tree's health or alternative solutions. Suspension of work edicts halt construction or change.

Accusations before the Public Ministry

As part of the Judicial Branch, the Public Ministry has its own prosecuting agencies (Agencias Fiscales) throughout the country. Any accusation of public crime can be presented to a prosecuting agency.

Restraining Order of the Effects of an Administrativ Act by the same Agency

Any person can request an institution not to implement a prejudicial action; however, seldom has a government official agreed to stay the action of his own institution.

Stay of Execution of Administrative Act

This type of edict tends to have similar effects as the former, but is more effective because it is handled by a judge. It is also obtainable in a relatively short time period (e.g. Palo Verde).

Accusations before Administrative Authorities

Crimes can also be reported to the Rural Assistance Guard; however, the probability of a positive response is low due to unwillingness or inability to cooperate or not knowing their legal authority under novel circumstances (e.g. extraction of turtle eggs). Actions contrary to watersheds or public health can be denounced before the respective ministries. Similarly, prejudicial actions in coastal areas can be denounced to the appropriate municipality. If the government institution fails to act on the accusation or comply with its legal mandate, defense appeal or penal accusation are possible recourses.

Accusation of Misdemeanor

Contraventions are activities of omissions that do not constitute a crime but are repressed by penalties in the penal code. Contraventions may not be effective preventatives, but may set important precedents that inhibit later acts.

Analysis of Norms

Environmentally important legal norms include both direct and indirect aspects. The political constitution contains norms with the greatest hierarchy in the juridical system. Subsequent laws and decrees are subordinate to constitutional norms and unconstitutional if they violate these principles.

Constitutional Norms Relevant to the Environment

Article 89 establishes as a cultural objective the protection of "natural beauties". Article 140, Clause 19, defines Executive power over the exploitation of natural resources; Clause 14 establishes the inalienability of water resources and coal and petroleum deposits. Article 6 establishes special jurisdiction of the State in territorial waters extending to 12 miles from low tide line, according to the principles of international law.

Several other constitutional norms apply indirectly to the environment. Because of the greater hierarchy of constitutional norms (Article 10) any law or decree that is counter to the protection of natural resources should be unconstitutional. Similarly, acts and agreements against prohibitive laws will be invalid, if the same laws do not provide otherwise (Article 129). Private property is inviolate unless expropriation is in the public interest and then only if expropriation is legally proven with prior

indemnization according to the law (Article 45). Thus, creation of national parks by decree or law has no legal basis if the government fails to pay the obligatory indemnization required by law.

The penal code contains many norms that bear indirectly on abuse of the environment, particularly contamination: Articles 226-230. 241, 244-248, 250-254, 256, 259-263, 268, 270, 289, 302-305, 309, 314-316, 320-323, 329-333, 338-344, 349, 376, 378, 383, 384, 390, 392, 394, 398, 400-403, and 408-413.

Analysis of Actual Cases

A. Reduction of Palo Verde National Park.

Article 22 of the Forestry Law (Nº 4465) approved by the Legislative Assembly states that national parks can be created by Executive Decree and that when privately owned lands are involved, they will be acquired by purchase or expropriation. Article 76 of the same law states that once a national park is created, it will not be reduced . . . without prior approval of the Legislative Assembly. Executive Decree Nº 11541-A (published June 13, 1980) created Palo Verde National Park.

On July 16, 1981, Executive Decree Nº 12765-A was published stipulating that Palo Verde National Park would be reduced by 75% of its original size principally due to the fact that there was no money to expropriate the privately owned lands contained therein. ASCONA filed suit to annul Decree Nº 12765-A, and within that suit filed a motion for a Prima Facie order restraining applications of Decree Nº 12765-A alleging special and irreparable damage to nature and the environment.

The position of the government was based upon two separate arguments. First, the park was created by Executive Decree, and therefore a legal norm of equal hierarchy can modify it, i.e., Article 76 of the Forestry Law is inoperative when it requires legislative approval to modify an Executive Decree. Second, since Article 22 requires purchase or expropriation of private lands to legally create a national park, the park was never "created" because 75% of the lands were not expropriated.

The position of ASCONA is also based upon two separate arguments. First, the wording of Article 76 prohibits reduction of a national park without legislative approval. Second, although the park was created by Executive Decree, an inferior legal norm, the Forestry Law, which prohibits reduction without legislative approval, was approved by the Legislature, i.e., there is no difference in the hierachy since the source of the norms for creating and reducing the national parks is one--the Legislature.

The temporary restraining order was granted to ASCONA and the case is still in process (it could take five or six years to process since the court competent to try any appeals is extremely overloaded).

A brief analysis demonstrates a number of interesting points:

1) Conflicts involving hierarchy of legal norms are common, relate to very basic points of law, result in confusion even among attorneys, and make it difficult to know what is the legal norm to be applied;

2) There are basic unanswered questions regarding major points of law, i.e., is a park created at the time a decree is promulgated, or when expropriation takes place?

3) The courts are willing to listen to arguments defending the interests of nature and give standing to conservation organizations defending said interests;

4) One branch of government can be used to control the allegedly illegal acts of the other;

5) Often valuable time can be gained to find solutions or wait for political changes, even if the definitive outcome of the lawsuit may prove to be unfavorable; and

6) Volunteer associations could expand their judicial conservation activities for the benefit of all Costa Ricans.

B. Unauthorized Construction of House in the 200 Meter Coastal Zone.

In September of 1979, a Mrs. FMS quickly fenced a 50 x 150 meter lot fifty meters inland from the coastal line of vegetation. The right to occupy the area was claimed by a corporation that had purchased the rights to the coconut grove years before, said purchase having been approved by the respective municipality. The company had paid the yearly rights of occupation and owned the farm behind the land claimed by FMS. After numerous attempts to convince the lady as well as the municipal inspection, both with no result, a penal suit was filed by the company against Mrs. FMS. She was charged with violation of Article 12 of the Maritime Zone Law (Nº 6043) that states: "In the coastal maritime zone it is prohibited, without the proper legal permission, . . . to construct buildings or installations . . ." Article 62 of the same law provides the penalty of prison for one month to three years for anyone who violates Article 12. The complaint was filed in the local courthouse, witnesses were named, and an inspection was made though there was no prior notification of witnesses and transportation had to be paid for by the plaintiff to move the case. Because of the gravity of the possible sentence, it was removed to a higher court located more than four hours by vehicle from the scene of the alleged crime.

More than a year passed and it was learned that the prosecuting attorney had decided to abandon the case. The house still stands, and the municipality still remains inactive, though no building permit was ever issued.

The above case demonstrates:

1) A civil action for damages should always be filed together with a criminal complaint so that the offended person is a party to the suit and is informed of the progress of the suit; also, it help to have a private attorney reinforcing the efforts of the prosecutor;

2) Municipalities are often more interested in votes and defending their residents, than enforcing the specific provision of a law passed by the Legislative Assembly;

3) The division of judicial territories often makes it almost impossible for courts to carefully investigate facts;

4) Investigations, when made without proper legal assistance, are often brief and inadequate;

5) Since a copy of the court record can only be obtained by an attorney or a law student, and the court was more than an hour away, it was too costly to find out the prosecutor's reason for abandoning the case; and

6) Without motivation many prosecuting attorneys will not take a case to heart.

C. Deforestation

The previously mentioned study, "Legal Causes of Deforestation in Costa Rica", has a chapter dedicated to the detailed analysis of seven cases of deforestation tried under the Forestry Law. The interested reader can go to that study. What is of interest to this report is as follows:

1) Of seven cases tried, only one resulted in a conviction, and in that case, the penalty was only a one-month prison sentence;

2) In three of the cases the court recognized ignorance of the law as a mitigating factor, even though Article 129 of the Constitution states that no one can allege ignorance of the law;

3) In two cases, the court relied upon forestry inspector's alleged verbal permission to cut trees, where the law clearly requires written permission;

4) Two cases were lost because of the statute of limitations;

5) In one case, the proper party was not tried.

In summary, the threat of legal sanction in cases of deforestation is minimal in comparison with the profits to be gained from timber exploitation. Moreover, many of the problems with obtaining a conviction are found in procedural and institutional inadequacies, and not in the law itself.

Although this section dealing with actual cases has been reduced from the original intent, the few examples cited indicate:

1) A great deal more study must be done in terms of procedural and institutional analysis, in addition to analyses of legal norms;

2) Cases must be tried with the aid of a supportive and experienced group of attorneys to improve investigations, proofs, legal arguments, as well as pressure the prosecuting attorneys and judges into realizing that offenses against the environment and natural resources are every bit as important as robberies, traffic accidents, and other customary cases.

Conclusions and Recommendations

1. A center for information on environmental la simply does not exist. Moreover, the classification syste used in legal information sources and centers does n recognize "Environmental Law" as a separate and sp cialized body of law.

Working with the directors of the law libraries (the University of Costa Rica, the Supreme Court, tl Supreme Court Law Journal and the Center of Enviro mental Information and Documentation (CIDA), a cla sification system could probably easily be instituted wit legal materials and cases being cross-referenced to it. beginning Environmental Law outline might include tl following subjects: A. Contamination (with headin including Noise, Solid Waste, Water, Air, Food); I Health and Sickness; C. Forests and Deforestation; I Water; E. Air; F. Native Population; G. Agricultur H. Urban Development; I. Wildlife; J. Soils; K. Energ Sources; L. Marine Resources; M. Coastal Zone; N. Mi eral Resources; O. Scenic Beauty; and P. Populatio Control.

2. No association for attorneys interested in enviror mental law exists, though there are attorneys who ar interested. An association should be formed of intereste attorneys including older, more experienced and respecte persons. Principal functions might include collaboratio on the improvement of information centers and sources selection and analysis of test cases, as well as providin direct assistance to the prosecuting attorneys in prepara tion and litigation of their cases; promoting informatio regarding environmental law among their colleague through the local bar association; publication of result obtained in trials; and creating experience for use i drafting of new legislation for environmental application

3. Very few prosecuting attorneys or judges ar familiar with an area of law known as "environmenta law". No such course was ever taught in law school no are materials available. Work with the University o Costa Rica law school and its Institute of Legal Re search, as well as with the offices of the Attorney Genera and Prosecuting Attorney, should begin or continue t research and promote the cause of environmental law

4. Convince the Supreme Court Law Journal t compile and publish a cross-referenced classified summary of case notes published to date. Said classification should include environmental law and numerous subheadings.

5. Each new law with possible environmental consequences, such as the mining code currently pending legislative approval should contain extensive and explicit norms for protection of the environment. Also, such laws should contain an Article similar to Article 1 of the Coastal Maritime Law which states: "The coastal maritime zone constitutes part of the national wealth, pertains to the State, and is inalienable and of indefinite duration (imprescritible). Its protection as well as the protection of its natural resources, is the obligation of the State, its institutions, and all the inhabitants of the country . . ." The language of the Article should be expanded to allow the State, its institutions, and private citizens to bring suit to protect their environment and recover damages for destruction of it.

6. In the event there is a constitutional convention, a broad, clear, explicit constitutional norm should be included establishing a right of each citizen to enjoy the environment and natural resources of the country, to bring suit when that right is impaired, and to recover damages for destruction or contamination of the environment.

7. With each major loan or construction project with environmental consequences, whether public or private, a detailed environmental impact statement should be required, prepared by independent, competent, responsible professionals, similar to that prepared for the TIBAS-GUAPILES highway or the BORUCA hydroelectric project.

8. There is no land tax that is levied according to advisable land use potential. Some of the best agricultural lands are used for grazing a few non-productive animals such as horses, whereas steep hillsides are slashed and burned to grow corn or provide pasture for cattle of the economically impoverished classes.

If agricultural production is to be one of the key levers for lifting Costa Rica out of its present economic crisis, Costa Rican rural land taxation will have to be carefully studied and compared with other countries such as New Zealand and Holland where it is a tool of production. People in those countries have to produce efficiently and to the capacity of the soil in order to make a profit and pay the taxes assessed.

9. One of the major problems in Costa Rica is knowing what the law is and which institution has effective control over a particular activity. One of the causes, as illustrated in the previously cited Palo Verde case, is that there are legal norms of different hierarchy that relate to a particular problem. Second, there is a tradition with the publication of each new law, of derrogating "in blank" other laws that oppose it, i.e., "this law derrogates laws... and any other that opposes it".

A well-drafted environmental code could simplify the existing legal situation of the environment by assigning specific functions to existing institutions, eliminating overlap, being realistic and derrogating all legal norms in opposition to the code.

10. An environmental prosecuting attorney should be named competent to act throughout the national territory. His function would be to raise the environmental consciousness of all local prosecuting attorneys; provide them with materials and suggestions on how to litigate environmental questions; receive copies of all environmental cases filed throughout the country; and personally litigate test cases throughout the country even if governmental agencies or corporations were the offenders.

11. The Attorney General's office should establish a department or an attorney to specialize in environmental law. His functions would be much the same as the environmental prosecuting attorney mentioned above.

One final observation. This chapter does not deal with political, administrative, and group pressure remedies which, though often more effective, are beyond the scope of this present chapter. This chapter does stress the need for legal environmental activity on the institutional, legislative and litigation fronts. The most common reaction of a Costa Rican facing a problem is to call for new legislation. New, well-drafted legislation could be very helpful, but there are effective measures at the institutional and litigation levels that can be taken, without the delay of passing a new law. Moreover, emphasis upon litigation is extremely important--not so much for the one that is punished, but for the publicized example and its effect on the population at large. Once the public respects the power of an administrative official, and the power behind him, most of the problems can be eliminated or resolved at the grass roots level, without ever going to trial. But when, as illustrated by the cases of deforestation, there is no clout behind the warnings of a forest guard, the deforestation continues at the expense of all Costa Ricans.

V-C. INSTITUTIONAL ANALYSIS

Introduction

Costa Rica has a number of institutions responsible for the administration, management, protection and improvement of the environment. Though there is no unified environmental policy, agencies plan and coordinate individual projects dealing with renewable resources. Universities offer courses and programs, including post-graduate levels, in specific and interdisciplinary areas. Attempts to introduce environmental sciences to primary and secondary schools are beginning to suceed.

Natural resources institutions are created and their functions defined according to specific laws, but duplication occurs as the institutions expand. However, no agency oversees programs nor evaluates results; there is no national research program covering environmental sciences.

Costa Rica's major institutions dealing with resources, conservation and the environment are discussed. Institutions are grouped according to their responsibilities as mandated by GOCR law; universities and other public institutions; and civil, private and international organizations.

Environmental Policy

There is no uniform environmental policy as a guide for public and private groups. Each institution prepares its own guidelines for specific projects. OFIPLAN (1974, 1980) defined the official national policies and objectives for each sector (i.e., watersheds, land use) in the National Social Economic Development Plan. The GOCR grants financial approval for projects and the legislature must approve policy that will become law. However, laws relating to natural resources have been so broad that their implementation does not occur. The institutions and their depedencies are guided by policies set by each director, minister or board. Policies are not always written; some policies are modified as necessary, especially when they have political origins. Some institutional policies are described below; from these ideas we may derive the official policy with respect to the environment.

The broadest definition given by official sources is that expressed by the GOCR in the Budget Law of 1981: "Within the policy of the Ministry of Agriculture and Livestock for 1981, fundamental priority will be given to forest development and the necessary momentum given to programs of national parks, fishing and wildlife."

Some institutions have specific policy. MAG's goals include an agriculture/livestock policy to fit conditions of the various regions with plant/animal needs; guarantee the best land use for renewable natural resources; conserve and rationally use renewable natural resources; provide protection and technical management for renewable natural resources; develop wildlife management techniques; and preserve ecosystems and exceptional scenery or geological formations in order to assure the continuation of the evolutionary process, genetic resources and provide for animal migrations. ITCO's goals are to contribute to socio-economic improvement in rural areas through adherence to land use classification.

Officials have expresed their institution's specific goals and policies.

DGF: To identify and define areas of productive forest; management, including exploitation, may occur only after physical and economic feasibility is determined. To identify forest areas for protection according to their social functions. In deforested areas, reforest for industrial purposes and permit natural regeneration as well. Protect the forest.

SPN: National Parks lands should be secured on the basis of potential rather than on a quota system; there should be a management plan for each wildlands, reserve and monument.

UNED: To develop an environmental education program to inform all academic levels in all areas of the country; to collaborate with educational institutions in the training of personnel who will communicate the concept of natural resources conservation.

ITCR: To direct teaching and research objectives toward economically feasible production; with respect to teaching, ITCR policy is to combine 50% theory with 50% practical training; to offer specialized environmental studies on the basis of employment demand; to help rural communities develop or manage their natural resources; to involve students in work-study programs for onsite learning.

UNA: To educate the student through direct contact with national problems; to upgrade academic standards by selecting better-qualified students and professors in natural resources areas.

ICE: Despite what is established by law, the policy of ICE is to allow other institutions to carry out their responsibilities without interference, and thereby remove some duplication of efforts.

ICAA: Collaborate rather than duplicate; lack of budget has caused ICAA to close a unit protecting watersheds; with respect to water and sewage, its policy is to offer the best service possible but without legal responsibility in case of negative consequences.

There are regulations regarding environmental co tamination but no clear and concise policy for food a water quality, use of chemicals, and urban developme Policy development can be a worthwhile endeavor, b there must be implementation and regulation, and especi ly communication through the popular media and politic routes. There is also a lack of coordination in the definitic integration and follow-up of one policy with anoth Policies are the responses to existing problems and S NAPROMA has been created to guarantee integrati and monitoring of policies and programs. Because of structure (see below), SINAPROMA could become political instrument; however, it does have the advanta that defined policies are supported by the involved i stitutions.

Growth and development in Costa Rica can b considered harmonious with the environment from policy and planning viewpoint. However, the executic of plans does not always occur. The opinion of publ officials, private and civil entities, universities and tl public in general is one of acceptance and support f these policies, but crucial projects are not clearly defin and politically supported. Heterogeneous groups of sma and large land owners and industrial groups are affecte by many of the stated policies; these people acce decisions that improve environmental quality. Whenev changes must be made, it must be remembered that the are private interests and therefore mediation with scientif support becomes necessary; technicians must give accura advice and adequately justify their actions to win suppo for environmental programs.

OFIPLAN coordinates projects and policy on enviro mental and natural resources for member institution however, OFIPLAN does not take responsibility for th execution of these projects or policies. The coordinatio among goverment institutions is done through commo agreement. The universities coordinate activities with stat environmental agencies.

GOCR-related institutions occasionally need stron pressure in order to come to policy agreement. Technica and financial cooperation offered by international orga nizations is coordinated by OFIPLAN and the Ministr of Foreign Affairs.

Human Resources

The difficult economic situation has limited any nev or replacement employment to very special cases. Insti tutions lack necessary personnel and while their need are much greater than the budget for positions, profession als generally occupy administrative positions in the cit for purely economic and status reasons; when they ar faced with transfer to the various regions as technica officers, they use every legal measure to stay within th bureaucracy. This does not allow the most efficient us of limited personnel (Table V-5).

The situation is not easy for the institutions and even less so for the universities: admission and graduation policy is not based on projected employment. Currently 50% of the graduates do not find jobs in their areas. Positions filled by trained personnel in the environmental/ natural resources areas are shown in Table V-6. At the

UNA space allows 60 students to be admitted to the programs, 35 are attending and only 17 will graduate. ITCR fills 60 of its 80 seats and graduates 15 professionals. At the CATIE/UCR program 10 students are enrolled and 9 will graduate. The total social and economic cost of educating a professional is very high.

Financial Resources

The GOCR finances its environmental programs through the national budget. Other financing comes from external and internal donations to the public and private sectors, foreign loans to state agencies and public bank credit. Government resources coming from ordinary and special budgets, intended for natural resources/environment have suffered many cuts and reallocation of funds. It is difficult to say what proportion of the national budget is used for natural resources policy and study, development and control. Donations from foreign sources to private organizations go to a single government account. The most important donation is an AID conservation and natural resources education grant to ASCONA for the sum of US$ 240,000 for a now-completed first stage and US$ 480,000 for a three-year second stage that started in 1981.

Financial Cooperation

A reforestation project with BID is being negotiated consisting of credit for small farmers, a research component and institutional reinforcement. In addition, the following projects are in the preparation stage: a) integrated rural development of the northern zone of the country with BIRF; b) installation and development of a pulp and paper plant with CIDA and BCIE; and c) a forest development project also with BIRF. A loan with AID is currently in operation aimed at a more rational use of renewable natural resources.

Table V-5. Summary of institutions involved in natural resources and the environment, giving principal activity.

	ACTIVITY				
Institution	Law	Planning	Coordination	Administration	Protection	Monitoring
OFIPLAN		x	x			
SINAPROMA		x	x			
SEPSA		x	x			
MAG				x	x	
DGF				x	x	
SPN				x	x	
DVS				x	x	
ITCO		x		x		
ICAA	x					
ICE	x			x		
JAPDEVA				x		
SENAS	x	x				
IFAM					x	
CASA PRESIDENCIAL		x	x			

Table V-6. Personnel occupying professional positions in the Natural Resources and Environment disciplines.

	LEVEL OF TRAINING					
Institution	Administration*	Ph.D.	Master's	Licenciatura	Bachelor's	Service
OFIPLAN	2		1	1	5	
SINAPROMA	2	1		1		
SEPSA	2		1	5	2	
DGF-MAG	20		3	36	114	115
SPN-MAG	23		2	6	9	14
DVS-DGF-MAG	3		1	4	5	8
ICE			9	1	30	
ITCO	2			1	3	
ICAA	2		1	4		
UNED	3		2	4	6	
UNA	6	1	8	6	13	
UCR/CATIE	7	4	13	3	5	
ITCR	3	1	4	3	7	
OTS	4	2	2	4	4	
TSC	3	3			4	5
ASCONA	7			2	8	2

* This number includes office staff as well.

International Context

Investment in the public sector for the next few years should be roughly US$ 600-700 million annually to finance all development projects, including health, housing, transport, education and energy. Even if the total investment in the public sector were destined only to the energy sector, it would be insufficient to finance the most important projects. Examples of the exorbitant costs of energy projects the country urgently requires to help alleviate the current economic crisis are: the mammoth Boruca hydroelectric project will cost more than $ 2 billion to generate 1,000 MW; the massive planting of sugar cane to produce alcohol fuel will require a tripling of the area planted, plus new distilleries for a program cost in excess of $ 1 billion; the construction and electrification of railway lines costs $ 400,000/km; petroleum exploration requires roughly $ 50 million per test well.

Clearly, Costa Rica does not have the internal resources to finance even one of these energy projects and traditional foreign loan sources are no longer a viable option due to IMF restrictions. Under these conditions it is imperative that Costa Rica initiate an aggressive policy to seek unconventional sources of financing and to design new strategies of regional cooperation. Costa Rica must now play a key role in designing and suggesting new approaches to regional cooperation within Latin America. Enormous financial excesses exist in Latin America (Venezuela, México); however, few mechanisms exist to direct some of those excess funds to areas of greater need. One of the great regional tasks is to design means to attract unconventional funding for economic and energy development.

The Mexican-Venezuela agreement to supply petroleum to Central America and the Caribbean represents an initial effort to help the small nations that lack petroleum. The agreement includes a loan of up to 30% of the petroleum bill, payable at 2% annual interest if the loan is used for energy projects. Although the agreement could provide $70-90 million annually, during the past two years Costa Rica has failed to propose projects to use these available funds. The country must demonstrate its ability to obtain, administer and rationally use these funds. Costa Rica should start by doing a detailed analysis of its energy problems, including future perspectives. These problems must be analyzed using accepted scientific and technical criteria; otherwise, the country will lose international credibility.

In addition to inter-governmental agreements, regional organizations are capable of generating coordination within Latin America. The Latin American Energy Organization (OLADE) represents the principal mechanism of regional cooperation on energy. OLADE is particularly effective in presenting regional needs to non-traditional donors, such as OPEP and the European Economic Community. The Latin American Program on Energy Cooperation (PLACE), recently approved by OLADE ministers, supplies a new means of regional cooperation, in addition to providing funds for energy planning, resource evaluation, training, and energy information. PLACE will also create a regional oil exploration company.

Institutions Concerned with Natural Resources or Environmental Quality

I. GOCR-Associated Institutions and Autonomous Institutions

The *National Planning Office (OFIPLAN)* reports directly to the Executive Branch of the GOCR. Its director is responsible to the President of the Republic and has the rank of Minister with voice and vote in the Government Council. OFIPLAN was created in 1963 (Law 3087, modified 1974, Law 5525) with the following functions: a) to carry out and publish results of studies, inventories and technical analysis on the status of the economy, the distribution of income, social evolution; planning regional and urban development, human resources, improvement of public administration and natural resources; b) principal responsibility in the elaboration of the National Development Plan; c) participation in the formulation and adoption of national development plans and policies; d) preparation of the national budget; e) to assure that public investment programs are compatible with the provisions and priorities of the National Development Plan; f) approval of external credit applications for government ministries and institutions; g) formulation, negotiation, coordination, approval and evaluation of technical assistance programs according to the objectives of the National Development Plan.

The *National System of Environmental Protection and Improvement (SINAPROMA)* was created by Executive Decree (12194-OP) January 1981. It is composed of a) a national board with seven state ministers, two autonomous institution executive presidents, a national community development director, a representative of the private sector and a representative of ASCONA; b) an Executive Sec tary who answers to OFIPLAN; c) a technical commit composed of administrators involved in environmental p tection or improvement from representative SINAPRON institutions; and d) all other organizations and committ that are created by SINAPROMA. The most import functions of SINAPROMA are: a) to revise, integr and harmonize policies, priorities, and strategies that found in various institutions according to the Natio Development Plan; b) to assure that environmental f tors are included in national development planning; to revise, integrate and harmonize the national pol of environmental protection and improvement; d) define the responsibilities of the state institutions t deal with environmental problems; e) to elaborate a approve SINAPROMA plans; f) to establish criteria the allocation of resources for environmental progran g) to recommend international financial and techni cooperation programs in order to promote activities; to maintain close coordination and collaboration w OFIPLAN to assure that environmental factors are cluded in the national development planning; i) to provi follow-up to recommendations and to accomplish effici integration of the policies, and coordination of activit of the participating organizations.

According to the Executive Decree, SINAPROM Executive Secretary assigns responsibilities to the pub institutions: a) MOPT--control air and noise comi from moving sources; b) ICAA--control and improveme of water quality; c) MS--air quality and noise from static ary sources; food; industrial safety and health; d) IFAN solid waste management; e) MAG--natural resources; MAG and OFIPLAN--use of soil; g) Ministry of Cultu Youth and Sports--community participation.

The *Agricultural/Natural Resources Planning Sect (SEPSA)* was created by Executive Decree in 1979. It h a nation l council and technical committee and it repor to MAG. Among its principal functions are: a) elaboratio of the National Development Plan for the Agro/Natur Resources area; b) execution of studies on nation and regional scale in order to propose policies; c) analysi evaluation and supervision of activities related to technic cooperation, investments and external financing; d) th establishment of suitable methods of communication an cooperation with natural resources institutions as well with the public and private entities; and e) coordinatio and collaboration with OFIPLAN.

SEPSA is the principal government agency involve in land capability classification. This office produced bot the preliminary soils map of the country at 1:200,00 (Pérez et al. 1978) and the land capability map of Cost Rica at the same scale (Pérez et al. 1979). SEPSA tec nicians continue to use purely physiographic criteria i land capability classification, largely disregarding climat and soil while applying the U.S. Soil Conservation Se vice's 8-Class system for classification (Klingebiel an Montgomery 1962). This Land Capability Map has bee subjected to criticism for its lack of realism and detai yet it is now the "official" map and a standard referenc for many technicians in government service.

The U.S. Soil Conservation Service 8-Class Lan Capability Classification System has features that mak

it less than appropriate for land capability classification in the tropics. Among these are its subjective, non-qualitative basis; its total lack of integrated ecological criteria; and above all, the scale at which it is designed to operate. This system was originally developed for application by soil conservation officials to planning on individual farms in the temperate region of the U.S.A. When applied to large, undifferentiated areas in the tropics on the basis of poorly-defined soils sub-groups, its findings are hopelessly inadequate as a measure of environmental conditions and land capability upon the ground.

It is surprising then to learn that in such government bureaus as the DGF and ITCO that these two extremely-generalized maps are actually being employed as the basis for policies and planning decisions at the local project and farm level. With this map at hand, the necessary but costly and time-consuming field studies of the immediate environment for farming, forestry, and rural colonization appear to have been by-passed altogether (L. González, pers. comm.).

The *Ministry of Agriculture and Livestock (MAG)* does not have an organic law, while most of its duties have been assigned by various specific laws. MAG has three branches through which it deals with renewable natural resources: The *DGF (Forest Service), SPN (National Park Service)* and the *DRPA (Fisheries and Aquiculture)*. MAG is responsible for protection, development, conservation, and fostering of the national forest reserves. This includes a) preserving and increasing the forest reserves; b) establishing protected zones, forest reserves, national parks and biological reserves; c) preventing and combating the degradation and erosion of soil in the watersheds; d) directing and controlling the rational development of forest resources; e) converting land which is unsuitable for agriculture into forest reserves; f) promoting scientific and technical research programs that allow the establishment of a serious and responsible policy in the management of forest resources; and g) protecting the forest fauna.

The *DGF (Forest Service)* was created in 1968 with the following functions: a) to advise MAG in forest policies, legislation and administration; b) to manage the country's forests; c) to establish the corresponding rights and obligations for forest development; d) to give technical assistance; e) to educate the population in the importance and functions of the woodlands; f) to promote the best use of the land and natural resources; g) to coordinate and execute activities that permit the rational development of forest lands; h) to promote the improvement of producing forest; i) to implement forest research planning, coordination and development; j) to plan and foster the establishment of timber plantations for commercial and conservation purposes; k) to plan, coordinate, administer and promote the establishment of tree nurseries; l) to promote the development of the forest industry; m) to contribute to the knowledge of the relationships between soil, vegetation and water; n) to plan with respect to watersheds; o) to carry out studies for forest reserves.

The DGF is less formally involved, but involved nonetheless, in making land use decisions based upon some sort of land capability classification. Logging concessions are granted by DGF. Timber extraction decisions are largely based on the SEPSA land capability map previously discussed. Such misuse of a general map for highly specific localized natural resources decision-making may contribute directly to soil erosion and watershed degradation from both initial logging and from subsequent squatter activity. Remaining logged but forested areas are not protected from squatter activity.

With all its present limitations, the DGF has been designated chief executor for MAG of the new project for Conservation of Natural Resources, partially funded by AID. A new unit within the DGF, the *Watershed and Soil Management Section*, was set up in 1981 and is working exclusively on this project.

The DGF *Department of Watersheds and Land Classification* has an almost impossible task protecting the country's watersheds with a minuscule budget and the political hegemony of the DGF and MAG. How can a tiny department compete with institutions like ITCO or JAPDEVA, or even within its own administrative hierarchy--DGF and MAG?

The absence of watershed management and protection is the most critical component of the deterioration of the country's natural resources. In spite of frequent statements of support, the political willingness has never existed that would provide the DGF with the human and financial resources, plus legal and technical control mechanisms, to carry out rational planning of land use in the country's watersheds. Uncontrolled land use has continually been used as a political tool to lessen land tenancy pressures of the poor or even for the power elite to acquire state lands for speculative purpose. Laws have been passed that affect the effectiveness of the Forestry Law, by permitting other institutions such as ITCO and JAPDEVA to make decisions on land use. The conflicting nature of land use demands and pressures usually leads to irrational forest exploitation and unsustainable agriculture to the detriment of the country's watersheds. Watershed protection by the DGF is impossible to carry out due to the lack of human resources, funds and decision-making authority.

The *Department of Wildlife (DVS)* has the essential function to promote the rational administration and protection of the country's wildlife, to generate the necessary biological information, and to carry out studies necessary for the creation of wildlife refuges. It is under the direction of the DGF. The DVS formerly was a part of the Section of Fish, Fisheries and Wildlife of MAG. Though there was little interest in wildlife programs, in September 1981, the agency was split, and the DVS was established within the Forest Service (DGF). Although most of the old section's personnel (including 11 of 14 wardens) remained in fisheries, the consensus in the DVS is that the move to the DGF was beneficial, and the prospects for action on wildlife programs have improved. For instance, the DGF is willing to let wildlife research be conducted in forest reserves, and its 200 or so forest guards may be able to help enforce wildlife laws, given some basic training. On the other hand, the DVS is one of 12 departments in the DGF, and it lacks the political clout to expand its personnel,

budget, or programs in the near future. In fact, MAG (La Nación, 21 II 1982) says it cannot help with basic budget proposals of DVS this year.

But the current *de facto* role of the DVS is to enforce wildlife laws, administer wildlife refuges (only one exists, the Rafael Lucas Rodríguez, otherwise known as Palo Verde), conduct studies on wildlife, develop management policies and practices, and respond to consultations from land owners, hunters and municipalities concerning wildlife-related problems. The current complement of the DVS is a director, subdirector, 3 biologists, 1 forester, 2 field assistants (including the administrator at Palo Verde) and 3 wardens. The degree of specialized formal training of these personnel for their functions is slight; all except the wardens have university bachelors' degrees, one a licenciatura, one masters' degree, but only one of these degrees is specifically in wildlife management. The lack of highly trained personnel is true of the country as a whole, thus there is only limited opportunity for in-country specialized training (see below). Possibilities for sending personnel overseas for extensive training are also scant, at least during the present economic crisis.

On the other hand, the DVS has a very positive attitude toward research. The head biologist is capable and dedicated and as an ornithologist conducts an active research program on waterbirds and other birds at Palo Verde. As a whole, the agency is acquiring a great deal of practical field experience through active participation in a variety of projects, many of them in cooperation with other institutions, both foreign and domestic. The DVS maintains good contacts with its homologues in the U.S A., the O.A.S., the ICBP, and the IUCN. Cooperative projects, based mainly at Palo Verde, including a radio tracking study of peccaries and deer in cooperation with the UNA School of Environmental Sciences; a study of deer populations on San Lucas Island with UNA and MAG; and a study of waterfowl (especially Muscovy Duck) biology with Texas Tech University. Recently a proposed study of the endangered Jabiru Stork was funded by the International Council for Bird Preservation (ICBP). The most serious limits to this research program are the lack of equipment, library facilities, and funds for local travel and field work. The impossibility of expanding the personnel base further complicates the situation with respect to personnel training: it is difficult to spare personnel from ongoing projects for extended periods.

Possibly the most pervasive problem of the DVS is the lack of a coherent national wildlife policy. This problem has two facets: the lack of a well defined role and plan of action for the DVS itself, and the inadequacy of present wildlife legislation. The absence of long-term goals, in effect a "master plan", has meant that the DVS has added (or lost) personnel and projects, and established refuges on an *ad hoc* basis. While this does not detract from the value of most of the programs so far established, it has hindered coordination with other government agencies and the universities, and probably has contributed to the difficulty of obtaining adequate funding. This problem is now being addressed; the DVS is in the early stages of preparing a "diagnosis" to clearly define its scope and function; this will probably imply some reorganization of the DVS itself. Also foreseen is the creation of a broad-based Advisory Committee to formalize a liaison with scientists and technicians both within and outside Costa Rica, to increase scientific input into wildlife programs.

Wildlife legislation ties the DVS's hands on several important fronts. For example, many conservation-minded private land owners have expressed interest in setting aside part of their lands as wildlife refuges and are willing to contribute towards maintenance and protection of these lands in exchange for matching contributions from the DVS in terms of legal status, administrative help, and some financial assistance for improvements and guard salaries. The lands offered include a number of critical wildlife areas in Costa Rica. However, under current laws the DVS cannot enter into any such agreements, use DVS personnel or government funds on privately-owned lands. The only legal option is for the government to expropriate such lands, which is undesirable on two points: it will certainly alienate these land owners whose interest in conservation is the main reason the areas in question are still wildlife centers; and in any case, the goverment does not have the money to pay for expropriated land. Other examples of problems with the present legislation have been given above.

Many of the legal problems would be alleviated or eliminated by a comprehensive new law, the Law of Wildlife Conservation, currently before the Legislative Assembly. Unfortunately, partisan politics and strong lobbying against the law by hunting clubs (who object to tighter controls on the issuing of licenses and stiffer penalties for poaching and other infractions) seem likely to delay passage of this law, at least for the duration of the present administration.

The *National Park Service (SPN)* was created as a result of various environmental problems such as deforestation, hunting, and erosion, that threaten the national patrimony. Its chief functions are a) to maintain representative examples of the principal biological units as ecosystems; b) to maintain ecological diversity and environmental regulation; c) to maintain genetic resources; d) to preserve the objects, structures and sites of the cultural patrimony; and e) to protect scenic beauty.

The SPN is intimately involved in wildlife conservation in Costa Rica through its administration of many of the country's most important wildlife areas. However, the SPN has no plans or programs for studying or managing wildlife populations per se, and has shown no interest in developing such programs, either alone or in cooperation with other agencies. The involvement of SPN with wildlife problems consists chiefly of occasional consultations with local scientists concerning the granting of scientific collecting permits to visiting scientists. The lack of a national wildlife policy means that there is no official liaison between SPN and DVS; the unfortunate bureaucratic bungling attendant upon the establishment of Palo Verde as a wildlife refuge has led to a feeling of rivalry, rather than cooperation, between the two agencies. Within the parks system, wildlife-related questions are decided without reference to other agencies; only if specimens are to be exported does DVS have a say in the matter.

This is especially unfortunate in that attitudes toward wildlife research (indeed, research in general) are far less positive in SPN than in DVS. Research is reluctantly tolerated rather than welcomed in most national parks (and it is tolerated more as a source of income than as a source of knowledge). Even the most cooperative foreign and local scientists find scant interest in their work among the SPN administration, and bureaucratic impediments are routine. A major part of the problem is the lack of biological input into SPN. No trained biologist is employed *as a biologist* in SPN; the personnel in charge of overseeing research activities have never in fact conducted research of any kind. There is no corps of park naturalists, no official interest in generating research activities within the SPN itself, nor in allowing SPN personnel to participate in research projects of foreign or local scientists with an eye towards training them as naturalists. This situation is lamentable as regards wildlife, in that the only large, accessible populations of several key wildlife species are now within national parks. With proper organization and a minimum of training, park guards could collect much valuable data on wildlife abundance and movement patterns, simply in the normal course of their patrols. Such data would be very useful in designing management and conservation programs for these species (including more scientifically-based establishment of, or adjustments of the limits of the parks themselves). In short, one of the aims of a national wildlife policy should be to integrate SPN and its resources, and to stimulate SPN to take a more active role in wildlife research.

The *Office of Fisheries Resources and Aquiculture (DRPA)* has primary administrative responsibility for the fisheries sector. DRPA is organized into departments of protection and registration, terrestrial and marine fishing, and aquiculture. The basic functions of DRPA are: a) to issue regulations for rational use of fisheries resources; b) to determine optimum utilization of fisheries resources, including processing and sale of products; c) to conserve and restore marine fauna and their environment; d) to stimulate aquatic production of protein through a national aquiculture program.

The *National Fishing Commission* (Comisión Nacional de Pesca) was established as a temporary commission by the Executive Branch in 1978 to coordinate interinstitutional activities in the fisheries sector. With MAG the Commission is developing national fisheries policy, including a new administrative structure. The Commission also advises the President on marine topics.

The *Costa Rican Electricity Institute (ICE)* provides the country's electric and telecommunications services. In addition to utilizing resources and generating energy, ICE must conserve and defend the water resources, protecting the watersheds and water distribution through a cooperative program with SNE, MAG, and MOPT. Only three of its 39 departments deal with environmental protection: a) Basic Studies, that carry out work on nonconventional energy resources and the environmental impact of hydroelectric projects; b) Properties and Reforestation, in charge of the forest nurseries and reforestation for protection, beautification and recreation around the dams and other institutional lands; and c) Population Relocation, relocation studies for populations affected by hydroelectric projects according to the recommendations of the Basic Studies Department and the environmental impact reports.

ICE has an outstanding record in developing hydroelectric projects that would be difficult to match in other developing countries. Although the notion exists that because of its size ICE has less flexibility in its policies and that its technical decisions have had to cede ground to political decisions, ICE's impressive accomplishments in electrification and telecommunications have far exceeded initial expectations.

In contrast to many developing countries, numerous aspects in Costa Rica favor an integrated policy of control and administration of watersheds coordinated by ICE. Unfortunately, the institutional efforts in constructing public works have detracted from the concern to watch over the status of the watersheds. The current financial restrictions and future development goals will undoubtedly require that ICE evolve to a less rigid administrative structure that will permit greater involvement in policy decisions on land use in upper watersheds. Investment costs in hydroelectric projects and the guarantee of adequate service to the user require the protection of water resources, which are intimately dependent on watershed protection.

The acute financial crisis of the country and the high costs of financing large projects require a policy evaluation of growth in electric consumption, as well as the economic scale of development projects.

ICE is a semi-autonomous institute with demonstrated technical capability in design and execution of hydroelectric projects, the principal national energy resource. ICE has an inventory of potential electrical energy resources, an index of projects in differing stages of feasibility study, and has considerable capability to increase the actual level of activities. The development of hydroelectric and geothermal projects is currently limited by government limits of ICE's indebtedness, even though the possibilities of foreign financing exist. ICE has been traditionally concerned with satisfying projected demand for electricity, rather than utilizing hydroelectric resources as a means of development. In spite of its basic preoccupation with electric production, it is necessary that ICE play a more important role in related areas such as the feasibility of electrified transport, use of generated excesses, recognition of geothermal resources, and rationalization of energy consumption. It is essential that ICE find a new means of project financing through collaborative efforts in new industries such as aluminum, hydrogen, ammonium, chlorine. The export of electricity should be given serious study. The closest coordination must exist between ICE and the Energy Ministry so that the former follows policies agreed upon by the rest of the national energy system.

The *National Electricity Service (SNE)* is the government regulatory agency for electric rates, plus several other non-integrated functions. This institution should either be expanded or consolidated with others in order to serve as regulator of the total energy system, including petroleum and transport.

As the regulatory agency for water resources, SNE has effectively carried out its mandate. Despite a lack of institutional coordination, major controversies over water use have not arisen. This is in part due to the abundance of the resources and a legal mandate to SNE that is precise, yet permits some flexibility in the administration of water resources. For example, if due to a lack of hydrologic data SNE grants irrigation concessions that exceed available water, SNE has the authority to rescind or modify the concessions. In addition to authority over irrigation concessions, SNE is also the administrative agency responsible for developing the lower Tempisque irrigation project.

Concessions to privately produce hydroelectricity are granted by SNE, following consultation with ICE (but ICE lacks veto power). For technical reasons SENAS has veto power over SNE concessions to exploit ground water. ICAA does not require concessions because the water law grants ICAA first priority in the use of water, plus on the request of ICAA, SNE can cancel without prejudice previous concessions for other water uses.

In consultation with ICAA, SNE also regulates the concessionary extraction of rock, gravel and sand from rivers. Despite SNE's authority to regulate such extraction, there are situations where SNE requires Civil Guard support to effect control. In some cases, e.g., extraction of sand and gravel near the Baily Bridge in Cartago, municipal and public pressure affect SNE's regulatory decisions. Municipalities tend to support unrestricted extraction because local income is based on volume extracted.

The *Institute of Land Colonization (ITCO)* has responsibility for the administration and assignment of national reserves in order to give lands to peasants for human and economic development. ITCO buys, expropriates, or transfers lands to the national reserve where a rational and efficient use of the natural resources should take place. It has a forest unit that is in charge of lands unsuitable for agriculture that are destined for forest projects.

ITCO has its own *Planning Department* in which the section of *Basic Studies* carries out land capability determinations on all lands under consideration for acquisition and re-distribution in small farms to needy, landless persons. ITCO has had a truly dismal record in this department. The agency has almost traditionally purchased large properties in sub-marginal areas for agriculture and grazing. All indications are that it is continuing to do so today, confusing "empty" lands with opportunity. Not all ITCO colonies have been failures, of course, but an inordinately high proportion of them have been troubled with serious problems of low productivity, forest devastation in areas unsuited to permanent cultivation or grazing, and high turnover of owners as soil resources were rapidly exhausted or proved from the outset to be too poor to provide a decent living to the original colonist. ITCO is often forced to react to squatter invasions by buying the property, regardless of soil and land suitability for small farmers.

ITCO can also be faulted for failure to develop the forest resources on its lands, either prior to parcelization in farms to maximize returns from standing old-growth timber or as an alternative to cultivation or grazing on lands of a purely forestry potential. This problem stems at least in part from the near absence of professionally-trained tropical foresters within the institution. Most decisions at ITCO are made by agronomists who lack a perception of the forestry opportunity altogether. The result is the subjective tendency to push the agricultural limits far beyond environmental capabilities in order to get the most out of each property purchased. Serious soil and forest depletions as well as less-evident human misery are the consequences.

The *Costa Rican Institute for Water and Sewer Systems (ICAA)* is responsible for directing and monitoring all activities concerned with the supply of drinking water, collection and evaluation of sewage and industrial residues, and rain waters in urban areas. It promotes the conservation of watersheds and ecological protection as well as controlling water contamination. ICAA has a *Departament of Water Quality* whose prime responsibility is sanitation control of the water supplied by ICAA and a *Department of Basic Studies* that is concerned with the watersheds and guidelines for maintaining optimum water quality, quantity and distribution.

Although in several areas ICAA has the necessary personnel, the large number of projects to be carried out makes it occasionally impossible to satisfy the technical requirements within the allotted time. Thus some large projects, such as the Orosi aqueduct, are assigned to consulting firms. For similar time restrictions, the solutions to problems have tended to be remedial, as in the cases of many rural aqueducts. In general, alternatives were not analyzed; rather, someone perceived a solution and then, the design process began. This situation seems to be changing.

Some ICAA officials feel that the institution lacks clear policies and is structurally weak. An agreement between ICAA and the UCR Civil Engineering School will channel undergraduate thesis topics to integrated development projects in communities of interest to ICAA. Student thesis projects should give a broader perspective to solving rural aqueduct and sewage problems.

The contents of ICAA technical publications demonstrate that some sections of the institution, e.g., *Studies and Projects*, are concerned about streamlining the tasks by better evaluation of the available resource, control of water losses, and a positive change in the patterns of exceptionally high consumption in certain localities.

The *Ground Water Service (SENAS)* was created in 1963 as an institution of hydrogeological and hydrological studies and services and it investigates the ground water resources in the national territory and plans the national policy for the best utilization and protection of water reserves.

In contrast to ICE and ICAA, SENAS almost completely lacks direct income, except for well-drilling services for the private sector or agreements with public institutions like ICAA. SENAS is one of the country's technical institutions with severe budget problems, since it is 90% dependent on the central government budget.

There is considerable institutional frustration because of the lack of funds to continue the evaluation of the country's ground water resources. SENAS's capable human resources and well-drilling equipment are only functioning at 25% capacity due to the shortage of operating funds and spare parts.

The *Ministry of Public Works and Transportation (MOPT)* is the planning and implementing agency concerned with transport, principally the design and construction of highways and ports rather than planning or public transport. MOPT has an important regulatory role in public transport and eventually will have to assume similar responsibility at the metropolitan and interurban levels. The initial efforts to improve the railway system, including electrification, need to be strengthened. As with other government agencies, ministerial-level coordination is needed to ensure the inclusion of energy factors in transport plans, as well as *vice-versa.*

The *Costa Rican Petroleum Refinery (RECOPE)* is a state institution of crucial importance due to its unique role in the importing, refining and distribution of petroleum derivatives. During the past decade the GOCR has used RECOPE funds for a multitude of projects thus abusing the institution while allowing the physical plant to deteriorate and become inefficient.

The refinery lacks operational flexibility since the type of crude processed determines the products obtained. With changes in the type of crude and the rigidity of the refinery, in 1975 the refinery began to produce less diesel and more fuel oil, just the opposite of developing market demands. The obvious consequence is the direct import of most of the diesel consumed. This is doubly prejudicial to the country because the international price of diesel is higher than gasoline, and the GOCR heavily subsidizes the diesel sold in the country. The dependency on diesel as the principal national energy source, the rigidity of the refinery, and the subsidized internal price of diesel constitutes the most urgent energy problem in the country.

It is essential that RECOPE improve its technical capability, encourage cooperation through ARPEL and obtain much stricter control over its own institutional operations.

CODESA and Associated Companies. Along with CATSA and TRANSMESA, the plans of this state corporation must be integrated with the energy sector. CATSA needs to set specific goals for alcohol production and design a system for alcohol storage and distribution. TRANSMESA needs considerable upgrading of its technical, economic, and planning capabilities.

FECOSA, (Ferrocarriles de Costa Rica), is a secondary institution that represents the deterioration and stagnant bureaucracy of the railway system. It needs considerable strengthening because its future role in transport will be important. Medium- and long-term goals must include electrification of public transport and cargo transport. The institution needs to acquire the technical and economic capacity, as well as the leadership to carry out this important task. A short-term goal should be to stimulate interurban transport by rail (Alajuela, Heredia, San José, Cartago).

The 10 year old, autonomous *INCOP (Pacific Ports Institute)* focuses exclusively on planning port facilities, especially for commercial traffic. INCOP has paid little attention to developing port facilities for handling and processing fish and molluscs. A clear policy of ports development does not exist. Consequently, a high percentage of existing Pacific facilities are under-utilized.

The *Atlantic Ports and Development Authority (JAPDEVA)* is the Caribbean analogue of INCOP, but with broader responsibilities for planning coastal development. Only coastal areas under control of the National Parks Service are officially excluded from JAPDEVA responsibility. JAPDEVA administers the lands situated in the areas of navigable channels in a strip of land 10 km wide parallel to the coast and three km on both sides of rivers of the zone. JAPDEVA management is responsible for encouraging agricultural development projects including forest-related ones, but its activity has been limited to a small nursery and the granting of permits for wood extraction (an area which corresponds to the DGF) and the charging of fees for canal use and forest rights. JAPDEVA is actively involved in planning development of the exensive lagoons and canals north of Limón. Strong local interest in fish rearing implies that these lagoons will be intensively used within five years.

The *Costa Rican Tourism Institute (ICT)* promotes, regulates and manages activities throughout the country. It is theoretically responsible for planning coastal zone development and does have veto power over use of the 200 m terrestrial maritime strip.

ICT shares administrative responsibility of the 200 m terrestrial maritime strip with the respective municipality. The municipal governments limit their activities within the 200 m strip to granting construction permits and land leases. The municipalities do not have the necessary infrastructure to analyze and control use of coastal resources, thus producing bureaucratic procrastination and contributing very little to orderly development of the coastal zone. These difficulties are clearly evident in the municipal actions concerning lucrative mariculture development within the 200 m terrestrial maritime zone.

The *National Institute for Promotion and Advice to Municipalities (IFAM)* advises the municipalities on the creation and development of policies and technical assistance. Its principal responsibilities include a) processing and control of solid wastes; b) supervision and inspection of the slaughter-houses run by the municipalities.

II. Universities and Training Centers

Universities and Training Centers of higher education offer programs in Renewable Natural Resources and the Environment.

UNA (The National Autonomous University) offers Bachelor and Licenciature degrees in Forest Sciences and Environmental Sciences and Biology.

ITCR (The Costa Rican Technological Institute) offers a Bachelor's in Forest Engineering.

UCR (The University of Costa Rica) has a Master's in Renewable Natural Resources through an agreement with the CATIE in Turrialba, and a Bachelor's and a Master's in Biology.

UNED (The State Extension University) also has an environmental program that attempts to reach the general population through the use of radio, television, publications, round table discussions and audio-visuals.

INA (The National Training Institute) also trains forest rangers, nursery workers, and other technical workers in environmental areas.

CONICIT (The National Science and Technology Council) contributes with financial support for research, professional training via post-graduate scholarships and institutional coordination in conflicts arising in research and technology policies.

CONICIT has the important task of integrating research and development. In the energy field a program is needed that would include broad aspects of energy production from biomass, such as the production of alcohol (from wood and sugar cane), vegetable oils, biogas, and firewood utilization. The useful resources of CATIE should be incorporated into the program so as to elevate Costa Rica as a regional center for research on agro-energy.

The universities should combine forces on research and development projects directed to solving urgent national problems. Post-graduate academic programs are needed to train professionals from other fields in energy planning and conservation. Universities are important national resources that tend to be underutilized or ignored by the government. Some university sectors are adapting and developing the technology necessary to solving national problems.

CATIE (The Tropical Agronomy Center for Teaching and Research) was created in 1973 by the GOCR and IICA. It is a non-profit scientific and educational association that stimulates, promotes and executes research and technical cooperation in agricultural, forestry and animal production in order to offer alternatives to the tropical regions. Its activities have been concentrated in forest planning, restructuring of the DGF, cooperation on the Parque Internacional de la Amistad between Costa Rica and Panamá, and in the establishment of a national forest reserve system.

III. Private, Civic and International Organizations

The Costa Rican Association for the Conservation of Natural Resources (ASCONA) is a non-profit organization whose principal functions are: a) to promote the development of the country by means of the rational use of the natural resources; b) to transmit the importance of protecting and preserving the environment; c) to promote the creation of environmental laws; d) to collaborate with the state and private institutions as well as municipalities to achieve a greater educational level with respect to the importance of protecting the environment; e) to serve as a monitor for the restitution and protection of environmental quality to the benefit of present and future generations.

The Organization for Tropical Studies (OTS) is a consortium of American universities including UCR and UNA, the National Museum, Smithsonian Tropical Research Institute and 25 universities in the U.S.A. Its principal function is to administer aid for teaching and research programs dedicated to tropical biology.

The Tropical Science Center (TSC) is a non-profit scientific association whose members and technical personnel contribute time and expertise for the rational use of Costa Rica's natural resources. The Center was created in order to conduct and support activities related to scientific research and education and to promote the acquisition and application of knowledge related to the relationships of man with the biological and physical resources of the tropical environment. It carries out work through contracts with private and public, national and international organizations.

International Organizations

Support for the environment from international organizations consists of technical cooperation and financial assistance to aid research to strengthen institutions, to prepare and execute projects and to evaluate and define policies.

Technical Cooperation

The United Nations Development Program (UNDP) has offices in Costa Rica which cooperate with the administration, representation, and channeling of resources for national and regional projects of FAO and UNEP. The UNEP Action Plan of the Caribbean has four fundamental priorities: a) oil spills; b) classification of watersheds; c) public health through the control of water and sewage; and d) environmental education. The UNDP also has a forest project with the FAO whose aim is to help the country in the integral development of forest resources and to identify, formulate, evaluate and promote research projects based on the economic and social needs of the country and in the preservation of the environment.

The Interamerican Institute for Agricultural Cooperation (IICA) stimulates, promotes and supports the efforts of the member states in accomplishing their agricultural development. It currently has an agreement with the GOCR whereby it acts as consultant for a SEPSA program in the execution of an AID-GOCR project for renewable natural resources.

A number of other institutions have had a greater or lesser impact on wildlife-related programs and policies in Costa Rica. International conservation groups like IUCN (International Union for the Conservation of Nature), WWF (World Wildlife Fund), ICBP (International Council for Bird Preservation), and RARE (Rare Animal Relief Effort), have encouraged and often partially funded wildlife-related programs such as the establishment of parks and reserves. A recently formed local chapter of the ICBP is actively promoting research on endangered birds, a program of educational newspaper articles, and television announcements concerning the local avifauna and its conservation. ASCONA has helped foster public awareness of wildlife problems and supported

major conservation measures like establishment of parks and reserves. Private corporations have supported conservation measures for particular species (e.g. the Caribbean Conservation Corporation for the Green Turtle). The banana company, ASBANA, is launching a cayman and crocodile raising program, with advice from DVS. OTS, through its field station and logistic services, helps mostly foreign scientists conduct ecological research.

Conclusions

1. The country does not have a uniform environmental policy; different guidelines appear to be compatible in the area of renewable natural resources and for health, pollution and water issues.

2. The most effective coordination and cooperation takes place on an informal level among officials at all levels; it doesn't depend on formal institutional agreement.

3. Institutional policy statements do not necesarily result in corresponding actions. Established planning mechanisms are underutilized and policies are not refined to bring goals to realization.

4. Evaluation systems based on theoretical reports serve as an information source but do not quantify specific results as they relate to policies.

5. No systems of evaluation and feedback exist to test the validity of policies and projects.

6. Research priorities have not been defined. Institutions investigate what they want, but even so, there is not enough financial or political support.

7. Each institution considers that it has complete dominion in its area and does not accept the guidance or supervision of the planning agencies.

8. Some institutions share responsibilities for the solution of environmental problems as in the case of watershed protection. However, instead of coordinating their activities and confronting the problem with an efficient use of available resources they delegate the responsibilities in a haphazard manner.

9. Despite implementation of important projects, most of them very recent, the general opinion is that the country's past development did not consider environmental effects and therefore most work to be done is of a corrective nature.

Recommendations

1. A uniform official environmental policy should be defined with the participation of competent members of private organizations and charged with environmental management, scientific research, use and conservation of natural resources.

2. SINAPROMA should be strengthened to coordinate the existing natural resources policy. Even though there is talk of some day creating a Ministry of the Environment or Renewable Natural Resources, the present structure should be made to function.

3. The autonomous institutions should increase the technical level of their councils and reduce political influence.

4. Project evaluation should begin before project implementation, i.e., priorities should be assigned to complete those activities which become irreversible in a short time. The evaluation should be ongoing and become the base on which to rate and evaluate other policy that might be generated.

5. The existing legislation should be revised, to assign responsibilities for environmental activities and to avoid duplication of efforts.

6. Activities in the area of renewable natural resources should be decentralized, creating regional centers involved with production rather than a large central bureaucracy. Professionals should be motivated to observe problems in the field and then see them corrected.

7. Natural resources research programs should be undertaken by a university with specialists in ecology, wildlife, forestry, conservation, watershed management, soils, etc. These programs and professionals could form the base for a research council on natural resources.

8. Professionals working with the administration and protection of natural resources should assume a firm definition of policies and priorities. Those expressed in the budget laws of 1981 have not yet been carried out.

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