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Country Environmental Profile

A Field Study

The Dominican Republic

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Preface

This environmental profile of the Dominican Republic is one of a series of country environmental profiles (CEPs) sponsored by the U.S. Agency for International Development, Office of Development Resources, Bureau for Latin America and the Caribbean (AID/DR/LAC). The scope of work for this in-country study was developed jointly by the AID mission in the Dominican Republic and Robert Otto, the environmental officer for LAC. Contractual arrangements for the profile, including publication, were handled by JRB Associates, 8400 Westpark Drive, McLean, Virignia 22102 (IQC: AID/SOD/PDC-C-0247). The following individuals contributed to the field study and preparation of this CEP:

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List of Acronyms and Abbreviations

ADN	Ayuntamiento del Distrito Nacional
ADP	Plan de Desarrollo AGropecuario, SEA
BID	Banco Interamericano de Desarrollo (= IDB)
BOTANICO	Jardin Botánico Nacional "Dr. Rafael M. Moscoso"
CAASD	Corporación de Acueducto y Alcantarillado de Santo Domingo
CATASTRO	Dirección General del Catastro Nacional
CDE	Corporación Dominicana de Electricidad
CEA	Consejo Estatal de Azúcar
CEDOPEX	Centro Dominicano de Promoción de Exportaciones
CENDA	Centro Norte de Desarrollo Agropecuario, SEA
CESDA	Centro Sur de Desarrollo Agropecuario, SEA
CIAZA	Centro de Investigación Agricola en Zonas Aridas, SEA
CIBIMA	Centro de Investigación de Biologia Marina, UASD
CNPV	Consejo Nacional de Población y Vivienda
CONARENA	Consejo Nacional de Recursos Nacionales
CORAASAN	Corporación de Aqueducto y Alcantarillado de Santiago
CORDE	Corporación Dominicana de Empresas Estatales
CRIES	Comprehensive Resource Inventory and Evaluation System, SEA
DAJABON	Escuela Agricola de Dajabón
DGF (= FORESTA)	Dirección General Forestal
DNP	Dirección National de Parques
DRP	Departamento de Recursos Pesqueros, SEA
DTA	Departamento de Tierras y Aguas, SEA
DVS	Departamento de Vida Silvestre, SEA
FAO	Food and Agriculture Organization of the United Nations
FDL	Fishery Development Ltd.
FENACOOPES	Federación Nacional de Cooperativas Pesqueras
FORESTA	Dirección General Forestal
GODR	Government of the Dominican Republic
IAD	Instituto Agrario Dominicano
IDB	Inter-American Development Bank
IDECOOP	Instituto de Desarrollo y Crédito Cooperativo
IICA	Inter-American Institute of Agricultural Cooperation
INDRHI	Instituto Nacional de Recursos Hidráulicos
INDESUR	Instituto de Desarrollo del Suroeste
INDOTEC	Instituto Dominicano de Tecnologia Industrial
INAPA	Instituto Nacional de Aguas Potables y Alcantarillados
INTEC	Instituto Tecnológico de Santo Domingo
ISA	Instituto Superior de Agricultura, Santiago
LOYOLA	Instituto Politécnico Loyola
MEDIO-AMBIENTE	Departamento del Medio Ambiente y Recursos Naturales
MDH	Museo del Hombre Dominicano (= Museo de las Casas Reales)
MNHM	Museo Nacional de Historia Natural
OAS	Organization of American States

List of Acronyms and Abbreviations *(continued)*

ONAP	Oficina Nacional de Administración y Personal
ONAPLAN	Oficina Nacional de Planificación
ONAPRES	Oficina Nacional de Presupuesto
OSISA	Oficina de Integración Agropecuaria de Azua, SEA
PIDAGRO	Programa Integrado de Desarrollo Agropecuario
PLAN SIERRA	Plan de Desarrollo Integral "La Sierra", SEA
PNUMA	Programa de las Naciones Unidas para el Medio Ambiente (= UNEP)
PRYN	Proyecto Riego Yaque del Norte
SALESIANA	Escuela Agricola Salesiana
SEA	Secretaria de Estado de Agricultura
SEAPLAN	Subsecretaria de Planificación Agropecuaria, SEA
SEICA	Subsecretaria de Investigación, Extensión e Investigación, SEA
SESPAS	Secretaria de Estado de Salud Pública y Asistencia Social
STP	Secretariado Técnico de la Presidencia
SURENA	Subsecretaria de Estado de Recursos Naturales, SEA
UASD	Universidad Autónoma de Santo Domingo
UCE	Universidad Central del Este
UCMM	Universidad Católica Madre y Maestra, Santiago
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNPHU	Universidad Nacional Pedro Henriquez Urena
USAID	Agéncia de los Estados Unidos par el Desarrollo Internacional
USDA	United States Department of Agriculture
ZOODOM	Parque Zoológico Nacional

I

Summary

This environmental profile of the Dominican Republic was carried out in a five week period during September-October, 1980, by a nine-man team of specialists in ecology, geography, marine ecology, forestry, rural anthropology, soils, hydrology, wildlands/wildlife, and pollution controls. Dominican counterparts arranged by SURENA contributed significantly to the sectorial analyses.

The Dominican Republic faces very serious challenges involving food, energy, and population that have already caused substantial environmental degradation and portend a bleak future not only for her natural resources but for the country as well. Despite the expansion of agriculture through major irrigation projects, the country is a net importer of food. Even though the government is aggressively developing the country's substantial hydroelectric potential, imported petroleum provides 85% of the national power needs. The Cordillera Central watersheds, that are absolutely fundamental to irrigated cropland and hydroelectric projects, have been and continue to be severely degraded by slash and burn agriculture. Protection and rehabilitation of critical watersheds merit emergency measures similar to the 1967 closure of sawmills and prohibition of tree cutting. With a projected doubling of population within 26 years and no traditional agricultural frontiers remaining, watershed protection and rehabilitation must involve the hillside farmers who have nowhere to go.

In this decade the Dominican Republic must accomplish what she has been unable or unwilling to do in the recent past: become self-sufficient in food, increase agricultural exports, generate more energy from local renewable resources and implement a realistic population policy. Only a fundamentally and qualitatively different relationship between the Dominican people and the country's natural resources will enable the Dominican Republic to meet essential goals.

Major conclusions and recommendations for each sector of Dominican natural resources are summarized below.

Natural Vegetation

Ecologically, nine Holdridge Life Zones occur in the Dominican Republic. Two Life Zones—Subtropical Moist and Subtropical Dry—cover 68% of the country, yet Subtropical Lower Montane Wet is the most critical Life Zone as a source of water for irrigation and hydropower. The latter Life Zone covers about 7% of the country, primarily in the Cordillera Central, where the major rivers originate.

The recent CRIES inventory of land cover indicates only 14% of the country remains in forest, primarily broad-leaved forests in the arid southwest and northwest. Some also remain in La Altagracia province and in Los Haitises. Due to low stand density, most pine forests were classified as limited rangeland.

The extensive pine forests in the Bermudez and del Carmen Ramirez national parks appear in excellent condition due to the protective efforts of FORESTA and DNP. The same cannot be said, however, for the lowland broad-leaved forests that are receiving intense pressure from slash and burn agriculturalists and from charcoal makers. FORESTA has largely ignored the non-pine forests in enforcing the 1967 law closing sawmills and prohibiting tree cutting. Although different criteria and classification techniques make it difficult to compare forest area statistics in the OAS, FAO and CRIES studies, observations and interviews indicate considerable deforestation continues largely unabated in the broad-leaved forests. Active protection by FORESTA and DNP of the two Cordillera Central national parks seems to have slowed the agricultural advance in the upper valleys. Slash and burn agriculturalists are active in western dry forests as well as the humid forests of Los Haitises and La Altagracia.

Increasing demand for charcoal is largely directed to the dry forests of the southwest. FORESTA's token control of charcoal transport monitors only about 20% of the estimated annual production of 4.8 million sacks. Control and management of tree-cutting for charcoal is non-existent. Charcoal making and goat browsing are causing substantial site degradation to the dry forests.

The national flora is estimated at 5,600 species, of which about 36% are endemic. A preliminary listing indicates 277 plant species threatened or in danger of extinction. The national botanical garden is very impressive, with an active botanical program.

Major Recommendations:

- Differentiate specific forest types in the national land cover inventory
- Identify the portions of Subtropical Lower Montane Wet Life Zone not already included in national parks and assure their proteciton
- Investigate management techniques for improving sustained use of the dry forests for goat browsing and charcoal production
- Evaluate unique ecological areas such as minor Life Zones and transitional areas for vegetation remnants or plant

species not already protected in the existing national parks and ensure their survival
- Change the status of existing national parks from reserves to legitimate national parks.

Plantation Forestry

There is a serious need in the Dominican Republic to expand forest plantations in order to slow soil erosion, to provide fuelwood, and to reduce the $30 million annual bill for imported wood products. Since 1969 only some 3,200 ha of forest plantations have been established, of which about 70% were government sponsored. Wood products and site stabilization are the major plantation objectives. The native *Pinus occidentalis* and the exotic *P. caribaea* var. *hondurensis* are the dominant plantation trees.

FORESTA is the principal government agency involved in plantation forestry, with assistance from FAO (1969)1792) and IDB (since 1977). The Secretariat of Agriculture also has a reforestation component in the Plan Sierra rural development project and in the Bao watershed project. Private reforestation programs involve the multinational firms ALCOA, Gulf & Western, Rosario; and Falconbridge, with the latter having planted slightly less than 1,000 ha.

Species trials and provenance studies are virtually non-existent in the Dominican Republic. Nursery practices appear to produce acceptable planting stock, but both the vigor of planting stock and the efficiency of operation could be improved. No local data is available on growth and yields.

Despite rampant deforestation and the obvious need for tree plantations in order to reduce erosion and aid in site rehabilitation, a massive reforestation program is *not* a workable solution at the present time. Major constraints to plantation forestry include a serious lack of technical expertise, little or poorly defined government land needing reforestation, absence of incentives and guarantees for private efforts in reforestation, and lack of a forestry consciousness. Both traditional plantations and tree planting as a component of agroforestry can play an important role in erosion control and site rehabilitation; however, they must be incorporated in integrated land management programs such as the Plan Sierra.

Plantations of fast-growing trees of high calorific value could appreciably lessen the abusive cutting of dry forests for charcoal. Only a few, small studies of the potentials and needs for fuelwood plantations are under way. Due to the ecological importance of the remaining pine forests as critical watershed catchments for the country's major rivers, they should not be considered to be a significant source of industrial wood. Any substantial reduction in Dominican imports of wood products should only come about by plantation forestry.

Primary responsibility for Dominican forests and reforestation is in FORESTA, headed by a military director who is appointed by the President. Most of FORESTA's personnel are field oriented, particularly in forest protection and fire control. The role of the military in FORESTA is politically contentious; however, FORESTA has done a fine job protecting the pine forests of the Cordillera Central. Transferal of FORESTA back to the Secretariat of Agriculture would probably not improve FORESTA's organizational structure, technical expertise or forest vigilance, but would greatly increase the political distance from the Presidency.

Major Recommendations:
- Substantially upgrade professional and technical staff of FORESTA
- Create a small research unit in FORESTA with initial emphasis on species-site selections, growth and yield data, and economic returns of plantation forestry
- Cooperate with other government agencies to begin pilot-scale integrated land managment projects in critical water sheds
- Expand reforestation programs
- Permit silvicultural treatment of non-critical private forests with the objective of scientific management for sustained timber yield
- Educate the public in the values of forest conservation.

Water

Water resources play fundamental roles in Dominican agriculture, energy and public health. Reservoirs on major rivers provide water to generate 15% of Dominican energy and to irrigate about 170,000 ha. Current projects will double installed hydroelectric capacity by 1983 and bring an additional 100,000 ha under irrigation by 1985. Many other projects and plans will continue to increase the use of water resources for hydropower and irrigation.

Inland water resources reflect precipitation on the watershed. Many factors influence watershed response, but land-use often has overriding and direct effects on watershed output. Dominican watersheds are in very poor condition due to pervasive conversion of natural forest vegetation to agricultural uses. Slash and burn agriculture, a complete absence of soil conservation techniques, and major hurricanes have devastated several important watersheds.

Massive watershed erosion on the order of 100-500 tons/ha/year is literally drowning the reservoir with sediments. The Valdesia reservoir has 22 m of sediments at the heel of the dam, only 8 m from the intake; the Tavera reservoir, completed in 1973, already has 18 m of sediments behind the dam causing 40% reduction in dead storage capacity and a 10-14 m loss of active storage.

The deterioration of Cordillera Central watersheds is so critical that the situation requires emergency measures and drastic actions comparable to the 1967 closure of sawmills and prohibiting of tree cutting. But watershed protection and/or rehabilitation is not as simple as closing sawmills. Watersheds are literally full of small farmers eking out a subsistence on their small parcels. Massive resettlement is impossible because there simply is no new frontier for traditional agriculture in the Dominican Republic. Integrated land management involving small farmers is the only viable solution to sustaining watershed productivity.

INDRHI is an autonomous government institution responsible for controlled development of all surface and groundwaters. Although INDRHI has actively developed major irrigation works, its legal mandate is complicated by interinstitutional conflicts and duplications over potable water with INAPA and CAASD and with CDE hydroelectric projects. Several national government agencies independently plan, develop and operate water projects. The consequent duplication and jealousy substantially increase the real costs at a time when the Dominican Republic has increasingly less money available for capital developments.

Major Recommendations:
- Declare watershed protection and rehabilitation a national emergency
- Require that each watershed be treated as an integrated system
- Develop and implement an integrated land and water management plan for each major watershed
- Coordinate irrigation and drainage projects so as to maximize efficiency and eliminate redundancy
- Minimize inter-institutional conflicts and duplications
- Include the costs of watershed rehabilitation and protection in the dam construction cost estimates.

Soils

The fertile and productive soils of the Cibao misrepresent the abundance of poor, shallow soils on steep slopes, mostly stony and subject to severe erosion throughout much of the country.

Most small farmers eke out a living on marginal and sub-marginal lands unsuitable for annual crops. Of the 37 major soil mapping units identified by CRIES, 24 soil types covering about 21,000 km² have moderate to high agricultural potential for specific crops. Yet, 27,000 km² are already in farms; only in the arid northwest, southwest and south are there substantial areas of potential lands for agriculture, but they will require irrigation. Farmland is divided almost equally between crops and pasture, with only about 13% in fallow or not used.

Exports crops include sugarcane, coffee and cacao, while rice, beans, plantains, and yucca are national staples. The bulk of basic food staples is produced on small or medium sized farms; nearly 70% of the farms are less than 5 ha, occupying less than 14% of the total farmland. Only 3.4% of the farms exceed 50 ha, but these farms occupy more than half of the total farmland.

Soil erosion is the most serious problem affecting the natural resources of the Dominican Republic due to the preponderance of shallow soils on steep slopes and the widespread prevalence of slash and burn agriculture for annual crops. Substantial loss of topsoil due to poor practices of hillside farming has greatly reduced soil fertility and crop productivity. The consequences are extensive areas of slash and burn agricultural based on a few years of annual crops followed by several years of poor pasture and, finally, abandonment. Soil erosion also deposits enormous quantities of sediments in reservoirs. The aggraded river beds also accentuate lower valley floods.

Salinity problems exist primarily in the dry southwest and northwest, where appreciable areas of irrigated land have been lost to crop production. Poor water management, including lack of drainage, is the primary cause of salinization.

The government-sponsored Plan Sierra is attempting to help small farmers convert from annual to perennial crops, in addition to promoting reforestation, forest management, social services and artisanal crafts. Although project area soils are relatively good compared to other critical watersheds in the Cordillera Central, Plan Sierra is an impressive national effort that can serve as a valuable model for seriously degraded watersheds.

Major Recommendations:

- Delay additional reservoir projects so as to concentrate protection and rehabilitation efforts above existing reservoirs
- Incorporate soil conservation measures into highway construction design
- Create soil conservation or irrigation districts to facilitate land and water management as well as soil rehabilitation
- Initiate research on more appropriate farming systems and soil conservation for hillside farmers.

Coastal and Marine Resources

The Dominican Republic has traditionally looked inland for development of natural resources, as shown by the dependence on sugar and minerals for export earnings. Land-oriented development has, until recently, largely protected the coastal zone from environmental problems associated with development, but current government priorities to develop tourism and marine fisheries indicate that the grace period is over. However, few mechanisms exist for integrated and ecologically sound development of coastal areas. Major constraints include: (1) non-traditional utilization of the resources; (2) a rapidly growing and still inexperienced group of administrative organizations; (3) an absence of coordinating mechanisms for an integrated approach; (4) a shortage of skilled, multidisciplinary professionals; and (5) an unclear legislative mandate.

The Dominican fishing sector is at an artesanal level, with imports accounting for 60% of fish consumption. A recently completed INDOTEC study indicates Dominican marine fisheries can meet the national demand; however, little attention is given to fisheries management for sustained yield.

Despite government emphasis on tourism development, the tourism secretariat appears unable to evaluate the environmental impact of concentrated development. Serious unaddressed questions include public access to beaches, sewage treatment, solid waste disposal, hurricane protection, food sources, shell and coral collecting, and critical habitat protection.

Although some endangered marine species are partially protected by law, significant harvesting of hawksbill and green turtles and manatees continues. An estimated 85% of the world's population of humpback whales uses Dominican offshore banks as calving grounds.

Legislative inadequacies hamper efforts to effectively manage and coordinate coastal resources, often producing adversary positions between competing agencies. In spite of major housing damage by the 1979 hurricanes, sand extraction (e.g. Nigua) from protective foredunes continues unbated. No official mechanisms exist to rapidly and effectively combat major disasters such as oil spills. A simulated spill in the Mona Passage indicates that oil would reach the eastern coast in three days and could extend as far as Laguan Limon and La Romana in five days.

Major Recommendations

- Create a national commission to function as a review and permit agency for coastal development
- Define policy and guidelines for coastal development, including independent environmental assessment of proposed projects
- Revitalize and strengthen CIBIMA, the only academic institution involved in marine sciences
- Develop a functional national emergency plan for disasters such as hurricanes, floods, oil spills and toxic substances
- Inventory coastal and marine resources and establish criteria for creating marine parks to protect critical habitats and endangered species.

Wildlands and Wildlife

Wildlands in the Dominican Republic are defined as those areas not capable of sustaining permanent agriculture, livestock, or intensive forestry, plus analagous aquatic areas. Wildlands exploitation is overwhelmingly for subsistence though charcoal making also depends on the resource. Wildlands use, whether consumptive or non-consumptive, has not been quantified.

The Dominican system of five national parks contains the largest and most important wildlands. The J. Armando Bermudez and and Jose del Carmen Ramirez national parks covering 1,530 km² adjoin in the Cordillera Central. These two parks are dominated by well-protected pine forests; however, FORESTA views them as forest reserves suitable for exploitation rather than true national parks. Los Haitises national park originally covered 208 km² of karst topography but nearly all has been seriously altered by slash and burn agriculturalists. Proposed boundary modifications would include the remaining 120 km² island in Lago Enriquillo. Native vegetation is recovering since the removal of domestic and feral livestock. Regional irrigation projects lessen freshwater flow into Lago Enriquillo, causing increasing salinity that threatens aquatic species. Parque Nacional del Este occupies 434 km² in the southeastern corner of the country. Although the park includes Saona island, intervening and surrounding marine areas are not in the park.

The national directorate of parks (DNP) is a young government agency that has effectively established staff presence in the national parks and initiated protection of the parks' habitats and biota.

The insular nature of Hispaniola and varied ecological conditions have resulted in a small fauna with considerable endemism. Rampant habitat destruction and the deliberate introduction of

exotic species such as the mongoose have depleted most native populations. Threatened or endangered fauna include 6 turtle species, at least 11 reptiles, 44 bird species, and 9 mammal species. The wildlife department (DVS) emphasizes commercial production of wildlife and control of vertebrate pests. Endangered fauna receive only minor attention, while marine fauna seem to have been completely ignored.

Major problems include: (1) antiquated or unclear legislation; (2) fragmented and confused management categories; (3) poorly defined or misdirected management responsibilities; (4) lack of control over exotic species introduction; (5) lack of control over export of endangered species (the government is not a signatory member of CITES, hence exports are not controlled by international convention); and (6) almost complete absence of interinstitution cooperation.

Major Recommendations.

- Develop environmental policy and the corresponding legislation that would establish government commitment to the conservation and rational management of natural resources
- Revise existing laws to consolidate wildlands management categories
- Become a signatory member of CITES
- Approve and implement the proposed Fauna Law
- Declare all island and keys as interim reserves until their natural resources are inventoried and evaluated
- Clarify the status of the two Cordillera Central national parks by placing them under the absolute jurisdiction of DNP.

Small Farmers

Not only do small farmers constitute the bulk of the rural population of what is essentially still an agrarian country, but they also produce most of the country's staple foods. Because of traditional slash and burn agriculture and rudimentary technology, small farmers are important agents of ecological transformations, part of the environmental problems and a necessary component of any solution.

There is an ongoing dual trend in land tenure towards fragmentation and concentration—the former creating ever more mini or microfarms and the latter to large estates dedicated to export commodities. The dominant crops raised by small farmers are plantains, yucca, beans, sweet potatoes, and pigeon peas. Another agrarian feature is the scarcity of jobs and the concentration of income, with the consequence of widespread underemployment (46%). The Agrarian Institute (IAD) estimates 60% of rural households survive on less than DR$450/year.

Burgeoning population on marginal or submarginal lands causes significant rural emigration. Rural population problems have caused a drastic increase in invasions of national and private lands.

Special emphasis was given to the small farmer production systems in the southwest—an area largely ignored by government agencies. During the past three decades subtle but significant changes have moved the Dominican peasants away from subsistence farming to an increasing involvement in the market economy. In order to satisfy his family's needs, the Dominican farmer must continually increase production with the concomitant disastrous consequences now so noticeable on Dominican hillsides.

Small farmers in the southwest depend on slash and burn agriculture, charcoal making and goats. After the family's food and seed needs are met, excess crop production is sold. Charcoal making has traditionally been a sporadic activity, but now with increasing urban demand, charcoal making is a full-time activity for many families. Goats are known as the poor man's cow, yet they are seldom milked in the southwest because peasants prefer that it go to the juvenile goats. Traditional goat rearing involves virtually no care and open range browsing. Though goats are an occasional source of milk and meat, they function primarily as a hedge against economic insecurity. Goats are especially important to small farmers now that pigs have been eradicated due to African swine fever.

Major Recommendations:

- Incorporate small farmers in any attempt to develop integrated land management and watershed rehabilitation
- Provide to small farmer production systems more government response, ranging from technical assistance with soil conservation to credit assistance
- Employ the Plan Sierra model to reach the small farmers and improve crop systems, charcoal making, and goat rearing.

Pollution

Three insitutions, INAPA, CAASD and CORAASAN are responsible for controlling municipal pollution, but none is responsible for controlling industrial or agricultural pollution. Mining is currently the only industry subject to environmental controls. Fisheries legislation requires that industry control wastewater discharge, but little attention is paid to this law.

Nearly 70% of the manufacturing dollar is produced by agriculture—primarily sugar, furfural, molasses, tobacco, food and beverages. The only heavy industries are mining (bauxite, ferronickel, gold and silver), cement, steel, petroleum refining and electric power generation.

Although the data base is weak, the dominant trends on water use, supply, potable water and sewer service do not appear encouraging. Only 10% of rural residences and 54% of urban homes have potable water service. The respective figures for community centers are also very low—23% rural and 32% urban. Only 15-25% of urban homes are connected to sewage systems, while these sanitary systems don't occur in rural areas. Potable water is periodically contaminated with bacteria and often with sediments.

Industries generate minor water and air pollution, have minor safety and few noise problems. Specific pollution comes from particulate or smoke emissions from the FDC cement plant and from Metaldom; suspended solids and sulfur oxide emissions from steam electric power generation using high sulfur bunker fuel oil; and the majority of waste waters from food processing, soap and detergent production and similar operations with minimal waste recovery operations. Major polluters are usually government-owned industries that are under capitalized and use old technology. Multinational companies, in contrast, have effective, state-of-the-art technology for control of emissions and wastes.

Rural pollution and health problems are rooted in poor education. Poor personal hygiene, contaminated water, lack of sanitation facilities, poor nutrition and high density in rural communities have increased the incidence of disease. The increasing abuse of pesticides causes chronic or acute poisoning, contaminates produce, and stimulates resistant pests.

Urban environmental problems are manifest in the slums that surround most urban centers. The location and expansion of slums is largely uncontrolled, hence they stretch or exceed the government capacity to provide service facilities.

Major Recommendations:

- Give priority status to quality of potable water
- Require that citizens pay full-user charges for potable water and sewer services; it will be necessary to subsidize these services to the poor
- Improve the pollution control efforts of government-owned industries
- Educate small farmers in the uses and abuses of pesticides

and fertilizers, as well as the need for personal hygiene and sanitation

- Institute a serious urban planning effort; urban sprawl through unplanned slums and residential areas is placing enormous strain on service facilities.

Interinstitutional Linkages

There are 18 public sector agencies and 9 private institutions involved with the environment and natural resources in the Dominican Republic. That there are problems of division of interest and institutional conflicts is due as much to the diverse responsibilities assigned each public agency, as it is to the absence of a natural resources policy. Virtually every natural resources sector has more than one primary government agency, hence there is considerable duplication of efforts and programs, as well as jealousy. Even worse, some institutions with similar programs have little substantive interchange of information.

There is little participation of the private sector in the public arena and no real coordination. Several international agencies are actively involved in technical assistance programs.

Major Recommendations:

- Interinstitutional cooperation must replace the current competition and duplication if the Dominican Republic is to come to grips with the serious environmental crises confronting most natural resources
- Passage and implementation of CONARENA could play a leading role in coordinating natural resources action programs
- Public agencies must take the lead in enlisting private sector assistance
- SURENA must continue to be strengthened in order to develop more fully its mandate to plan, implement and supervise national policy for natural resources
- Other key institutions such as FORESTA, INDRHI, and National Parks must be strengthened and they must coordinate more closely with SURENA in attaining common goals.

Human Resources

As part of this environmental profile, surveys were made of 26 public, semi-autonomous and private agencies involved in ing, research, planning and implementation in natural resources. Although several educational institutions offer undergraduate training in natural resources, graduate degree programs are not offered. In natural resources 321 professionals and 127 technicians are employed. Project implementation accounts for 6[illegible]% (298) of the work force. researchers total 140, while only 10 work entirely in planning.

Implementing institutions with a large professional/techincal staff are FORESTA (53), INDRHI (47), Land and Water (34), Fisheries (30), and Meteorological Service (21). The best staffed research institutions are INDOTEC (47) and CENDA (39).

Human resource needs and additions to 1985 are detailed. Most new staff should be with masters' degree (82) or with a bachelor's degree (85). The prospective doubling of the number of technicians by 1985 is a direct response to the consensus that lack of qualified technicians is a primary impediment to project implementation. The greatest need for additional technicians is in SURENA, FORESTA and INDRHI.

Major Recommendations:

- Strengthen the Department of Natural Resources at UNPHU
- Initiate a professional training program to satisfy middle management and intermediate professional staff needs
- Define sectorial research priorities for each public institution so that scholarship students are aware of potential theses topics.

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II

Introduction

Objectives and Scope

The general objective of a Country Environmental Profile (CEP) is to identify major existing and potential problems and areas of concern for natural resources and environmental management, including an analysis of the social and economic impacts of these problems, and to develop an overview of government institutions, policies and resources related to natural resource conservation and environmental management. Specific purposes of this CEP are:

1. to define environmental problems and trends, especially those that relate to the small farmer;
2. to compile in one definitive document the information, data and analyses concerning environmental problems;
3. to develop an analytic framework for better understanding of and taking action on environmental problems;
4. to provide a detailed analysis of the constraints hindering more effective action on environmental problems;
5. to prepare a document that will stimulate greater public and private sector debate on environmental problems;
6. to provide an environmental assessment that will facilitate the efforts and cooperation of international development agencies in dealing with environmental problems;
7. to make recommendations on future public and private sector actions for environmental improvement;
8. to identify possible environmental improvement projects that could be financed by the government and/or private sector with financial assistance from international agencies.

The scope of work for this CEP included a review of existing reports, environmental legislation, conditions and trends of the natural resource base, natural resource management, and an assessment of the demographic, social and economic factors affecting the environment. Specific areas addressed in this CEP include deforestation; soil erosion; watershed degradation; loss of wildlife and wildlands; contamination of air and water resources; natural resources development projects in hydropower, irrigation and marine fisheries; and institutional capabilities and constraints to natural resource management and environmental protection.

Sector analyses were conducted during a three-to-five week period in September-October, 1980, by a nine-man team of independent consultants. The team included specialists in tropical ecology (G. Hartshorn), forestry (D. Harcharik), soils (H. Newton), water resources (C. Quesada), marine and coastal resources (R. DuBois), wildlife and wildlands (J. Shores), rural anthropology (S. Heckadon), pollution (G. Staples), and Dominican geography and institutions (G. Antonini). Each consultant worked closely with one or more Dominican counterparts, who provided extremely valuable assistance with literature, field trips and a rapid introduction to Dominican natural resources. Numerous field trips by car, jeep and one by mule provided an excellent reconnaissance of the country that was further enhanced by aerial flights to Cabo Rojo, over Parque Nacional del Este and Los Haitises and around the Cordillera Central. The extensive field reconnaissance by the consultants, augmented appreciably by the competence and knowledge of the Dominican counterparts combine to provide in this CEP the most detailed analyses of natural resources and the environment offered to date by a CEP.

Each consultant prepared a sector report that was reviewed and edited by the team leader into a draft CEP. The draft CEP was submitted to the local AID mission and to the Dominican counterparts for review before the team leader prepared the final draft of this CEP of the Dominican Republic.

Principal Environmental Characteristics

The Dominican Republic shares with Haiti the island of Hispaniola; the second largest (77,914 km²) of the Antilles. Occupying the eastern portion of Hispaniola, the Dominican Republic covers 48,442 km², with 1,575 km of coastline, and maximum distances of 390 km east-west and 265 km more or less north-south. With geographical coordinates 17°36'-19°58' N and 68°19'-72°01' W, the Dominican Republic lies in the subtropical hurricane belt. Its insularity and relatively small area permit a strong maritime influence to control the general climatic patterns. An excellent overview of Dominican geography can be found in de la Fuente (1976).

The physiographic complexity of the Dominican Republic adds considerable heterogeneity and variability to local climatic regimes. Four major mountain ranges lie in a more or less parallel northwest-southeast trend (Fig. II-1). The three intervening valleys, but particularly the Cibao, are major agricultrual regions. The northernmost Cordillera Septentrional extends parallel to the Atlantic Coast from Monte Cristi to Nagua, with small areas of narrow coastal plain squeezed between the hills and the Atlantic Ocean. Major fault zones on the southern flank result in most drainages flowing north. Exposure to northeasterly tradewinds

Provinces:

1. Distrito Nacional
2. Altagracia
3. Azua
4. Baoruco
5. Barahona
6. Dajabon
7. Duarte
8. Espaillat
9. Estrelleta
10. Independencia
11. Maria Trinidad Sanchez
12. Montecristi
13. Pedernales
14. Peravia
15. Puerto Plata
16. La Romana
17. Salcedo
18. Samana
19. San Cristobal
20. S. Juan de la Maguana
21. San Pedro de Macoris
22. Sanchez Ramirez
23. Santiago
24. Santiago Rodriguez
25. El Seibo
26. Valverde
27. La Vega

Fig. II-1. *Political divisions and geographic features of the Dominican Republic.*

for more than half of the year causes abundant orographic rainfall to fall on the north flank of the Cordillera Septentrional, an important coffee producing region. Due to widespread deforestation, no significant blocks of undisturbed forest remain on this cordillera. It is of interest that the Cordillera Septentrional is the primary source of amber, a fossilized pine resin of Miocene age, however, pines are not found naturally in these mountains.

The Cordillera Central is the principal mountain system in the Dominican Republic, extending from northwest Haiti almost to Santo Domingo. The central massif contains the highest point, Pico Duarte (3,807 m), in the Antilles. In addition to Pico Duarte (Fig. II-2a), two other peaks excede 3,000 m and 22 are over 2,000 m. The lengthy Cordillera Central has a maximum width of 80 km, occupying much of the central region of the country. Its central location, ample width and considerable height make it the source of all the important rivers in the country. It is a geologically and geomorphologically complex mountain range. The highlands are characterized by poor, shallow soils dominated by the native *Pinus occidentalis*. The J. Armando Bermudez and Jose del Carmen Ramirez National Parks contain the most extensive pine forests in the country. The southeastern flanks of the Cordillera Central received direct hits from Hurricanes David and Frederic in 1979, causing massive floods and landslides (Fig. II-3a).

A major branch of the Cordillera Central extends eastward, forming two sections—Sierra Yamasa and Cordillera Oriental. Both are low ranges, with no peaks exceeding 1000 m. The Sierra Yamasa, which separates the Yuna Valley and Los Haitises from the Caribbean coastal plain, is the major source area of ferronickel (Falconbridge) and gold (Rosario). The Cordillera Oriental (Sierra del Seibo) is a series of low hills south and east of Samana Bay.

Two lesser ranges, Sierra de Neiba and Sierra de Baoruca, occur in the southwest as continuations of major Haitian ranges. The Sierra de Neiba oscillates between 1,000 and 1,500 m, with a few peaks over 2,000 m. The Sierra de Baoruco also exceeds 2,000 m, but is more irregular with numerous block faults on the north flank and wide marine terraces bordering the Caribbean. Both ranges still have pine forests covering the higher and less accessible slopes. Prior to development of ferronickel and gold mining in the Sierra de Yamasa, the Sierra de Boaruco was the most important mining region, producing bauxite, gypsum and salt.

The aforementioned mountain ranges delimit three major valleys—Cibao, San Juan and the Enriquillo Basin. The Cibao Valley lies between the Cordilleras Septentrional and Central, extending from Monte Cristi in the northwest to Samana Bay. The Cibao actually consists of two valleys: the Santiago Valley (or Western Cibao) drained by the Rio Yaque del Norte and the Vega Real (or Eastern Cibao) drained by the Rio Yuna. The drainage divide is at Licey al Medio (175 m) near Santiago. Both valleys are very flat, with 1-2% slopes to sea level.

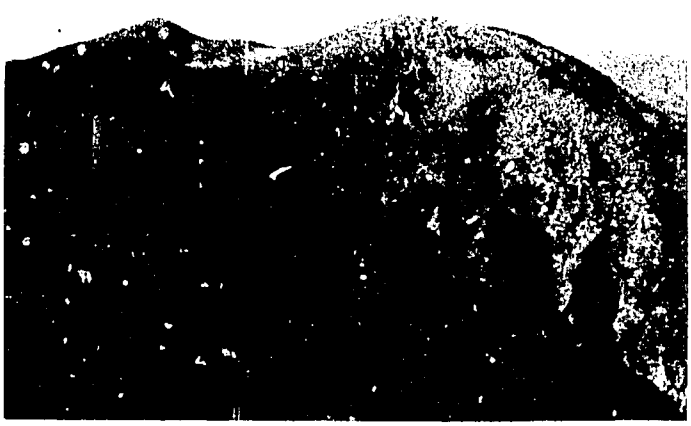

Fig. II-2a. *Pico Durate (left), highest point (3,087 m) in the Antilles and La Pelona, second highest. Pure pine forest of native* Pinus occidentalis *is naturally sparse on the shallow soils. These forests in the two national parks straddling the Cordillera Central were only slightly damaged by Hurricanes David and Frederic in 1979. (Hand-held aerial photo, Gary Hartshorn.)*

Figure II-2b. *Convoluted karst topography of limestone hills and sinks, Los Haitises. The white areas lack soil. (Photo, John Shores.)*

The Cibao Valley is the most important agricultural region of the country. There is a pronounced rainfall gradient from the wet eastern Cibao to the xeric western Cibao. Aridity and salinity are limiting factors in the western half of the Santiago Valley. The eastern Santiago Valley is the primary production area for tobacco. The Vega Real contains the best agricultural soils, with impressive production of plantains, cacao and rice.

The San Juan Valley lies between the Cordillera Central and the Sierra de Neiba, extending from the Haitian border to Ocoa Bay. Physiographically similar to the Cibao with a low drainage divide into two subvalleys, the San Juan Valley is relatively arid but lacks the extremes of the Cibao. With excellent soils and irrigation, the San Juan Valley is a major rice growing region.

Farther to the south between the Sierras de Neiba and Baoruco is the Enriquillo Basin extending from the Haitian border to Neiba Bay. The saline Lake Enriquillo is about 40 m below sea level. Due to the general aridity of the basin, saline soils are abundant.

A few intermountain valleys occur in the Cordillera Central: Constanza (30 km²), Jarabacoa (23 km²), and Bonao-Altogracia (128 km²). The higher Constanza and Jarabacoa Valleys have become important tourist and vacation attractions. The low Bonao and Altogracia Valleys are primarily in rice and sugarcane.

Although patches of coastal plain occur along the north coast, the Caribbean coastal plain is the most extensive and important. It extends south of the Cordillera Oriental-Sierra de Yamasa from Ocoa Bay to the eastern tip of the island. The Caribbean coastal plain consists of a series of limestone terraces and varies in width 10-40 km. It is the principal sugarcane area of the country, as well as the major pasture zone for beef cattle. the only undisturbed natural forests are protected in the Parque Nacional del Este.

The Peninsula de Samana is an isolated low mountain range and contains one of the wettest areas of the country. Some marble is quarried from the northeastern part of the peninsula.

Los Haitises is the most striking region of the country due to the extensive karst topography (1,000 km²). Differential dissolution of the Miocene limestone has produced the characteristic "cockpit" or "egg-carton" country (Fig. II-2b), with innumerable sinks among rounded hills. Other karst areas occur in the Sierra de Baoruco, Peninsula de Samana, and south of Sosua.

Figure II-3a. *The effects of direct hits by Hurricanes David and Frederic in 1979 on the deforested hills in the Rio Ocoa watershed. The few trees in the foreground are native* Pinus occidentalis. *Note the wide scouring of the valley floor by the major flooding of the Rio Ocoa. (Hand-held aerial photo, Italo Russo.)*

The insularity and heterogeneous topography of the Dominican Republic determine local climatic regimes that vary markedly from arid to wet. Although frost is common at high elevations and snow is occasional on the highest peaks, temperatures vary regularly and predictably. Even in the lowlands, polar air masses can push surprisingly cool air over the Dominican Republic during the winter. Atmospheric moisture and wind conditions can accentuate local temperature differences.

The amount and distribution of rainfall play a much more important role in determining natural vegetation (Chapter III) and agricultural crops (Chapter VI).

Not only does rainfall vary appreciably in the country (from 350 mm in the Neiba Valley to 2,750 mm at Laguna Limon), it also varies in annual total and seasonal distribution at a given location. Annual variations in rainfall in mountainous watersheds affect the amount of water available for irrigation and hydropower. Seasonal fluctuations in rainfall are critical to the success or failure of short-term crops, particularly in non-irrigated, subhumid areas. The lengthy dry season and unpredictability of rain can cause seasonal crop failure in areas that average less than 1,500 mm per year (Fig. II-4).

March is usually the driest month and May the rainiest. December to March is usually the driest period throughout the country, except for the Cordillera Septentrional, which often is wettest in November-January due to strengthening tradewinds.

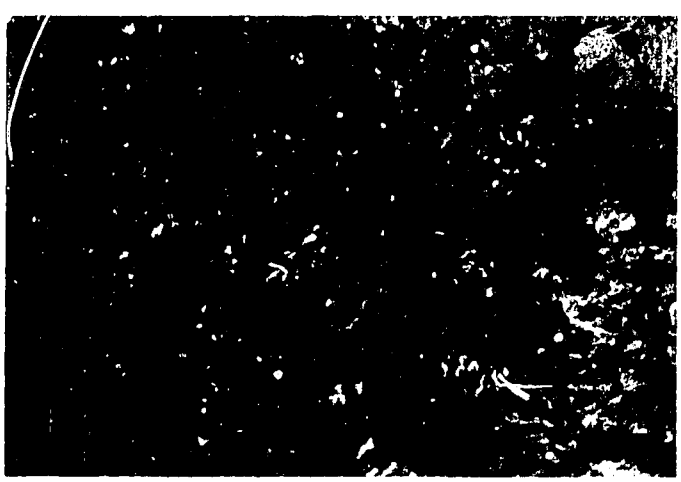

Figure II-3b. *Abundant landslides in a deforested area with unstable soils between Manobao and Loma de la Sal; most were presumably caused by the heavy rains of Hurricanes David and Frederic in 1979. (Hand-held aerial photo, Carlos Quesada.)*

Orographic rainshadows are the primary cause of xeric conditions in the Enriquillo, Azua, Neiba and western Cibao Valleys. The rainy season from May to Novmeber is characterized by weak tradewinds and convective rainfall—both sea to land and mountain-valley.

Summer often spawns hurricanes that occasionally bring tremendous winds and rains to the Dominican Republic. September, 1979, was particularly bad as two hurricanes, David and Frederic, hit the country within one week. Frederic was not as severe meteorologically as David, but caused much greater environmental damage. Apparently soils were saturated by David's heavy rains, so that when Frederic struck landslides were abundant and flooding was much greater (Fig. II-3b). Hurricanes cause tremendous environmental damage and economic losses.

Development Policies and Natural Resources Management

Background

The Dominican Republic has neither an explicit short nor long-term policy of environmental and natural resources management (H. Mejia, pers. comm.). Specific short-term actions are taken as the need arises by any one of several public policy formulating and implementing agencies. This manner of handling environmental matters reflects both the recent awakening of public sentiment and scientific concern as well as interinstitutional rivalries that have tended to keep apart rather than foster closer cooperation (Ml. de Jesus Vinas Caceres, pers. comm.).

Though Chardon (1937) demonstrated public awareness of the deforestation and soil erosion problems based on scientific observations as far back as 1937, very little action could be taken during the years of the Trujillo regime (1930-61) that was not in the dictator's interest. Rights to land, forest, and water were controlled outright by Trujillo or through the guise of quasi-independent companies. After his overthrow in 1961, a wide range of political, economic and social restrictions were removed. Movements of people, goods and services became the rule rather than the exception; staged migrations from rural hamlet to town and city took place.

In the forested mountainous interior of the Republic, the demise of the dictator precipitated mass invasions of lumber company lands than many considered were owned in part by Trujillo. Standing timber was indiscriminately cut by peasants intent upon establishing their land claims by introducing slash-and-burn farms. Some planners and policy makers have suggested that this indiscriminate cutting of the forests in the early 1960s represented a true peasant revolt against the dictator's inhumane policies. In 1967, the OAS estimated that only a fraction of the republic could be classified as forested. As a result of this indiscriminate cutting, President Balaguer decreed a complete cessation of lumbering activities; he placed the matters of legal enforcement as well as reforestation in the hands of the Armed Forces (UNEP 1977).

The Dominican Republic in the late 1960s and early 1970s was a country trying to make up for years of social decay and economic stagnation. Relatively rich in natural resources and labor but poor in capital, the country sought to utilize its base to bolster primary agricultural production. The overriding concern was to improve the standard of living of the people. The method used to achieve this improvement was through fuller integration of the Dominican economy with foreign markets. Given the country's comparative advantage in selling agricultural commodities such as sugar and coffee, it was assumed that export earnings derived from these products could finance development of the other sectors of the economy.

Unfortunately, a number of serious obstacles surfaced that impeded development. These obstacles included: (a) inherent weakness of the Republic's single crop export sector; (b) weakness of the country's industrialization process; (c) externally caused price fluctuations; (d) regidity and fragility of the demand function; and (e) excessive increases in the country's import bill due to the spiraling cost of fossil fuels. Collapse of the price of sugar along with dramatic increases in the cost of imported petroleum in 1976 called for immediate actions to diversify the economy and improve the rational use of the country's natural resources. Over the past two years, the government has reoriented economic policy by placing major emphasis on the agricultural and mining sectors.

Current Policies

The present national development policy not only reasserts the previous administration's goal to improve the social and economic well-being of the population, but in addition it places emphasis on providing opportunities for improving the conditions of the poorest segments of society. To achieve these goals, the medium-range Agricultural Development Plan (ADP) for the 1980-82 period contemplates activities with the following objectives: (a) improve the nutritional level of the population, especially the two lowest income levels; (b) increase food production; (c) improve income distribution in the rural areas; (d) reduce agricultural imports; (3) increase the exports of farm products as a means for alleviating the negative effects cause by price increases of petroleum products; (f) settle new families on agrarian reform projects and consolidate settlements; and (g) create new sources of salaried work in the rural areas (SEA 1979).

The ADP program of activities combines direct government action to increase productivity and improve the standard of living of small-holder agriculturalists with indirect incentives to stimulate greater private sector involvement in the development process. This Plan is being carried out at the present time, though with some variations in the ranking of priorities due to the damage caused by Hurricanes David and Frederic in 1979.

The Plan's basic objective is to eliminate the condition of malnutrition in low income population groups. The strategy pursued is to increase food crop production to benefit both small-holders and salaried farm workers, since both groups suffer from limited availability of land and low salary levels—situations that have given rise to the high rate of under-employment in the rural sector.

The objectives to increase both food production and food supply go hand-in-hand with the need simultaneously to increase available farm income. The Plan does not exclude the role that large farmers should play to more fully employ and better remunerate on-farm labor. Stated in another way, the Dominican Republic's principal rural development policy is to provide a more equitable distribution of the factors of production so that increases in agricultural and livestock yields will benefit all income groups, but most especially the underprivileged small-holders, tenants and salaried farm workers. Already, a number of important steps have been taken to stimulate this change process: applied research, in-service training, institutional reorganization, credit and other extension services, construction of roads and irrigation works.

Future Prospects

The implications of such developmental impacts on the environment are unmistakable. Population pressures, the search for universally greater economic well-being, land restrictions imposed by the country's relatively small size and absence of any frontier areas awaiting colonization, are factors that urgently call for the development of short and medium-term strategies that can harmonize rural development schemes with future natural resources management policies. The ADP recognizes this need and calls for the formulation of a natural resources development policy that addresses community or living space concerns as well as considers factors of production directly related to physical landscape characteristics such as slopes, land cover, agricultural soils and water.

The Plan underscores the need to formulate and propose a natural resources management policy. Obviously, such a clearly established policy does not exist at the present time. Nonetheless, there is an awareness both in government circles and in the mind of the general public that the socioeconomic development goals of the country's growing population must be set within the context of a finite resource base, that use of such resources should be determined in a manner that does not imperil their use by future generations, and that natural resources management is a dynamic, constantly changing process whose problems and solutions must be considered within a holistic framework of relationships between people and the land.

Demographic and Economic Aspects

The Dominican Republic population is estimated at 5,570,000; an average density of 115 inhabitants per square kilometer (Benjamin, 1981). However, if only the good agricultural land (see Table VI-9) is considered, the density jumps to 267 inhabitants/km². In 1977, 21% of the gross domestic product was produced by agriculture. Even though sugar is the top export (gold and tourism follow), the Dominican Republic is not even close to self-sufficiency in basic foods.

High population growth rate of approximately 3.5% per year during the 1950's and '60's contributed to the burgeoning population. Government supported family planning policies dropped the annual growth rate to 3% by the mid-70's. The GODR Family Planning Council estimates current population growth at 2.5% per year—a very significant decrease in one decade.

The baby boom of the '50's and '60's put the economically active population (15-64 years of age) in the minority (49%) in 1978. In that same year 48% of the population was under 15 years of age. In the past few years the birth rate (per 1000) has risen to 45—the highest for the Caribbean region. Infant mortality of 83 per 1000 live births is one of the highest in Latin America.

Rapid population growth in the absence of traditional agricultural frontiers (see Chapters VI and IX) has caused considerable rural-urban migration. The urban population of the Dominican Republic now exceeds the rural population; one in four Dominicans lives in Santo Domingo. Urban growth rate is over 5% per year, whereas rural growth rate is only 0.75%.

Even though the Dominican Republic has achieved an appreciable lowering of the rate of population growth, a 2.6% annual rate yields a doubling of the population in 26 years. How will the GODR feed and service 10 million inhabitants by the year 2000? What will be the consequences of 10 million Dominicans on limited natural resources and an already stressed environment? How will national energy demands be met? Difficult but fundamental questions such as these form the basis of the following analyses of the natural resources and the environment of the Dominican Republic.

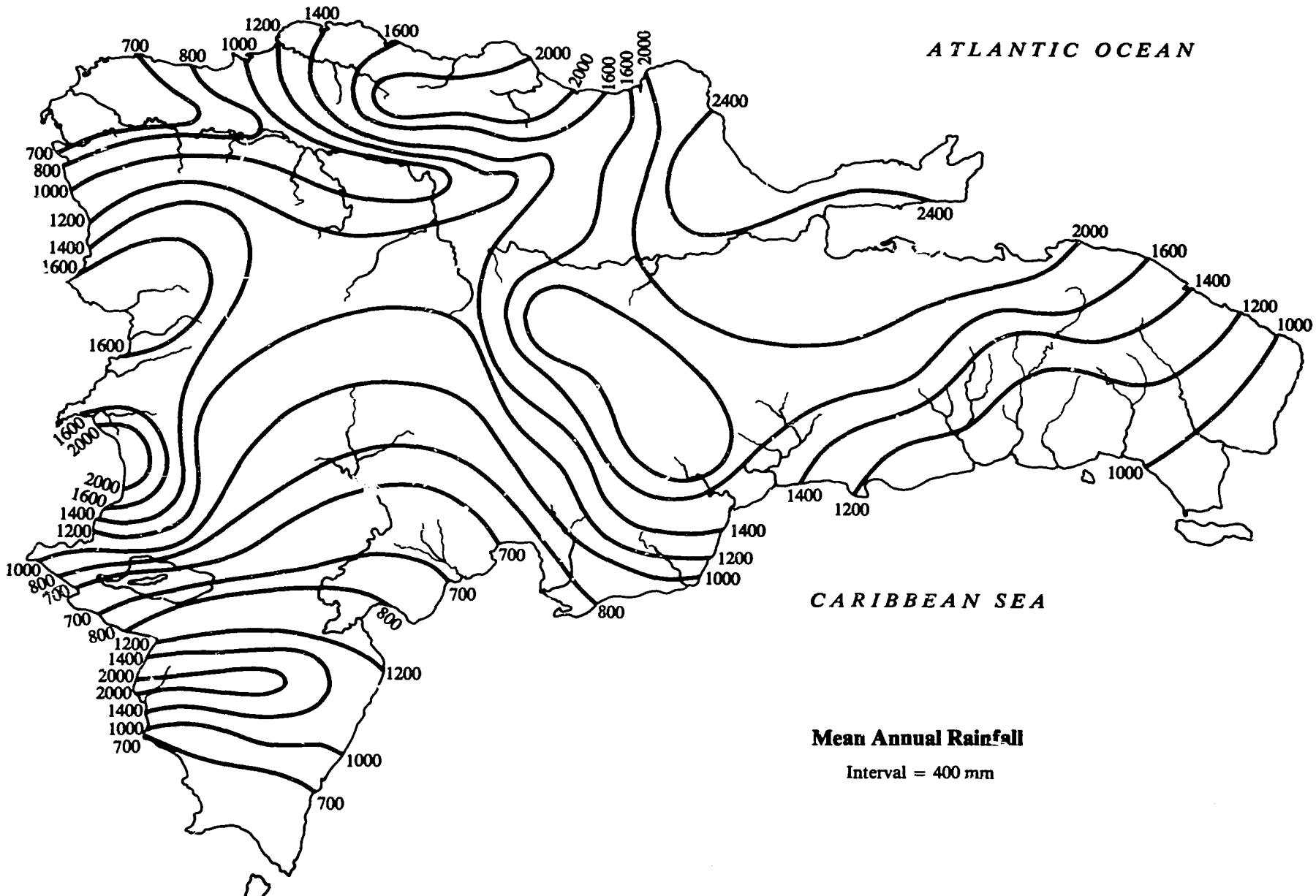

Figure II-4. *Rainfall isohyets for the Dominican Republic. (Adapted from de la Fuente 1975.)*

III

Natural Vegetation

General Description

The vegetation of the Dominican Republic is most easily interpreted using Holdridges Life Zone System, (Fig. III-1), a deceptively simple bioclimatic classification using two independent climatic parameters, mean annual rainfall and bio-temperature. The latter parameter differs from regular temperature in that it substitutes zero for all unit values above 30 ° C and below 0 ° C, e.g. bio-temperature in the Dominican lowlands is lower than the standard temperature average. With normal climatic conditions a Holdridge Life Zone will have a characteristic vegetation that will be similar in structure anywhere in the world where the same climatic conditions exist.

The Life Zone system is not dependent on floristic relations or taxonomy, e.g. Hispaniola and northern Central America have different pine species dominating subtropical lower montane life zones, yet pines are completely absent from the same life zones in the Bolivian Andes. Despite the non-floristic basis of the Holdridge Life Zone system, geographic limits to species distributions do often coincide with Life Zone boundaries.

The Holdridge Life Zone system (Holdridge 1967) is actually a hierarchiacal classification with the Life Zone as the first order or most general level. Other hierarchical levels include (2) association-grouping, (3) associations and (4) actual vegetation, whether an agricultural crop or a successional stage. Local differences in vegetation structure caused by soil, drainage or atmospheric conditions are recognzied as distinctive ecological association that typifies a particular Life Zone, any number of edaphic, hydric and/or atmospheric associations may also occur in that same Life Zone.

First order classification can be used to produce an ecological map of Life Zones as was done for the Dominican Republic by OAS in 1967 (Fig. III-2). The intermediate level association-grouping is analogous to the catena concept of soil science and is particularly appropriate for regional mapping of land-use capability. The more-detailed association level is useful for detailed ecological mapping, watershed zoning or farm planning. It is important to note that the Life Zone, assocition-grouping and association levels all indicate *potential* vegetation, i.e. the naturally developed vegetation largely undisturbed by man or his activities. Only the fourth level takes into account the *actual* vegetation whether agricultural crops, pastures or successional vegetation.

Nine Life Zones and seven transitionals occur in the Dominican Republic (Table III-1), with two basal belt (lowland) Life Zones covering 68% of the country. The following synopsis of Dominican Life Zones is taken primarily from the major OAS (1967) study of the country's natural resources.

Table III-1. Area of Holdridge Life Zones in the Dominican Republic (OAS, 1967).

Life Zones	Unit km² (%)	Total km² (%)
1. Subtropical Thorn Woodland		1,001 (2.08)
2. Subtropical Dry Forest		9,962 (20.72)
a. Non-transitional	9,812 (20.42)	
b. Warm-moist transition	150 (0.31)	
3. Subtropical Moist Forest		22,794 (47.42)
a. Non-transitional	22,139 (46.08)	
b. Warm-dry transition	500 (1.04)	
c. Warm-moist transition	155 (0.32)	
4. Subtropical Wet Forest		6,834 (14.22)
a. Non-transitional	6,808 (14.17)	
b. Warm-moist transition	26 (0.05)	
5. Subtropical Rain Forest		56 (0.12)
6. Subtropical Lower Montane Moist Forest		3,480 (7.24)
a. Non-transitional	3,214 (6.69)	
b. Cool-dry transition	23 (0.05)	
c. Cool-moist transition	243 (0.51)	
7. Subtropical Lower Montane Wet Forest		3,577 (7.44)
a. Non-transitional	3,557 (7.40)	
b. Cool-moist transition	20 (0.04)	
8. Subtropical Lower Montane Rain Forest		36 (0.08)
9. Subtropical Montane Wet Forest		303 (0.63)

Subtropical Thorn Woodland Life Zone

This Life Zone occurs in the driest areas of the country, particularly in the southwest where it extends from Lake Enriquillo to Puerto Viejo, usually less than 300 m in elevation. Minor outliers fringe Bahia Honda (Cabo Rojo), Bahia de Ocoa and Bahia de las Calderas (Punta Salinas). In northwestern Cibao a small area of this Life Zone occurs at the base of the Aguacate hills.

Climatic conditions are characterized by less than 500 mm of annual rainfall and mean annual biotemperature of 18 and 24 ° C. The combination of high temperatures and little rainfall produces a potential evapotranspiration (PET) ratio between 2.0 and 4.0, i.e. the evapotranspirative demand of natural vegetation exceeds rainfall by a factor of 2 to 4 times.

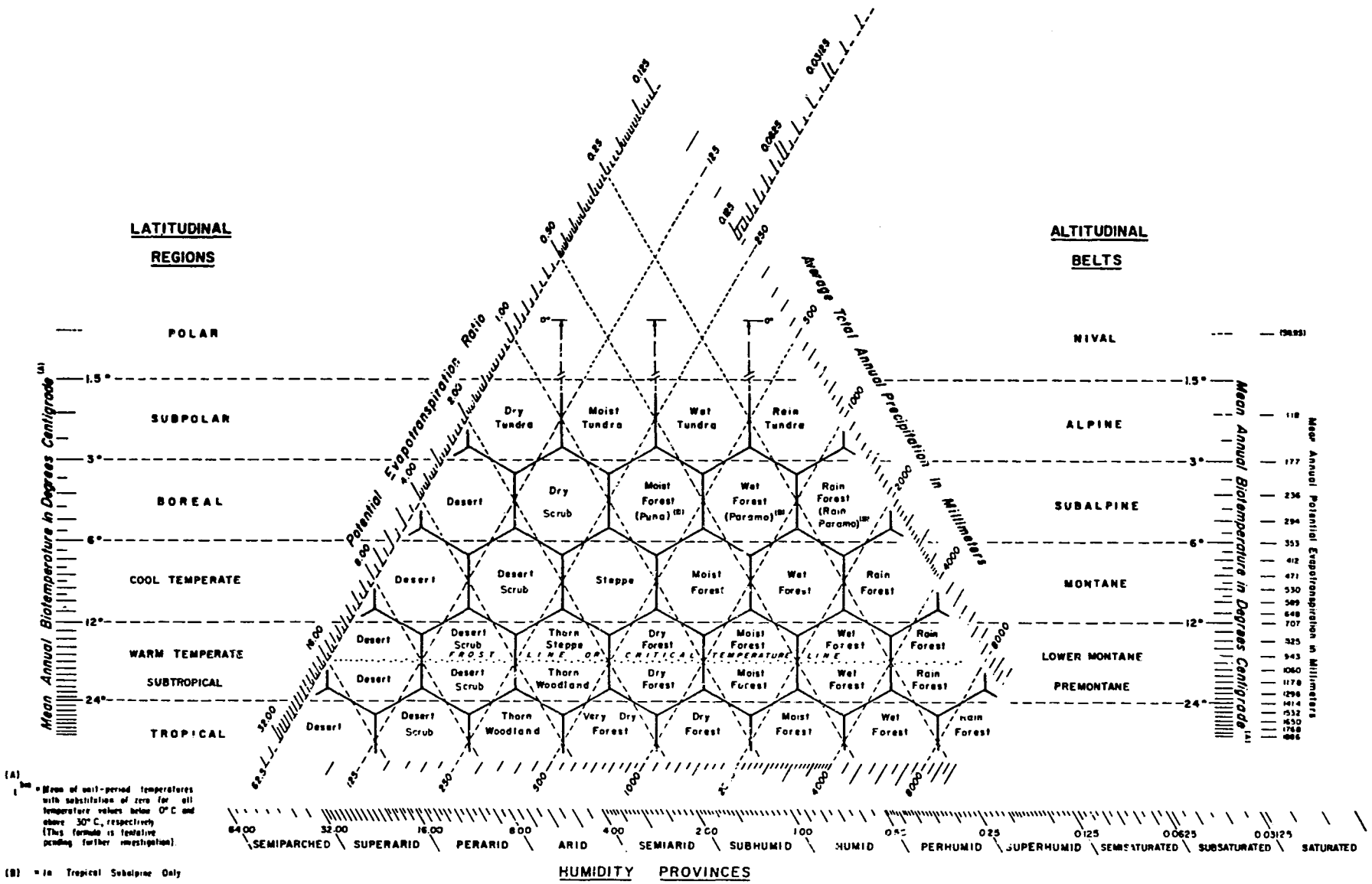

Figure III-1. *Life Zone Diagram for the Holdridge Classification of World Plant Formations. (Courtesy of Tropical Science Center, San Jose, Costa Rica.)*

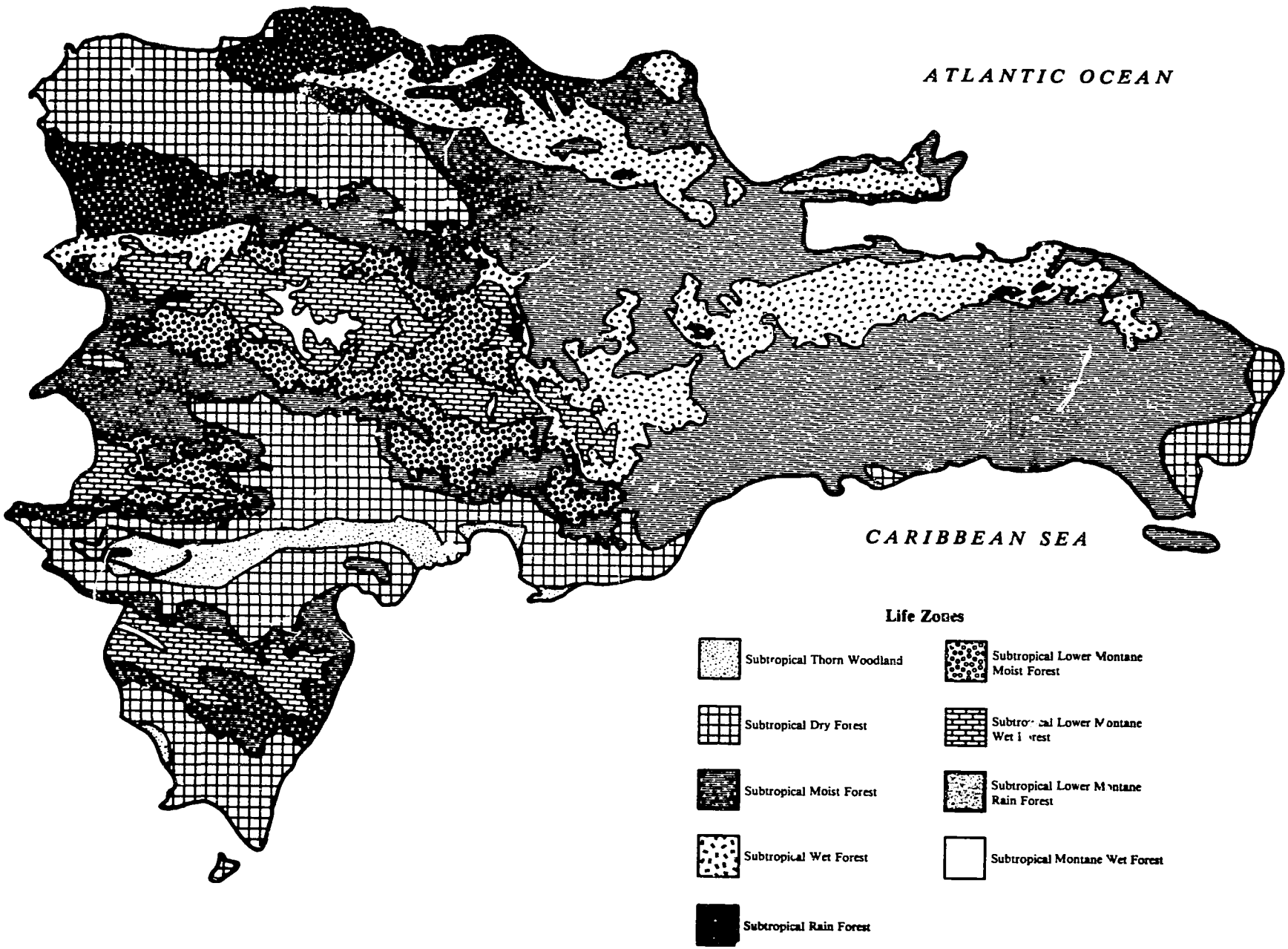

Figure III-2. *Holdridge Life Zones in the Dominican Republic. (From: OAS 1967).*

The natural vegetation of Subtropical Thorn Woodland is dominated by spiny shrubs and cacti. The latter include *Opuntia caribaea* ("quazabara") and *Neoabbottia paniculata*. Also common are *Copernicia berteroana* ("Yarey", Palmae), *Prosopis julifora*, ("bayahonda", Mimosaceae) and *Capparis* spp. (Capparidaceae).

Fertile alluvium in this Life Zone is used for irrigated seasonal crops; however, salinization problems have arisen due to poor irrigation management and the very high PET ratio. The abundant rolling land is used as a source of firewood and as extensive rangeland for goat browsing. The complete absence of management of these limited resources has led to considerable degradation of the natural vegetation, including desertification.

Subtropical Dry Forest Life Zone

The second most extensive Life Zone in the country covers most of the western Cibao (lower Yaque del Norte valley), San Juan and Neiba valleys, as well as much of the Azua and Bani plains as far as Hato Viejo south of San Cristobal. This Life Zone also covers the southern plains and foothills of the Baoruco peninsula and in the southeast it occurs around Bahia de Yuma to Cabo Cuerno. Topographically, it extends from sea level to about 700 m.

Subtropical Dry Forest Life Zone receives 500-1000 mm of annual rainfall with mean annual biotemperature of 18-24 °C. This Life Zone has a PET ratio between 2.0 and 1.0. Small transitional areas to Moist Forest occur on some higher hills due to orographic rainfall and slightly cooler temperatures.

Natural vegetation in Subtropical Dry Forest Life Zone is a low, single-stratum forest with an abundance of sclerophyll-leaved species. Some slow-growing tree species have exceptionally hard and heavy wood, such as *Guaiacum officinale* ("guayacan", Zygophyllaceae) and *G. snactum* ("vera"). The most abundant tree species is usually *Prosopis juliflora* or the invasive *Acacia farnesiana* ("cambron", Mimosaceae); however, *Bursera simaruba* ("almacigo", Burseraceae), *Phyllostylon brasiliense* ("baitoa", Ulmaceae), *Acacia scleroxyla* ("candelon") and *Plumeria alba* ("alelis", Apocynaceae) may be locally abundant. In areas transitional to Moist Forest *Sabal umbraculifera* ("cana", Palmae) and *Swietenia mahogani* ("caoba", Meliaceae) are common.

Figure III-3a. *Substropical dry forest between Barahona and Azua degraded by over-grazing and cutting for charcoal. Note the large landslides (upper left) and extensive gully formation (center) in this dry region. (Photo, Carlos Quesada.)*

The fertile valley soils of the Subtropical Dry Forest Life Zone are the major areas used for irrigated agriculture, hence virtually no natural vegetation remains in irrigated areas. The rolling or undulating land unsuitable for irrigation and too dry for the majority of crops is often covered with natural vegetation (Fig. III-3b).

Figure III-3b. *Subtropical dry forest overlooking Lake Enriquillo. (Photo, Stanley Heckadon.)*

These dry forests are the major source area for firewood and charcoal, as well as the primary browse for goats. Indiscriminant and uncontrolled cutting of trees for charcoal and an open-range approach with goats has led to significant degradation wherever natural vegetation is accessible. Slash-and-burn farmers ("conuqueros") who have traditionally avoided this Life Zone due to the high risk of drought-caused crop failure, are now beginning to advance the "agricultural frontier" into the dry forests.

Subtropical Moist Forest Life Zone

Covering almost half of the country, this Life Zone includes practically the entire Caribbean coastal plain east of San Cristobal, as well as the eastern Cibao (lower Yuna and Camu valleys) and the Cordillera Central foothills below about 850 m elevation. Substantial areas of this Life Zone also occur in the western San Juan valley, and on the low foothills of the Sierra de Baoruco and the Cordillera Septentrional.

Mean annual rainfall of 1000-2000 mm and biotemperature of 18-24 °C characterize this Life Zone. Rainfall tends to increase from west to east for this Life Zone, with the western part receiving less than 1500 mm, while the eastern part receives more than 1500 mm. Rainfall generally occurs in two maxima over a nine-month period, consequently the PET ratio is slightly less than 1.0, i.e. a modest excess of rainfall over evapotranspiration.

Natural vegetation for this Life Zone is characterized by a well-developed, heterogeneous forest of broad-leaved trees (Fig. III-4a). Despite its extension over nearly half of the country,

Figure III-4a. *Subtropical moist forest in Parque Nacional del Este; note the abandoned clearing (center). (Hand-held aerial photo, John Shores.)*

clearing for agriculture has reduced the natural vegetation to mere remnants. *Catalpa longisiliqua* ("capa, roble dominicano", Bignoniaceae) and mahogany are characteristic tree species of this Life Zone. The royal palm *(Roystonea regia)* is very common on limestone-derived soils (Fig. III-4b). Other occasional trees include *Bucida buceras* ("guaranguao", Combretaceae), *Chlorphora tinctoria* ("fustete, mora", Moraceae), *Citharexylum fruticosum* ("penda", Verbenaceae), *Genipa americana* ("jagua", Rubiaceae), *Guazuma ulmifolia* ("guacima", Sterculiaceae), *Haematoxylum campechianum* ("campeche", Caesalpiniaceae), *Lonchocarpus domingensis* ("anon de majagua", Fabaceae), *Oxandra lanceolata* ("yaya", Annonaceae), *Pithecellobium berteroanum* ("corbano", Mimosaceae), *P. glaucum* ("caracoli"), *Simarouba glauca* ("Juan Primero", Simaroubaceae), *Tetragastris balsamifera* ("amacey", Burseraceae). Restrictive sites such as savannas or poor, shallow soils often have *Anacardium occidentale* "cajuil", Anacardiaceae), *Coccoloba pubescens* ("hojancha", Polygonaceae), *Curatella americana* ("peralejo", Dillneiaceae), *Tabebuia berteri* ("aceituno", Bignoniaceae) and *Trema micrantha* ("memizo", Ulmaceae).

Although mangrove forest is a hydric association that may occur in several tropical and subtropical Life Zones it is commonly encountered in Subtropical Moist Forest Life Zone in the Dominican Republic. Characteristic mangrove tree species include *Rhizophora mangle* ("mangle colorado", Rhizophoraceae) *Avicennia nitida* ("mangle prieto, Avicenniaceae), *Conocarpus sericea* and *C. erectus* ("botoncillo", Combretaceae) and *Laguncularia racemosa* ("mangle blanco", Combretaceae). In swampy areas *Pterocarpus officinalis* ("drago", Fabaceae) may be locally dominant.

Of the nine Life Zones in the Dominican Republic, the Subtropical Moist Forest Life Zone is the most suitable for agriculture in the broadest sense. Many of the best soils (e.g. in the Vega Rel) are found in this Life Zone. Less fertile, but still adequate soils have long been converted to pasture or slash and burn agriculture. Several major population centers also are located in this Life Zone, hence it is not surprising that very little natural vegetation remains.

Subtropical Wet Forest Life Zone

The Cordilleras Septentrional and Oriental have the most extensive areas of this Life Zone in the country; it also occurs on the Cabrera promontory, Samana peninsula, Sierra de Yamasa, Los Haitises, the southeastern part of the Cordillera Central, as well as in a narrow ban on the northwestern flank of the Cordillera Central. In relation to Subtropical Moist, the Wet Life Zone generally occurs in topographically higher positions, although it

Figure III-4b. *Subtropical moist forest near La Vega converted to seasonal crops and pasture. The abundant* Roystonea regia *palm on calcareous soils has many local uses: the sheathing leaf base (yagua) is still used as siding material for shacks; fruit is a major food for pigs; and heart of palm. (Photo, Gary Hartshorn.)*

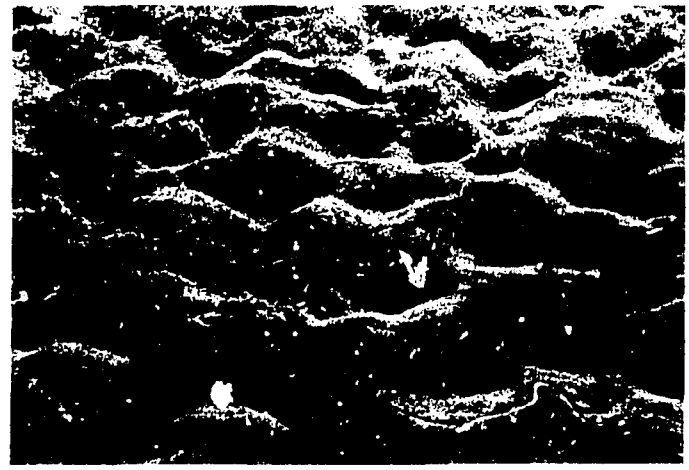

Figure III-5a. *Deforested karst topography, Los Haitises, primarily for seasonal crops before conversion to extensive pasture. (Photo, John Shores.)*

extends to sea level in some places between Cabrera promontory and Laguna Limon.

This Life Zone has mean annual rainfall of 2000-4000 mm and biotemperature of 18-24 °C. Orographic lifting of moisture-laden tradewinds from the northeast is the primary source of the high rainfall. A small patch of warm moist transition occurs north of Villa Altagracia.

The natural vegetation of Subtropical Wet Forest Life Zone is a hetergeneous multi-stratal forest usually dominated by broad-leaved tree species. Characteristic trees include *Alchornea latifolia* ("aguacatillo", Euphorbiaceae), *Buchenavia capitata* ("gri-gri", Combretaceae), *Byrsonima spicata* ("mandrono", Malpihiaceae), *Calphyllum brasiliense* ("varia", Guttiferae), *Casearia arborea* ("palo de yagua". Flacourtiaceae), *Didymopanax morototoni* ("sablito", Araliaceae), *Hymenaea courbaril* ("algarrobo". Caesalpiniaceae), *Manilkara bidentata* ("balata", Sapotaceae) and *Prunnus myrtifolia* ("almendrillo", Rosaceae). the only native pine, *Pinus occidentalis*, dominates on lateritic soils (see Fig. IV-1b).

Primarily due to higher rainfall, this Wet Life Zone is not as suitable for seasonal crops as in the Moist Life Zone. The best agricultural soils (usually fertile alluvium) support perennial crops, particularly cacao, although some areas grow coffee, rubber, or tea. The poorer hillside soils are generally used for slash and burn agriculture or converted to extensive pasture. Natural vegetation has been largely destroyed, leaving minor remnants only in the most inaccessible places. Even in the beautiful karstic terrain of Los Haitises, slash and burn agriculture has destroyed much of the natural vegetation (Fig. III-5a); uncontrolled fires often sweep up the limestone hills and degrade the uncut forest.

Subtropical Rain Forest Life Zone

Of extremely minor occurrence in the country, this Life Zone is found around Casabito hill and two isolated areas in the Cordilleras Septentrional and Oriental. Rainfall in excess of 4,000 mm is due to strong orographic influences. The natural vegetation is broad-leaved forest festooned with epiphytes. Tree ferns are especially abundant. A characteristic broad-leaved tree is *Linociera domingensis* ("lirio", Oleaceae).

Subtropical Lower Montane Moist Forest Life Zone

This Life Zone occurs primarily on the eastern and southern flanks of the Cordillera Central. It is less abundant in the Sierras de Neiba and Baoruco, and on the northern flank of the Cordillera Central. This Life Zone is usually found above 800 m elevation.

Mean annual rainfall varies between 1000 and 2000 mm, with average annual biotemperature of 12-18°C. Cool-dry transitional

areas to Subtropical Lower Montane Dry Forest Life Zone occur in two small patches on the south flank of the Cordillera Central and on the eastern end of the Sierra de Neiba. These cool-dry transitions are due primarily to rain-shadow reductions in rainfall. Cool-moist transitional areas with rainfall between 1800-2000 mm occur in two small, isolated patches on the south flank of the Cordillera Central, as well as on the Sierra de Neiba.

The natural vegetation is primarily open pine forest. In addition to *Pinus occidentalis*, the native conifers *Junipreus gracilior* ("sabina", Cupressaceae) and *Podocarpus buchii* (Podocarpaceae) also occur in this Life Zone. Typical broad-leaved tree species include *Guazuam tomentosa* (Sterculiaceae), *Garrya fadyenii* (Garryaceae), *Rapanea ferruginea* (Myrsinaceae) and *Vaccinium cubense* (Ericaceae).

The majority of the land in this Life Zone has been deforested or seriously degraded by slash and burn agriculturists (Fig. III-5b). Inappropriate hillside farming on poor, shallow soils has resulted in serious erosion and loss of fertility, with the consequence of substantial abandonment of land or conversion to poor pasture.

Subtropical Lower Montane Wet Forest Life Zone

This Life Zone covers much of the mid-elevations (850-2,100 m) of the Cordillera Central, Sierra de Neiba and Sierra de Baoruco. Small areas of cool-moist transition to Subtropical Lower Montane Rain Forest Life Zone occur on each of these mountain ranges. The non-transitional Life Zone also occurs in a few patches on the Cordillera Septentrional.

Mean annual rainfall is 2000-4000 mm and biotemperature of 18-12°C. With a PET ratio of 0.50-0.25, there is a considerable excess of rainfall over evapotranspiration. The occurrence of this Life Zone over some 7% of the country in combination with steep terrain provides the bulk of the water for the major rivers. The importance of these rivers for irrigation and hydroelectricity make the Subtropical Lower Montane Wet Forest Life Zone the most critical ecological region of the country.

The natural vegetation of this Life Zone is characterized by a complex mixture of broad-leaved and pine forests. The former occur in valleys and lower slopes, grading to pine forest on the ridges and upper slopes. Pine is usually present in the broad-leaved forest and regenerates well following disturbance, particularly fire. Characteristic broad-leaved tree species include *Brunellia comociadifolia* (Brunelliaceae), *Didymopanax tremulum* ("temblon", Araliaceae), *Diospyros ebenaster* ("ebano", Ebenaceae), *Garrya fadyenii* (Garryaceae), *Oreopanax capitatum* (Araliaceae), *Prunus occidentalis* ("almendro", Rosaceae) and *Weinmannia pinnata* (Cunoniaceae).

This Life Zone is receiving considerable pressure from slash and burn agriculturalists, who are advancing deeper into the major mountain ranges. There are precious few patches in this Life Zone with soil suitable for permanent agriculture. Conversion of the broad-leaved forest on the lower slopes greatly reduces the water absorptive and retentive capacity of the topsoil, hence there is much greater fluctuation in runoff. Debris-clearing fires often escape up-slope into the pine forest where the temporary loss of groundwater results in serious erosion of the shallow soils. Natural forest vegetation is the best soil protector and regulator of runoff. The thick root-mat under broad-leaved forest functions like a gigantic sponge absorbing enormous quantities of rainwater during the wet season and slowly releasing water during the dry season. The sponge-like capacity moderates extremes—reducing peak flow during floods and maximizing discharge during droughts. Protection of natural vegetation in the Subtropical Lower Montane Wet Forest Life Zone should be a top priority of the Dominican government.

Subtropical Lower Montane Rain Forest Life Zone

Of very limited occurrence, this Life Zone is found only in three isolated patches in the Cordillera Central. Though mean annual rainfall exceeds 4000 mm, the total area of only 36 km² contributes much less total runoff than the Subtropical Lower Montane Wet Forest Life Zone with 100 times more catchment area.

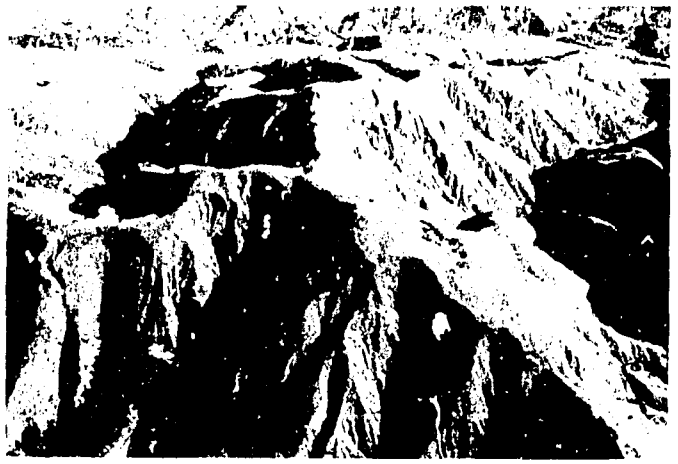

Figure III-5b. *Denuded landscape in the Rio Las Cuevas watershed. The area was probably deforested decades ago for seasonal crops such as beans. Note the freshly prepared field (lower center). (Hand-held aerial photo, Gary Hartshorn.)*

The natural vegetation of this Life Zone is characterized by the dominance of broad-leaved species, and the abundance of tree ferns and epiphytes.

Subtropical Montane Wet Forest Life Zone

This Life Zone occurs above 2100 m and encompasses the highest peaks of the country. The most extensive representative of this Life Zone occurs around Pico Durate (3,087 m), with lesser areas in the headwaters of the Rio Nizao and on the Sierra de Baoruco.

Mean annual rainfall is 1000-2000 mm and biotemperature is 12-6 ° C. Freezing temperatures occur regularly in this Life Zone.

The natural vegetation is predominantly open pine stands (see Fig II-2a) of substantially lower height than in Lower Montane Wet Forest Life Zone. Typical broad-leaved species include *Buddleia domingensis* (Loganiaceae), *Lyonia* spp. (Ericaceae), *Verbena domingensis* (Verbenaceae) and *Weinmannia pinnata* (Cunoniaceae).

Status of Major Forest Types

The most recent inventory (Table III-2) of land cover indicates slightly less than 7,000 km² of forest remain in the country (CRIES 1980). Unfortunately, the CRIES study defines forest as having canopy closure of at least 75%, which exludes the majority of the open pine forests. Due to low density of trees, most

Table III-2. Classes of actual land use or cover in the Dominican Republic; Data from CRIES (1980).

Code	Actual Land Use or Cover	Km²	(%)
1.0	Urban and Built-up	292	(0.6)
2.1	Sugarcane (75%)	4,205	(8.8)
2.2	Intensive Agriculture (75% in crops)	6,496	(13.6)
2.3	Marginal Agriculture (25-74% in crops)	8,281	(17.4)
2.4	Pasture (planted grass)	2,325	(4.9)
3.0	Rangeland	5,278	(11.1)
3.1	Limited Rangeland	12,788	(26.8)
4.1	Broadleaved Forest	6,518	(13.7)
4.2	Pine Forest	311	(0.7)
5.0	Wetlands (excluding rice)	269	(0.6)
6.0	Barren or Open	402	(0.8)
7.0	Inland Water	315	(0.7)
8.0	Cloud Cover	177	(0.4)
	Total	47,657	**(100)**

pine forests are classified as limited rangeland by CRIES. The lack of distincition of forest types makes it impossible to compare the CRIES results with earier estimates of forest cover (Table III-3).

The two major forestry studies done by OAS (1967) and FAO (1973) do not permit substantive comparisons in forest cover (Table III-3). The OAS study conducted during the 1965 and 1966 determined 5,570 km² of forest area with commercial trees. The FAO field work done in 1968-1971 classified as forest nearly double the total area reported by OAS; FAO reports twice as much humid broadleaved forest and five times more subhumid broadleaved forest. However, there is an important caveat buried in the FAO report that states only about one-third of the nearly 11,000 km² of forest area is *undisturbed* by fire or slash and burn agriculture. FAO's figure of 3,350 km² of undisturbed forest is about 40% less than the OAS area of commercial forests.

Table III-3. Comparative estimates of major forest types in the Dominican Republic.

	Primaeval		OAS 1967		FAO 1973		CRIES 1980	
Forest Type	**Km²**	**(%)**	**Km²**	**(%)**	**Km²**	**(%)**	**Km²**	**(%)**
Pine	2,800[a]	(5.8)	2,155	(4.5)	1,962	(4.1)	311	(0.6)
Mixed Pine-Broadleaved	4,800[a]	(9.9)	835	(1.7)	1,385	(2.9)		
Humid Broadleaved	29,378[b]	(61)	1,890	(3.9)	4,135	(8.5)	6,518	(13.5)
Subhumid Broadleaved	10,963[c]	(23)	690	(1.4)	3,382	(7.0)		
Mangroves	102	(0.2)	—		102	(0.2)		
Other (Lakes, etc.)	399	(0.8)						
Total	**48,442**	**(100)**	**5,570**	**(11.5)**	**10,966**	**(22.6)**	**6,829**	**(14.1)**

[a]Estimates based on aerial photo-interpretation by FAO (1973).

[b]Includes all Life Zones with PET ratio less than 1.0, minus the FAO estimates of original pine and mixed pine-broadleaved forests.

[c]Includes all Life Zones with PET ratio greater than 1.0.

FAO (1973) offers interesting figures of the primaeval (pre-Colombian?) extent of pine and mixed pine-broadleaved forests (Table III-3). When compared with actual forest cover according to FAO, the pure pine forest decreased in area about 30% while the mixed pine-broadleaved forest lost over 70%. The striking difference in rates of presumed deforestation is probably due to the topographically lower location of the mixed forest, hence it was more accessible for logging, and the better soil under the mixed forest.

Further extrapolations of the primaeval broad-leaved forests using Life Zones (see Table III-1) suggests 86% of the humid broadleaved forests and 69% of the subhumid broadleaved forests have been deforested (Table III-3). These very crude estimates of deforestation do indicate the pressures for conversion of lowland forests to non-forest use. Only in the highlands are the deforestation pressures less on the pure pine forests. The 1967 law closing sawmills and prohibiting the cutting of trees certainly is a major factor in reduced deforestation. It should be noted that pine forests occur on poor soils in remote and rugged terrain, hence of neglibible interest to agriculturalists. Consequently the closing of sawmills took away the major threat and FORESTA (Forest Service) has done an excellent job protecting the remaining pine forests.

While concentrating on pine forest protection, FORESTA has virtually ignored the other major forest types. The emphasis on enforcement prohibiting harvesting of commercial timber, primarily pine, seems to ignore the rampant and continuous deforestation for slash and burn agriculture, as well as for charcoal production and firewood. Significant areas of Los Haitises, including the national park, are currently being deforested. Slash and burn agriculturalists are rapidly advancing the agricultural frontier in La Altogracia province. FORESTA has token control of charcoal transport on the major highways, but makes no pretentions about regulating the cutting of wood to make into charcoal. FORESTA's (1980) report that national production totals 900,000 sacks of charcoal is only about 20% of the production estimated by Jennings and Ferreira (1979). The role of charocal production in the rural economy and the need for energy plantations are addressed in chapters IX and IV, respectively. The government, through FORESTA, clearly needs to address the charcoal economy in a much more thorough manner. FORESTA should take the lead in ensuring rational use of natural forests for charcoal, development of trial energy plantations, use of more efficient kilns and stoves; and encourage industrial and home conversion from firewood to briquettes.

Flora

The ecological diversity of Hispaniola is reflected by great floristic richness, certainly the richest flora in the Antilles. Moscosa (1943) produced the first catalog of the Dominican flora; it was later expanded by Jimenez (1959). More recently, Logier (1974) compiled a dictionary of common plant names. A comprehensive systematic treatment of the flora has not been initiated. Approximately 36% of the 5,600 species are thought to be endemic (Hernandez 1980). A preliminary effort (Table III-4) lists 137 plant species as threatened or in danger of extinction.

The national herbarium is housed at the very impressive botanical garden—Jardin Botanico Nacional "Dr. Rafael M. Moscoso". The botanical garden was created by Law 456 (1976) with modifications in its legal base enacted under Law 921 (1978). As a dependency of the executive branch of government, the botanical garden receives annual government appropriations. The general administrator is appointed for an indefinite period by the President of the Republic. In addition to maintaining live collections and the national herbarium, major funcitons include (1) strengthening educational and cultural appreciation of the botanical sciences, especially with respect to preserving the national flora; (2) conducting the necessary studies of the flora to assure its preservation or where necessary, restoration of green areas; (3) collaborating with the National Parks Directorate in botanical and ecological studies not only in parks and reserves but in areas destined for conversion to other uses; and (4) utilizing the green areas around Isabel de Torres as a substation for botanical garden programs (ONAP 1980).

Table III-4. Threatened and endangered plant species in the Dominican Republic. Based on a list prepared by CIBIMA by Dr. José de Jesús Jiménez, with a few additions suggested by Alain Liogier. Orchid list prepared by D.D. Dod. *Denotes Endemic Species.

AGAVACEAE
**Agave intermixta* Trel.

BIGNONIACEAE
Elomanianthe longifolia (Griseb.) Urb.
Tynnanthus caryophylleus (Bello) Alain

BOMBACACEAE
Ceiba pentandra (L.) Gaertn.

CACTACEAE
Dendrocereus undulosus (DC) Britton & Rose
Harrisia hurstii Marshall
**Neoabbotia paniculata* (Lam) Britton & Rose
Opuntia urbaniana Werdem
Pereskia portulacifolia (L) Haw

CAMPANULACEAE
**Lobelia salicina* Lam. var. *Brachyantha* Urb.

COMPOSITAE
Ageratum domingense Spreng.
**Chaptalia eggersii* Urb.
**Chaptalia vegaensis* Urb.
**Erigeron domingensis* Urb.
**Erigeron fuertesii* Urb.
**Erigeron ocaensis* Urb.
**Erigeron psilocaulis* Urb.
**Erigeron subalpinus* Urb.
**Erigeron tuerckheimii* Urb.
**Erigeron vegaensis* Urb.
**Eupatorium constanzae* Urb.
**Eupatorium heteros-quameum* Urb.
**Gnaphalium rosillense* Urb.
**Gundlachia domingensis* (Spreng.) A. Gray
**Gundlachia ocoana* Urb. & Ekm.
**Heterodonta haitiensis* Urb. & Ekm.
**Heterodonta mikanioides* Urb. & Ekm.
**Heterodonta alinii* Jimenez
Mikania cyanosma Urb. & Ekm.
Mikania platyloba Urb. & Ekm.
Mikania producta Urb. & Ekm.

CUCURBITACEAE
Doyerea emetocathartica Gros.
**Melothria domingensis* Cogn.
**Penelopeia suburceolata* Cogn.

CUPRESSACEAE
**Juniperus gracilior* Pilger
Cupressus sempervirens L.

EBENACEAE
Diospyros domingensis (Urb.) Alain
Diospyros revoluta Poir.

EUPHORBIACEAE
**Acidotun microphyllus* Urb.
Croton belanseanus Urb. & Ekm.
Croton fuertesii Urb.
Cubanthus umbelliformis Urb. & Ekm.
Euphorbia defoliata Urb.
Leucocroton leprosas (Willd.) Pax & Hoffm.
Victorinia acrandra (Urb.) Leon

GUTTIFERAE
Mammea americana L.

HERNANDIACEAE
Hernandia sonora L.

LEGUMINOSAE (MIMOSACEAE)
**Acacia barahonensis* Urb.
**Calliandra nervosa* (Urb.) Urb. & Ekm.
**Mimosa azuensis* Britt
**Mimosa farisii* Leonard ex Britt
**Pithecellobium abbotti* Rose & Leonard
**Pithecellobium micranthum* Benth
Samanea valeuriana Britt & Alain

LEGUMINOSAE (CAESALPINIACEAE)
**Caesalpinia anacantha* Urban.
**Caesalpinia barahonensis* Urb.
Caesalpinia domingensis Urb.
**Cassia angustisiligua* Lam
Cassia enneryana (Britt.) Jimenez
**Mora abbottii* Rose & Leonard
Mora ekmanii (Urb.) Britt. & Rose
**Peltophorum berteroanum* Urb.
Stahlia monosperma (Tul.) Urb.

LEGUMINOSAE (FABACEAE or PAPILIONAIDEAE)
Adenanthera perigrina (L.) Sperg.
**Aeschynomene pleuronervia* DC
**Calopogonium domingensis* Urb. & Ekm.
Clitoria laurifolia Poir
Piscidia piscipula (L) Sarg.
Sophora oligosperma Urb. & Ekm.

MAGNOLIACEAE
Illicium ekmanii A. C. Smith
Magnolia hamori R. A. Howard
Magnolia pallescens Urb. & Ekm.

MALVACEAE
Hibiscus furcellatus Lam. var. *azuensis* Urb. & Helw
Melachra radiata (L) L
Phymosia abutiloides (L) Desv.
**Ulbrichia beatensis* Urb.

MELASTOMATACEAE
Clidemia oligantha Urb.
Conostegia furfuraceae Urb. & Ekm.
Graffenrieda barahonensis Urb.
**Mecranium ovatum* Cogn.
**Miconia fuertesii* Cogn.
Tetrazygia cordata Urb. & Ekm. ex Alain

MELIACEAE
Cedrela odorata L.
Swietenia mahagoni (L) Jacq.
Trichilia cuneifolia (L) Urb.

MORACEAE
Pseudolmedia spuria (SW) Griseb.

MYRSINACEAE
Ardisia angustata Urb.
Ardisia fuertesii Urb.
**Wallenia apiculata* Urb.
**Wallenia urbaniana* Mez

MYRTACEAE
**Cryptorhiza haitiensis* Urb.
Pimenta ozua (U & Ekm.) Burret
Psidium salutare (H.B.K.) Berg

ORCHIDACEAE (by D. D. Dod)
Orchids Threatened by Habitat Destruction
Barbosella monstrabilia (Ames) Garay
Bletia purpurea (Lam.) D.C.
Bulbophyllum aristatum Hemsl.
Bulbophyllum pachyrrhachis (A. Rich) Griseb.
Campylocentrum monteverdii (Rchb. f.) Rolfe
Campylocentrum porrectum (Rchb. f.) Rolfe
Cranichis diphylla Sw.
Dendrophylax ariza-juliae (Ames) Dod
Dichaea swartzii (C. Schweinf.) Garay & Sweet.
Dilomilis scirpoidea (Schltr.) Surmmerh.
Domingoa nodosa (Cogn.) Schltr.
Encyclia domingense (Cogn.) Dod
Epidendrum neoporpax Ames
Epidendrum paranuense Rarb.-Rodr.
Epidendrum strobiliferum Rchf. f.
Erythrodes hirtella (Sw.) Fawc. & Rendle.
Eulophia alta (L.) Fawc. & Rendle.
Ionopsis satyoides (Sw.) Lindl.
Lepanthopsis melanantha (Rchb. f.) Ames
Lepanthopsis serrulata (Cogn) Hespenheide & Garay
Malaxis umbelliflora Sw
Malaxis unifolia Michx.
Maxillaria adendrobium (Rchb. f.) Dressler
Maxillaria crassifolia (Lindl.) Rchb. f.
Neocogniauxia hexaptera (Griseb.) Schltr.
Oncidium osmentii Withner
Oncidium quadrilobum C. Schweinf.
Pleurothallis appendiculata Cogn.
Pleurothallis aristata Hook.
Pleurothallis erosa Urb.
Pleurothallis foliata Griseb.
Pleurothallis helenae Fawc. & Rendle.
Pleurothallis parvula A. & S.
Pleurothallis quisqueyana Dod
Pleurothallis testifolia (Sw.) Lindl.
Ponthieva pauciflora (Sw.) F. & R.
Reichenbachanthus emarginatus Garay
Spiranthes cranichoides (Griseb.) Cogn.
Spiranthes domingensis Dod
Stelis domingensis Cogn.
Tropidia polystachya (Sw.) Ames

Orchids in Danger of Extinction
Antillanorchis gundlachii (Wright ex Griseb.) Garay
Basiphyllaea angustifolia Schltr.
Basiphyllaea sarcophylla (Rchb. f.) Schltr.
Brachionidium sherringii Rolfe
Campylocentrum constanzense Garay
Campylocentrum macrocarpum Dod
Campylocentrum serpentilingua Dod
Comparettia falcata Poepp. & Engl.
Corallorhiza ekmanii Mansf.
Corymborkis flava (Sw.) Kuntze
Corymborkis forcipigera (Rchb. f.) L. O. Wms.
Cranichis wageneri Rchb. f.
Cryptophoranthus aurantiacus Dod
Cryptophoranthus atropurpureus (Lindl.) Rolfe
Cryptophoranthus erosus Garay
Domingoa x susiana Dod
Encyclia acutifolia Schltr.
Encyclia bipapulares Rchb. f.
Encyclia bletiodes Griseb.
Encyclia boothiana (Lindl.) Dressler
Encyclia buchii (Cogn.) Dod
Encyclia cochleata var. *alba* Dod
Encyclia diurna (Jacq.) Schltr.

Table III-4. (continued)

Orchids in Danger of Extinction (continued)

Encyclia ekmanii (Mansf.) Dod
Encyclia fucata (Lindl.) Britt. & Mil.
Encyclia hodgeiana (Lindl.) Dod
Encyclia phoenicea (Lindl.) Dod
Encyclia polygonata (Lindl) Dressler
Encyclia vernicosa Dod
Epidendrum rivulare Lindl.
Epidendrum serrulatum Sw.
Epidendrum soratae Rchb. f.
Epidendropsis vicentina (Lindl.) Garay & Dunst.
Eurystyles alticola Dod
Eurystyles anamassacomos (Rchb. f.) Schltr.
Eurystyles domingensis Dod
Fuertesiella pterichoides Schltr.
Galeandra beyrichii Rchb. f.
Goodyera striata Rchb. f.
Habenaria quinqueseta (Michx.) Garay
Habenaria odontopetala Rchb. f.
Lankesterella orthantha (Kransl.) Garay
Leochilus labiatus (Sw.) Kuntze
Lepanthes dussii Urb.
Lepanthes furcatipetala Garay
Lepanthopsis anthoctenium (Rchb. f.) Ames
Lepanthopsis dentifera (L. O. Wms.) Garay
Lepanthopsis dodii Garay
Lepanthopsis domingensis Dod
Lepanthopsis glandulifera Dod
Lepanthopsis hotteana (Mansf.) Garay
Lepanthopsis microlepanthes (Griseb.) Ames
Lepanthopsis moniliformis Dod
Lepanthopsis pygmaea C. Schweinf.
Lepanthopsis stellaris Dod
Liparis neuroglossa Rchb. f.
Liparis viridipurpurea Griseb.
Malaxis hispaniolae (Schltr.) L. O. Wms.
Malaxis keonardii Ames
Malaxis parthonii Morren
Maxillaria inflexa (Lindl.) Griseb.
(*M. croeesrubens*)
Oncidium ariza-julianum Withner & Jimenez
Oncidium calochilum Cogn.
Oncidium guianense var. *alborubrum* Moir.
Oncidium henekenii Schomb. ex Lindl.
Oncidium meirax Rchb. f.
Oncidium tuerckheimii Cogn.
Pinelia leochilus (Rchb. f.) Garay & Sweet.
Platystele querceticola (Lindl.) Garay
Pleurothallis alainii Dod
Pleurothallis claudii Rchb. f. ex Dod
Pleurothallis corniculata (Sw.) Lindl.
Pleurothallis dod" Garay
Pleurothallis grobyi Batem. ex Lindl.
Pleurothallis imrayi Lindl.
Pleurothallis lanceola Spreng.
Pleurothallis laxa Lindl.
Pleurothallis longilabris Lindl.
Pleurothallis mazei Urb.
Pleurothallis murex Rchb. f.
Pleurothallis pendens Dod
Pleurothallis simpliciflora Dod
Pleurothallis spilo-porphureus Dod
Pleurothallis tribuloides (Sw.) Lindl.
Pleurothallis tricostata Cogn.
Ponthieva ekmanii Mansf.
Ponthieva harrisii Cogn.
Ponthieva petiolata Lindl.
Prescottia sp. nov.
Pseudocentrum minus Benth.
Quisqueya ekmanii Dod
Quisqueya fuertesii Dod
Quisqueya holdridgei Dod
Quisqueya karstii Dod
Spiranthes costaricensis Rchb. f.
Spiranthes fauci-sanguinea Dod
Spiranthes monophylla (Griseb.) Dod
Spiranthes polyantha Rchb. f.
Spiranthes speciosa (Bmel.) A. Rich.
Stelis chabreana Mansf.
Stellilabium minutiflora (Krangl.) Garay
Tetramicra bulbosa Mansf.
Tetramicra canaliculata var. *alba*
Tetramicra ekmanii Mansf.
Tetramicra schoenina (Rchb. f.) Rolfe
Triphora gentianoides (Sw.) Ames & Schwenfueth
Triphora surinamensis Lindl.
Vanilla mexicana Mill
Vanilla phaeantha Rchb. f.
Wullschlaegelia aphylla (Sw.) Rchb. f.

PALMAE

**Acrocomia quisqueyana* Bailey
**Bactris plumeriana* Mart.
Calyptrogyne dulcis (Wright ex Griseb.) Gomez Maza
Calyptrogyne rivalis (O.F. Cook) Leon
Copernicia berteroana Becc
**Haitiella ekmanii* (Burret) Bailey
Prestoea montana (Grah.) Nichols.
**Pseudophoenix sargentii* Subsp. *saonae* var. *saonae* (Cook) Red

PODOCARPACEAE

Podocarpus buchii Urb.

RUBIACEAE

Antirhea elliptica Urb. & Ekm.
Antirhea involucrata Urb. & Ekm.
Casasia haitiensis Urb. & Ekm.
Exostema nitens Urb.
Exostema rupicolum Urb.
Exostema subcordatum Krug. & Urb.
Gonzalagunia brachyanthe (A. Rich.) Urb.
Guettarda barahonensis Urb.
Guettarda stenophylla Urb.
Ottoschmidtia haitiensis Urb.
Palicourea micrantha Urb.

RUTACEAE

Zanthoxylum flavum Vahla

SAPOTACEAE

Bumelia integra Cronq.
Dipholis ferruginea
Micropholis chrysophylloides Pierre
Pouteria sapota (Jacq.) H.E. Moore & Stearn.

STERCULIACEAE

Byttneria microphylla Jacq.
Neoregnellia cubensis Urb.
Waltheria calciocola Urb.

THEOPHRASTACEAE

**Jacquinia conosa* Urb.
**Jacquinia eggersii* Urb.

ZYGOPHYLLACEAE

Guaiacum officinale L.
Guaiacum sanctum L.

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IV

Plantation Forestry

Introduction

The Dominican Republic was once well-endowed with pine, hardwood and mixed pine-hardwood forests, but uncontrolled cutting, wildfire, hurricanes and conversion to agriculture have destroyed all but occasional stands in higher elevations, a few private forests and scattered remnant plots and strips along property boundaries or water courses. Much of the low elevation, dry scrub forest also remains. Devastation of the nation's better forests has resulted in widespread erosion and led the government to close all private mills in 1967 and to prohibit harvesting of live trees. The country has since become a net importer of about $30 million of wood products annually.

Although deforestation is the root cause of most of the country's most critical environmental problems, a massive reforestation program is not a workable solution at the present time. Reforestation of selected, controlled sites and tree planting in conjunction with integrated watershed management, however, are possible and desirable. This chapter aims to describe the state of the art of plantation forestry in the Dominican Republic and the role that reforestation can play in restoring the nation's land resource to a protective and productive state.

The Status of Plantation Forestry

Extent of Existing Plantations

Efforts to establish forest plantations in the Dominican Republic have been extremely modest. Planting of ornamental species has occurred for some time, but the first forest plantations of any significant extent were not begun until 1969. Progress has been slow since then.

Statistics on forest tree plantations are rare or non-existent. Most organizations record the number of seedlings planted, but because of variable planting densities, some replanting of failed areas, and occasionally the tallying of plants which leave the nursery instead of those actually planted, it is difficult to accurately ascertain the area of land reforested in the Dominican Republic. Records of seedlings planted provided by the Dirrecion General de Foresta, converted to area, indicate that from 1969 to 1978 about 1,9000 hectares were reforested by the government. Locations and approximate areas of these stands are given in Table IV-1. By 1980 the government plantations may have been increased to about 2,200 hectares. In addition, private industry (especially Falconbridge Dominicana) is estimated to have planted about 1,000 hectares to mid-1980, bringing the country-wide total to approximately 3,200 hectare, of which about 70% were government sponsored and 30% were privately established. The main species planted are *Pinus occidentalis* and *P. caribaea* var. *hondurensis*. Most of the plantations have the objectives of site stabilization and the future production of wood products.

Table IV-1. Estimated areas and locations of government forest plantations established in the Dominican Republic through 1978.

Location	Main Species	Year Planting Started	Approximate Area (Hectares)
Constanza (Jarabacoa)	*P. Caribaea*, *P. occidentalis*	1975	107
Loma de la Sal (Jarabacoa)	*P. caribaea* *P. occidentalis*	1969	280
Los Gajitos (San Juan)	*Swietenic mahagoni* *P. caribaea*, others	1975	40
Manabao (Jarabacoa)	*P. caribaea* *P. occidentalis*	1969	1,230
Sabana Clara (Dajabón)	*P. caribaea* *P. occidentalis* *P. occidentalis* others	1976	262
			1,919

National Organizations Active in Reforestation

Direccion General de Foresta. The organization most active in plantation forestry in the country is the national forest service, the Direccion General Forestal, or FORESTA. FORESTA began planting for combined protective and productive purposes in 1969 with technical assistance from the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Development Program (UNDP). This assistance lasted until 1972. Planting has continued since then at a modest scale, and government plantations now cover an estimated 2,200 hectares, mainly in the province of La Vega near Jarabacoa, but with smaller stands in San Juan and Dajabon. Since 1977 the FORESTA planting program has benefitted from financial and technical assistance from the Interamerican Development Bank (IDB). FORESTA has made a

start at reforestation, but they need to expand planting on government land and to extend it to private holdings as well. The possibilities and limitations of FORESTA doing this are covered elsewhere in this chapter.

Other Government Agencies. Other than FORESTA, the government organization most active in reforestation is the Secretaria de Estado de Agricultura (SEA). Two major SEA plans with reforestation components are the Plan Sierra, prepared by the Planning Department (SEA 1978 and 1979), and the Project Bao, prepared by the Department of Lands and Water (Tamayo 1980).

With headquarters in San Jose de Las Matas, Plan Sierra aims to promote development and integration into the national economy of the mountainous region covering about 2,000 square kilometers in parts of the provinces of Santiago and Santiago Rodriguez by improving cropping systems and by fostering better management of natural resources. The forestry component of Plan Sierra calls for harvesting and management of natural forests as well as reforestation. Initially, plans are to reforest by planting about 50 hectares annually to suitable species, mainly *Pinus caribaea* var. *hondurensis.* Planting is to be done on agriculturally underproductive private lands through a cropping system called taungya which encourages establishment and cultivation of mixed plantations of trees and agricultural crops for a period of three to four years, after which the trees are left to take over the site. On the better soils this same taungya system is being used to convert from annual or seasonal crops to more permanent coffee plantations, by first planting a short-term cash crop together with leguminous shade trees, and then by setting out coffee seedlings once sufficient shade is assured. Some 40,000 hectares are thought to be suitable for coffee production. Other components of the Plan Sierra are the devlopment of disease-resistant, adaptable varieties of fruit trees (such as avocado) suitable for export, as well as pasture improvement and fuelwood plantations. There has been only minimal cooperation between FORESTA and Plan Sierra, due largely to the technical weakness of FORESTA.

As Plan Sierra had been operational for only about 18 months prior to the profile team's visit, it was difficult to evaluate how successful it has been in meeting its objectives. It is obvious, however, that the Plan is off to an excellent start. It has confronted the major problems head on and is developing local solutions to solve them. In particular, Plan Sierra is striving to work with the rural poor, to gain their trust, and to enlist their collaboration. It is, for example, helping to teach housewives better family nutrition, explaining to farmers' organizations the benefits of agroforestry, and working through lending institutions to promote conversion to coffee production on suitable sites. Nonetheless, these efforts will need to be intensified and expanded if Plan Sierra is to have a significant impact on the region. In particular, it will need management, and in some areas terrace construction, on the poor, dry, and often shallow soils which exist in much of the region. Aid agencies could be of great assistance to Plan Sierra by providing much needed technical expertise as well as incentives to small farmers either in the form of cash subsidies or food. There is a real opportunity for international agencies to face the challenge of helping the rural poor by assisting Plan Sierra.

The second major SEA project with a forest plantation component is Project Bao. This plan, with offices in Janico, is a soil and water conservation scheme aimed at protecting the Tavera-Bao dams and reservoirs. Geographically, it concentrates on the 864 square kilometer Bao watershed which includes the rivers Bao, Jagua and Janico. an estimated 9,000 hectares of the project area are public lands of greater than 40% slope which are now occupied by small farmers, and about 5,000 hectares lie within Bermudez National Park. Most of the rest of the land is in private ownership.

The forestry component of Project Bao aims to change the cropping system from seasonal crops to more permanent types, such as trees, through taungya, and to reduce forest fires. Specifically it proposes to plant annually some 1.6 million fruit and forest trees (about 1,000 hectares) outside the park and another 1.6 million trees of *P. occidentalis* and possibly *P. caribaea** inside the park. Although FORESTA has been cooperating with Project Bao, the reforestation goals of the project are viewed here as being unrealistic. No organization in the country has been able to plant anywhere near 2,000 hectares annually, and in light of the seriousness of land tenure problems in the Bao watershed and the need for technical assistance and incentives, Project Bao will certainly not be able to reach its goal anytime in the near future. No figures were available for the area of land actually reforested to date, but it must be remembered that the project is only two years old—a very young age for forest plantation schemes. Project Bao should be considered as a candidate for bilateral and multilateral technical and financial assistance based largely on the need for protecting the Tavera-Bao watersheds, but success in improving the lot of the rural poor is likely to be faster by supporting Plan Sierra.

Alcoa Corporation. Although time did not allow a visit to Alcoa Corporation's bauxite mining operation in the extreme southwest of the country, the following information was obtained through an interview with a company representative.

Alcoa started forest plantations in 1973 out of a desire to rehabilitate mined-over land and to provide a useful product to the local people. The area planted is small, but the planting rate is increasing. In 1980 about 12 hectares were afforested while another 30 were prepared for future planting. The main species used are almonds, *Cupressus arizonica* (two varieties), *Eucalyptus globus, E. Citriodora* and *Fraxinus alba.* A number of North American fruit trees were also tried but most were severely damaged by climatic extremes which ranged from hot, dry daytime conditions followed by night temperatures approaching freezing. Two technicians are employed full-time in afforestation.

Falconbridge Dominicana. Falconbridge is a ferro-nickel mining firm operating a government concession of about 10,000 hectares near Bonao. In 1971, at their own initiative and with some technical advice from FAO, Falconbridge started planting cut-over lands which were not intended to be mined. They later expanded planting to include mined land, and subsequently a provision calling for the rehabilitation of mine spoils was written into the concession agreement. The company also has a government permit to harvest natural pine forests on land scheduled for strip mining. Logs are sawn in two small FORESTA mills and the wood is used for government sponsored low-income housing.

Falconbridge claims to have planted about 1,000 hectares in the 1971-1980 period, but this estimate is likely on the high side. Currently, planting is restricted to mine spoils and is down to about 24 hectares annually. About 70-75% of the plantations are of *Pinus caribaea* var. *hondurensis* with seed coming largely from Belize; most of the remaining plantations are *P. occidentalis.*

Falconbridge appears to have an excellent overall forestry operation. Including the five sections of 1) administration and planning, 2) forestry, 3) mine reclamation and rehabilitation, 4) technical services and 5) harvesting their woodlands division has the services of 56 full-time employees. Although the company does not have a university-trained forester, the techical staff interviewed by the profile team was knowledgeable and has developed appropriate site rehabilitation techniques for mine spoils. Falconbridge should be commended for its success in restoring

*Exotic species, such as *P. caribaea,* are not recommended here for planting in national parks. In addition, *P. caribaea* is unlikely to be as adaptable as the indigenous *P. occidentalis* at elevations above about 800 meters, which includes most of the park.

ugly, mined-over sites to a productive and aesthetically pleasing state.

Gulf and Western. This large sugar producer in the southern and southeastern part of the country was not contacted about its interest in reforestation. It is known, however, that the firm recently established some small plantations of *Swientenia mahagoni* near La Romana.

Rosario Dominicana. Rosario is a gold mine operation northeast of Bonao which started production in 1974 on a government concession of 758 hectares. Since October, 1979, the operation has been completely govenment owned.

As did other companies, Rosario started reforestation at its own initiative before a planting clause was added to the concession agreement. Planting began in 1973 and has covered an estimated 175 hectares through mid-1980. About 92% of the stands are composed of pines, largely *Pinus cribaea* from Honduras; the rest are of eucalypts and mahogany *(Swietenia mahogani).* The objective is to reforest and slow erosion on cut-over land not scheduled for mining. All of such available land is likely to be planted by the next couple of years, after which plantation establishment will come to a halt. The chemical mining process used by Rosario does not allow planting of mine spoils. Rosario employs two technicians and 26 laborers full-time in reforestation and grounds work around the concession. A special feature of the Rosario operation is tha 5% of the net profits are channelled to a government forestry fund to finance reforestation and related forestry development projects.

Foreign Assistance to Plantation Projects

FOA/UNDP. The Food and Agriculture Organization of the United Nations (FAO) and the United Nations Special Fund, now called the United Nations Development Program (UNDP), were the first to provide outside assistance for reforestation to the Dominican Republic. Reforestation, however, was only one component of a larger project (described in the chapter on the institutional analysis of FORESTA) which was operated from 1968 to 1972 by FAO/UNDP together with FORESTA. This project was largely responsible for initiating the reforestation work at Manabao near Jarabacoa. It also prepared a plan for extending reforestation to other parts of the country, but except for the Jarabacoa region, FORESTA has been unable to follow the plan.

IDB. A second assistance to FORESTA's reforestation program came in 1977 when a three-year soil conservation project was begun in the watershed of the Rio Yaque del Norte to protect the Tavera dam and reservoir. The total project budget was for $2.74 million, of which $1.22 million was in the form of a soft loan at 4% interest from the Inter-American Development Bank (IDB). The original objectives were 1) to reforest 2,500 hectares of public land on slopes greater than 40%, 2) to construct terraces and related conservation works on 1,500 hectares of land in the vicinity of the Tavera reservoir, 3) to build 822 check dams for torrent control, 4) to provide technical advice and training, and 5) build the required physical infrastructure (primarily offices). In retrospect it is apparent that the plans were over-ambitious and as a result of delays in project execution, severe damages to roads and watersheds by hurricanes David and Frederic in 1979, and an inability to identify available public land for planting, the project was unable to meet its objectives. By the end of 1979, for example, only 10% of the reforestation goals were reached, 16% of the terraces constructed and 17% of the check dams built (FORESTA 1980). Technical assistance, training and infrastructure goals met a similar fate. An extension was requested and granted to continue with a revised project through 1981 whose total reforestation component (1977-81) was scaled down to 625 hectares. Whether or not this goal will be met will depend on how successful the project is in 1) finding available government land for planting, 2) convincing private landholders to plant trees and undertake conservation works, and 3) securing enough technically trained staff.

Technical Evaluation of Forest Plantations

For lack of time, an in-depth country-wide evaluation of forest plantations was not possible. The following cursory assessment is based largely on brief visits to Manabao (Fig IV-1a) and Loma de la Sal near Jarabacoa and to Falconbridge and Rosario.

Species

The two main species planted are the indigenous *Pinus occidentalis* and the introduced *P. caribaea* var. *hondurensis.* Both are planted for the dual purposes of watershed stabilization and wood products. Where growth is good, they are well-suited to these uses. More so than most broadleaf species, both of these pines can tolerate low nutrient levels and competition from grass and shrubs, and their needles produce an excellent, interwoven mat of protective layer to cover exposed sites. They also have thick bark which makes them resistant to light ground fires once the trees are past the juvenile stage. In addition, their wood is suitable for a variety of wood products.

Although planned species-site studies have not been initated and no comparative data is available from existing plantations, it appears that *P. occidentalis* is more windfirm and is the superior performer at elevations above about 800 meters, whereas *P. caribaea* does better in lower areas. Planting could continue with these two species on selected sites, at least in the Cordillera Central.

Other species existing in small plots, as roadside plantings, or under trial are *Swientenai mahagoni* and *Leucaena leucocephala,* both of which are indigenous, as well as *Cassia siamea* and various eucalypts, especially *Eucalyptus robusta.*

Species which should be considered for initial or expanded testing are *Pinus oocarpa, Eucalyptus camaldulensis, E. tereticornis, luecaena leucocephala* and possibly some species of *Prosopis* and *Acacia.* The fast-growing *P. oocarpa* merits introduction as a possible alternative to *P. occidentalis,* especially at elevations above 800 meters, while the eucalypts, leucaena and dry scrub species should be tested as possible trees for fuelwood plantations.

In addition to fuelwood plantations, leucaena may have an expanded role to play in agroforestry schemes, particularly on moderately fertile, moist, non-acidic soils. Leucaena has a number

Figure IV-1a. *Reforestation in Manobao with* Pinus occidentalis *(the uniform darker swath extnding from lower right up the ridge, across the upper valley and down the left slopes). This is the largest forest plantation in the country and was done by FORESTA. (Hand-held aerial photo, Gary Hartshorn.)*

of features, for example, which make it a versatile and potentially valuable component in agroforestry programs: it is easily propagated by seed or cuttings, grows fast, fixes nitrogen, performs well in mixtures or intercropped with other species, is effective in reducing erosion, and has wood useful for charcoal and firewood and leaves suitable for fodder. Caution is advised, however, not to view leucaena as a panacea or so-called "miracle" species; rather, it should be tested in a scientific and rational manner on available sites and for needed uses just as other promising species. Some work has recently been started with leucaena, but it needs to be expanded.

Seed Source

Due primarily to the limited scope of the plantation program in the Dominican Republic, very little attention has been paid to seed source. For *P. occidentalis*, most seed is collected from natural stands near the planting area. This is recommended procedure as long as mother trees of good phenotype are selected from a number of different stands. No seed production areas have been established. Most of the *P. caribaea* var. *hondurensis* seed used has been imported from Honduras and Belize, but provenance tests have not been made.

Other than a small, recently initiated trial of *Leucaena leucocephala* cultivars near Azua and Falconbridge's test of progeny from 12 controlled crosses each of *Eucalyptus robusta* and *E. grandis* made in Florida, no seed source studies are underway. These should be started for promising species, both native and introduced, if expanded planting for erosion control, fuelwood or industrial products is to be highly successful.

Nurseries

Tree nurseries in the country are small, labor intensive and poorly equipped, yet most of them apparently produce acceptable planting stock; nonetheless there is room for a great deal of improvement both in efficiency of operation and in seedling vigor.

The most common practice is to sow pine seed in a germination bed and to prick-out the newly emerged seedlings into soil-filled polythene bags before the seed coat is dropped. This is acceptable practice. Some nurseries, however, such as those of Plan Sierra near San Jose de las Matas, apparently delay pricking-out until new needles are formed, and insufficient care in placing the larger root sytem into the bag has resulted in root deformation. Some of these nurseries have also experienced a problem with insufficient mycorrhizal inoculation for good pine seedling growth. This could be overcome by mixing the duff and pine straw from a natural pine forest into the soil of the germination beds. Other nurseries visited apparently received adequate natural mycorrhizal inoculation from fungal spores from surrounding pine forests.

Outplanting and Tending

Most government reforestation has taken place on steep, cut-over, but vegetated sites. Since minimization of soil erosion is a primary objective, these sites are not intensively prepared for planting. The usual practice is to clear a swath on the contour through any existing brush and to prepare a hole to recieve the seedling. In early years of the planting program, a spacing of 2 x 2 meters was used; this has since been extended to 2.5 x 2.5 meters. Occasional weeding is done the first couple of years after planting if needed to free seedlings from overtopping competition, but usually the young pines are able to grow through the grass and small shrubs. Failure to weed is likely to result in some reduction of growth but is acceptable practice considering the justifiable concern over soil erosion and the need to minimize it.

At Falconbridge and Alcoa very intensive site preparation is practiced in the rehabilitation of strip mine spoils. Prior to mining, the topsoil is scraped away, piled and saved. After the mineral ore is removed, the site is shaped, terraces are constructed, and the topsoil replaced. At Falconbridge, terraces 2-2.5 meters wide and spaced 3-7 meters apart, depending on slope, are built. A grass cover, African star, is them planted, followed by pines at a 2 x 2 meter spacing. Alcoa plants Bermuda grass and prefers a wider tree spacing of 5 x 5 meters. Both firms fertilize lightly; Alcoa also spreads manure and waters from a tank truck. The keys to the success of these opertions are the saving and reusing of the topsoil, shaping and terracing to slow runoff, and rapid establishment of a good cover crop.

Post establishment tending is generally not practiced, although some pruning has been done at Loma de La Sal as laboratory exercises by students. Thought is now being given to thinning some stands. This can be done judiciously without significantly increasing the risk of erosion.

Growth and Yield

No information is available on the growth and yield of plantations, but some studies apparently have been initiated with the assistance of students from the forestry school at Jarabacoa. Such studies need to be expanded. There is no information on rotation length.

The Need for Forest Plantations

The priority need for forest plantations in the Dominican Republic is as a means of slowing accelerated, water-caused soil erosion. Plantations are also viewed as a source of fuelwood and, to a lesser extent, of future industrial wood products.

Erosion Control

Soil erosion has reached serious proportions in most of the watersheds visited by the profile team, and unless it is checked urgently the soil resource in which much of the nation's food is produced will be lost and the reservoirs so important as sources of irrigation water and hydroelectric power will soon become choked with sediment. Nonetheless, checking accelerated soil erosion is no simple matter, especially on already degraded lands which are often of unsure ownership yet which in many cases are under intensive use. Effective erosion control will require a concerted, long-term effort which must begin immediately.

Technically, erosion can be slowed by covering the soil surface to protect it against rain drops and by breaking the flow of runoff from the land. Often a vegetative cover alone is sufficient, but where erosion is severe mechanical measures will also be needed. For a given watershed, overall erosion control can best be achieved through a program of integrated land management which includes both pasture and forest management, reforestation, gully control measures, better road construction and maintenance, improved agricultural practices, and in some cases terrace construction and the conversion from short-term crops to more permanent types.

Both reforestation in the traditional sense of establishing closely-spaced plantations and tree planting as a component of agroforestry have important roles to play in rehabilitating eroded land in the Dominican Republic. On cut-over lands unequivocally under government control and vigilance, reforestation can proceed almost immediately if staff and funds are available. All that is needed is cadastral information to locate and mark the land and an on-site soil inspection to determine whether sufficient soil remains for adequate tree growth and anchorage. Although generally a minimum of about two meters of soil is required for economic timber production, tree planting for erosion control can be done on somewhat shallower soils as long as one

is willing to accept a reduction in growth and as long as the tree roots are able to anchor themselves adequately into deeper, friable material. However, where little soil remains and terrain is steep, rehabilitation is likely to be more effective by managing for pasture or for other low forms of vegetation. Many of the upper catchment areas of watersheds in the Central Cordillera could likely be reforested with pines using existing technology if land tenure is assured and if soils are first assessed on-site.

On non-industrial, private holdings and on land of contested ownership, traditional reforestation of large blocks of closely spaced plantations holds little promise. Although plantations would be effective in slowing erosion on many such lands, it will be all but impossible to convince landowners and users to reforest, especially with pines, until such time as they can be shown that a tree crop is a superior investment to agriculture or grazing. At present, there is no data in the Dominican Republic to support such an argument. Obtaining this information should be a research priority.

Meanwhile, the planting of multi-purpose tree species on small holdings as components of integrated land management, or agroforestry, may have an important role to play in slowing erosion and increasing the income of rural people. Species such as *Leucaena leucocephala*, fruit and nut trees, and other versatile species should be promoted for interplanting with agricultural crops and for planting along proprety boundaries, terraces, gullies and water courses. In some areas, conversion to a semi-permanent tree crop by taungya may be possible, such as is now being tried by Plan Sierra. Of major importance here is that trees not be looked upon as the sole solution, rather that they be considered as a part of a more comprehensive land management program that includes erosion control works, pasture managment and better farming techniques. Even then, however, implementation of an integrated program will require public education, extension, demonstration, and most of all financial incentives (and/or food aid) to landowners. In addition to Plan Sierra, such projects are urgently needed on most of the water catchment areas above key dams in the Cordillera Central.

Fuelwood

There is a large and growing demand for fuelwood in the Dominican Republic, both in the form of firewood and charcoal. FAO (1971) estimated the consumption at about 0.45 cubic meters per person annually in 1970, or roughly 1,840,000 m^3 for the country as a whole and 87% of the total use of roundwood. With a population growth rate of about 3% annually, fuelwood consumption may have reached 2,470,000 m^3 per year by 1980

Although data is not available, much of the fuelwood demand is apparently met by the dry, scrub forest, with the remainder coming from high forest illegally cleared by shifting cultivators, private landowners or trespassers. How long the forest can continue to meet the fuelwood needs is unknown, but it is certain that as sites are cleared for irrigated agriculture and as land pressure forces shifting cultivators from the higher, wetter mountains to lower, dryer regions (both of which are already happening), the pressure on the natural forest for fuelwood will increase. In some other tropical countries, the demand for fuelwood has led to uncontrolled cutting of forests and the virtual denuding of forest land, which in turn has resulted in accelerated soil erosion, in some cases desertification, and extreme hardships on rural people. It should be a top priority of government to ensure that this does not happen in the Dominican Republic.

Among the ways to slow the abusive cutting of forests for fuelwood are to improve the management and utilization of natural forests and to establish plantations of fast-growing species of high calorific value. Due to their greater productivity than natural forests, plantations in particular are viewed as an important future source of fuelwood in the Dominican Republic. An estimated 13,000 hectares of plantations, for example, could likely meet the entire national fuelwood demand. Plans are currently being made to test species and develop techniques for establishing and managing fuelwood plantations, but only a few, small studies are underway to date. These studies need to be intensified and expanded immediately, both in Cibao and in the Southwest, so that data and on-site information are available on which to base a decision concerning large-scale fuelwood plantations in the future.

Industrial Wood Products

The Dominican Republic is a net importer of about $30 million of wood-based products annually. Much of this demand could be met by the existing natural forests if they were wisely managed (Fig IV-1b). Current policy, however, is to preserve existing forests. In the future, plantations could be important supplies of industrial wood if sites suitable for intensive forestry were made available. The establishment of industrial plantations would permit a reduction in the import bill and still allow large blocks of natural forest to be maintained in parks. Again, studies of species, sites, plantation management, and profitability are needed if industrial plantations are to be founded on a sound technical base.

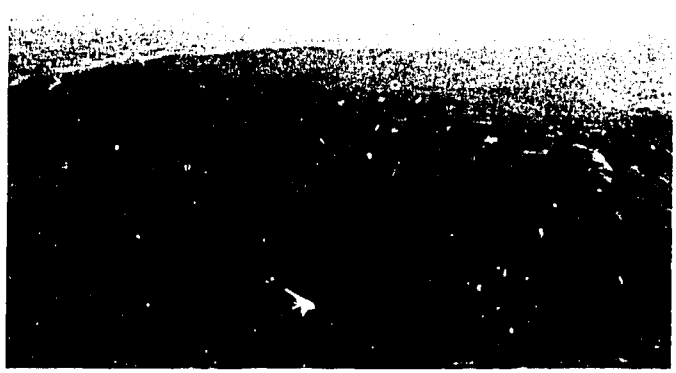


Figure IV-1b. *Subtropical wet pine forest near La Vega. This is the largest block of pines in private ownership, as well as the only extensive pine forest remaining in the lowlands. This forest has excellent potential for production forestry, but the 1967 closure of sawmills and prohibiting of tree cutting does not encourage private efforts in forestry. (Hand-held aerial photo, Gary Hartshorn.)*

Constraints on Progress

Insufficient Professionally-Trained Foresters

There is a serious shortage of university-trained foresters in the Dominican Republic. Technicians are also in limited supply but the immediate needs are likely to be met by the newly reopened school at Jarabacoa and by the 3-year school at Siguatepeque, Honduras, which is now training Dominican forest technicians. At present the country has a mere eight professional foresters, only one of whom works for FORESTA. The lack of well-trained personnel is the primary reason that little, if any, statistical information is available on plantations or on species' productivity. It also explains why there is not coordinated research on species-site relationships, seed sources, yield, nursery and plantation practices, the profitability of growing trees as a crop or on the suitability of different species for erosion control, fuelwood or as components in agroforestry schemes. The lack of professional staff is, at least in part, responsible for the FORESTA subprogram's realization of only about 10% of its reforestation goals. It also no doubt accounts for some of the apparent lack of coop-

eration between FORESTA and other government agencies on forestry matters—in many cases, FORESTA simply does not have the expertise to lend. Unless something is done soon to upgrade the professional qualifications of personnel working on forestry projects, little progress can be expected on the key reforestation priorities outlined in the previous section.

Land Tenure and Control

Two obivous and related constraints on reforestation are the difficulty of determining land ownership and the problem of providing adequate vigiliance and protection to public lands. Although strictly speaking FORESTA is empowered to define and manage all forest land, both public and private, in practice government-sponsored reforestation has taken place only on lands clearly under government control. Little public land remains around Manabao and Loma de la Sal and its location elsewhere in the country is unclear, except for some national parks which are, for the most part, forested. Much of the so-called public land is in practice being converted to agricultural crops or pasture by shifting cultivators. There is a real need to define the boundary of public land in the country and to decide which lands can realistically be controlled. Starting with the high priority areas, such as critical watersheds, such land needs to be mapped, physically marked on the ground and patrolled. Unless this is done the real scope and potential of reforestation cannot be gauged.

The Law

The forest law itself is a constraint on reforestation. Although the closing of all private sawmills and the restrictions placed on tree cutting were the salvation of existing forests, they have also served as strong deterrents to reforestation. Logically, in the absence of other incentives, there is little interest on the part of private landholders to plant when harvesting is effectively prohibited. In theory, legal cutting permits can be obtained through FORESTA but in practice few are issued. If sound management of private forest land is to be encouraged and if tree planting on small holdings is to be successfully promoted, FORESTA will need to start granting harvesting permits, at least to landowners willing to accept government supervision of logging.

Lack of Forestry Consciousness

A common affliction of many fledgling forest services is a lack of a conservation awareness on the part of rural people. In the Dominican Republic, the native forest was considered as a resource to exploit and convert to agriculture or pasture. It was not viewed as a crop, nor was its role in rural land management fully appreciated. This viewpoint continues today. If FORESTA and other government agencies are to be successful in promoting integrated land management which includes tree plantations, they will need to foster a conservation ethic among the people, especially those in rural areas. This is no simple matter, but a start can be made in the school systems, through the mass media, by setting up demonstration areas, and by strengthening extension programs.

Institutional Analysis of the Direccion General Forestal

The Formative Period and Legal Base

The primary organization charged with protecting and managing the nation's forest land is the Direccion General Forestal, also called the Direccion General de Foresta, but more commonly referred to as FORESTA. FORESTA was created in 1962 as dependency of the Secretaria de Estado de Agricultura (SEA) with the passage of Law No. 5856. This law, as subsequently amended, entrusts FORESTA with the conservation, restoration, development and utilization of forest vegetation and the transport and commerce of forest products. It also provides for the central administration of the previously created national forest services and the development and integration of forest industries by FORESTA. The law applies to all forest land, both public and private, and authorizes FORESTA to define forest land and to dictate the measures convenient for its conservation and reforestation. Another important and salient feature of Law 5956 is Article 87 which made it illegal to cut any fruit or forest tree without a permit from SEA.

Unfortunately, FORESTA lacked the resources to adequately implement the law, and in the turbulent years following the death of Trujillo in 1961, forests disappeared at an alarming rate due to uncontrolled logging, conversion to agriculture and wildfire. It is said, for example, that the number of sawmills incrased from about 65 in 1961 to 172 in 1967. Concern over this accelerated destruction of the nation's forests led to the passage of Law No. 206 (1967) which transferred FORESTA from SEA to the armed forces and national police with a direct line to the presidency. Direct involvement of the armed forces and national police in administering the forest law led to a sudden and sharp decrease in forest abuse. The law was tightened still further in 1969 with the adoption of Decree No. 3777 which specified that no tree cutting permits could be authorized by FORESTA save for exceptional cases and then only with the approval of the President. Together Law 206 and Decree 3777 effectively closed all private sawmills and stopped all cutting except for the salvage of dead timber or that to be removed by mining concerns or certain public works projects.

Organizztional Structure

FORESTA is headed by a director-general who carries the rank of brigadier general in the armed forces and who answers directly to the president. The general's staff and a captain who is in charge of the technician school at Jarabacoa are also involved in the administration of FORESTA, but all other personnel are civilian.

Structurally, the organization of FORESTA is in a period of change and it was difficult to secure specific information on the duties and responsibilities of some offices. The only organization chart that could be obtained shows two main divisions, one technical and one administrative, each answering to the director-general's office. Each division in turn is composed of various sections, some of which are no longer operative, e.g., forest inventories. Recently a third *ad hoc* division has been nominally set up whose duties are unclear but are apparently in the area of project evaluation. Although details were unavailable, there apparently is also a reorganization proposal pending which would place most of the day-to-day operation of FORESTA under one professional forester, who in turn would report to the director-general.

At the regional level, FORESTA has eight districts and 24 subdistricts. Each district has an officer-in-charge (civilian) who is responsible to the central office in Santo Domingo, but the lines of communication between the districts and Headquarters are not clear. Except for minor routine matters, the district offices apparently answer directly to the director-general.

Objectives and Major Projects

Although there is no detailed statement of forest policy, by law the basic objective of FORESTA is to manage all forest land in the country, regardless of ownership, in accordance with acceptable norms of protection, conservation, development and rational utilization. In practice, most of FORESTA's personnel are occupied with vigilance and fire control while most of the more highly trained staff work on planning and implementing projects dealing with the rehabilitation of degraded land. There is no integrated or sustained yield management of forest land and little utilization except for salvage operations.

A major subprogram of FORESTA deals with the reforestation and conservation of the Tavera watershed and comprises part of the larger PIDAGRO program (Integrated Program for Agricultural Development) with SEA. The subprogram is financed by a soft loan of US $1.22 million from IDB at 4% interest and a Dominican input of $1.5 million for a total of $2.72 million over a 3-year period from 1977 to 1980. Further details are given in a previous section.

Finances

Although an in-depth financial analysis was not possible, FORESTA does not seem to have the extreme monetary limitations so prevalent in the forest services of many other developing countries. Most of FORESTA's operating budget comes directly from government funds. In fiscal 1980 this amounted to $3.9 million; some $6.4 million have been requested by FORESTA for 1981. This is in addition to incidental revenue, such as that collected from fines, and the PIDAGRO subprogram, which is budgeted separately. Approximately 70% of the budget goes to pay salaries.

An additional source of revenue for the forestry sector, although not specifically for FORESTA, is the Forestry Fund. This fund, started in 1979, takes 5% of the profits from Rosario Dominicana and makes them available as soft loans for forestry development projects. However, until the profitability of growing trees is determined and until more harvesting permits are granted, there is likely to be little demand for forestry loans. In 1980 about $600,000 were lent through the Forestry Fund to Plan Sierra for coffee plantations. In the future, efforts will need to be intensified to channel this money to specific forestry projects instead of institutions.

Human Resources

A noteworthy feature of FORESTA is that it appears to be a field oriented organization with commitment to on-site vigilance and protection rather than a top-heavy, central office bureaucracy. Although it was not possible to obtain a current breakdown of FORESTA employees by responsibility and location of assignment, an accounting made in 1976 showed 840 employees, 784 (92%) of whom were assigned to district offices. The situation is not thought to have changed much since then.

In terms of sheer numbers, FORESTA does not appear to be badly staffed. However, there is an obvious shortage of professionally-trained people. In 1976 there were only two engineers, two lawyers, and one professional forester with a B.S. degree, all in the central office. At a minimum, it would be desirable to have at least one professional forester at each district office and an additional five or six for special projects and central office administration of technical programs.

The need for additional training at the university level was recognized by a team of two foresters from Texas A&M University who visited the Dominican Republic recently on the behalf of AID. It is possible that a follow-up to their mission will include forestry training of some Dominicans in the US.

The Dominican Government also recognized the need for future training, and in 1980 FORESTA reopened the forestry school Escuela Nacional Forestal "Dennis Stamers Smith" at Jarabacoa. The school trains forest guards in a few weeks and forest technicians in two years. About 18 technicians are expected to be graduated annually. In addition, twelve Dominican students will be sent to Honduras during 1981-85 to attend the three-year technical school Escuela Nacional de Ciencias Forestales at Siguatepeque.

University-level training in agronomy with specialization in forestry is available at the Universidad Catolica Madre y Maestra in conjunction with the Instituto Superior de Agricultura in Santiago. This is a five-year program. The first forestry class was given in 1978, and in 1980, 15 students were enrolled in the forestry option. Students receive both practical and academic training. The program is off to an excellent start, but should not at present be considered as substitute for a B.S. degree in forestry. There is a need to strengthen the teaching staff and curriculum as well as a need for more equipment and laboratory facilities, particularly in wood technology. The program could benefit greatly from outside aid.

Foreign Assistance

At present the only foreign assistance to the forestry sector is that provided to FORESTA by IDB, as earlier described. Prior to this, the principal aid project was that operated by FAO and UNDP with FORESTA from 1968 to 1972. The main objectives were to 1) inventory the nation's forest resources, 2) plan the protection, development and utilization of forest resources, and 3) train FORESTA personnel. The only other assistance in forestry was that offered by AID in the mid-sixties to help establish the forestry school, which was subsequently assisted by the FAO/UNDP project.

Other Government Institutions Involved in Forestry

Conflicts and Constraints

The Military. The role of the military in FORESTA is an obvious point of political contention in the country. Recently a bill was vetoed by the president which would have removed FORESTA from the armed forces and returned it to SEA, but which would have provided for military assistance in vigilance and law enforcement. Military involvement in the operation of forest services and other agencies is not unique to the Dominican Republic and should not be viewed with outright alarm. For one, the military has been highly effective in slowing the rate of forest destruction and must be credited with saving most of the remaining natural forests in the higher catchment areas of mountainous regions, particularly in the Cordillera Central. Second, the direct line that the director-general of FORESTA has to the president can be a decided advantage in decreasing governmental red tape and in gaining support for programs. However, for this to be a beneficial arrangement it requires 1) that the director-general cultivate an active concern for the operations of FORESTA, and 2) that he receive sound technical advice from his subordinates. A dedicated military with direct access to the president and supported by well-trained civilian foresters could, in theory, be a highly effective arrangement. In practice, it appears that FORESTA has been more content to maintain the *status quo* by continuing with some vigilance and only a small rehabilitation program than to engage in active forest management. Whether the fault lies with the military leadership or with an undertrained staff is open to conjecture; certainly it is at least in part due to the latter and more likely than not may be due to both.

Professional Staff. There is an obvious and urgent need for more highly trained staff throughout FORESTA, from top to bottom, and especially for more professional, university-trained foresters. Lack of qualified staff has clearly limited the implementation of some programs and has probably caused fewer project proposals and suggestions to be passed to the directorship for consideration.

Forester as Leader. In particular there is a need for a professional forester with demonstrated leadership capabilities to direct the day-to-day operation of FORESTA. This need not be done at the expense of the military, but could be accomplished by a reorganization which would make the forester responsible for technical and administrative programs but answerable directly to the director-general.

Land Tenure. Poor definition of national land, as opposed to private ones, has hampered field activities. Those lands where FORESTA can operate directly and imperviously need to be physically marked on the ground, mapped and patrolled. This has been covered earlier.

Public Relations Program. As covered earlier, development of conservation measures on private lands has been hampered by the lack of an incentive program and a promotional campaign to educate people in improved land use.

Lack of Technical Information. Management of both state and private lands has been inhibited by a lack of technical information. There is no research organization and no one engaged in any form of scientific research. What little has been accomplished to date has been done haphazardly by trial and error. With the possible exception of *Pinus occidentalis* and *P. caribaea*, for example, in most cases there is little evidence to suggest which species and sources should be planted on which sites for different objectives, and there is no data on either biological or economic productivity.

The Law. The laws restricting the harvest and commerce of timber crops have created an environmental/developmental conflict of sizable proportions. The laws have no doubt been a boon to the general environment, but at the expense of short-term economic development which would have been fostered by forest industries. They have also resulted in the *de facto* limitation of the scope of FORESTA's activities to protection and conservation and the inhibition of integrated forest management. Once FORESTA is able to build up a qualified professional and technical cadre and improve its vigilance of forest lands, it should be possible and desirable to loosen the controls on cutting to permit the implementation of sound forest management plans, including harvesting, where it can be done without undue damage to the environment. with confidence that forests may be harvested, private landowners would also be encouraged to engage in reforestation.

Recommendations

1. FORESTA should continue to try to upgrade the professional and technical level of its staff by strengthening the forestry school at Jarabacoa and by seeking study grants for qualified students to seek professional degrees outside the country. In-service refresher training should also be pursued for existing staff, especially by offering short courses. FORESTA should explore all existing channels to provide scholarships for Dominican foresters to study overseas. They should also seek teaching assistance and equipment.

2. FORESTA, with international assistance, should create a small research unit whose initial priorities would be to 1) establish species-site studies of tree species suitable for agroforestry, erosion control, fuel wood and industrial wood, 2) obtain growth and yield data from existing plantations, and 3) determine the profitability of reforestation, especially for fuel wood, agroforestry, and industrial products.

3. FORESTA, with the cooperation of other government agencies and with technical and financial assistance from international donors should immediately begin pilot-scale integrated land management projects on critical watersheds, especially on private land.

4. Where cut-over government lands can be protected from trespassers and sufficient soil remains, FORESTA should expand its reforestation program to reduce erosion and to restore the land to a productive use.

5. FORESTA should launch a public relations program which would include use of extension techniques, the mass media and the school systems to educate the public on the value of conservation. This should be supported with an incentive program to encourage tree planting.

6. FORESTA should continue and expand the issuing of thinning permits and should start approving some harvesting permits on private lands under government supervision.

V

Water Resources & Watershed Management

Introduction

In addition to environmental problems related to use of water resources and the impact of land use within watersheds there are multiple water uses and problems related to hydropower, water supply, irrigation, drainage, flooding, etc. Within river basin systems the characteristics of water supply and demand are changing. Water quality and streamflow regimes are also dynamic, being closely linked to human activities in the river basins and to the degree of stability and protection of the watersheds.

Numerous comprehensive studies, in some cases consisting of several volumes each, have been written on general aspects of Dominican water resources, e.g. OAS 1967, Boyle 1971, PLANIMEX 1978, INDRHI-BID 1978, Bromley and Crosson 1978, Figueroa 1978 and CONARENA 1979. De La Fuente (1976) summarizes the basic information on general hydrography. Similarly, numerous specific studies on projects, river systems or watershed problems also exist (e.g. Italo-Consult 1972, Hanson-Rodriguez 1973, Tahal 1977, ONAPLAN 1978, Hydrocomp 1979, Dourojeanni 1980, and Anon. 1980).

This chapter does not attempt to summarize the voluminous technical information nor to reproduce published material. Rather, the author wishes to capitalize mainly on his experiences derived from several field trips throughout most of the accessible Dominican Republic, and the many hours of very productive interviews with key people in several institutions dealing either with water resources and/or watershed management. This diagnostic approach provides an updated version of environmental problems, particularly as they have evolved since Hurricanes David and Frederic, and will contribute to the perception of specific problems dealing with present and future uses of water resources.

The Role of Water Resources

Water continues to be a key element in the development process of any nation, as well as an irreplaceable resource for improving or maintaining the quality of life. The rise and fall of most of the so-called ancient riverine civilizations was closely linked to the wise or unwise management of their soil and water resources (Carter and Dale 1974; Hughes 1975).

The goals of the 1980-82 Agricultural Development Plan (SEA 1979) are: 1) to improve agricultural production in rural areas so that more food can be grown both for internal consumption as well as for generating exports to help pay the cost of increasing oil imports; 2) creating permanent jobs for the landless peasants; and 3) to decrease the dependency on petroleum products by generating more local electricity from hydropower. It is obvious that water resources development must play the key role in achieving these goals. As a matter of fact, no more land can be put into intensive use unless irrigation is available, no new swamplands or saline areas can be reclaimed unless a sound program of soil and water management is established through irrigation and drainage, and no more energy can be obtained from the relatively abundant hydropower resources still untapped within the country unless costly new dams are built on rivers with an adequate supply of good quality water.

However, it must be remembered that inland fresh water resources are nothing more than the output response of the watershed system to precipitation. Thus, watershed characteristics such as topography,climate, geology, soil, river morphology, and vegetation cover, and what goes on within the watershed boundaries in terms of man-related activities, particularly land use (Fig. V-1), will have significant effects on the type of water resources that a particular society must depend on, now and in the future. It is within the perspective of integrated natural resources management using the watershed system as the base, that the important role of water in the socio-economic development of the Dominican Republic should be viewed. This approach will lead to appreciation of the importance of water as a catalyst to development and the necessity to keep the resource in good condition to insure sustained benefits from it.

To fully understand the critical economic situation of the Dominican Republic and the role of water resources projects in helping to alleviate it, two economic aspects are relevent: 1) the escalating balance of payments deficit, largely induced by increasing petroleum imports and 2) the investments in water resources projects for the 1980-82 three-year plan (Table V-1). The three-year projected investments associated with water related projects amount to almost 80% of the total export income generated by the Dominican Republic during 1978. Obviously, under any circumstance but especially under the unfavorable national economic situation, actions (institutional and fiscal) should be taken to insure high, sustained productivity from these large and costly investments in water resources. The main issue is how many of the important existing water resources works (e.g. Fig V-2) as well as future ones will be able to serve their projected

Figure V-1a. *Watershed degradation on the southern flank of the Cordillera Central caused by massive deforestation, erosion and hurricane-induced landslides. Though there is an almost complete absence of houses, slash and burn agriculturalists practice shifting cultivation for seasonal crops on these steep slopes. (Photo, Italo Russo.)*

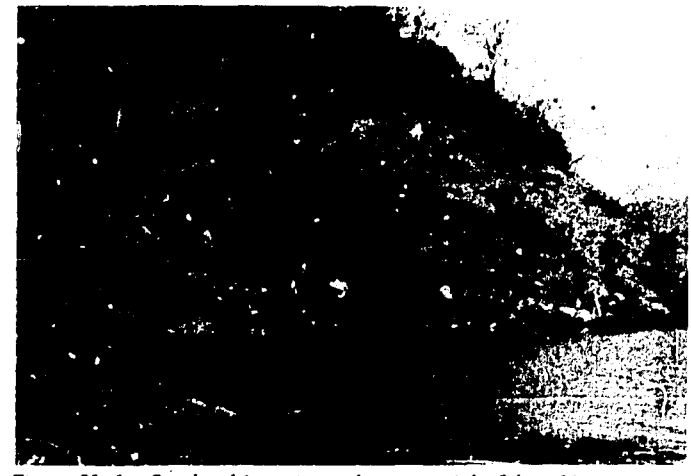


Figure V-1b. *Complete deforestation at the margin of the Sabana Yegua reservoir. The wood is used to make charcoal. Note the debris in the lake (foreground). The men fishing for tilapia were former small farmers displaced by the filling of the reservoir. (Photo, Stanley Heckadon.)*

economic life, and if they will ever attain the rates of returns and other secondary benefits anticipated in their investments.

The actual situation of widespread watershed destruction, high river silt loads, present instability and unpredictability of some of the most important fluvial systems, and heavy silting of existing reservoirs and canals seem to indicate that only a major effort to effectively carry out massive watershed protection and erosion control can guarantee that many of the future investments may turn out to be productive. However, even if immediate appropriate actions are taken, the lag time needed for them to be implemented and be effective, does not guarantee that some existing projects such as Tavera or Valdesia can be salvaged or recuperated. The Dominican Republic is in the path of destructive hurricanes and tropical storms and many of its soils are highly erodable, hence contingency plans must be made for the probability of future destructive events. even if massive watershed protection and erosion control are soon undertaken.

Although immediate needs must be somehow satisfied, long term economic losses and benefits, including some of the irreversible social costs imposed on future generations, should be accounted for in the planning efforts. Planning must certainly go well beyond the usual four year political promises to win an election. Some of the planning efforts should aim for long term watershed rehabilitation and consolidation of costly existing projects that are now operating well below their potential, such as several of the large irrigation systems in the Cibao and in Azua.

Resource Base

Hydrographic Units

The physiographic characeristics and orientation of the mountain ranges and valleys of the Dominican Republic determine hydrography and highly influence climate. Four mountain ranges running parallel to each other and oriented in an east-west direction with flat valleys between define drainage units of the main river systems whose headwaters originate in the mountains in the western and central part (see Fig. II-1 of the Dominican Republic).

Between these four mountain ranges three agriculturally important valleys occur with different precipitation characteristics. The Cibao Valley located between the northern and central mountain ranges contains the two most important river systems in the Dominican Republic, the Yaque del Norte and the Yuna Rivers. The Cibao Valley is the richest agricultural area and, except for Santo Domingo, has the highest concentration of population. Second in importance is the fertile San Juan Valley between the cordillera Central and the Sierra de Neiba. This valley is irrigated by the Yaque del Sur River and its tributaries. The hot, dry Neiba Valley extends between the Sierra de Neiba and the Sierra de Bahoruco, and includes the below sea level, saline Enriquillo Lake. In some parts of the country such as the Azura plain and the karst topography of Los Haitises, streams actually disappear before reaching the sea.

The central mountain range is by far the most important. It is the highest mountain range in the Antilles and from it originate the three important river systems of the Dominican Republic: The Yaque del Norte, the Yuna, and the Yaque del Sur.

Running first north and then west through the Cibao, the Yaque del Norte River has a length of 296 km and drains a watershed of 7044 km² or about 15% of the country. Precipation in this watershed ranges between 500 and 2000 mm per year, amounting to approximately 9169 x 10^6 m³/year; average annual flow is on the order of 2017 x 10^6 m³/year or about 64 m³/second. This river system contains the largest irrigation network in the country and has great hydroelectric potential, a small part of which is now being utilized. The Tavera-Bao project will soon be completed, increasing the hydroelectric energy generated, helping to regulate more water for irrigation, and supplying additional domestic and industrial water for Santiago. One of the main problems with this river system is the high sediment load eroded from seriously deteriorated, steep watersheds.

The second largest river is the Yuna with a length of 209 km, draining 5498 km². From the Cordillera Central it runs east to Samana Bay, crossing one of the most humid regions of the country known as the Cibao Oriental. Average annual precipitation of this valley ranges between 1170 mm and 2256 mm. Average annual flow at Villa Riva is about 91 m³/second, with max-

Table V-1. Projected investments in water resources and energy related projects for the 1980-82 period (thermal plants excluded).

INSTITUTION	MILLIONS DR$
CAASD	49.9
INAPA	79.2
CDE	168.6
INDRHI (Energy)	37.5
INDRHI (Agriculture)	189.6
	524.8

Table V-2. Characteristics of the hydrographic subdivisions of the Dominican Republic shown in Figure V-1. (Information adapted from UNEP 1979). **Not studied.

Hydrographic Subdivision	Location	Rivers Included	Precipitaion in mmyear	Area in Km2	Water Quality
1. Sierra de Bahoruco zone	South of the Sierra de Bahoruco	Pedernales and Nizalto	2,000 in the mountains, 750 on the plains	2,814	Shallow or poorly developed wells may contain chlorides
2. Azua, Bani and San Cristobal zones	South of the Central mountain range between the Yaque del Sur and the Ozama Rivers	Haina, Nigua, Nizao, Ocoa and Bani	750-2,000	4,460	Ground waters show good potential
3. Ozama River basin	Santo Domingo area	Ozama, Yabacao Canal	1,400-2,250	2,706	Poor water quality because of the high concentration of solids in suspension, micro-organisms and dissolved gases.
4. San Pedro Macoris and La Romana	San Pedro Macoris zone	Chavon, Dulce, Soco, Cumayasa, Macrois	1,000-2,250	4,626	High degree of erosion and dredging of sediments.
5. Higuey zone	Higuey and San Rafael del Yuma areas	Yuma	1,000-1,750	2,207	Good water quality; positive potential for use.
6. Miches and Sabana de la Mar zone	Miches zone	Small rivers	2,000-2,700	2,265	Good ground water potential.
7. Samana Peninsula zone	Samaná	— (**)	— (**)	— (**)	— (**)
8. Northern coast zone	Atlantic coast zone	Boba, Nagua, San Juan, Yasica, Bajabonico	1,000-2,300	4,266	Good water quality.
9. Yuna river basin	Central mountain range to the Bay of Samana	Jima, Camu, Yuna	1,170-2,250	5,630	Problems caused by poor drainage and salinity. Good potential in deep wells.
10. Dajabon river basin	Central mountain range	—	750-2,000	858	Good for agricultural uses.
11. Yaque del Sur Basin	Central mountain range. Sierra Neyba and Martin	San Juan, Hijo del Medio, Las Cuevas and Los Baos	700-1,500	5,345	Good water quality but contains many solids in suspension.
12. Hoyo del Lago Enriquillo	Lago Enriquillo	Guayabal, Las Damas, Marguita, Barrero, Arro, Los Pinos	Very arid zone	3,048	Waters of moderate agricultural yield.
13. Artibonito River basin	Near Haitian border	Macaria	1,200-2,000	2,643	Good water quality but contains many solids in suspension.
14. Yaque del Norte basin	Yaque del Norte	Yaque del Norte	500-2,000	7,053	Poor water quality; contains solids in suspension and numerous micro-organisms.

imum monthly flows averaging 162 and 114 m³/second in May and November, respectively, and 57 and 42 m³/second in January and July, respectively. This river experiences cyclic floods every two or three years. Especially during the rainy season, the river carries very high silt loads that obstruct the existing irrigation canals and aggrade the river bed, accentuating the flooding problems (de La Fuente 1976).

Ending in Neiba Bay near Barahona, the Yaque del Sur River drains an area of 4972 km² with an approximate length of 183 km. With the highest (2707 m) headwaters in the country the Yaque del Sur drains the southern flank of the cordillera Central and part of the Sierra de Neiba. This river runs across an arid and semi-arid region with precipitation of 500 to 1200 mm/year. The rainfall patterns in this watershed vary greatly in the uplands and from year to year (de La Fuente 1976). Due to an abundance of shallow soils and sparse vegetation, watershed response to precipitation is rather quick, causing serious floods associated with high intensity storms.

Although there are at least three different maps of the hydrographic subdivisions of the Dominican Republic, the most appro-

Figure V-2. *The Sabaneta reservoir and its deforested watershed. Note the sediments entering the reservoir from the quarry on the right margin. (Hand-held aerial photo, Carlos Quesada.)*

priate for the purpose of this work is the one (Fig. V-3) prepared by OAS (1967). Table V-2 presents a brief description of the main characteristics of this hydrographic system (UNEP 1979). Information on the Samana Peninsula is lacking because the area is not among the priorities for hydrologic studies due to a lack of water demand or useful availability.

The Dominican Republic possesses national and regional climatological and hydrometric networks that exceed the specifications and recommendations of the World Meteorological Organization (Salas 1980). The major Dominican Republic watersheds have probably received more attention than other Latin American countries. They have been studied extensively by PLANIMEX (1976) including basic data and regional plans at a project level, several specific studies for the Yaque del Norte River, a peliminary study of the water resources for the Yaque del Norte, Cajabon, and Chacuey Rivers (PLANIMEX 1975) and others (e.g. de La Cruz de Suazo et al. 1972; CDE 1972). The Yuna River has also been studied at different levels of detail, from the multiple purpose general reconnaissance study by Tahal (1967), to more specific ones such as those by Hansen-Rodriguez (1973) on the feasibility of the Alto Yuna and Hatillo dam. There is also a ten volume report by Tahal (1977) on the lower Yuna. Similarly, several general and detailed reports (e.g. a seven-volume study made by SOGREAH, 1978) concern the multiple development of the Yaque del Norte and the Yaque del Sur watersheds. A later five-volume study by ITALO-CONSULT (1972) was dedicated specifically to the Yaque del Sur. Several other specific studies can be found in the literature on hydroelectric projects, irrigation systems and flooding problems for most of the major river systems in the Dominican Republic.

Smaller river systems have also been studied by Parsons Corporation (1967), and an important plan for water resources development, including possible uses both for water supply and hydropower purposes, in the neighborhood of Santo Domingo was made by Boyle Engineering (1972). PLANIACAS (1978) and Figueroa (1978) have studied groundwater resources. Regional water quality studies both for superficial and groundwater are available (CENDA 1979).

The available information on Dominican river systems has served as a good basis for more detailed studies and information syntheses now being used in the preparation of comprehensive water resources planning and development, such as in the regional studies by ONAPLAN. Serious inter-institutional conflicts must be solved before realistic integrated and comprehensive large scale watershed protection and rehabilitation programs can be started in order to guarantee the effectiveness and usefulness of the many existing and future water resources projects.

Hydrometeorology and Precipitation

Most hydrometeorological data are collected by INDRHI, the Meteorological Department, and the CEA (State Sugar Council). there are 96 climatological stations operated by INDRHI and 72 by the Meteorological Department (PLANIACAS 1978). The INDRHI network consists of 7 first order climatological stations, 29 secondary climatological stations, 31 non-recording rain gauges and 6 recording cumulative rain gauges. The Meteorological Service network consists of 6 agroclimatological stations and 66 stations to record daily temperature and rainfall. Stream gauge measurements are conducted by INDRI at 124 stations throughout the country. Fifty-three of these are continuous recording stream gauges and the remaining 71 are non-recording fixed gauges.

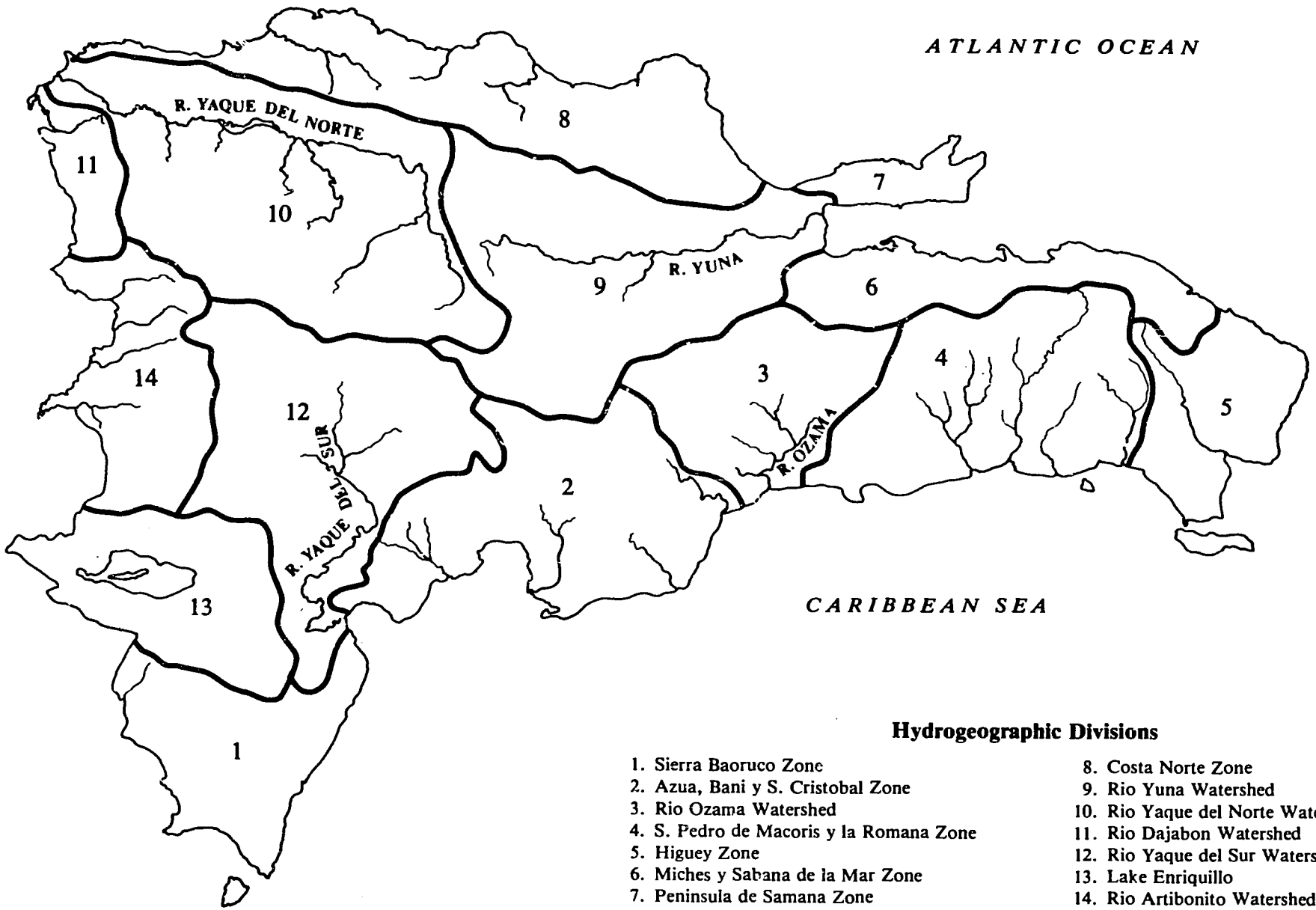
Although the country's hydrometeorological network exceeds the WMO standards, the quality of data has not been evaluated, thereby limiting its use. Deficiencies are found in the collection, processing retrieval, publication, and analysis of data (Salas 1980). Many of these deficiencies are apparently the result of lack of capital and human resources, as well as inter-institutional duplication.

Better trained hydrologists could use the available information more effectively. Even though new equipment started generating data in 1975, they are still basically unavailable because of lack of processing and publication. With today's computer and software technology this type of information could be easily updated every other year. Nevertheless, there are indications that corrective steps will be taken in the near future (INDRHI and Meteorological Department, pers. comm.).

An excellent inter-institutional effort produced an isoerosivity map (Fig. V-4) based on maximum rainfall intensity and erosivity of rainfall for 30 selected meteorological stations (SEA 1978). Independent of its precision, this map is useful as an assessment tool regarding the relative erosivity between different locations and regions in the Dominican Republic.

Surface Runoff

Based on OAS (1967) data for 14 hydrographic units, de La Fuente (1976) estimated mean annual discharge of 14.8 x 109 m^3/year. However, PLANIACAS estimates the surface runoff to the 20 x 109 m^3/year. Of the latter amount, about 3.5 x 109 m^3/year are expected to be stored in existing and projected dams. Table V-3 presents an estimation of the surface water resources by hydrographic zone as presented by the World Bank. This value agrees very closely with the estimates of PLANIACAS (1978). Regulated surface runoff plays its most important role in the irrigation and hydropower, while the industrial and domestic sectors depend more on groundwater.



Hydrogeographic Divisions

1. Sierra Baoruco Zone
2. Azua, Bani y S. Cristobal Zone
3. Rio Ozama Watershed
4. S. Pedro de Macoris y la Romana Zone
5. Higuey Zone
6. Miches y Sabana de la Mar Zone
7. Peninsula de Samana Zone
8. Costa Norte Zone
9. Rio Yuna Watershed
10. Rio Yaque del Norte Watershed
11. Rio Dajabon Watershed
12. Rio Yaque del Sur Watershed
13. Lake Enriquillo
14. Rio Artibonito Watershed

Figure V-3. *Hydrogeographic divisions and watersheds. (OAS 1967.)*

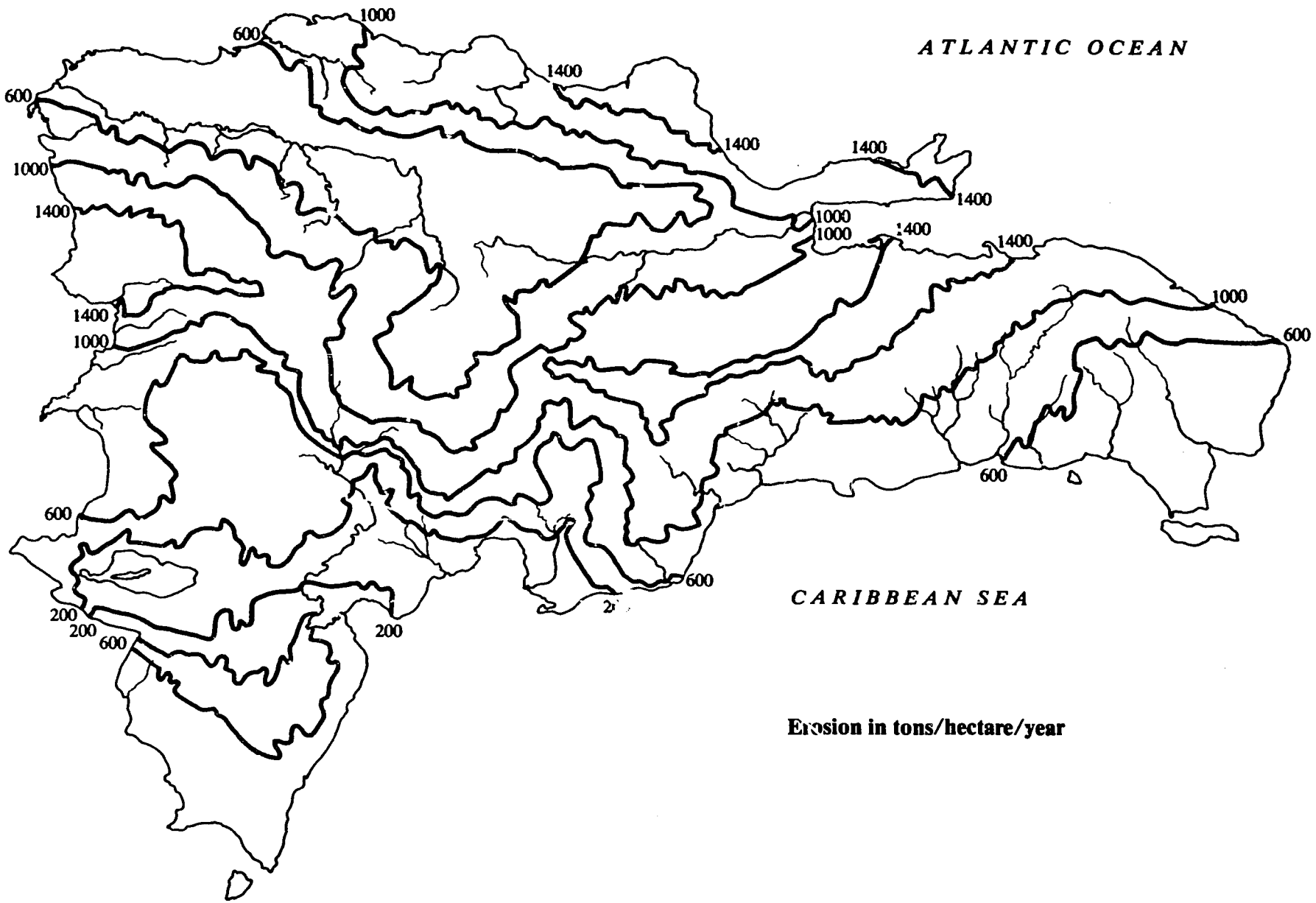


Figure V-4. *Iscrosivity map for the Dominican Republic.*

An important thou gh undetermined number of people make direct use of stream waters, especially those in the lowest income level in rural areas not connected to any type of aqueducts (pers. observation).

Many water resources projects will be needed in the future to enhance economic development through hydropower, irrigation, and industrial and domestic supplies. Water for recreational uses could also become somewhat important in the future. Most regulations of important surface waters require expensive works which depend, for their effective functioning, not only on water quantity but also its quality.

A great deal of hope has been placed in existing or projected water resources projects, but not enough consideration has been given to the silt loads that these rivers are carrying. At this point, it is appropriate to quote Eric Eckholm (1976):

> Engineers build one dam after another, paying only modest heed to the farming practices and deforestation upstream that will, by influencing river silt loads, determine the dam's life span.

Groundwater

An estimated 1500 x 10^6 m^3/year of groundwater recharge the three important aquifers of the Dominican Republic (PLANIACAS 1978). Most of it circulates within the tertiary limestones. Further studies to be carried out as part of the PLANIACAS project will provide more precise information on the groundwater resources. In general, the groundwater quality is good except in some coastal areas where saline intrusion has taken place. Low areas such as the Neiba Valley also experience groundwater salinity problems.

There are 4000 to 5000 wells in the country, of which about 30% are out of order. About 75% of the wells are estimated to be registered. Annual extraction of groundwater is estimated at 500 x 10^6 m^3. About 50% of the wells have a discharge of less than 80 l/minute and 30% have a depth less than 25 meters; the deepest wells barely exceed 200 meters.

As more pressures are put on surface water resources, the groundwater resources may play an increasing role in meeting the requirements, particularly for irrigation. Already groundwater resources contribute largely to meet important demands in the domestic and industrial sectors. PLANIACAS projections from the mid-1970's to 1985 suggest demands will increase by 71% for potable water, 39% for industrial uses and 80% for agricultural uses (Table V-4). The substantially increasing demands for potable and agricultural uses (primarily irrigation in the latter case) are putting considerable pressure on the major aquifers and surface waters. These critical water resources are the keystone to continued development and socio-economic progress of the Dominican Republic; hence they must be managed in the most rational and sustainable form possible.

Table V-3. Surface water resources by hydrographic zone in the Dominican Republic. Source: World Bank (1978).

Zone	Area (ha)	Annual Rainfall (mm)	Annual Great Flow (billion m^3)
Sierra de Bahoruco	281,400	750-2,000	320
Azua, Bani, San Cristobal	446,000	750-2,250	1,516
Ozama River Basin	270,600	1,400-2,250	1,586
San Pedro de Macorís and La Romana	462,900	1,000-2,250	2,444
Higuey	220,700	1,000-1,750	609
Miches and Sabana del Mar	226,500	2,000-2,700	1,284
Samaná Peninsula	n.a.		
Northern Coastal Zone	426,600	1,000-2,300	3,870
Yuna River Basin	563,000	1,170-2,250	2,375
Yaque del Norte River Basin	705,300	500-2,000	2,017
Dajabon River Basin	85,800	750-2,000	370
Yaque del Sur River Basin	534,500	700-1,500	1,181
Lake Enriquillo Basin	304,800	600-1,200	312
Artibonito River Basin	265,300	1,200-2,000	1,190
TOTAL	4,793,400		19,074

Current and Projected Demands

General Comments

The economy of a country, its rate of development, and ultimately, the quality of its citizens' lives, are closely related to the availability and cost of energy. With the second escalation of the oil prices since 1977, and with the real possibility of severe shortages in the 1980's due to Middle East political instability and/or prices that could reach the fifty dollar a barrel mark in a not too distant future, it is reasonable to think that the evolving economic scenarios do not look promising at all. This situation will impose a severe burden on the less-developed oil-importing countries, not only because they may have to face the future with less energy but also because the increasing costs will keep accentuating the balance of payments deficit.

On the other hand, large capital investments may be mandatory in order to build infrastructure and develop options to mitigate this energy/financial crisis and to decrease international dependency. This contradiction of expecting to invest more with less available income and higher costs is taking place in countries like the Dominican Republic, and under these circumstances it is crucial to implement a highly efficient management of resources for the projects to be successful.

Many developing countries are facing economic and social pressures resulting from unsatisfied needs and wants. This dissatisfaction continues to expand because of rising expectations, appreciable population growth, and a decrease in relative prices between the exported primary products and the ever-expanding cost of both imported industrial commodities and the value of borrowed capital necessary to build developmental projects. Therefore, it is important to reevaluate how realistic the projections made a few years back have turned out to be and what changes need to be made to adjust actual and future production and projections according to the priorities and restrictions imposed by new economic and social circumstances. Regardless of accuracy, it must be realized that the more expensive the solutions and the higher the financial, operating, and maintenance costs, the higher the burden resulting from poor, unwise use of funds and of shorter useful life of projects affected by the deterioration of the natural resources on which they depend. It is therefore necessary to make every possible effort to insure that 1) the projects will prove to be technically and economically sound; 2) that the resources on which those projects depend are, as much as possible, maintained or upgraded and 3) that the projects are efficiently operated.

Irrigation

There isn't a precise figure of how much land is currently irrigated in the Dominican Republic. The literature and water resources specialists provide conflicting information for there is no updated map of the area under irrigation nor a reliable layout of the main irrigation canals. Probably the most reliable figures are those of INDRHI indicating about 170,000 ha irrigated in 1980. An additional 100,000 ha are expected to be irrigated by 1985, and it is estimated (depending upon soil studies) that the total potential irrigated land could be as much as 500,000 ha (Reynoso and Encarnacion 1980).

Table V-5 indicates the land irrigated in 1978 as well as projections for 1985 and the total potential land for irrigation where

Table V-4. Hydrogeologic zones, water demands and water resources in the Dominican Republic (Adapted from PLANIACAS 1978).

			Irrigated		Demand (10^6 m^3/year)						Water Resources						
											Surface		Subterranean				
Zone Number	Hydrogeologic Zone	Area (km^2)	Actual (km^2)	Potential (km^2)	Potable 1977	Potable 1985	Industry 1974	Industry 1985	Agriculture 1975	Agriculture 1985	Principal Rivers	Runoff (m^3/sec)	Aquifer	Area (km^2)	Well Depth (m)	Expected Flow (l/min)	Other Criteria
1	Eastern Coastal Plain	6872	128	428	80.0	137.0	6.0	10.2	60	210.0	Nizao, Haina, Ozama, Soco, Chavon, Yuma, Guamo	90	Alluvium Marine Limestone Lake sediments	414 5163 1258	50 100 —	600 800 40	Danger of saline instrusion
2	Eastern Cordillera	2910	—	77	9.0	15.9	—	—	—	8.0	—	10	Alluvium Igneous Faults	4 2435	20 50	100 40	Insignificant demand Minimal groundwater resources
3	Los Haitises	1452	—	—	3.5	5.9	—	—	—	—	—	4	Tert. Limestone	1415	100-500	100-500	Potential aquifer, no demand
4	Samana	627	4	4	3.8	6.5	0.3	0.5	4.0	4.0	—	5	Alluvium Marine Limestone	79 106	100 20-30	20-200 300	Insignificant demand
5	Norhern Cordillera and Valleys	4951	30	100	18.0	31.3	10.0	17.0	4.0	10.0	Bajobonico, Yasica, Boba	62	Alluvium Marine Limestone Tert. Limestone	178 250 924	50 50 100	250 300 50-200	High rainfall Supplies local demand
6	Cibao Valley	6304	635	1162	85.0	144.0	10.4	16.0	425.0	780.0	Yaque del Norte, Yuna	74 90	Alluvium Tert. Sediments	1416 1371	60 100	100-200 100	West is semi-arid Inadequate surface waters
7	Central Cordillera	14590	90	218	40.0	65.5	8.1	13.5	5.0	11.0	Upper Yaque Norte Upper Yaque Sur Upper Yuna	18 8 35	Alluvium Tert. Sediments Igneous Faults	545 414 10553	50 100 50	400 50 20	High rainfall Supplies local demand
8	San Juan Valley	1735	178	298	13.0	22.6	—	—	120.0	200.0	Macasia, San Juan	7 8	Alluvium Tert. Sediments	764 582	50 50	100 50	Agricultural demands supplied by surface waters
9	Neiba Hills	2496	39	120	2.5	4.7	—	—	3.0	12.0	Yaque del Sur	50	Alluvium Tert. Limestone	43 2174	100 150-400	100 800	Potential aquifer supplies for zone 10
10	Neiba Valley	2012	154	264	13.0	23.0	4.7	7.6	160.0	280.0	Yaque del Sur	50	Alluvium Marine Limestone	690 26	50 25	300 100	Semi-arid Inadequate surface waters
11	Bahoruco Hills	2433	2	2	1.5	2.4	—	—	1.0	1.0	Pedernales, Nizaito	6	Tert. Limestone	2302	150-300	800	Potential aquifer supplies for zones 10 and 12
12	South Peninsula	1030	10	59	0.8	1.5	1.0	1.6	2.0	5.0	—	2	Tert. Limestone	1782	100-200	400	Irrigation demand Proximity to good aquifer
13	Azua Plain	564	55	123	6.4	11.0	0.3	0.4	60.0	88.0	—	2	Alluvium	513	100	200	Demand met by surface waters
14	Bani Plain	466	80	140	5.5	9.6	0.2	0.3	55.0	95.0	Ocoa	6	Alluvium	926	50	200	Irrigation demand
	TOTAL	48442	1405	2995	282.0	480.9	41.0	67.1	701.0	1263.0							

Table V-5. Actual and potential land for irrigation. (Source: PLANIACAS 1978).

Hydrogeologic Zone	Actual area under Irrigation	Total Area Expected to be Irrigated by 1985	Additional Area with Potential for Irrigation	Total Potential Land for Irrigation
Oriental Coastal Plains	12,800 ha	42,800 ha	50,000 ha	92,800 ha
Oriental Mountain Range	—	7,700	10,000	17,000
Los Haitises	—	—	—	—
Samaná Peninsula	400	400	—	—
Northern Mountain Range and Atlantic Coast	3,000	10,000	15,000	25,000
Cibao Valley	63,500	116,200	100,000	216,200
Central Mountain Range	9,000	21,800	30,000	51,800
San Juan Valley	17,800	29,800	20,000	49,800
Neiba Mountain Range	3,900	12,000	—	12,000
Neiba Valley	15,400	26,400	20,000	46,400
Bahoruco Mountain Range	240	240	—	240
Barahona Southern Peninsula	975	5,875	—	5,875
Azua Valley	5,500	12,310	5,000	17,310
Bani Valley	8,000	14,000	4,000	18,000
TOTAL	140,515 ha	299,525 ha	254,000 ha	552,426 ha

soil conditions permit. More detailed information on irrigated land by resource production units (RPU's) and types of crops cultivated is given by Bromley and Crosson (1978). Their total of 192,000 ha of irrigated land in 1978 differs from INDRHI's figure of 170,000 ha and the World Bank's estimate of 153,600 ha.

Hydropower

The installed electrical capacity (1980) is 683 Megawatts (mw) under CDE control plus about 367 Mw generated by several industries (Table V-6). Of the total installed capacity, only 15% is generated by hydropower, produced mainly from the Tavera and Valdesia reservoirs, with 80 and 54 Mw of generating capacity, respectively. Both reservoirs have been subjected to heavy silting due to the poor conditions of the watersheds. The effects of hurricanes David and Frederic on the gates of the Valdesia reservoir and the flooding of the Tavera powerhouse significantly reduced their original capacity and operation.

The electric industry has been going through a critical period of severe rationing in the last few years because of delays in the installation of additional units, lack of proper maintenance of the thermal units, and the excessive draw-down of the Tavera and Valdesia reservoirs (World Bank 1978). Frequent blackouts are now normal even in Santo Domingo.

Projects under construction with completion planned for 1983 will almost double the existing hydropower generation capacity in the Dominican Republic. A list of these projects, their expected year of completion, and energy in GWH are given below:

Hydroelectric Project	GWH
Bao, 1981	110
Hatillo, 1982	40.9
Sabaneta, 1983	30

A recent study on energy strategies (CNPE 1980) lists 14 projects that could be completed by 1987 if funding of a hundred million dollars per year were available. These projects would add 450 Mw of new installed capacity, almost a threefold increase in existing hydropower capacity. Annual generation would be approximately 1110 GWH. This same study lists 18 additional projects that could be completed by 1990 with additional funding of some $1400 million. These projects would add 860.6 Mw of additional installed capacity and an increase of 2586 GWH in annual generation. The CNEP (1980) figures should be carefully checked and taken with precaution since the Sabana Yegua dam is listed for completion by 1990 when in fact it is already built.

Although many hydroelectric projects are proposed, it remains to be seen if the country has the capacity to undertake so many

Table V-6. Installed electricity capacity, 1980. (Source: CNEP 1980)

	MW
Corporacion Dominicana de Electricidad (CDE)	
Hydro	159
Steam plants (fuel oil)	377
Gas turbines (diesel)	147
TOTAL CDE	683
Industrial Generation	
Falconbridge	90
Sugar Industry	ca.100
Emergency Generators	177
TOTAL INDUSTRIAL GENERATION	367

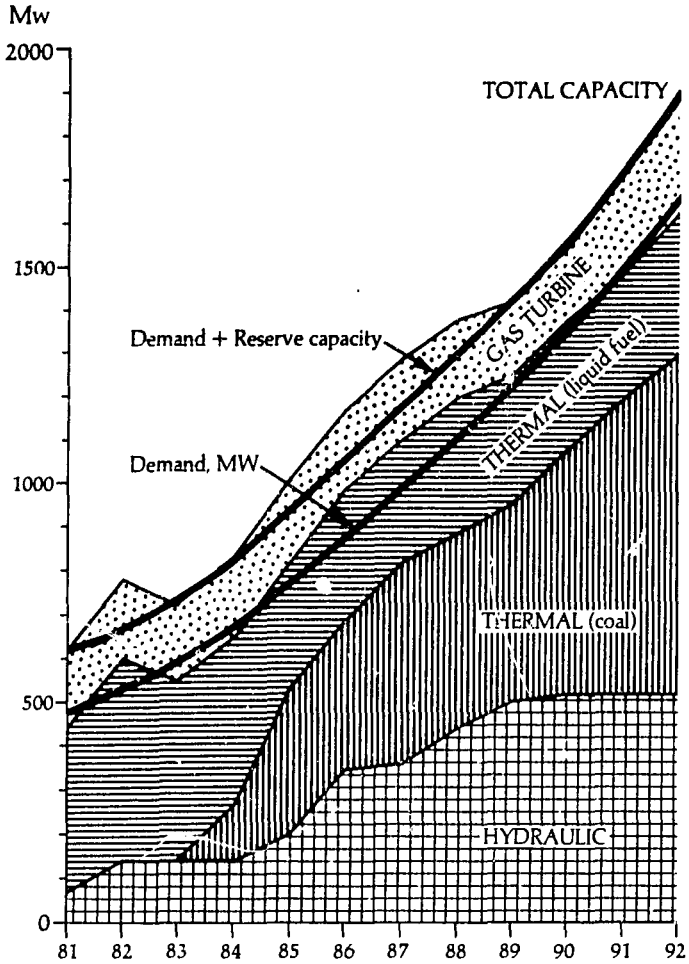


Figure V-5. *Power balance projections of energy demands to 1982. (SOFRELEC 1980.)*

major projects in such a short time, since they demand a great deal of organization, human resources and capital availability. Despite all these, the implications are that with enough funding at hand and proper organization, the Dominican Republic could probably increase its generation capacity tenfold in a ten year period. One aspect that must be addressed if these expectations are to be fulfilled is the critical problem of watershed deterioration. Two questions must be raised: 1) Will some funding proportional to the projected investments in hydropower generation be available for watershed protection and rehabilitation? 2) Will the decision makers, economists, engineers, and lending institutions realize that silting rates, increased danger of flooding, and decreased base-flow significantly alter the economic or technical feasibility of hydropower projects? These questions must be given serious consideration in order to assure the success of the hydroelectric and irrigation projects.

The number of projects either in the design process or in preliminary study indicates that the Dominican Republic has enough resources to help mitigate, on a short-term basis, the so-called energy crisis, at least in the electrical sector. Despite the existing potential hydropower estimates, the figures could change because of the unfeasibility in some projects. On the other hand, there may be some hydropower projects not yet identified, and additional energy could be generated through systems optimization, pump storage, or the development of small hydroelectric projects not yet considered. Besides hydropower, water resources projects also play an important part in providing water for irrigation and in meeting domestic and industrial demands, as well as in helping to control flooding.

The scenarios (CNEP 1980) calling for massive investments in hydropower that would lead to total installed capacity of 1460 Mw by 1990 contrast with the demand and supply scenarios presented by SOFRELEC (1980) shown in Figure V-5. The SOFRELEC study shows that after 1984, emphasis is placed on coal-fueled thermal plants and that by 1990 about 1500 Mw of total installed power capacity is required, of which only about 1/3 will be met by hydropower generation amounting to some 500 Mw of installed capacity.

The SOFRELEC emphasis on thermal units raises the question of whether the Dominican Republic can afford, in the future, to import the necessary coal and oil required, given the expected escalation in their prices, while still depending on its agricultural projects to earn the much needed foreign exchange. One aspect that is not clear with regard to total demand considerations is the projected demand for charcoal and its supply potential. This consideration could lead to a much larger amount of biomass energy required if the country were to face, as it probably will (unless massive fuel wood plantation is undertaken), a drastic reduction in supply of charcoal and wood in future years. The study by SOFRELEC (1980) does not include alternative options to switch away from non-renewable sources of energy. Therefore, studies and research should emphasize non-conventional energy options to reduce energy dependency, even though these new technologies may not be currently feasible from the economic standpoint. Depending on world prices of energy, some of these appropriate technologies could become competitive in the future; however, hydropower is the alternative now.

The total potential capacity of hydropower resources in the Dominican Republic should be studied in an integrated and systematic way. At the present time, different institutions such as CDE and INDRHI are each considering or planning their independent projects, without taking into account what the effects of a project upstream can have on other projects downstream.

Municipal Water

The actual usage and future demands for municipal water are difficult to estimate because, besides population growth, they are tied to many cultural, economic, and technical factors. Water losses in some localities may exceed 50% depending on the condition of the aqueduct. An average value of 40% is used by INAPA (pers. comm.). Besides the losses, another important factor to consider is waste, especially in rural areas. In many localities people use up to 50% of the potable water in non-domestic activities, such as for livestock or for irrigating garden plots.

INAPA data (Table V-7) for 1970 and 1979 are estimations which in turn served as the basis to project the needs for 1985 and 1990. Other projections (Table V-8) on water demands in million cubic meters (MCM) by hydrogeologic zone and for population growth rates of 1.8% and 2.8% are based on estimated annual per capita use of 80 m^3. Expected industrial demand is projected to reach 255 MCM/year by 1995.

Two corporations independent of INAPA are responsible for the planning, design, construction, and operation of the potable water and sewer systems of the two largest urban centers and surrounding areas in Santo Domingo and Santiago. The Santo Domingo region is under the control of CAASD (Corporacion del Acueducto Alcantarillado de Santo Domingo), while the city of Santiago has CORAASAN.

A good picture of water resources requirements in the Santo Domingo area and the water supply projects to meet expected demands can be obtained in a study made by Boyle Engineering Corporation (1972) who prepared a master plan for the water resources usage in greater Santo Domingo.

According to CAASD sources, the number of people served by direct connections is about 940,000, amounting to 74% of the estimated 1980 population. Each connection serves an average of

Table V-7. Projected population served with potable water and sewage systems in the Dominican Republic. (Source: INAPA 1980)

	Diagnostic				Projection			
	1970*		1979*		1985		1990	
	No	%	No	%	No	%	No	%
Total Population	4,061,935	—	5,275,410	—	6,365,000	—	7,253,000	—
Urban Population	1,626,946	40	2,616,767	50	3,424,000	54	4,243,000	58
Rural Population	2,434,989	60	2,658,643	50	2,941,000	46	3,010,000	42
A. Potable water								
Population served with home connection					516,494	18	718,716	24
— Rural	117,568	5	273,828	10	1,981,396	58	2,674,885	63
— Urban	974,893	60	1,395,349	53				
Population served with close by connection								
— Rural	257,474	11	599,683	23	1,131,122	38	1,573,988	52
— Urban	406,736	25	836,036	32	929,007	27	1,143,815	27
B. Sewer Systems								
— Urban population served	258,000	16	648,271	25	1,302,117	38	1,846,989	44

*Estimation made by ONE, July 1

Table V-8. Projected urban, rural, and industrial demands for 1995 (MCM/year) in different hydrogeologic zones. Adapted from PLANIACAS 1978.

Hydrogeologic Zone	Urban and Rural Demand 1.8%*	Urban and Rural Demand 2.8%*	Industrial Demand
Oriental Coastal Plains	142.0	181.3	162.0
Oriental Mountain Range	16.6	21.0	0.03
Los Haitises	6.2	7.3	—
Samaná Peninsula	6.7	8.5	0.8
Northern Mountain Range and Atlantic Coast	32.5	41.3	27.0
Cibao Valley	150.0	190.5	27.2
Central Mountain Range	68.1	86.5	21.8
San Juan Valley	23.5	29.5	0.07
Neiba Mountain Range	4.9	6.2	—
Neiba Valley	24.0	30.5	12.3
Bahoruco Mountain Range	2.6	3.0	—
Barahona Southern Peninsula	1.6	2.0	2.7
Azua Valley	11.4	14.5	0.6
Baní Valley	9.9	12.6	0.5
TOTAL	500.0	635.0	255.0

*Demand estimated at 80 m^3/year/person and according to two different population growth rates: 1.8% and 2.8%.

seven persons which implies a total of 134,000 connections. Most of the water for the Santo Domingo region comes from groundwater of good quality; however, about 0.63 m^3/second are taken directly from the contaminated Haina River. The total production system for Santo Domingo is 4.39 m^3/second; but with an estimated 38% loss, net production is probably about 2.74 m^3/second. Since the total expected demand for 1980 is 5.30 m^3/second, there is a present deficit of 0.91 m^3/second. Besides this deficit, there are also deficiencies in production that cause discontinuities in the service, increasing the real deficits in relation to actual demand.

Table V-9 provides total water demands as a function of time for Santo Domingo. This information provides evidence that major investments and technical efforts should be undertaken in order to tap both the surface and groundwater resources needed to satisfy the water requirements of a growing population. An example of these efforts is the important Madrigal project on the Haina River that will store some 400 million cubic meters, in order to regulate a supply of 8 m^3/second for the Santo Domingo area.

In contrast, only 420 of 8646 rural communities throughout the country possess potable water. Despite the efforts of INAPA to install new service connections to the people, a growing number of rural families disconnect the services because they consider the INAPA fees are too expensive. Cost of water, however, is rather low since rural water fees have not been increased since 1960. Although the official minimum monthly fee is DR$1.50, in underpriviledged areas the monthly rate oscillates between DR$0.50 and DR$1.00. Therefore, INAPA is losing money on its rural services since the average income per connection is DR$0.84, while the actual cost per connection is DR$1.52. Furthermore, it has been estimated that 14% of the connections are illegal.

The previous aspects, plus the fact that only an urban minority possess measurement devices, make it difficult to estimate effective water demands. Large investments are necessary in order to upgrade, maintain, and initiate projects that will provide the much needed water so vital to the public and to the country's development in general. Special care must be given this precious resource, since its quality and time distribution have been and

Table V-9. Total water demand under CAASD administration for the Santo Domingo region. Source: Personal communication.

Year	Population to be served	Unit Demand (LPCD)*	Total Demand (m^3/sec.)	Total Demand ($m^3 x 10^6$/year)
1980	1,272,000	360	5.3	167
1985	1,665,000	333	6.4	202
1990	2,196,000	323	8.2	259
1995	2,858,000	325	10.8	339
2000	3,637,000	333	14.0	442

*LPCD: Liters per capita per day.

could be severely affected by the poor watershed conditions in the case of the surface water and overpumping and/or pollution in the case of the groundwater resources.

Resource Management

INDRHI, CDE, INAPA, CAASD, CORAASAN, FORESTA, TIERRAS Y AGUA and SEA's Meteorology Department are Dominican institutions involved in water resources. FORESTA is discussed in Chapter III, Tierras y Aguas is discussed Chapter IV and INAPA and CAASD are discussed in Chapter X.

National Hydraulic Resources Institute (INDRHI)

INDRHI was created as an autonomous institution by Law 6 (1965) with the following principal functions:

a. To serve as the authority for surface and groundwaters and to regulate their use.
b. To study, protect, and program all the energy and hydraulic works necessary for the integral development of the hydrographic watersheds in coordination with national development plans.
c. To organize and manage the utilization and conservation of national irrigation systems.
d. To administer use of watersheds, reservoirs, springs, and national waters.
e. To organize, direct, and regulate works involving water use with the Corporation of Industrial Development, with CDE concerning energy aspects, and with INAPA for water supply.
f. To organize, direct and regulate works concerning watershed hydrology, springs, and national waters, both superficial and underground.
g. To take part in the conservation of stream flows, lakes, lagoons and watershed protection, including environmental and erosion control.

Some of INDRHI's regulations have become inoperative because it was never able to gain full control of all its legal functions due to the inertia of previously existing institutions such as INAPA and CDE and overlapping mandates of newer institutions such as CAASD and Tierras y Agua. Lack of technical capability, funding and political support also make it difficult for INDRHI to fulfill its legal mandate.

The institution has grown both in human resources and responsibilities—by 1979 INDRHI had some 1650 employees, including 160 agronomy and civil engineers (Febrille, pers. comm.). Though the financial situation was critical during 1978 and 1979 with INDRHI receiving funds to pay only its acquired commitments and counterpart programs with its DR$21 million budget, during 1980 it was expected to operate on a DR$77 million budget (Febrille, pers. comm.). This new support allows INDRHI to plan projects and manpower needs.

Important concerns at INDRHI include sedimentation rates of water storage dams, irrigation efficiencies, silting of canals, salinity and drainage problems, and in general, the operation and maintenance of large irrigation canals under their control. Reservoir sedimentation is one of the most serious environmental problems in the Dominican Republic. INDRHI has been undertaking soil conservation programs in the Sabana Yegua watershed since 1977. A recognizance study and a technical watershed management plan for the Hatillo watershed have been conducted with Chinese cooperation (Gonzalez 1980). Political pressures cause expensive canal systems to be inaugurated prior to completion, lacking measuring devices and drainage systems, and in several occasions without access to farms (Reynoso & Enarnacion, pers. comm.). Farmers must construct their own feeder canals which leads to a chaotic canal system plus erosion, sedimentation, and drainage problems. Cultural practices and the very low costs for irrigation water have led to inefficiencies and excessive irrigation, in many cases accentuating the drainage, leaching, and salinity problems. Lack of funds and of qualified personnel lead to difficult situations such as in the Yaque del Norte region where five engineers administer 50,000 hectares under irrigation.

INDRHI's offical magazine (La Gaceta) shows well how great expectations can lead to big calamities within a year when inappropriate planning, incomplete construction and poor operation, management and cultural practices take place. A DR$33 million investment to irrigate 25,000 ha, and benefitting 10,000 families by transporting 24 m^3/second from the Yaque del Sur River was expected to transform the Azua Valley into a garden (Ventura 1978).

Perez (1979) describes the severe problem and side effects of this Azua Valley irrigation project. The plain that was previously irrigated from a groundwater aquifer is now inundated by irrigation water and the old wells are serving as artesian outlets for the high groundwater. The combined effect of decreased pumping and excessive infiltration has raised the groundwater table eight meters. Today, extensive areas previously cultivated are ruined (Fig. V-6b), a concrete lateral of the canal damaged by high groundwater pressure, roads and a town have been inundated (Fig. V-6a), and drinking water supplies are contaminated.

Poor irrigation practices and designs should be given priority status among remedial solutions. Though irrigation engineers in INDRHI are aware of existing problems, they must urgently solve them. A map of irrigated lands by district at a 1:50,000 scale indicating the main canals and problem areas would help. Priorities to upgrade irrigation systems and educate farmers are necessary.

Recently signed cooperative agreements with IICA and with Colorado State University (CSU) should greatly strengthen INDRHI's technical capability. The IICA objective is to strengthen INDRHI's role in the development and administration of water resources, with special emphasis on the agricultural sector (INDRHI 1980a). The major objectives of the CSU agreement include: 1) Formulation of a national plan for water resources management; 2) Improvement in the gathering and analysis of hydrologic data; 3) Planning for the creation of a research hydraulic laboratory in the Dominican Republic; and 4) Administration and operation of hydraulic systems with emphasis on irrigation optimization (INDRHI 1980b).

The IICA and CSU cooperative agreements have already brought in experts to assist INDRHI in diagnosing the multitude of problems associated with Dominican water resources. In analyzing problems related to quality, collection, processing, and retrieval of hydrologic information, Salas (1980) found considerable duplication of activities between the Hydrologic division of INDRHI and the Meteorological Department of SEA. Fuentes (1980) analyzes the lack of water measuring devices at all water transmission levels in most of the important irrigation projects, a

Figure V-6a. *Main street of El Rosario inundated by irrigation water that has nowhere to go due to the lack of drainage canals. (Photo, Gary Hartshorn.)*

Figure V-6b. *An irrigation canal near El Rosario that literally ends by flooding the area due to a lack of drainage canals. Salinization has destroyed the usefulness of the adjoining fields. (Photo, Gary Hartshorn.)*

severe problem that INDRH must face due to the negative effects of over-irrigation.

Since INDRHI does not have an educational program to upgrade the technical capabilities of its personnel, the IICA and CSU agreements should help strengthen the professional training of INDRHI's engineers and technicians. The small number of INDRHI personnel with graduate studies or degrees is a serious limiting factor to INDRHI's professional capabilities. Problems in evaluation, control, optimization and upgrading the water resources of the Dominican Republic require the expertise of well-trained individuals.

Dominican Electricity Corporation (CDE)

CDE was created as an autonomous institution by Law 4115 (1955) to provide for the production, transmission and distribution of electrical energy. A section of Article 8 of the CDE enabling legislation explicitly assigns responsibility to CDE for national electrification. CDE's autonomous status and financial independence allow it to plan on a longer term basis and with more stability than institutions such as INDRHI.

Rapid growth in national demand for electricity has produced comparable institutional growth of CDE. Approximately 200 engineers work at CDE in six different divisions (E. Garcia, pers. comm.); however, few CDE engineers have completed graduate studies or degrees. Those with higher degrees often become saddled with administrative duties.

Escalating costs of imported petroleum are forcing the Dominican Republic to quickly develop her considerable hydroelectric potential by constructing several major dams. Most CDE hydroelectric projects are contracted to foreign or private consultants for feasibility and design studies. CDE then forms a specific corporation to construct a dam. Upon completion of the construction project the corporation is dissovled.

Although it may have administrative and financial advantages, CDE's creation of a separate corporation for each dam construction has some serious consequences. CDE has traditionally ignored the condition of the watershed and any interest or effort in watershed management. The construction corporation is only interested in completing the dam, thus puts no money into studies or actions in the watershed above the hydroelectric project. The creation of a separate construction corporation for each project effectively excludes CDE engineers from substantive involvement in a hydroelectric project. Experience in Costa Rica shows that competent national engineers working closely with consultants, coupled with foreign training for national engineers, leads to a gradual build-up of professional knowledge and experience that allows a developing country to handle most of its own projects.

Friction between INDRHI and CDE and lack of communication seem to exist. Apparent mutual distrust for the quality of work and policies of each institution is shown by lack of knowledge and indifference at the technical level regarding the activities in which each institution is involved, and the maps of locations of future dams being considered separately by each institution that do not show the projected dams of the other.

The signing of the INDRHI-CDE inter-institutional cooperation agreement (August 1980), though the result of the vision, good will, and responsibility of a few motivated officials, has apparently not brought about the commitment of the leaders to work together. Indifference and distrust during the signing of the INDRHI, IICA, and CSU agreement, nevertheless, did not dismay the participants because they see no other way out. As an INDRHI official puts it, "Coordination or death."

It is important to stress the effort of CDE to meet the demand for power and energy under very difficult conditions such as increasing oil prices, and watershed problems causing heavy sedimentation rates and large risks for major flooding. Given the interrelationship and competition between land cultivation, highway projects, and multiple uses for water, the need for coordination between the government agencies dealing with water is absolutely necessary, especially so in the case of INDRHI and CDE. It is extremely important that all efforts must be made in order to make this inter-institutional cooperation work.

CDE receives technical assistance from the University of Texas for the establishment of a microseismic network. A consultant on Watershed Management recently came to the Dominican Republic in order to establish a protection plan for the Rio Blanco Watershed (Dourojeanni 1980). CDE has a hydrology department and its emphasis seems concentrated in the area of mathematical modelling and computer simulation of hydrologic phenomena. This type of work is not being currently pursued by any hydrologic divisions of other institutions. However, implementation of software technology and procedures seem basically the efforts of a few individuals.

General Comments

Competition rather than cooperation has resulted from the similarities in mandates to institutions. Each institution desires control though funds or human resources may not be available to fulfill the objectives. Where overlapping activities occur, it is common to hear officials openly criticize each other. It appears that politics and funding often override legal mandates.

Although centralization with good leadership may lead to unification and eliminate duplication, it can also be dangerous since it usually leads to very powerful institutions where politics may become more important than technical aspects (e.g. Guatemala). Large government institutions may lead to a dilution of responsibilities and loss of motivation to get things done; this could take place because of loss of personal communication, and identification of the workers with their working units and superiors.

When dealing with multiple institutions, it is very important to clearly define realistic activities in which each institution can most effectively work. The alternative seems to call for a systemic integration through institutional coordination. The proposal to create the Consejo Nacional de Recursos Naturales is an excellent effort in this direction.

Major Problems and Issues

Environmental problems with water resources and watershed management in the Dominican Republic intimately involve the small farmer, specifically the "conuquero", in that he is a major factor inducing environmental degradation as well as the unintended recipient of several negative consequences. Land and water degradation are the first order consequences of his slash and burn agricultural activities.

Traditional agriclutural practices on steep mountain environments in the upper watersheds cause a series of negative consequences both on the land the farmer uses for subsistence and in the water resources projects developed downstream as incentives for economic development and social well-being. The high rates of erosion reported in the literature and observed in the fields in the Dominican Republic indicate that the productivity of these lands is decreasing due to more intensive use and shorter fallow periods (see Chapter VI), partly because of the population pressures on scarce land resources and poor agricultural practices. Regional and national developments including irrigation systems hydroelectric projects, and aqueducts, are being severely affected by rapid siltation, poor water quality, and/or changes in the streamflow regimes. The social and economic costs of sedimentation and changes in streamflow characteristics such as increases in peak flows and lower base flows may severely affect the design and operation of existing and projected engineering works, increasing therefore not only the cost of initial investments but also the maintenance and operating costs, to say nothing about the potential for drastic reduction in the economic and/or useful life of the projects (Quesada 1979). In some instances (e.g. a silt-filled reservoir), the consequences are irreversible since a dam site is a non-renewable resource (Koelzer 1969).

Serious watershed degradation probably began in earnest during the 1961-67 timber boom (see Chapter III) when loggers and campesinos made massive advances into the pine forests of the Cordillera Central. Although the forced closure of all sawmills in 1967 brought an abrupt halt to logging, it did not lessen the campesino demand for new land. The continued high rate of population growth and unequal land tenure patterns have pushed the small farmers even higher in the Cordillera Central watersheds, almost invariably onto steep, highly erodable slopes incapable of supporting annual cropping. Pressure for land has taken small farmers up to the boundary of the two national parks (see Chapter VIII) in the Cordillera Central, thus there is literally no more unoccupied land available for colonization in the Cordillera Central.

The two major reservoirs, Tavera and Valdesia, have accumulated considerable quantities of sediments in less than one decade. Tavera has lost 40% of the dead storage and the sediment accumulation at the heel of the dam is about 18 meters; in the upper reaches the reservoir has lost 10-14 m of active storage. It is estimated that 6% of the area round the reservoir contributes 30% of the sediments reaching the lake. The Valdesia reservioir has 22 m of sediments at the heel of the dam, only 8 meters away from the intakes (CDE, pers. comm.). Hurricanes David and Frederic caused devastating floods that destroyed the spillway gates of Valdesia and flooded the powerhouse at Tavera. The substantial reductions in active storage capacity greatly decrease the useful life of the Tavera and Valdesia reservoirs (Fig. V-7b). The nearly complete disinterest of CDE and INDRHI in a watershed protection and management leads to a very pessimistic prognosis on the useful life of existing and future hydroelectric projects.

Inadequate road-building practices also contribute enormous quantities of sediments to the nation's river systems. Field observations vividly demonstrate the lack of concern by road engineers about erodability, runoff and sediment loads. North of Padre las Casas, a simple rural road through very fragile, unconsolidated soil contributes to an enormous gully (Fig. V-7a) carrying tons of sediments downstream—in this case into the recently completed Sabana-Yegua reservoir. Penetration roads into the upper watersheds of the Cordillera Central cause frequent landslides and seldom are effectively stabilized (Fig. V-8a).

Watershed degradation has serious downstream consequences. High sediment loads contribute to riverbed aggrading, which causes changes in river basin morphology and higher flood levels

Figure V-7a. *Severe gully erosion of unconsolidated sediments in the semi-arid lower Sabana-Yegua watershed. The lack of runoff control from construction of a rural road is the primary cause of this rapidly advancing gully. (Photo, Gary Hartshorn.)*

Figure V-7b. *Sediment load (center left) of the major tributary to the Tavera reservoir. In only 8 years, the reservoir has lost 10-14 m of active storage. (Hand-held aerial photo, Gary Hartshorn.)*

Figure V-8a. *Landslides caused by road building and deforestation on steep slopes between Manobao and Loma de la Sal in the Cordillera Central. (Hand-held aerial photo, Carlos Quesada.)*

(e.g. lower Rio Yuna). Although hurricanes David and Frederic were the prime cause of major floods and significant changes in basin morphology (e.g. Rio Las Cuevas, Rio Ocoa), natural disasters exacerbate man-induced problems. There is a tendency in the Dominican Republic to blame all natural resources problems (e.g. Tavera, Valdesia) on hurricanes David and Frederic. The Cordillera Central watersheds were already seriously degraded before the 1980 hurricanes struck, hence man's destruction of the watersheds amplified the catastrophic consequences of natural disasters. The resilience of natural vegetation clearly demonstrates that inappropriate land use dramatically increases watershed degradation (Fig. V-8b).

High contents of silt and clay in potable water not only cause a visual nuisance, but increase health hazards (see Chapter X). The sediments also contribute to internal corroding of the water system. High turbidity requires large amounts of coagulating agents to remove the sediments. Watershed deterioration has increased the need for water treatment in systems that initially did not require treatment.

Watershed deterioration has also changed the magnitude of floodwaters, causing considerable damage to intakes, derivation structures, and anchored structures. High sediment loads carried from degraded watersheds also cause problems to irrigation systems by rapidly filling canals with sediments, thus reducing canal capacity. When deposited on fields, the high silt load in irrigation waters reduces soil infiltration capacity.

Poor irrigation planning and practices, including over-irrigation, incomplete canal systems, lack of integrated irrigation and drainage systems, water logged soils and salinization, abuse the country's water and soil resources. Numerous examples exist: high salinity is a problem west of La Esperanza in the Yaque del Norte River Basin; in Villa Vasquez farmers dam irrigation canals to divert saline water to their fields, accentuating their soil salinity problems; lack of maintenance allows the canals to fill with sediments and weeds (Fig V-9a), reducing irrigation potential and in some cases precluding the possibility of growing two crops per year; lack of drainage of irrigation waters causes soil salinization and even flooding (Fig. V-9b).

Some efforts are being made to lessen soil erosion and upgrade irrigation systems, but they are woefully inadequate to significantly reduce the severity of water resources problems in the Dominican Republic. The chaotic, independent, and usually competitive approach to irrational use and management of Dominican water resources continues to degrade this valuable renewable natural resource. The decreasing potential of Dominican water resources will only be reversed through a united and integrated national effort in watershed protection and rehabilitation.

Conclusions

The Dominican Republic is richly endowed with water resources, particularly those river systems originating in the Cordillera Central. The three important river basins, Yaque del Norte, Yuna, and Yaque del Sur, cover about 35% of the country. This renewable natural resource is only modestly developed to provide 15% of the nation's power and to irrigate less than 200,000 ha (4% of the country). Government projects are expected to substantially increase these values during the 1980's.

Institutional responsibilities for water resources development and administration are fragmented among several overlapping and competing agencies. Development projects such as irrigation systems were poorly planned, designed and implemented with the consequence that extensive areas of productive agricultural land are being lost due to poor drainage, salinization, or inconsistent delivery of irrigation water. Planning of development projects ignores existing or planned developments pertaining to other institutions.

Watershed degradation is a national catastrophe posing grave threats to costly development projects. Irrigation systems, hydroelectric dams, and aqueducts are rapidly losing functional capacity due to massive siltation, poor water quality and changes in streamflow regimes.

Slash and burn agriculturalists are intimately involved in watershed deterioration, not only as causative agents with their traditional techniques and crops, but as recipients, as they rapidly deplete the productive capacity of their small farms. The absence of new frontiers for traditional agriculturalists precludes evacuation of critical watersheds. The "conuquero" must be an integral component in watershed rehabilitation.

Inadequate road-building practices and natural disasters such as hurricanes also contribute enormous quantities of sediments to the nation's river systems. There is a tendency to blame the 1979 hurricanes for the sorry condition of Domincan watersheds. Natural disasters only exacerbate the serious environmental problems caused by man.

The modest efforts in watershed rehabilitation and protection are usually directed at the consequences of watershed degradation (e.g. gully control) rather than to the causes (inappropriate land use). Given the serious and pervasive deterioration of watersheds, the institutional conflicts and unwillingness to address the problem in an integrated effort, and the increasing human pressure for land, one can only conclude that Dominican watersheds will continue to deteriorate in the near future. The lack of a massive and priority program in watershed protection

Figure V-8b. *Landslide activity increased by deforestation. Although many of these landslides in the eastern Cordillera Central between Manobao and Loma de la Sal were probably caused by the 1979 hurricanes, note the appreciably lower frequency of landslides in the upper forest. (Hand-held aerial photo, Gary Hartshorn.)*

Figure V-9a. *Inoperative irrigation canal near San Jose de Ocoa filled with sediments from the 1979 hurricanes. (Photo, Gary Hartshorn.)*

and rehabilitation will continue to allow Dominican watersheds to deteriorate, converting a renewable natural resource to a nonrenewable or increasingly costly resource.

Recommendations

Declare Watershed Degradation a National Emergency

The seriousness and extent of watershed deterioration in the Dominican Republic merits emergency measures analagous to those taken in 1967 to halt deforestation. However, slowing of watershed degradation will not be nearly as simple as closing all sawmills. Specific actions could include:

- create an inter-agency task force to assess the capabilities and responsibilities of institutions involved in water resources
- develop integrated watershed management plans for major river basins such as the Yaque del Norte, Yuna, and Yaque del Sur
- implement watershed protection and rehabilitation programs on a sub-watershed basis rather than as roadside demonstrations
- halt all hydroelectric, irrigation, and reservoir projects until specific watershed management plans are prepared, accepted and initiated
- include an environmental assessment in the economic feasibility analysis of proposed water resources projects
- analyze existing projects to determine which ones can be improved or rehabilitated before starting new projects.

Institutional Collaboration and Coordination Is Imperative

Duplication and jealously must be minimized if the Dominican Republic is to effectively develop and administer her water resources. The proposal to establish CONARENA could be an effective means of increasing cooperation and coordination of the numerous agencies involved in Dominican water resources.

Figure V-9b. *Excellent agricultural land near El Rosario. This field formerly produced 90 m tons/ha of industrial tomatoes, but poor irrigation management has flooded the area and increased soil salinity. (Photo, Gary Hartshorn.)*

VI

Soils

Resource Base

Introduction

The most important farmlands are in two main regions, the Cibao, which is a geomorphic region composed of the valleys of the Yuna and Yaque del Norte Rivers, and the Caribbean coastal plain, a region devoted mainly to sugarcane and livestock production. The latter area has a complex distribution of residual soils derived from limestone or calcareous materials deposited under lacustrine conditions.

The eastern Cibao, Between Santiago and San Francisco de Macoris, has the country's largest area of highly productive soils. The climate of eastern Cibao is excellent for the almost continuous cultivation of the dark brown, granular calcareous clays and of the alluvial soils. The main crops of the densely populated eastern Cibao are tobacco, corn and plantains. Rice is grown under irrigation in the compact clays farther to the east in the Yuna basin.

Arid conditions in the western Cibao make irrigation indispensible for farming the alluvial soils of the Yaque del Norte Valley. The western Cibao has about 8-9,000 ha of irrigated rice, along with considerable areas of tobacco, plus some sorghum and tomatoes. Some of these soils have fairly light surface texture. Free salt in the profile coupled with poor quality and inept management of irrigation water has caused some salinity problems in the area.

Another important agricultural area is the arid basin of the Yaque del Sur River. The clay soils of the valley of its main tributary, the San Juan River, are suitable for irrigated rice. The lower part of the Yaque del Sur Valley, which is part of the Enriquillo Basin, is an extensive plain with deep, light-textured, alluvial soils, mostly devoted to sugarcane and plantains. Saline soils occur close to Lake Enriquillo as well as in the lowlands near the mouth of the Yaque del Norte River.

The only agricultural soils not used are in the sub-humid or arid areas of the country lacking irrigation. In other areas, wherever there is enough precipitation for crops or pasture, the land has been cleared of forest for crop or livestock production, ignoring the fact that there are areas of steep slopes or poor drainage. Throughout the mountain areas there are small valleys with areas of productive soils.

The eulogy to the "rich soils of the Dominican Republic" found in literary works is mostly a myth. While there are some areas of good and productive soils in the country, most of the country's farmers eke out a living on marginal and sub-marginal lands not fit for annual food crops. A reconnaissance through major parts of the country reveals a predominance of very shallow soil situated on extremely steep slopes, mostly stoney and subject to severe erosion, either because of topography or the soil materials involved, or both. Some additional discussion of soil quality and erosion follows.

Description of Major Soils

The Dominican Republic has a great diversity of soils. They range from sands to clays, acid to alkaline, fertile to infertile, no-saline to saline, and include well-developed soils and younger ones. The Comprehensive Resource Inventory and Evaluation System (CRIES) project identified 37 soil map units which are briefly described in Table VI-1 in the order of area covered. More detailed descriptions are available in SIEDRA publications.

Current and Projected Land Use

Farm Size Distribution

Recent data indicate 57% of the country's land area is in farms. Land in farms expanded from 47% of the country in 1960 to 57% in 1971 and remained at an almost identical level in 1977 (Table VI-2). regional percentages reflect the abundance of good soils in the northeast, east and central regions, as well as the dominance of sub-marginal land, inimical climatic conditions and inaccessibility in the southwest and south regions.

While only about 13% of Dominican farmland is not in use, the bulk of the farmland is divided almost equally between crops and pasture. Four regions—north, northeast, central and east—account for 76% of the national croplands and 85% of the pastures.

Farm size distribution in 1971 (Table VI-3) is remarkably uniform across regions. Nearly 70% of all farms are less than 5 ha in size, yet they occupy less than 14% of the country's farmland. Only 3.4% of the farms exceed 50 ha, but they occupy over half of the national farmland. The many large sugarcane estates have a strong impact on the farm size statistics. Nevertheless, the data indicate there are a large number of subsistence farmers that probably include many part-time farmers who earn additional income in off-farm activities.

Table VI-1. U.S. soil taxonomy names, their map symbol and CRIES (SIEDRA) number, the total area in the Dominican Republic (often in many separate parcels in different parts of the country) and a brief description of some of their main characteristics involving erosiveness or productive use of Dominican soils.

Name (subgroups)	Map Symbol	Area km ^{2}	Brief Description of Character and/or Potential
Dystropepts (typic)	ITYs M/RB (4431)	8223	Steep slopes, acid, mostly shallow, stony, erosive; some coffee, some food crops
Ustropepts (typic)	ITUa RH/LSS(4322)	4661	Medium to steep slopes, mostly shallow, stony, slightly alkaline, very erosive, some are droughty; mostly grazing land, some food crops
Ustropepts (shallow typic)	ITUs M/LSS(4325)	3474	Mostly on very steep slopes, shallow, stony, slightly alkaline, mostly droughty, free carbonates, very erosive; small areas in food crops
Eutropepts (shallow typic)	ITEs M/LSS(4220)	3548	Very steep slopes, mostly shallow, stony, slightly alkaline, high base saturation, erosive because of slope; some in coffee, plantains, food crops
Camborthids (typic)	DOAaFA DOAa (1102)	2479	Alluvial material, low water holding capacity, erosive; too dry for agriculture, no available water sources
Ustorthents (skeletal lithic)	EOUdK UR/LS92409)	2173	Over coraline material, shallow, extremely stony, droughty; almost no agricultural potential
Dystropepts (shallow typic)	ITYs S/RB(4432)	1502	Mostly on very steep topography, very erosive, very acid, stony; some of the better areas are used for coffee, cacao, food crops
Eutropepts (lithic)	ITEg K/LS(4219)	1471	Mostly on extremely steep topography, karst over limestone, droughty, inaccessible; scattered plots in agricultural use, no potential
Ustropepts (typic)	ITUa U/LS(4323)	1460	Slight erosion hazard, fine texture, some waterlogging; suitable for reclamation; used for sugarcane without irrigation
Tropaquepts (Plinthic) and Dystropepts (Aquic)	IATb L/M ITYc U/M (4113)	1408	Slight to moderate erosion hazard, very acid, slow permeability, non-stony, suitable for mechanization; mostly in pasture, but better drained sections suitable for crops, increasingly used for sugarcane
Ustropepts (typic)	ITUa UR/A (4324)	1329	Moderate erosion hazard, some mechanization possible, would have potential for crops with irrigation, no water sources apparent; grazing lands
Dystropepts (lithic)	ITYf S/T (4430)	1272	High erosion hazard due to topography, shallow, very acid; pasture, some food crops with hand labor
Tropaquepts (Aeric) and Tropofluvents (typic)	IATd T/M EFTa FP/A (4114)	1083	Coastal terraces, flood plains, beaches, dunes; slight erosion hazard from water, some areas susceptible to wind erosion; some are flooded or poorly drained; used for sugarcane, pasture, rice, cacao and food crops
Eutropepts (typic, shallow)	ITEs RH/LSS	1079	Some calcareous, high base saturation, most are shallow; some in coffee, plantains and food crops
Pellusterts (Udic)	VUPg T/A (6137)	1059	No erosion hazard, fairly level, suitable for mechanization; productive agricultural soils used for cacao, coffee, plantains, and seasonal crops
Torrifluvents (Ustic)	EFHf FP/A (2105)	1050	Floodplains, need irrigation for full production; slightly saline due to improper irrigation practices; produce rice, bananas and other crops
Ustropepts (shallow typic)	ITUs RH/T (4326)	1045	Erosional valleys and uplands over tuff; steeper and shallower areas used for pasture and small plots of food crops; gentler slopes can be used for sugarcane, food crops or pasture
Torrisorthents (Skeletal lithic)	EOHck UR/LS (2307)	1015	Undulating and rolling plains over limestone; no agricultural potential; native thorn scrub used in charcoal production
Pellusterts (typic)	VUPa L/LS (6135)	1007	Little erosion hazard, suited for mechanization, wetness and heavy texture are limiting factors; used for sugarcane and some pasture
Ustorthents (shallow typic)	EOU RH/LS (2410)	816	Rolling and hilly uplands with erosional slopes, shallow, some stones, droughty; used for papaya, citrus, pasture, some food crops

Table VI-1. (Continued)

Name (subgroups)	Map Symbol	Area km 2	Brief Description of Character and/or Potential
Pellusterts and Ustropepts (typic)	VUPa T/A (6136)	682	Stream and lacustrine terraces over alluvium, some erosion hazard on slopes; suitable for many corps with irrigation; otherwise, pasture, rice, vegetables
Ustolfic Haplargids	DRHn UR/A (1204)	633	Moderate erosion hazard, arid; too steep for irrigation and no water source
Terriorthents (Ustic)	EOHj L/LA (2308)	567	Level for mechanization, but difficult to irrigate due to salinity; better parts in sugarcane and plantains
Tropaquepts (Aeric) and Chromuderts (Aquic)	IARs T/M -VDCb T/M (4116)	506	Marine terrace over marine clay; wet soils for rice and pasture; others for cacao, coffee and food crops
Tropaquepts (aeric) and Ustropepts (typic)	IATd T/M-ITUs RH/LS (4115)	446	Coastal marine terrace over marine sediments interspersed with shallow erosional rolling and hilly uplands; level lands for sugarcane and food crops
Tropudults (typic) Dystropepts (lithic)	UDTa RH/T-ITYp S/T	438	Erosion hazard, mostly deep red clays, very acid; pasture and food crops
Camborthids (typic)	DOAa F/A (1101)	410	Alluvial, slight erosion hazard, suited for mechanization, needs irrigation; produce irrigated bananas, plantains, sugarcane, could produce other crops
Camborthids (typic)	DOAa RH/LSS	407	Erosion hazard, steep; no agricultrual use
Tropudults (typic) Dystropepts (fluventic)	UDTa DT/A (5133)	379	Floodplain, fine texture, acid; used for sugarcane
Tropohemists (typic) Sulfihemists (typic)	HHTa WS/A (3112)	325	Mostly tidal level, strongly saline; mangrove swamp; almost no agricultural value
Dystropepts (Aquic) Dystropepts (shallow to paralithic contact)	ITYc T/A-ITYs RH/RB (4428)	312	Slight to moderate erosion hazard, shallow; crop growth limited by wetness, acidity, clayey texture; used for pasture, cacao, sugarcane and food crops
Dystropepts (Aquic) Eutropepts (typic shallow)	ITYc U/M-ITEs RH/LS (4429)	285	Very fine marine clays, slight erosion hazard; used for pasture, sugarcane, cacao, coffee, and food crops
Dystropepts (Aquic) Dystropepts (fluvic)	ITYc T/A ITYd FP/A (4427)	282	Slight erosion hazard; at Constanza used for temperate region vegetables; at Banao for irrigated rice and other crops
Eutropepts (Aquic and shallow typic)	ITEc U/LS-ITEs RH/LS (4217)	252	Slight erosion hazard; can be reclaimed for sugarcane
Ustifluvents (typic) Ustifluvents (aeric tropic)	EFUa FP/A (2206)	242	Slight erosion hazard; suitable for irrigated sugarcane also food crops
Eutropepts (Fluventic)	ITEe FP/A (4218)	180	Fine silts or fine loams; suitable for cacao, coffee, and food crops
Tropaquepts (typic) Chromuderts (Aquic)	IATa FP/A VDCb FP/A	172	Use limited by wetness; used for irrigated rice, pasture, food crops and cacao

Abbreviated use symbols (from Map):

Land form /
DT dissected terrace
F Fans at base of mountain

FP Floodplain
L Level plain
M Mountains
K Karst topography

RH Rolling and hilly terrain
S Steep hilly
T Terrace
U Undulating plain
UR Undulating and rolling plain
WS Swamp

Underlying material
A Alluvium, unconsolidated
LA Lacustrine alluvium, unconsolidated
LS Limestone
LSS Limestone and shale
M Marine, unconsolidated rocks
RB Mixed acid and basic metamorphic rocks
T Tuff

Names (subgroups) according to the U.S. Soil Taxonomy, USDA Handbook No. 436, Washington, D.C.

For a detailed description the handbook would have to be consulted. The various publications of SIEDRA (CRIES)* also give more information on these soils than is contained in the very brief descriptions above.

* from which the above list and descriptions are adapted

Table VI-2. Regional distribution of land in farms in 1960, 1971 and 1977. Base data from CRIES project.

	I North	II Northeast	III Northwest	IV Central	V Southwest	VI South	VII East	TOTAL
Total Land Area* (km^2)	9,065	5,324	4,769	6,983	7,503	6,890	7,745	48,297*
1960 Farmland (km^2)	5,532	3,646	1,880	4,436	1,240	1,152	4,690	22,576
%	61	68	39	64	17	17	61	47
1971 Farmland (km^2)	6,049	4,695	1,953	5,090	2,031	1,368	6,176	27,362
%	67	88	41	73	27	20	80	57
1977 Farmland (km^2)	6,049	4,796	1,952	5,127	2,031	1,321	6,176	27,452
%	67	90	41	73	27	19	80	57
1977 Crops (km^2)	2,011	2,294	848	2,649	1,336	757	2,169	12,064
1977 Pastures (km^2)	3,126	2,113	845	1,605	511	367	3,301	11,868
1977 Other**	912	389	259	873	184	197	706	3,520

*Excludes 163 km^2 of islands
**Uncultivated and non-pastured land on farms

Table VI-3. Percentage distribution of land use by farm size and regions; base data from the 1971 Agricultural Census. *Denotes no data available.

	I North	II Northeast	III Northwest	IV Central	V Southwest	VI South	VII East	National Average
Percentage of farms								
0.5-4.9 ha	73.9	69.6	62.1	73.0	*	78.2	58.7	69.2
5.0-9.9 ha	11.5	12.9	13.6	10.3	*	13.9	11.3	12.2
10.0-49.9 ha	11.8	15.2	20.5	14.3	*	7.0	22.3	15.2
50 ha	2.7	3.0	3.8	2.4	*	0.9	7.7	3.4
Percentage of farmland								
0.5-4.9 ha	13.6	12.3	10.5	13.9	*	28.6	3.5	13.8
5.0-9.9 ha	8.4	8.1	8.2	7.1	*	17.1	2.7	8.6
10.9-49.9 ha	26.5	28.7	39.9	28.4	*	22.8	16.4	27.1
50 ha	56.5	50.9	41.4	50.6	*	31.5	77.4	51.5
Percentage in Crops								
0.5-4.9 ha	65.0	68.4	49.6	61.8	*	67.3	87.4	66.6
5.0-9.9 ha	48.2	54.5	32.2	38.0	*	58.6	41.1	45.4
10.0-49.9 ha	27.9	35.3	32.2	38.0	*	38.6	20.8	26.8
50.0-99.9 ha	7.9	12.4	10.4	14.7	*	12.5	10.5	11.4
100 ha	18.0	32.3	43.5	53.6	*	53.8	34.3	39.3
Percentage in Fallow								
0.5-4.9 ha	6.7	16.2	11.0	7.0	*	16.5	2.5	10.0
5.0-9.9 ha	7.3	21.0	6.5	7.3	*	12.0	6.5	10.1
10.0-49.9 ha	6.0	11.8	6.5	5.8	*	11.5	4.2	4.6
50-99 ha	0.0	0.2	0.0	0.9	*	0.8	0.5	0.4
100 ha	2.4	3.6	7.6	3.1	*	5.1	4.2	4.3
Percentage in Pasture								
0.5-4.9 ha	22.6	12.0	34.0	24.1	*	10.0	7.2	18.3
5.0-9.9 ha	37.8	19.2	52.8	38.9	*	19.3	39.7	34.6
10.0-49.9 ha	57.9	39.4	69.3	50.7	*	35.9	63.5	52.8
50 ha	*	*	*	*	*	*	*	*
Percentage in Other								
0.5-4.9 ha	5.7	3.4	5.4	7.1	*	6.2	2.9	5.1
5.0-9.9 ha	6.7	5.3	8.5	15.8	*	10.1	12.7	9.9
10.0-49.9	8.2	3.5	10.7	19.0	*	14.3	11.5	11.2
50-99 ha	8.1	3.9	10.2	0.7	*	9.6	2.5	5.8
100 ha	14.8	19.1	51.8	27.3	*	43.1	10.5	27.8

Table VI-3 also shows the regional distribution of land use by size of farm. The highest percentage of land in crops consistently occurs on the smallest farms. Land devoted to crops decreases with increasing farm size to 100 ha, above which there is an appreciable increase in crops due to sugarcane estates. Farms smaller than 10 ha average 10% in fallow, which is an indicator of the prevalence of shifting cultivation for subsistence crops on small farms.

The strong increase in percentage of land in pasture as farm size increases is no surprise; however, the average of 18% pasture on the smallest farms is unusually high; fallow land used for grazing may account for the high percentage of pasture.

Land is put into fallow either for lack of managerial skill in organized harvesting, or because the farmer believes the soil is so exhausted it will not produce an acceptable return. In both cases, improved technology, including proper conservation measures on marginal lands, would keep these lands productive.

Pasture is either a managerial choice, because it seems to yield the best return, or it is a measure applied by the small farmer on land too exhausted to produce a crop. Most good pasture is a cropland reserve, while poor pasture generally yields very little return, and this land would probably be better under trees.

We were unable to obtain national data on land tenure. In our conversations with technicians in the field, it was learned there is substantial absentee ownership of farmland. The widespread practice of sharecropping and frequent changes in the sharecropper on a particular field make it very difficult to encourage soil conservation measures or even general land stewardship.

It appears that the Dominican Republic has virtually no land reserves under the conditions of rain-fed agriculture as can be seen by the extensive areas of marginal and sub-marginal cultivated lands. However, thanks to orographic rainfall it has many areas where irrigation projects are in existence, are being developed and still can be developed.

A reconnaissance indicated large tracts of land with xerophitic brush cover, probably on most maps appearing as low grade forest or brush cover. Some of these lands, like those in the San Juan-Azua area, will be irrigated by projects now being developed.

Agricultural Productivity

Table VI-4 shows the area and production of important crops harvested in 1979. Rice, red beans, cassava, and plantains are the major food crops. National averages of these crops are fairly low, as should be expected since a large part of this production comes from marginal and sub-marginal lands. Table VI-4 does not include sugarcane, the principal export crop of the Dominican Republic.

Table VI-4. 1979 area and production data for important crops in the Dominican Republic; data from URPE.

Crop	Area Harvested (hectares)	Total Production (metric tons)	Average Yield (kg/ha)
Rice	106,408	245,437	2,307
Red Beans	54,853	37,927	691
Black Beans	10,355	11,883	1,148
Corn	36,581	48,177	1,317
Cassava	22,933	119,556	1,317
Sweet Potatoes	6,659	59,495	8,934
Yams	6,402	41,320	6,454
Plantains	30,580	204,250	6,679
Pigeon Peas	11,205	9,928	877
Bananas	7,058	71,926	10,191
Name Root	2,707	17,274	6,382
Potatoes	897	8,987	10,019
Onions	1,447	10,248	7,082
Table Tomatoes	615	7,131	11,595
Industrial Tomatoes	5,082	100,969	19,868
Hot Peppers	911	3,624	3,978
Garlic	651	3,452	5,302
Tobacco	29,402	33 931	1,154

The country had a total of about 212,000 ha of sugarcane in 1978. Sugarcane land is divided among three major producers: Gulf & Western Company, the Vincini family, and the government's Consejo Estatal de Azucar (CEA). Gulf & Western harvests about 71,200 ha, with a mill capacity of about 400,000 tons/year of sugar, or 28% of the national production. They are located in the eastern region of the country, and grow their cane without irrigation on land mostly considered average for agricultural (Class III). The Vicini family owns 3 sugar estates in the central region with a sugar capacity of 80,000 tons/year, accounting for 7% of the national production. CEA owns 12 estates, mostly in the eastern part of the country. Two of the CEA estates are irrigated—Esperanza in the north, and Barahona, near the city with the same name in the south. In addition there are about 156 small producers who sell their cane to the CEA and the Vincini group. Estate yield without irrigation is about 45-46 tons/ha, with the small producers getting about 20% less. Irrigated production has dropped to around 95 tons/ha due to salinity problems and poor management.

Coffee covered about 207,000 ha in 1960 on some 43,000 farms in many parts of the country, mostly at middle elevations. The present area in coffee (about 155,000 ha) is expected to increase substantially due to recent efforts to use it as a soil conserving crop. However, some of its is interplanted with cacao, which will only thrive under hot humid conditions. Cacao is concentrated in the northeastern area of the country, where 94,000 ha (1979) are in production on some 50,000 small farms. Other crops include coconut palm (28,548 ha), sorghum (2,702 ha), ginger (659 ha), and grapes (108 ha).

Resource Management

Legal Basis

No specific laws exist to protect the soils of the country. A considerable number of laws protecting forest and water resources have an indirect effect on soil resources and conservation. The Departmento de Tierras y Aguas (DTA) in the Secretariat of Agriculture (SEA) is preparing a draft law based on existing laws in Puerto Rico for the formation of soil conservation districts. Also a draft law before the Legislature proposes Committees for Conservation of Natural Resources (COCORENA) at the grass roots level. COCORENA could greatly help government efforts in soil and water conservation.

Institutions

Soils are dealt with by several departments. The DTA conducts taxonomic inventories at reconnaissance, semi-detailed and detailed levels, tests soil fertility in relation to plant growth by means of fertilizer experiments using various nutrient combinations on a number of agricultural and horticultural crops. It also determines fertility level by soil and leaf analyses in the laboratory. According to the department's spokesman it is sufficiently staffed and will carry out its program on a reasonable schedule to have all areas with agricultural potential mapped within the next 3-4 years. It seems to have little interest in the marginal areas in the mountains.

The Instituto Agrario Dominicano (IAD) has no soils staff, but uses the DTA to appraise lands before acquiring them, and uses the department to organize farming activities of their settlers on a national basis.

The DTA originated as the soil conservation section of the Department of Soils. It has been a separate department for about two years and comes under SURENA instead of the Secretariat

for Research, Extension and Agricultural Training. DTA is trying to transform itself into a general soil conservation service. While it has some well-trained and enthusiastic people, it appears that it is much too small in relation to the task it faces.

INDRHI possesses a soils section to appraise the irrigation capability of lands within potential reach of its irrigation canals.

FORESTA is concerned with soil conservation through some reforestation programs and has the responsibility to reduce soil erosion in the Tavera reservoir watershed. The latter task, which should have been done prior to construction, is now being pursued with some vigor; however, the results so far are very unsatisfactory.

The Departamento de Inventarios, Evaluacion y Ordenamiento de Recursos Naturales uses soils information as one of the basic factors to determine the Resources Planning Units (SIEDRA project). They use existing soils information and that provided through LandSat imagery.

There appears to exist some rivalry between departments and an occasional duplication of effort. The major deficiency seems to be the size of the DTA in relation to its task. The mission did not have a chance to contact and appraise the regular agricultural extension service, which comes under the Subsecretariat for Research, Extension and Agriculture Training. It appears to be one of the most essential tasks for the DTA to enlist the services of the extension service to make its members fully aware of the problems of soil and water conservation and to train them properly to assist the program country-wide.

To get maximum cooperation in the field between the different agencies it might be well to consider setting up coordinating offices on a regional basis, i.e., irrigation districts in the various watershed areas, soil conservation districts in others. These offices would have primary responsibility for the work in their area, and would draw on the services of the other departments as needed. To facilitate setting up a soil conservation district and to assure it grass roots support and cooperation, the DTA proposes the formation of "Comites de Conservacion de los Recursos Naturales" (COCORENA). These would be local family groups, who could then be enlisted in the carrying out and planning of programs for the conservation of soils and waters.

The office in Azua "Oficina para el Desarrollo Integral Agropecuario del Valle de Azua" seems a right step in this direction. it would be most imortant that such offices are headed by dynamic well-qualified individuals with medium to long range tenure in this position. Unfortunately it has been reported that the person heading the office in Azua has already been transferred to other responsibilities.

According to Gonzalez (1978) there are two basic problems which hamper the effective coordination of policies between institutions in the agricultural sector. One, many activities are duplicates: Banco Agricola; IDECOOP; IAD, and SEA all have agricultural credit programs. SEA, IAD, and IDECOOP all have agricultural extension functions. INDRHI and IAD both duplicate functions in respect to irrigation. All of these organizations collect agricultural statistics. Second, the long term priorities are not well defined. Plans are developed and programs are carried out in response to immediate needs. Inter-institutional relations between government agencies are defined by laws and decrees, but these relations do not function in private. From Gonzalez' experience, it is essential that agencies not only coordinate to avoid duplication, but work together and share resonsibility.

A Section of Soil Conservation was founded in June 1973 as part of the Subsecretariat of Research and Agricultural Extension. Together with the Section of Soil Fertility, the Section of Soil Classifications and the Section of Soil Laboratories, they formed the Department of Soils. This section did considerable work in the northwest Cibao "Linea Noroeste" including 31 km of terraces, and 52 small reservoirs and dams. It also did a semi-detailed soil survey of about 60,000 ha in this area.

Land and Water Department (DTA). Since August 1978 the DTA operates in its present form as a dependency of SURENA. The section of Soil Conservation of the Department of Soils was incorporated into DTA at the same time. The DTA is currently organized into the three sections: Basic Studies, Soil Conservation and the Unit for Programs and Progress Control. The DTA has made a considerable effort during the last two years to train its staff through short courses both within and outside the country. The DTA has 77 employees of which about one half work in a technical capacity. The technical staff includes four with M.Sc. degrees and 25 more with an Ingeniero Agronomia or equivalent degree. The DTA expects a regular budget of DR$500,000 for 1981 from SEA and an equal amount of support from AID. In addition it receives technical assistance from the local of the InterAmerican Institute of Agricultural Cooperation (IICA-OAS). It also seems to have a good working relationship with the U.S. Soil Conservation Service in Puerto Rico.

The DTA has accumulated a considerable amount of technical information about the erosiveness of rainfall in the country and the potential loss of different soils under various conditions of surface cover, rotations, degree and length of slope. In a study of the relative soil loss under different crops on a given soil in the San Jose de Ocoa area, coffee produced a loss of about 32 tons/ha per acre, whereas potatoes, peanuts and beans produced losses 65-75 times greater than the coffee.

The DTA established a priority list for selecting watersheds based on population density and locality patterns, the watershed area, area irrigated, value of the infrastructure (electrical, irrigation, etc.), estimated erosion losses, and local interest in soil conservation. On this basis priority watersheds include the Bao, Ocoa, Nizao, Sabana Yegua, Maguacis, Chacuey and Guayubin. The watershed of the Tavera reservoir was not included as it is the responsibility of FORESTA.

The Bao watershed has served as a training ground for the DTA during the past two years, which will spread out efficiency in the future. Work includes demonstrations in soil conservation, planting fruit trees on the contour, channel terraces, small sedimentation dams costructed with bags filled with soil, grassed waterways and vegetation barriers. Similar work has been going on in the San Jose de Ocoa watershed, where the cooperation of the populations is considered to be better.

The Departamento de Suelos comes under the Subsecretariat de Investigacion, Extension y Capacitacion Agropecuarla within the Secretariat of Agriculture (SEA). This Subsecretariat has the following departments: soils, plant protection (Sanidad Vegetal), technical information, research, extensions and training and rural organizations. It is physically located on the premises of "Centro Sur de Desarrollo Agropecuario" (CESDA) in San Cristobal, but is not a part of it.

The soils laboratory provides all soil and leaf analyses needed by research workers within the ministry. Furthermore it supplies the analytical needs for soil fertility research and for soil mapping. It also analyzes farmers' samples and makes fertilizer recommendations. It is the only laboratory in the country providing this service free. There is a similar one in Santiago, which, however, charges a fee.

The soil fertility section does traditional fertilizer experiments using major and trace elements on 16 major crops of the region, i.e. corn, plantains, yuca, tomatoes, onions, hot peppers, eggplant and other vegetables. Fertilizer work on coffee and cacao is carried out by CENDA (Centro Norte de Desarrollo Agropecuario) in Santiago.

The Soil Survey Section follows the U.S. Taxonomy in preparing its soil maps. They prepare land capability maps, as well as carry out reconnaissance surveys and catastral studies for the IAD or other government entities. They also do detailed soils surveys for farm plans in the settlements of the IAD. They carry out semi-detailed soil surveys in areas of potential development.

Table VI-5. Commentary on major Resource Production Units (RPU); from SIEDRA 1977.

RPU#	Remarks	Agricultural Potential	Limiting Factors
1	Highly Productive	Moderately High	60% Clayey, 20% Slope, Shallow
2	Forest	None	None
3	Pasture	Low/Subsistence	None
4	Generally Productive: Rice, Coconuts, Pasture	Moderately High	Clayey; Flooding
5	Unproductive	Very Low	Rock; Slopes; Shallow
6	Good for Cotton	Moderately High	Clay; Slope, Shallow
7	Sugarcane; Pasture	Moderate to Moderately High	Wet; Acid; Slope
8	Sugarcane; Rice; Coconuts; Cocoa	Moderately High to High and Unsuited	Wet; Some Sandy
9	Valueless	Very Low	None
10	Limited Potential	Unsuited	Wet; Acid
11	Sugarcane Now, but Better for Pasture	Moderate	Slope; Shallow
12	Sugar, Pasture; Steep Slope Farming by Poor	Moderately High	Clay; Shallow; Slope
13	Suited for Perennials	Low	Slope; Shallow
14	Best for Watershed	Very Low	Slope; Shallow
15	Floods	Moderately High to High	Flooding
16	Periodic Flooding	Moderately High to Moderate	Wet; Saline
17	Most Productive in Dominican Republic	High	Clay
18	Present Use Optimum	Moderate to High	Wet; Slope; Shallow
19	Sugar (rain) but Best for Pasture	Moderately High & Low	Wet; Slope; Shallow
20	Pasture; Sugar (rain); Subsistance	Moderate to High	Slope; Clay
21	Intensive Production, Valley Rice and Sugar	Moderately High to High	Drainage
22	Best for Pasture; Some Sugar	Moderate to Moderately High & Low	Acid; Slope; Wet; Shallow
23	Little Potential	Very Low	Rock
24	No Potential	Very Low	Rock
25	Has Most of Major Irrigated Crops	Low to Moderately High with Irrigation	Droughty; Coarse; Slope
26	Vegetables	Moderately High to High	Drainage
27	Some Poor Farming	Low to Very Low	Slope; Shallow
28	Saline; Needs Irrigation	Moderately to Moderately High	Droughty; Saline
29	Little Value	Low	Slope; Dry
30	Bad	Low	Slope; Dry
31	Highly Variable, Needs Irrigation	Moderately Low	Slope; Dry; Shallow
32	Good Perennial; Annuals Without Irrigation	Moderately Low	Slope; Dry; Shallow
33	Lack of Rain Throughout Year; Seasonally Variable	Moderate to Moderately High	Clay; Slope; Dry
34	Intensive Agriculture	Moderate to Moderately High	Clay; Slope
35	Variable Rain	Moderate	Dry; Slope
36	Naturally Unproductive	Low to Moderate With Irrigation	Dry; Slope
37	Highly mixed	Moderately High & Low	Wet; Slope; Shallow

The department plans to complete semi-detailed soil surveys for the Caribbean coastal plain by 1982. This is to be followed by the coastal plains in the north, so that semi-detailed maps for all level lands should be available by 1983.

The department has 65 employees, of which about two-thirds work in a technical capacity. The budget request for 1981 is DR$900,000. The department receives funds from AID under PPA-II (Programa para pequena agricultura). The Department of Land and Waters (DTA) in SURENA, was formed from personnel originating in this department, where at one time a soil conservation section existed.

Plan Sierra (Plan de Desarrollo Integral "La Sierra"). Plan Sierra covers an area of approximately 2,000 km^2 in the municipalities of San Jose de las Matas and Janico in Santiago Province and in Moncion municipality in Santiago Rodriguez Province. Fourteen rivers, including the Rios Bao and Mao, originate in or above the Plan Sierra area, making it one of the most important catchments in the country. Population is estimated at over 20,000 families or 100-200,000 people.

The Plan Sierra program is comprehensive, including agricultural diversification, reforestation, forest management, social services and artisanal crafts. From agricultural and soil conservation perspectives, the objective to change existing farming systems from seasonal to perennial crops is extremely important. The crop conversion system attempts to replace beans with coffee through credit and technical assistance to small farmers. Participating farmers plant *Inga vera*, a nitrogen-fixing leguminous tree used for coffee shade, at the same time the beans are planted. After establishment, beans are interplanted with yuca. As soon as the yuca starts to grow vigorously, bananas or plantains are interplanted to provide temporary coffee shade. Coffee is planted as the beans mature and yuca and bananas are growing vigorously. The credit program enables the small farmer to weather the intervals between bean, yuca and banana production prior to coffee production in year 3. Valuable fruit trees, such as avocado, macadamia and apple, are also being considered, though no local market currently exists. Where fertile, level land occurs in small intermountain valleys, annual food crops can be grown with irrigation.

Plan Sierra has been in operation less than two years. Its staff appears to be competent and enthusiastic. Except for some assistance from the Dutch government for their nutrition program with 104 clubs of housewives, the government-financed program operates without foreign assistance. While it is a little early to evaluate any results of the programs, it definitely seems to be aimed in the right direction. One minor criticism is that the program seems to lack a research component. For example, it was stated that attempts to improve pasture land failed; however, varieties of grasses and fodder plants that are deep rooted, soil conserving and adapted to the area undoubtedly exist.

Foreign Assistance. The Comprehensive Resource Inventory and Evaluation System (CRIES) has been carried out in the Domini-

Table VI-6. Estimated area (km^2) of Resource Production Units by region; from SIEDRA, 1977.

Region	RPU#												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1. North	—	4,283	—	212	—	—	—	—	—	—	—	—	213
2. Northeast	—	730	—	589	—	—	—	—	633	223	—	—	917
3. Northwest	—	867	—	—	—	—	—	—	—	93	—	—	—
4. Central	337	2,740	—	—	—	22	1,171	—	567	—	358	28	—
5. Southwest	—	3,236	—	—	—	—	—	—	—	—	—	—	—
6. South	—	1,189	—	—	—	104	—	—	—	22	131	—	—
7. East	525	1,269	438	174	1,715	19	237	98	271	—	1,407	1,432	—
National Total	862	14,314	438	975	1,715	145	1,408	98	1,471	338	1,896	1,460	1,130
	14	15	16	17	18	19	20	21	22	23	24	25	26
1. North	1,359	—	253	580	27	—	—	227	—	—	—	—	27
2. Northeast	561	351	494	422	285	69	55	—	—	—	—	—	—
3. Northwest	—	—	756	—	—	—	—	—	—	—	—	—	—
4. Central	—	—	99	—	—	183	324	28	285	290	8	543	—
5. Southwest	419	—	—	—	—	—	—	—	—	—	—	1,254	—
6. South	1,389	—	191	—	—	—	—	—	—	—	—	1,188	—
7. East	—	—	—	—	—	—	—	—	—	125	35	—	—
National Total	3,728	351	1,793	1,002	312	252	379	255	285	415	43	2,985	27
	27	28	29	30	31	32	33	34	35	36	37	Water	Reg. TL*
1. North	—	—	—	—	781	693	—	—	—	—	410	—	9,065
2. Northeast	—	—	—	—	—	—	—	—	—	—	—	—	5,329
3. Northwest	—	—	—	—	1,004	655	—	—	725	633	36	—	4,769
4. Central	—	—	—	—	—	—	—	—	—	—	—	—	6,983
5. Southwest	198	—	—	—	478	806	340	342	430	—	—	—	7,503
6. South	—	567	287	1,135	—	347	—	—	—	—	—	335	6,885
7. East	—	—	—	—	—	—	—	—	—	—	—	—	7,745
National Total	198	567	287	1,135	2,263	2,501	340	342	1,155	633	446	335	48,279

can Republic with the cooperation of the USDA, AID, and Michigan State University since 1976. It is now a permanent component of SURENA in the Departamento de Inventarios, Evaluacion y Ordenamiento de Recursos Naturales.

SIEDRA has used CRIES LandSat imagry, aerial photographs and relevant information on soils, climate, ecological life zones, major land use, crops, agricultural production, techniques, crop yields, production inputs and costs, and social institutional factors to define 45 Resource Production Units (RPU) for the Dominican Republic (Table VI-5). Table VI-6 indicates the regional distribution of RPU's for the whole country.

There is no specific foreign assistance program directed solely to soils. IICA is a fairly small hemispheric institution that includes one soil scientist, who has been very effective in assisting the DTA in technical matters and policy concepts.

AID has supported a variety of programs in the soils and natural resources fields, including assistance to the Soils Department of SEA at San Cristobal. Furthemore, AID has assisted with money and technical advice to the SIEDRA and CRIES programs. The Inter-American Development Bank (IDB), besides financing the construction of irrigation works and other infrastructure developments, is presently financing a consortium of Canadian (SNC-Montreal) and national consultants to conduct the Sabana-Yegua Influences Project. This work is done in cooperation with INDRHI and has a distinct soils component.

The World Bank plans to finance a sugar rehabilitation project that includes components in soil survey, land suitability and aerial photography. The World Bank with UNDP has also financed studies of the development possibilities of the Yaque del Sur and Yaque del Norte Rivers, which contain extensive soil studies.

Principal Problems and Needs

Erosion

Even the casual visitor would notice that accelerated soil erosion is occurring in the Dominican Republic (Fig. VI-1). Small mountain streams are brown with sediments; actively cutting gullies are characteristic of fields and road-sides.

Erosion caused by water has these effects: 1) reduces agricultural productivity of the fields affected; 2) forms gullies that destroy fields and change the landscape; 3) produces sediment loads in streams and rivers that fill reservoirs, clog irrigation canals and ruin turbines in power plants. In areas bare of protective plant cover, eroding water will run off faster rather than infiltrate into soil with the consequence that less water will be available for the aquifer recharge as well as plant growth, streams will carry more water during periods of precipitation and less during dry periods, and the more concentrated runoff will be more destructive on soils, river channels, and infrastructure and carry heavier sediment loads over longer distances.

In the conuco type of agriculture practiced in the Dominican Republic, the small farmer plants beans as his major food crop, and then switches after 2 or 3 years to a new area, because the original field has become exhausted. While the crop will have used some of the nutrient capital accumulated under forest protection, a much stronger reason for abandonment is insidious sheet erosion which the farmer may barely realize. As the soils are shallow in the first place, the thin topsoil may have been washed away even if no gullies are visible. In many fields incipient gullies are visible after a few years of use; gullies may appear after one heavy downpour if conditions are right.

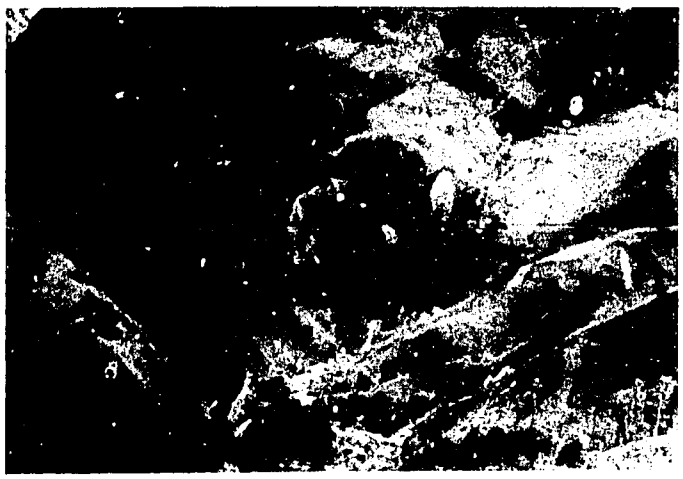


Figure VI-1a. *Erosion is converting the Cordillera Central from renewable to non-renewable natural resources. Massive landslides from steep, deforested slopes fill the narrow valley floor with sediments (upper left and lower center). The large, dark splotch (lower left) was recently burned. (Photo, Italo Russo.)*

Figure VI-2a. *Denuded landscape in the Rio Las Cuevas watershed. What appear as forests (right center) are shaded coffee plantations. (Hand-held aerial photo, Gary Hartshorn.)*

The amount of erosion is a function of several factors such as amount and intensity of rain, percent of slope and its length, certain inherent soil characteristics like the type and amount of clay, and vegetative cover. While each crop has its specific erosion or soil protecting factor, land mangement practices also influence susceptibility to erosion.

The main problem lands as far as erosion is concerned are those with rather low agricultural potential. Under standard classification systms, these lands have been generally classified as "unsuitable for agriculture, should be under forest cover." A few exceptional zones might be adapted for perennial crops.

Steep, forested hillsides in the Dominican Republic show occasional landslides (see Fig. II-3 and V-8). One can see the effect on such lands when the forest is removed and people try to raise crops on them. Unfortunately a visual reconnaissance shows that only small areas, and some have been declared National Parks, are still under forest. In many other areas farming is attempted up to the mountain top (Fig. VI-2), with the result of erosion discussed elsewhere. The end result is that many of these lands are totally stripped of any soil they may have had, and expose the base parent material, producing an almost moon-like landscape, empty of people (Fig. VI-3). Of course not all the damage was done by the small farmer. Some of the bare lower hillsides of today were deforested and simply abandoned. Once the soil is gone, attempts to reestablish protective vegetative cover will be slow and costly.

Standard rules of soil conservation practices dictate that very steep lands should be under permanent forest cover, and lands less steep under permanent pasture. Unfortunately, in the Dominican Republic one cannot apply these rules as population pressure has led farmers to cultivate ever-steeper slopes for subsistence food crops.

It is not politically feasible to move these farmers out of these lands as there are no suitable reserves where they could be settled. Thus the only alternative is to find a system which will reduce the damage to the minimum possible, and permit the farm families to live, preferably on a higher standard than at the present.

The Dominican Republic reportedly has a population of 5.6 million today with a population growth rate of 2.6 to 3.0% per year. Predictions are for 10 million inhabitants by the year 2000. There are efforts to reduce the rate of population increase. However, even under the most optimistic prediction, population pressure on the available land will increase. Even the suggestion to convert some of the sugarcane lands away from export production to the use of food crops would not substantially change the soil erosion problem.

Figure VI-1b. *Complete deforestation in the Rio Las Cuevas watershed left the shallow soils unprotected from the heavy rains of the 1979 hurricanes. (Photo, Italo Russo.)*

Figure VI-2b. *Serious deforestation of upper slopes in the southern Cordillera Central. The forested area (center) is a shaded coffee plantation. Note the gully erosion (upper left) and landslides. (Photo, Italo Russo.)*

"Conuco" farming on many of the steep lands involves the growing of a food crop, like beans, for 2-3 years on newly cleared land. When yields go down, the land is shifted to a low grade pasture which later is planted to fruit trees on an extensive basis. Food crop cultivation as now practiced, as well as pasture, produce a high amount of erosion.

As it is impossible to return the lands to their original state or reforest all the steep lands occupied by small farmers growing food crops, the only alterntive is to minimize erosion. This would involve improving small farm agriculture through standard soil conserving measures like contour planting, terraces, grassed waterways, gully repair, etc.

Improved farming systems should involve the use of fruit and forest trees, close-growing soil conserving crops and improved deep rooting forage plants. The farming system has to fulfill these tasks: feed the farmer; provide an adequate income for him; be acceptable to the small farmer; i.e. he must be able to manage it with a minimum of technical assistance; and conserve the soil.

Some imaginative beginnings have been made in the Dominican Republic in this respect through the "Plan Sierra" and the "Project Bao" of the Departamento de Tierras y Aguas. However, it appears that more research and planning is needed. "Plan Sierra" and other projects, if successful with their changeover from annual food crops like beans to perennial crops like coffee, may well improve the lot of these farmers through higher income. At the same time it would likely produce a shortage of beans, the main food staple. Also, while coffee may work well in some places, it may not be suitable for some other climatic or soil conditions, especially if erosion has progressed too far. Research on suitable pasture grasses seems indicated. It does not seem reasonable for "Plan Sierra" to declare a failure so early on its efforts to improve pastures in the area. There are thousands of pasture grasses and fodder plants world-wide, some of which are excellent soil conserving crops. Some of these should be suited for the Dominican Republic's reclamation areas. However, more effort is needed to introduce and test them under different soil-slope conditions, as well as climatic regimes.

No data were collected on land tenancy and ownership. However, one complaint of soil conservation technicians was that they might obtain a tenant farmer's cooperation to establish soil conservation practices on a certain farm this year, but the successive tenant farmers might not cooperate. It is obvious that owner-operated farms, regardless of their size, use the most desirable conservation techniques for many reasons, and greatly help any soil conservation efforts.

The dam sites and reservoirs of Las Cuevas, Nizao, Ocoa, Tavera, Bao, Buayubin, Chacuey and Maguaca represent an investment of at least $500 million, just for the hydroelectric and irrigation infrastructure. There are many additional costs such as access roads, additional canals, power lines, and the loss of possible farmlands and communities flooded by the reservoir.

Such an investment has to be protected if it is to help national development. Nevertheless, data calculated for these watersheds indicate that accelerated erosion is dumping millions of tons of sediments into reservoirs. Based on the "Universal Soil Loss Equation" it has been estimated that the soil loss above the previously listed reservoirs ranges from 95 tons/ha/yr in the Chacuey reservoir to 507 tons/ha/yr in the Ocoa watershed. Almost all of this will end up in the reservoir, which after a number of years will store sediments instead of water. Table VI-7 gives the soil losses in 7 watersheds.

An example: The Tavera reservoir receives about 275 tons/ha/yr from its, 7,370 ha watershed. This reservoir is new, and represents an investment of $141 million. It has been stated that its 50 year lifetime (used in cost/benefit analyses) has been reduced by the avalanche of sediments to less than half this time. A visual inspection of the reservoir reveals the heavy sediment load entering it, even on days without rain. Agriculture, including clean cultivation, has been practiced and still is being practiced to the waterline, although a 5 m strip just above the expected water level is being reforested. FORESTA, in charge of soil conservation in this watershed, belatedly launched a major effort in tree plantings, terracing, vegetative strips and other soil conservation measures. Their effort is handicapped, as farmer cooperation is strictly voluntary. Furthermore, the land tenancy situation is such that much land is not owner-operated, but cultivated by tenants. Changes are frequent—while this year's tenant may cooperate, next year's may refuse to do so, nullifying past efforts on a parcel of land.

Figure VI-3a. *Massive gully and rill erosion in degraded subtropical dry forest in the Rio Ocoa watershed caused by the 1979 hurricanes. (Photo, Italo Russo.)*

The situation has been aggravated by highways built around reservoirs. In many places water collecting on or along the highway is passed underneath the highway through a culvert. The water is permitted to descend from the culvert on its own, thus producing a solid stream of water during rainy periods. As a result many newly formed gullies can be observed producing tremendous amounts of sediments, ruining the mountainside, and which in time, if not controlled will cut the highway by advancing right throught it. In the entire Tavera reservoir area, only one waterway was observed carrying the water down in steps to level land, thus dissipating its energy and preventing erosion.

One other factor aggravating erosion into the Tavera reservoir is that farmers who were located on land flooded by the reser-

Figure VI-3b. *Steep slopes stripped of soil by the 1979 hurricanes. This is subtropical lower montane moist with sparse pine forest on shallow soils in the upper Rio Las Cuevas watershed. (Hand-held aerial photo, Carlos Quesada.)*

Table VI-7. Soil loss by watershed: Adapted from AID Project 517-0126.

Watershed	Area(ha)	Erosion (tons/ha/yr)	Surface Layer Erosion (cm/yr)
Las Cuevas	5,690	275	1.8
Tavera	7,370	275	1.8
Bao	9,330	346	2.3
Nizao	9,920	125	0.8
Ocoa	5,630	507	3.4
Guayubín	7,340	111	0.7
Chacuey	3,860	95	0.6

voir, were relocated on the higher lands above the reservoir. While this decision is understandable in view of the population pressure in general, the difficulty of finding new land, and the reluctance to move people far away form their former houses, it certainly has helped to increase the sediment load arriving in the reservoir. Former settlers of the reservoir area complain that the new land supplied is very inferior to their old farmland.

Wind erosion is a problem in some dune areas and along some beaches on the north coast. While some wind erosion may also take place on denuded fields in the mountains, the damage caused by this type of erosion is insignificant when compared to water erosion.

Land Capability

No comprehensive appraisal of the natural resources of the country was attempted prior to the OAS study in 1965-1967. Some of the pre-investment studies in the OAS report have been followed up. However, it seems that the data presented in the land capability classification did not impress any decision making authorities.

According to the OAS study (Table VI-8) only 53,700 ha or 1.1% of the national territory is excellent agricultural land. This land is in a strip east of Santiago to San Francisco de Macoris. Other good agricultural land (Classes II and III) covers 547,000 ha or 11.5% of national territory. The Class II lands are mostly alluvial lands along rivers. While of good quality for crop production, some of the Class II land is exposed to flooding. Class III land occupies large areas in the eastern region in topographically higher and less level positions than Class II land. Much of the sugarcane is apparently on Class III lands.

Class IV lands occupy 363,900 ha, covering 7.7% of the national territory, mostly along the Caribbean coast from about Punta Catalina through the area in and around Santo Domingo to Rio Chavon. There are also large pieces of Class IV land south of the Class I, II, and III land in the north and along Lake Enriquillo and scattered patches throughout the mountains. This class includes soils with free salts in the profile in the western part of the Cibao valley and around Lake Enriquillo. These soils are all marginal for crop production, i.e. they will not produce good yields, or only certain crops can be grown, or they require very special and skilled management. Depending on slope, they could be highly erosive or quite shallow.

Lands in Classes V and VI, or slightly less than one million hectares covering almost a quarter of the national territory, have been classified as grazing lands, almost half of them (Class VI) with a definite erosion hazard. Most of the Class V lands are in a fairly solid block in San Cristobal Province, and portions of El Seibo and Altagracia Provinces.

Class VII lands, only suitable for forests and forest exploitation, include practically all the mountainous areas of the country, as well as limestone areas around Barahona and south of Higuey, and the karst area of Los Haitises. Many of these mountain areas are densely populated, and little forest is left.

There is some Class VIII land, mostly in the high mountains, covering 120,200 ha or 2.5% of the country's territory. These have been classified as wildland, i.e. they should be left untouched.

It should be noted the SIEDRA project provides data on the potential land use on a more detailed base, i.e. done to the various Resource Planning Units (RPU). However, they have only published data for some regions, though the rest of the data is forthcoming. As their soils data are essentially the same as those of the OAS study, it will not change the overall picture.

Summary data available from the SIEDRA project are shown in Table VI-9 which summarizes these data by regions, indicating total land, low quality lands and land unsuitable for agriculture, land of moderate or high quality, land in farms, and land in farms as a percentage of high or moderate quality land. Table VI-9 indicates that the northwest, southwest and south are regions with a potential for expansion in agriculture, while the other regions are largely marginal and sub-marginal lands that probably should be taken out of production and placed under a permanent tree cover.

Table VI-8. Land capability classification. Source: National Statistics Office and OAS Survey of the Natural Resources of the Dominican Republic (taken from W. B. Report No. 1705-DO, 1977).

Class	Km^2	%	Production Capacity
I	537	1.1	Excellent for cultivation
II	2,350	4.9	Very good for cultivation
III	3,122	6.6	Good for cultivation
IV	3,639	7.7	Limited or marginal for cultivation
V	6,071	12.7	Pasture; no erosion hazard
VI	5,611	11.8	Pasture; erosion hazard
VII	25,161	52.7	Forest
VIII	1,202	2.5	Wildlands
Total[a]	47,693	100.0	

[a]Does not include 588 km^2 in islands, lakes and other unclassified areas.

Land Rehabilitation

Many eroded soils can be restored to productivity, but it is a costly and slow process. Where only the topsoil has been eroded from a moderately deep profile, it is often possible to plant green manure crops, fertilize the crop, then burn it all into the soil to produce a new surface layer with organic material, improved physical condition and nutrients in more accessible and longer lasting form. This may be possible with many of the soils used for "conuco" agriculture. Small gullies can be stabilized by establishing protective vegetation with well-developed root systems.

A more serious problem is the denuded mountainsides in many parts of the country. Unfortunately these were observed only from the air. The appearance of only a slight coloration of green even in the rainy season, and the absence of signs of life, suggest that bare bedrock is exposed. The soil-forming process continues even over bedrock. The balance between soil formation and erosion is generally disrupted by human activity.

Salinity

Salinity destroys soil for agricultural use. The sources of saline soils are either salts located in the soil profile, or irrigation water with a high salt content. The main areas where salinity problems have been observed are the rice growing area and the sugarcane estate of CEA Ingenio Esperanza in the northwest and Igenio Barahona in the southwest. It its also known that the area west

Table VI-9. Agricultural land and its potential by regions in the Dominican Republic; base data recalculated from SIEDRA (1977).

No.	Region	Total land km²	Land in farms km²	Lands of low quality or unsuited to agriculture [a] km²	Lands of moderate or high agricultural potential [b] km²
I	North	9,065	6,049	5,855	3,210
II	Northeast	5,329	4,796	3,064	2,265
III	Northwest	4,769	1,952	960	3,809
IV	Central	6,983	5,127	3,963	3,020
V	Southwest	7,503	2,031	3,853	3,650
VI	South	6,885	1,321	4,488	2,397
VII	East	7,745	6,176	5,260	2,485
	Total	48,279	27,452	27,443	20,836

[a]Includes RPU's 2, 3, 5, 9, 10, 13, 14, 23, 24, 27, 29, 30, 38.
[b]Includes all other RPU's.

of Ingenio Barahona, i.e. the area between Sierra de Neiba and Sierra Baoruca, which includes the depression around Lake Enriquillo, has some saline soils.

In the case of the Ingenio Barahona about 2,000 ha out of 11,500 ha had to be taken out of production because of high salinity. It is estimated that 70% of the plantation's sugarcane area is affected by salinity. Production on remaining lands has decreased from 130-140 tons/ha a few years ago to about 95 tons/ha. The only other irrigated sugarcane estate is Ingenio Esperanza in the Cibao valley. It is about 2,200 ha in size, and does have minor salinity problems, but all areas planted to sugarcane continue in production.

The study done by FAO in the Cibao region shows that many of the soils contain free salts somewhere in the profile. If these soils are improperly irrigated, evaporation will bring these salts into the root zone and reduce yields at first, and, if the accumulation is sufficient, will prevent plant growth.

It should be noted that one of the principal causes of bringing salinity to the surface, i.e. into the root zones of crops, is poor water mengement. In many soils where salinity exists below the root zone, overirrigating will dissolve the salts and move them upward. Overirrigation also raises the water table and therefore affects root growth, Education for improved technical management of irrigation will help; also water users fees based on quantity will reduce the temptation to use excess water.

Conclusions and Recommendations

1) The GODR should delay any additional projects that involve the construction of reservoirs, and concentrate its efforts on protecting and operating those already in existence, regardless of attractiveness of the project under consideration and easy terms offered by international financing organizations.
2) The GODR should instruct its highway department to form a commission consisting of engineers and soil conservation specialists to review all recent highway construction to determine where highways cause erosion problems, as is definitely the case around the Tavera reservoir.
3) The GODR should present to the legislative branch a draft law which permits the formation of soil conservation-irrigation districts. Some of the principal requirements contained in this law should be provisions which require farmers to cooperate with the soil conserving efforts of the government. Perhaps it should contain a graduated level tax, which may be nil for farmers conducting good soil conservation practices, but take the form of a fine for non-cooperative farmers. Furthermore, the law should provide a basis for collecting fees from irrigation water users on the basis of quantity used.
4) The GODR should initiate a country-wide research program through the research facilities of SEA and in close cooperation with "Plan Sierra" to determine farming systems that will permit farmers on steep lands to survive, and if possible, to improve their living, and at the same time minimize soil erosion.
5) The GODR should conduct a parallel research program to introduce grasses or forage plants that have a soil conserving effect and will produce under the different soil-slope and climatic conditions of the DR.
6) The GODR should strengthen the DTA and give its program the highest priority as it is an investment in the future prosperity and stability of this country.
7) In the same vein as above, the GODR should consider, if other areas would be suitable to launch a program similar to "Plan Sierra".
8) The GODR should continue and amplify its efforts to determine what to do with lands having soils with free salts in their profile and to reclaim those previously productive soils.
9) The GODR, through the DTA and possibly other agencies, should set up a comprehensive system of monitoring stations to determine the extent of the country's soil losses, the sediments in its water courses and the effectiveness of its soil conservation measures.
10) The GODR, possibly with assistance of outside agencies, should start a program of soil rehabilitation (which goes beyond soil conservation) in areas completely ruined for agriculture and forestry.

VII

Coastal and Near-shore Marine Characteristics

The Dominican Republic is bordered by the Atlantic Ocean to the north, the Caribbean Sea to the south and separated from Puerto Rico by the Mona Passage to the east. The insular shield area of 8,130 km² is characterized by its narrow width, averaging only 7.5 km (Guidicelli 1979). Over one half of the total shelf area is concentrated in five areas, Banco Monte Cristi, Bahia de Samana, Cabo Engano, San Pedro de Maroris and the Bani-Barahona region (Fig. VII-1). The submerged banks Navidad and Plata are 70 km north and 150 km northwest, respectively, of Cabo Samana.

The current regime is dominated by the western flowing North Equatorial Current that divides at the Mona Passage into northern and southern components. Despite this permanent oceanic feature, near-shore countercurrents, primarily tidal in nature, are common. The Mona Passage, a heavy ship traffic lane, is known for its strong currents, occasionally exceeding 3 knots/hr (Van Ost and Kline 1978).

The tide on the northern coast is semidiurnal with a mean spring tide range of 90 cm. On the south coast a semidurnal tide predominates with a reduced tidal range of only 30 cm (de La Fuente 1976).

The Dominican coastal zone is characterized by reef escarpments, beaches and wetlands often with associated lagoons. (Fig. VII-2 and 3a). In the northwest from Pepillo-Salcedo to Puerto Plata extensive wetlands and mangroves associated with the Rio Yaque del Norte continue to Luperon where a transition begins to a zone more characterized by beaches and rocky headlands. Offshore a major reef system extends from Monte Cristi to Punta de Buren.

From Puerto Plata to Samana the coastline consists of sand beaches alternating with rocky escarpments. There are few extensive coral systems or wetlands with the exception of Cabareto and Rio Baqui. Coastal coconut plantations are found near Matancita, Las Terrenas and Sanchez-Samana.

To the northeast the most extensive beach system occurs from Miches to Cabo Engano. This beach system is bordered by coastal wetlands and coconut plantations near Los Ranchitos. To the south of Cabo Engano there is a coastal reef escarpment only occasionally broken by sandy beaches.

In the southeast from Isla Saona to San Pedro de Macoris the coast is low and flat with extensive escarpments and occasional sand beaches, the latter usually in proximity to rivers. A major wetland system is found on the south insular tip in Bahia Catalinita.

From San Pedro to the Bahia de Neiba the coast is relatively featureless with escarpments dominating, but with increasing occurrence of sand beaches to the west.

To the south and west the coast becomes increasingly diverse with alternating escarpments, sandy and rocky beaches and an extensive wetlands and mangrove system south of Punta Regalada to Punta Inglesa and north of Punta Bucan Base to Laguan de Manuel Matos.

Based on available information a macroscopic coastal inventory of critical areas is provided in Table VII-1. Mangrove systems are widely recognized as one of the most productive tropical ecosystems. They function as a major source of nutrients to surrounding nutrient-depleted waters, provide habitat for a diverse assemblage of animals and birds, act as sediment traps protecting delicate offshore ecosystems such as coral communities and provide nursery grounds for many marine species. To humans their value is often as storm barrier systems and critical habitats for consumable fish and shellfish. In the Dominican Republic mangroves have been used extensively for tannin, charcoal, posts and construction materials (Alvarez and Bonnelly 1978). In Puerto Viejo and the nearby coastal islands an estimated 50% of the mangroves were destroyed in the period 1919-1962 (Alvarez and Bonnelly 1978).

In the Dominican Republic, mangroves are essential to several fisheries: as habitat for the mangrove oyster *Crassostrea rhizophorae;* as nursery grounds for many species of coral-associated fish, the major fishery in the country; and for shrimp in the Bahia de Samana. At the head of Samana Bay, the largest mangrove forest in the country may be threatened by encroaching rice cultivation.

The numerous brackish and freshwater lagoon systems throughout the country represent a major coastal resource thus far underutilized. Protected by coastal barriers, these lagoon systems are natural and accessible sources of fish. Major quantities of fish inhabit Lagunas Rincon and Redonda. In addition, the potential exists for utilizing lagoons for aquaculture, *Artemia* production, salt production, recreation and possibly even solar energy production. Due to a very slow rate of water turnover, lagoons are very susceptible to contaminant build-up.

Coral reefs have been compared with mangroves as representing the most diverse and productive of marine ecosystems. As such they fulfill many of the functions of mangrove systems, including provision of habitat, a nutrient source, offshore beach protection and as a tourist attraction. Though the reefs are not as

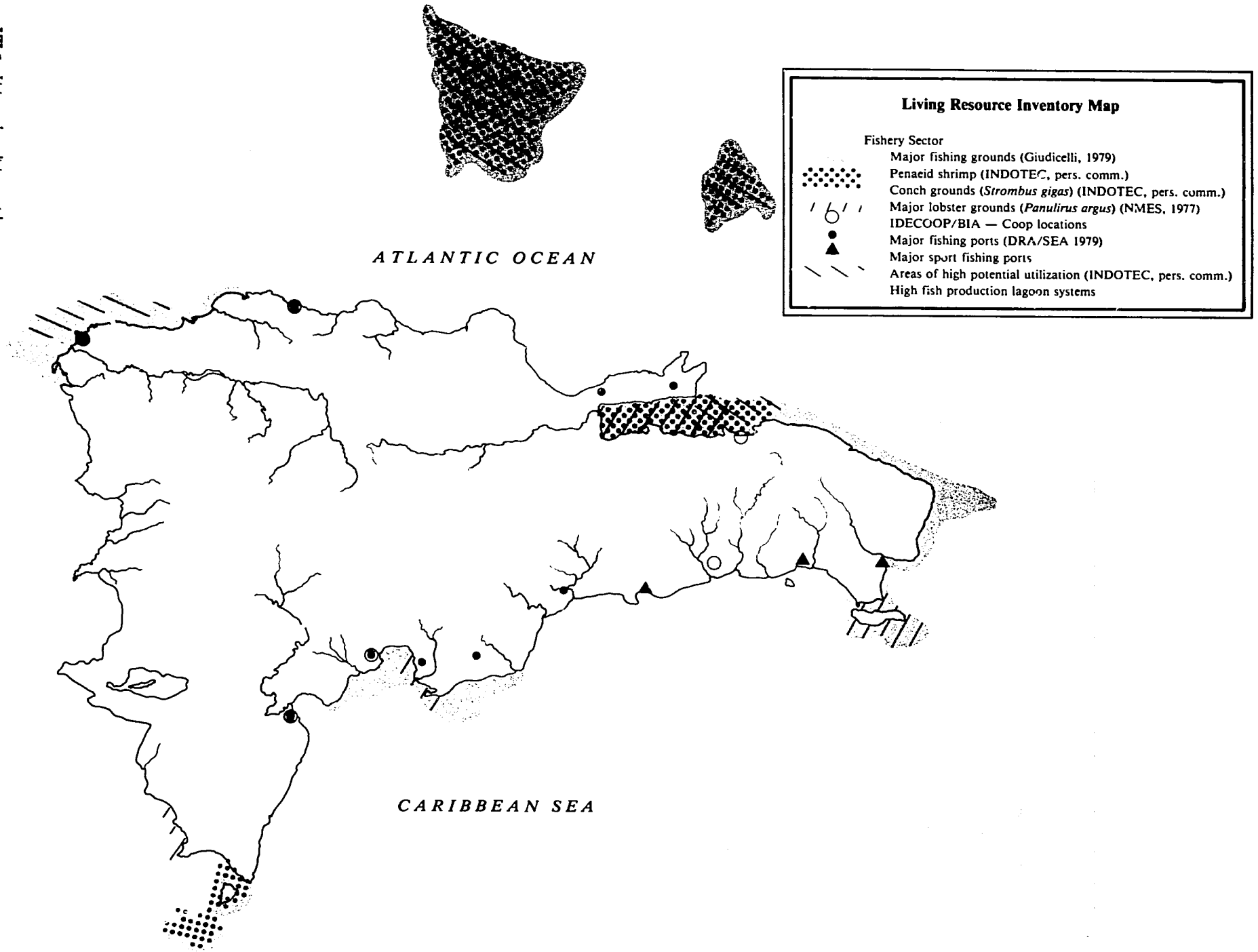


Figure VII-1. *Living and non-living coastal resources map.*

Figure VII-1 *(continued)*

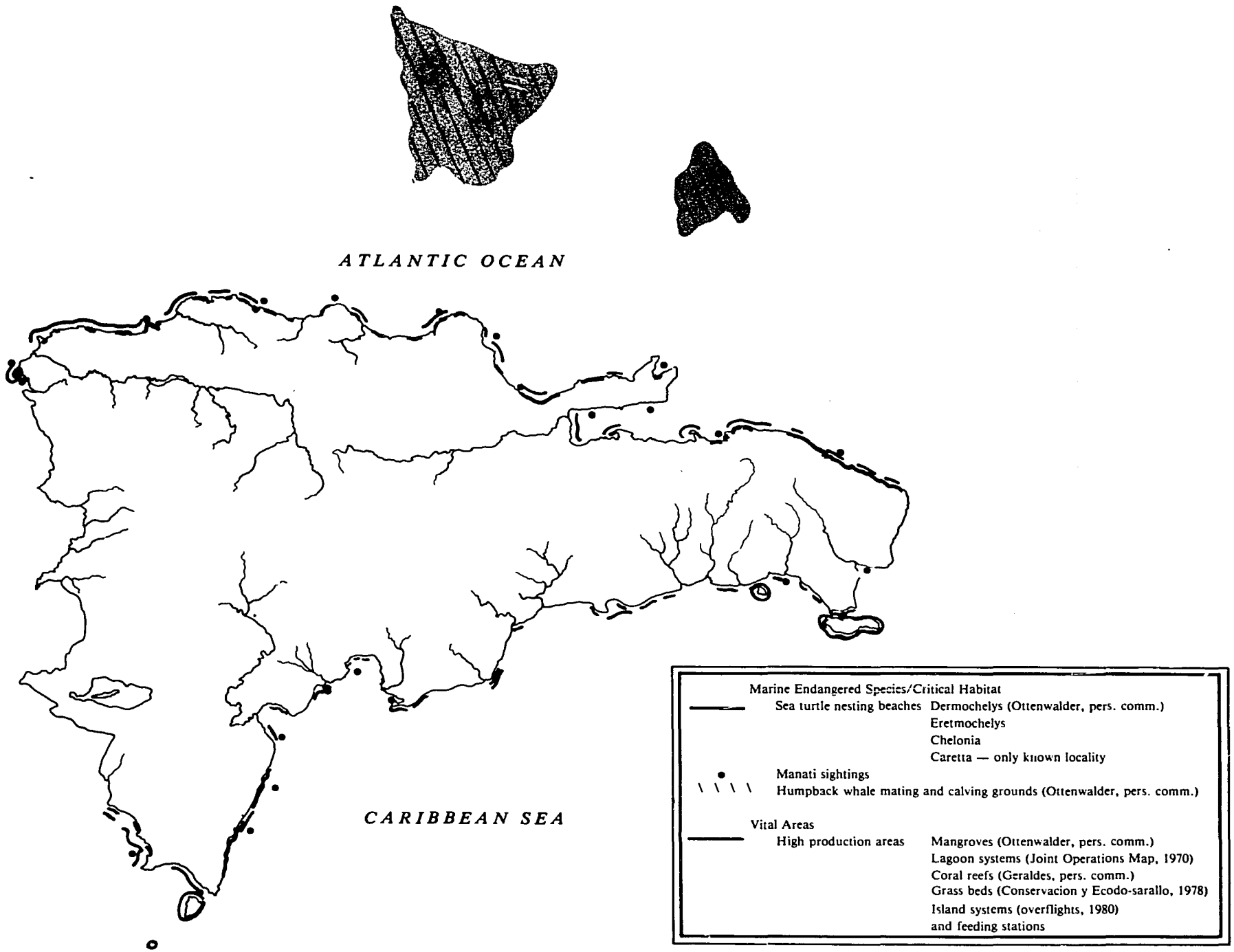


Figure VII-1 *(continued)*

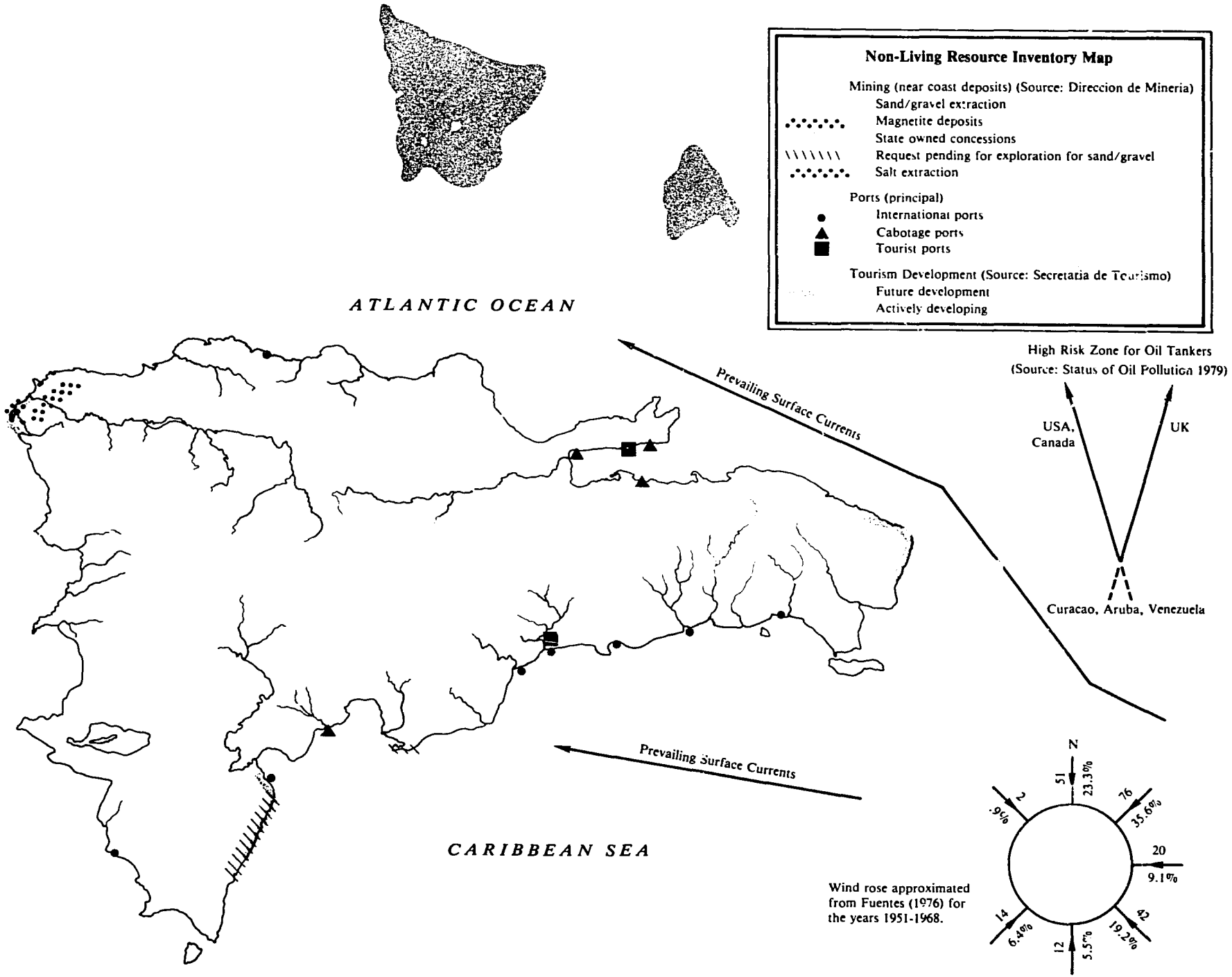


Figure VII-2a. *Limestone cliff, Los Haitises. (Photo, John Shores.)*

well developed as in the smaller islands in the Antillean chain, the numerous patch reefs found throughout the waters of the Dominican Republic represent habitats for the major fishery as well as prized resources for tourism development. Until recently, corals were harvested for both local sale as souvenirs and for export. Harvesting of coral requires a license from the DRP (Law 1728, 1976). In 1975 an estimated 6,626 kg of corals were exported between January and October (Geraldes and Bonnelly 1978). There were no exports of coral in 1979, though illegally harvested corals are still sold in local markets. Coral reefs are highly susceptible to sedimentation, high levels of turbidity and toxic substances, hence protection of coral reefs should be a major consideration in any tourist development.

Grass beds in tropical waters signify the greatest concentrated source of primary productivity. As such they provide a food source for numerous animals, a nutrient source to surrounding waters, a source of oxygen and a means to stabilize the bottom substrate. Their distribution is very poorly known in the country despite their importance in providing habitat to the edible conch *Strombus gigas*. Grass beds also are highly sensitive to turbidity and sedimentation.

Islands are few but significant in the Dominican Republic. As a result of their insular nature they represent unique ecosystems that must be carefully managed to protect them from degradation. In light of their pristine character, limited carrying capacity and lack of understanding of these areas, they should be carefully studied before any utilization is initiated.

Figure VII-2b. *Coral rock coast on north shore of Isla Saona, Parque Nacional del Este. (Photo, John Shores).*

Critical habitat for endangered species will be covered in a separate section.

Existing or Potential Problems and/or Needs: Absence of a comprehensive coastal and near-shore marine resource inventory data base; absence of a scientific data base to facilitate the understanding of separate ecosystems and the linkages between these systems; and enforcement of existing legislation to protect critical resource areas such as coral reefs and mangroves.

Marine Fisheries

In contrast to highly productive northern temperate fisheries, tropical and subtropical fish resources generally are considered low in productivity. Low productivity of the waters combined with a narrow continental shelf and the lack of a true fishing tradition explain the necessity for the Dominican Republic to import approximately 60% of the fish consumed.

The major fishing zones are associated with the wider shelf areas and submerged banks including Banco Monte Cristi (892 km²), Bahia de Samana (858 km²), Cabo Engano (772 km²), San Pedro de Macoris (463 km²), Bani-Barahona (858 km²), Banco Navidad (772 km²) and Banco Plata (1,955 km²).

Figure VII-3a. *White sand beach and coconut palms, Parque Nacional del Este. (Photo, John Shores.)*

Data on landings are estimates at best, but production over the past five years appears to be near 7,000 m tons/year. Though specific fish identification data are not collected, landings appear to be dominated by demersal species. Landings of pelagic species were estimated to be only 16% of total landings over the same period of time (INDOTEC, per. comm.).

In addition to the finfish resource there are valuable shellfish resources, including the spiny lobster *Panulirus argus*, several species of shrimp—the most important being *Penaeus schmitti*, and the West Indian fighting conch, *Strombus gigas*.

The major lobster fishing grounds are the west and south coast of Isla Saona and areas adjacent to Salinas, Cabo Rojo and Samana (NMFS 1977). The penaeid shrimp fishery is concentrated in the Bahia de Samana and extends to the eastern bank. Major collecting grounds for conch include the northern offshore banks and areas adjacent to Isla Beata (INDOTEC, pers. comm.).

The fishing effort in the Dominican Republic is at an artisanal level. Giudicelli (1979) estimated there were 1,826 professional and 1,648 part-time fishermen in 1978. The fishing fleet is estimated to be 1,400, dominated by dugout-canoes—"cayucos" (420) measuring 3-5 meters in length and "yolas" (830) between 4-6 meters in length. The majority of boats larger than the "yola"

Table VII-1 Macroscopic coastal classification of critical areas. Sources: Joint Operations Map (1970), Geraldes (pers. comm.), Bonnelly (1978).

Geographical Area	Mangroves and Associated Wetlands	Lagoon System	Grass Beds	Coral Reefs	Islands
North West					
Pepillo-Salcedo-Puerto Plata	Pepillo-Salcedo Bahía de Icaquitos	Laguna la Salina Laguan de Marigo Laguna de la Piedra Laguna Corto Pies	Bahía de Monte Cristi Bahía de Icaquitos	Extensive from Monte Cristi-Punta de Buren, Cabo Isabela, Puerto Plata	Siete Hermanos
North Central					
Puerto Plata-Samaná	Arroyo Honda Río Yuna-Río Barracote Bahía de San Lorenzo Bahía de La Jina	Laguan Cabarete		Scattered Patch Reefs	
North East					
Samaná-Isla Saona	Laguna Redonda Laguna de Limón Ciénaga La Majaqua Punte Macao-Cabo Engano	Laguna Redonda Laguna del Limòn Laguna Bavuro		Scattered Patch Reefs	
South East					
Isla Saona-S.P. de Macorís	Las Calderas Río Soco Río Higuamo Río Ocoa	Laguna Secucho	Bahía Catalinita	Scattered Patch Reefs	Isla Saona Isla Catalina
South Central					
S.P. de Macroís-Bahía de Neiba	Punta Palenque Puerto Viejo		Bahía Las Calderas Bahía Este de Ocoa Puerto Viejo	Scattered Patch Reefs Bahia de Andres Bahia de Ocoa	
South West					
Bahía de Neiba-Pedernales	Río Yaque del Sur Punta San Luís Punta Bucán Base-Laguna Manuel Matos	Laguna Oviedo Laguna Salda Laguna Manuel Matos		Developed system Near Barahona Scattered Patch Reefs	Isla Beata Isla Alto Velo

are located in the north and fish the offshore banks. Approximately half of the 1,400 boats are motorized. The predominant fishing gear used are pots and handlines (WI LAF 1978).

Based on DRP/SEA (1979) statistics, Table VII-2 shows the most important ports in number of fishermen and Table VII-3 gives regions in percentage of total national landings.

The Dominican Republic fishery sector relies heavily on fish imports mostly in the form salted fish from Norway (Table VII-4). The 1989 estimated deficit in the balance of payments in fish production based on import-export figures was calculated to be approximately RD$19 million. Based on an estimate of 7,000 M tons local production (which includes exports) and total consumption of about 21,000 M tons, about 70% of marine fish products consumed in the country is imported.

Preliminary results from a recently completed survey of the country's fishing potential, funded by Bid, estimate that the insular platform and submerged banks of the Dominican Republic could support on a sustained basis a production level of 800 kg/km²/year. By multiplying this value by the area of platform and banks considered accessible (85%), INDOTEC calculated a total potential production of 10,454 M tons. This level of production would more than meet the present national demand. The areas capable of supporting the greatest increase in fishing effort are Monte Cristi, Zona del Este, the offshore banks, and the eastern shelf area of the Bahia de Samana.

Primary administrative responsibility in fisheries lies in the Fishery Resource Department in the Agriculture Secretariat. The Department's primary mandate as outlined in Law 5914 (1962), is to protect and regulate all marine and freshwater fish stocks.

Table VII-2. Important ports and number of fishermen. Source: DRP 1979.

Port	Licensed Fishermen
Santo Domingo	514
Puerto Plata	407
Sanchez	391
La Romana	371
Bani	298
Barahona	273
Samaná	264
Azua	243
Palmar de Ocoa	198
Manzanillo	157
Subtotal	3,116 (71%)
Others	1,273
TOTAL	4,389

Table VII-3. Major regional ports based on landings. Source: DRP 1979.

Region	% Landings
Altagrácia	14
Santo Domingo	12
Puerto Plata	12
Samaná	10
Pedernales	8
National Total	56

Registration of fishermen is required. The only landings data being collected are estimated total volume; thus no figures exist to determine the status of the resource. Despite the existence of numerous laws regulating the capture of living marine resources such as turtle, lobster, and crab, there appears to be widespread abuse of existing legislation.

Activities in the mariculture field have been insignificant. A large facility near Boca Chica went bankrupt in an attempt to culture pompano, *Trachinatus carolinus*. Juvenile marine eels, *Anguilla* sp., are being captured near Puerto Plata, raised in Dajabon, and exported to Japan by a small Japanese firm. There has been interest expressed in the potential for mariculture of the indigenous mangrove oyster, *Crssostrea rhizophorae*.

Existing or Potential Problems and/or Needs: Inadequate data collection system to assess status of fish stocks; inadequate enforcement of existing fishery legislation; possible over-fishing of lobster stocks (INDOTEC, pers. comm.); possible uneven distribution of fishing effort on Samana shrimp stocks (INDOTEC, pers. comm.).

Fresh Water Fisheries

As a result of a government mandate to the former Department of Hunting and Fishing to increase the production of the country's waters (Law 5914, 1962), the major native edible fresh water species have been displaced by introduced species. The dominant fresh-water fish included carp (*Cyprinus* sp.), *Tilapia*, and to a lesser extent *Micropterus* sp. Geraldes *et al.* (1979) estimate that during the period 1970-1977 the Fishery Resources Department (DRP) released 456,132 carp, 2 million *Tilapia* and 260,000 bass fingerlings. The ecological ramifications of this program will be discussed in the section entitled Exotic Species Introduction.

In addition to the finfishes, fresh-water *Macrobrachium* shrimp, including *M. carcinus*, and two species of fresh-water turtle, *Chrysemys*, are widely fished. With the exception of fresh-water shrimp, the fish resources are consumed locally. These resources are distributed throughout the country's rivers and in more than 250 ponds and lagoons. Most important are the Lagunas Rincon, Redonda and Limon (INDOTEC, pers. comm.), of which only Redonda is brackish. Two other high production areas are the enclosed estuary in the Rio Baqui-Boba area and the large Tavera reservoir.

Very little documentation is available related to fresh-water fishermen. In the INDOTEC-administered survey three types of fishermen were classified in the Laguan Rincon area: professional, artesanal and subsistence, totaling about 300 fishermen. The dominant boat used is the small dugout or cayuco. The dominant type gear used is the fishing pot, but hook and line and gill nets are also used.

Estimated production in the INDOTEC study from freshwater resources was 2,000 m tons/year. One half was harvested from two lagoons (i.e. L. Rincon, 715 m tons; L. Redonda, 380 m tons). An estimated 100 m tons were harvested from the Baqui-Boba estuary and Tavera reservoir. Estimated 1979 production was 80 m tons of fresh-water shrimp and six m tons of turtle (DRP 1979).

The number and diversity of fresh and brackish water systems suggest substantial and thus far underutilized resources. This appears to have been recognized as resources are being inventoried in these water bodies by DRP. CIBIMA (Marine Biology Research Center) and INDRHI (Water Resources Institute) have initiated a joint project for stocking the 23 reservoirs planned by INDRHI. *Artemia* production, oyster mariculture and solar radiation collectors (similar to experimental projects in Israel) may be potential resources.

The responsibility for managing the fresh and brackish water resources as well as increasing their production and utilization

Table VII-4. Fish imports, exports, value and country of origin or destination; data from CEDOPEX 1980 and Estadistica Dominicana 1979.

Product	Exports kg	Value RD$	Destination	Imports kg	Value RD$	Origin
Fresh fish (chilled/frozen)	329,560	339,559	Puerto Rico	33,103	24,118	Canada
Salted fish	28,367	26,032	Puerto Rico	8,736,128	14,585,037	Norway
Shellfish						
Turtle (chilled/frozen)	1,554	1,535	Puerto Rico			
Shrimp (chilled/frozen)	4,277	13,933	Puerto Rico			
Lobster tails (chilled/frozen)	40,427	151,141	Puerto Rico			
Conch (chilled/frozen)	138,462	164,306	Puerto Rico			
Oysters (chilled/frozen)	87	62	Curacao			
Octopus (chilled/frozen)	24	30	PR, Aruba			
Makey --	2,437	789	U.S.A.			
Subtotal	187,268	331,796		17,180	23,025	U.S.A.
Processed						
Crab	23,438	55,080	Puerto Rico			
Conch	44,297	46,794	Puerto Rico			
Lobster	1,188	9,540	Puerto Rico			
Shrimp	1,007	3,175	Puerto Rico			
Subtotal	69,930	114,689	Puerto Rico	6,034,569	4,927,452	Japan
Total	615,125	812,076		14,820,980	19,559,632	
Balance of Payments					-18,747,556	

also rests with the Fishery Resources Department (Law 5915, 1962). Major emphasis has been directed toward stocking ponds with fingerlings produced at the Nigua hatchery. Though production figures exist for the respective water bodies, there are no species/time/size data being collected to calculate population parameters for stock management.

Aquaculture projects, species introduction and available freshwater resources are interrelated. In 1953, FAO-sponsored programs helped develop the government's fish hatchery in Nigua. The first fish species introduced was *Tilapia mossambica.* Since that time, in accord with DRP's legal mandate, incentives have been provided to both private and public sectors to expand fish culture. The larger aquaculture projects currently being developed or now in production are shown in Table VII-5. In addition to these large projects there are an estimated 160 private and commercial ponds in the country (Brullon, pers. comm.).

Existing or Potential Problems and/or Needs: Absence of a clearly defined and coordinated policy in aquaculture and fish stocking activities; absence of data collection systems to assess current status of stocks; and absence of effort to manage the country's fresh-water fish stocks.

Exotic Species Introduction

The introduction of exotic aquatic species has had a long history in the Dominican Republic. Based on a brief literature review the known species introduced into the country are listed in Table VII-6. As a result of these introductions few if any "natural" fresh or brackish water environments are left in the country. *Tilapia mossambica* is now found in most fresh and brackish water bodies. Other species such as carp, *Cyprinus Carpio,* and the bass, *Micropterus salmoides,* have been less successful in replacing native species and remain restricted to a few fresh-water coastal lakes and lagoons (Lovshin 1979;.

It is surprising that the carnivorous peacock bass, *Chichla ocellaris,* was introduced into the country in 1976 after the negative results following its introduction into Panama and Nicaragua. In the former country, Zaret and Paine (1973) documented that within 15 years local native populations, including a second introduced fish, were completely decimated by the exotic carnivore. In the Dominican Republic the peacock bass was introduced to control a previously introduced *Tilapia* sp., but apparently failed to survive.

At present, the greatest concern is the introduction of the fresh-water shrimp *Macrobrachium rosenbergii.* Because of the known life cycle of this exotic species it is preferred over the culture of indigenous species of *Macrobrachium.* Potential impact from introduction on native species is not known or being studied.

Importation of exotic species requires a permit from DRP/SEA. Review of the application is internal and does not require any preliminary impact study. Apparently there are no guidelines to minimize problems related to the release of exotic species into the environment. Communication and restrictions appear to be lax between customs officials and the DRP in this area.

Existing or Potential Problems and/or Needs: Already existing populations have been or will be replaced by introduced species; absence of a joint review process to assess the ramifications of species introduction by competent personnel from public, private and academic sectors; absence of a requirement for preliminary impact study prior to species introduction; absence of safety requirements to minimize exotic species escape into the environment; absence of monitoring programs to assess the stability of existing populations and success of introduced species; and absence of a training program for customs inspectors to become familiar with exotic aquatic species as well as the possible environmental ramifications of species introductions.

Table VII-5. Major aquaculture projects currently being developed or now in production in the Dominican Republic (excludes most private and commercial ventures).

Lead Agency	Assistance*	Site	# Ponds	Pond Surface	Principal Species
DRP/SEA	IDB	Nigua	16	7.6 ha	*Tilapia mossambica*
	Taiwan				*Micropterus salmoides*
	Israel				*Cyprinus carpio*
					Ctenopharingodon idella
					Hiphoitalmichthys molitrix
					Arichtichthys nobilis
Church World Service	AID Peace Corps	—	20	1+ ha	*Tilapia* hybrids
CIBIMA/ INDRHI	INDRHI	Engombe	24	1.8 ha	Not in production
INDOTEC	Central Bank	Sto. Domingo	6	0.1 ha	*Tilapia mossambica*
					Macrobrachium rosenbergii
Save the Children	Church World Service				
Federation for Community Development			3	0.05 ha	

*Technical or Financial.

Table VII-6. List of aquatic species introduced into the Dominican Republic.

Species	Year Introduced	Country of Origin
Tilapia mossambica	1953	Haiti
Cyprinus carpio	1954	Haiti
Micropterus salmoides	1954	Haiti
Ictalurus punctatus	1970	USA
Tilapia rendalli	1974	Mexico
Cichla ocellaris	1976	Colombia
Tilapia nilotica	1979	Puerto Rico
Tilapia aurea	1980	Puerto Rico
Ctenopharingodon idella	1980	Taiwan
Hiphoitalmichthys molitrix	1980	Taiwan
Arichtichthys nobilis	1980	Taiwan
Macrobrachium rosenbergii	1980	USA

Endangered Species and Critical Habitats

Threatened or endangered animal species inhabiting coastal wetlands and marine areas include birds, reptiles, and marine mammals (Table VII-7; also see Table VIII-1). Many of the water-

Table VII-7. Threatened and endangered species in coastal and marine habitats in the Dominican Republic.

Species	Common Name	Habitat	Known Distribution	Status
Podiceps dominicus	Least Grebe	Lagoons, wetlands, lakes	Guerra, Payaguara, Tres Ojos	Endangered
Dichromanassa rufescens	Reddish Egret	Coast, saline lagoons	Tortuguero, Estero Balsa, Boca del Yaque del Norte	Endangered
Phoenicopterus ruber [1]	Flamingo	Coastal lagoons, lakes, wetlands	Isla Saona, Beata, Azua, Enriquillo	Threatened
Ajaia ajaja [1]	Spoonbill	Coastal lagoons, wetlands, mangroves	Lago Enriquillo, Lago Limón	Rare
Dendrocygna arborea	West Indian Whistling Duck	Lakes, wetlands	Bahia San Lorenzo, Sanchez, Enriquillo, Monte Cristi	Endangered
Porzana flaviventer	Yellow-breasted Crake	Lakes, wetlands	Unknown	Unknown
Haematepus ostralegus	Oyster Catcher	Rocky beach	Playa Azul	Rare
Columba leucocephala [1]	White-crowned Pigeon	Coastal areas, mangroves	Monte Cristi-Higuey, Isla Beata, Saona	Unknown
Eretmochelys imbricata [2]	Hawksbill	Marine, sand beaches	See map	Endangered
Chelonia mydas [2]	Green Turtle	Marine, sand beaches	See map	Endangered
Caretta caretta	Loggerhead	Marine, sand beaches	See map	Endangered
Dermochelys coriacea	Leatherback	Marine, sand beaches	See map	Endangered
Trichechus manatus [1]	Manatee	Marine coastal areas, bays		Endangered
Megaptera novaeangliae	Humpback Whale	Offshore banks, (seasonal)	Bancos de Playa and Navidad	Endangered

[1]Protected by law; [2]Partially protected by law.

fowl threatened with extinction have lost habitat due to draining and clearing of wetlands or harvesting of mangroves for wood and charcoal. Flamingos and spoonbills are hunted for their eggs and feathers, and the white-crowned pigeon is hunted for sport (Ottenwalder 1973). There are an estimated 1,000-1,500 resident flamingos and an additional 2,000 that migrate yearly to the Dominican Republic. Two other migratory birds, both boobies—*Sterna fuscata* and *Anous stolidus*, nest on two cays in the Siete Hermanos off Monte Cristi (Alvarez 1980).

The four species of sea turtles recognized by the International Union for the Conservation of Nature and Natural Resources (IUCN) as in danger of extinction in the Caribbean are reported for the Dominican Republic. Of these four the hawksbill and green are still legally hunted for food (eggs and meat) and the shell for jewelry purposes. Jewelry is made from turtle shell for local sales and use, as well as the tourist trade and export. Though in less demand, the green turtle is also hunted as a substitute for the more highly-prized hawksbill (Ottenwalder 1978). Until recently it was thought the remaining two species, the loggerhead and the leatherback, were relatively scarce. Based on beach surveys, however, Ross and Ottenwalder (1980) calculate that approximately 300 leatherbacks nest per year on the country's beaches. Primary nesting season occurs from mid April through June, favoring beaches with undeveloped hinterland and the absence of an offshore fringing reef. These latter two species are also hunted, though illegally, for food and the shell.

Of the marine mammals, the West Indian manatee is in danger of extinction. Despite government protection in the Dominican Republic, manatees are still widely hunted for meat and bones. Based on aerial surveys, Belitsky and Belitsky (1980) conclude that two separate populations exist with higher concentration around the Monte Crisit area and more dispersed populations in Ocoa and Neiba bays. Abundance appears correlated with presence of grassbeds in an around areas of freshwater discharge.

The northern offshore banks of Plata and Navidad appear to be significant for several species of whales. An estimated 85% of the world's population of the humpback whale, *Megaptera novaeangliae*, concentrate in the area during the winter months for mating and calving purposes (Ottenwalder, pers. comm.). In addition to the humpback whale, other marine mammals observed in Dominican waters include *Stenella coerulealba, Tursiops truncatus, Mesoplodon europaeus, Ziphius cavirostris, Physeter catadon, Orcinus orca,* and *Balaenoptera borealis.* Based on current information critical areas for these groups have been mapped (Fig. VII-1).

The DRP/SEA is responsible for enforcement of existing legislation for marine reptiles and mammals. Responsibility for protection of avifauna lies with the DVS/SEA (Wildlife Department). Based on available information, enforcement is lax and there is little coordination between the two departments.

Existing or Potential Problems and/or Needs: Legislation to protect all endangered and threatened species (that are only partially protected or currently unprotected), with highest priority given the actively hunted turtles; initiate a conservation education campaign to make existing legislation more effective; stimulate enforcement inspectors through workshops; increase the penalties for abuses of endangered species, and request increased assistance from the navy; prohibit export of any product from an endangered or threatened species; require a review process for all proposed national and private projects to assess potential for damage to critical habitat; increase activities calling for parks and preserves, establish qualifing criteria for protection or production, review candidate areas for protection and submit for legislation.

Examine the potential for marine park designation for one or more of the following sites: (1) Siete Hermanos cays near Monte Cristi due to their pristine quality, isolation and critical habitat for several endangered species; (2) the offshore banks of Navidad and Plata due to their use as mating and calving grounds by the humpback whale; and (3) the beaches extending approximately from Laguan Limon to Cabo Engano due to their importance as turtle nesting beaches.

Mining

Very little mining occurs in or near the coastal zone. Sand, gravel and sandstone are extracted, mostly concentrated in the Nigua River basin and mouth, with apparent disregard for habitat and coastal degradation. Other coastal areas damaged by sand extraction are Juan Esteban, Playa Estero, and Cuello y Cuello (Bonnelly 1978). Marine salt extraction through evaporation occurs principally in the Monte Cristi area near Lagunas de Marigo, Salina and Piedra and near Las Salinas in the Bahia Las Calderas.

There are three areas in the country being considered for future mining exploration. Five requests have been represented by private companies for exploratory mining concessions for sand and sandstone in a near-coast strip between Barahona and Enriquillo. In the Samana peninsula the government owns two marble reserves, one adjacent to Sanchez and a second at the easternmost point of the peninsula. A third government reserve in Bahia de Manzanillo between Punta Luna and Punta Pozo has potential for magnetite ore.

There are no petroleum wells in the country. The possibility exists for State-financed petroleum exploration to begin in 1981 on the south insular platform and/or northern offshore banks (Madera, pers. comm.).

Sand extraction has been singled out as the "worst case" example of coastal destruction observed in the country (Fig VII-3b). The Nigua river basin and delta have been the traditional area for obtaining construction aggregate for the metropolitan area. The area has suffered from ineffective administration due to overlapping jurisdiction among the Nigua Municipality, the Secretariat of Public Works and the Government Mining Office. Scars from past extractions remain throughout the basin area, resulting in serious erosion and high sediment loads. Coastal protection has been lost due to sand extraction, especially from dunes near the mouth of the river. Loss of these coastal barriers was noticed during the passage of Hurricane allen when the storm surge crossed the wide delta area and damaged some of the housing on a raised escarpment overlooking the delta Despite acknowledgement of the problem and establishment of a coordinating group, dune destruction continues.

Figure VII-3b. *Scars of uncontrolled extraction of beach sand near the Nigua River, the traditional source area for the Santo Domingo construction industry. (Photo, Randon DuBois.)*

The Government Mining Office created in 1971 (Law 146) was a very small dependent organization of the Secretariat of Industry and Commerce until 1978. Since that time it has grown in budget and staff and is now attempting to carry out its legal mandate to safeguard, through effective management, the national interest in the mining and metallurgy industries. Sand and gravel extraction is an exception to the law as an interministerial council was formed in 1971 to coordinate overlapping jurisdiction (Law 123). A second exception is salt extraction administered by CORDE, formerly a Trujillo-owned industry.

Existing or Potential Problems and/or Needs: Interinstitutional bodies have failed to coordinate activities causing environmental degradation; inadequate enforcement of existing legislation to protect the environment; and need for environmental guidelines for future mining in or near the coastal zone.

Ports

Depending on the interests served, ports are classified as international, cabotage, or tourist. On the north coast where there are few sheltered roadsteads, four of the six ports are situated in the Bahia de Samana. On the Caribbean coast with fewer reefs and submerged rocks and several large estuarine systems, nine ports are utilized. In addition to these ports some private loading facilities (ALCOA, Gulf & Western) and a number of anchorages also occur (Fig. VII-1).

In general, most of the ports have been neglected over the past 20-30 years. An example is the port of Sanchez where high sediment rates from the Rio Yuna and the failure to maintain channel clearance have led to its abandonment as a conventional port; it is presently utilized by fishing and yachting boats (ONAP 1980). However, modernization efforts are being undertaken in Puerto Plata, Punta Botado, San Pedro de Macoris, and Puerto Haina.

The major emphasis in port modernization and expansion is in Puerto Haina with government and IDB funds. Already the most important of three ports serving the Santo Domingo area, it is being expanded to meet future needs. Improvements include channel dredging to 11 m, removal of a sunken dock, renovations and improvements to the eastern pier area, enlarging the storage area for containerized cargo, construction of the Port Authority building, and the installation of a moveable derrick system. These improvements will expand annual handling capacity from the current three million m tons to an estimated 4.5 million m tons (Pena, pers. comm.).

Management of port facilities is split primarily between the Navy with responsibility for naval facilities and port security, and the newly activated Port Authority, responsible for administration and management of the various ports. The Authority, created by law in 1970, did not become functional until early 1979. It is an autonomous agency directed by an Executive Council composed of three members from the private sector and three Secretaries of State. The Authority is divided into Divisions of Operations, Engineering and Materials, Personnel and Finance. There is no capability for pollution monitoring or clean-up in the Authority structure; nor does a mechanism exist for chain-of-command response to contamination accidents.

Existing or Potential Problems and/or Needs: Establish a contaminant-monitoring mechanism for major ports and the development of a toxic spill emergency plan to coordinte the utilization of all necessary human and physical resources.

Tourism

In many smaller islands in the eastern Caribbean tourism is being examined as a plentiful and clean export in an area of limited natural resources. Since the signing of Executive Decree 2536

1968), the Dominican Republic has developed tourism as a high priority income resource.

In 1968 a UNESCO consultant identified four zones for potential tourist development. This was followed by creation of the Tourist Office in 1971 (Law 103) and the declaration of two priority zones for development, Puerto Plata and its immediate surroundings (Decree 2125, 1972) and the zone between La Caleta and the Rio Higuamo (Decree 3133, 1973). In 1980 modifications were made to Law 153 designating seven priority areas for development, six of which border the coastal zone. They are Santo Domingo-La Romana, Luperon-Cabrera, Macao-Punta Cana, Samana-las Terrenas, Barahona-Enriquillo, and Monte Cristi-Pepillo Salcedo. These tourism development "strips" surround the respective cities and extend 5 km landward from the littoral zone.

In the short term, major activity will be concentrated in the Luperon-Cabrera or "Costa Ambar" area with the projects Costa Ambar, Playa Dorado, and Playa Grande, and in the Santo Domingo-La Romana or "Costa Caribe" strip with proposed projects Complejo Turistico Rio Mar, Estancias Las Cabuyas and Los Kapriles.

Incentives for development are provided in Law 153. They are only applicable to the tourist zones and provide for the government paying for all infrastructure, exemption from all taxes for 10 years from completion of construction for any project that ". . .would foment tourism or increase accommodations for the visiting tourist".

During the period 1966-1976 the estimated government investments for tourism infrastructure were RD$82 million for Puerto Plata and RD$41 million for Samana, mostly oriented to tourist development (Secretariado Tecnico de la Presidencia 1978). In addition, the Central Bank has or will invest funds in hotel development in the Playa Dorado and Playa Grande projects totalling RD$111 million (Plan CIBAO 1980). Government funds have also been invested in hotel development in Santo Domingo and La Romana through INFRATUR, an institution of the Central Bank charged with tourism development.

The return of these investments calculated for 1977 compared with visible exports was RD$91 million gross revenues or 12.7% of all foreign income. The National balance of payments deficit was RD$244 million. Direct and indirect tourist employment was estimated at 11,000 jobs (UNEP 1979b).

In December, 1979, the Tourism Office was converted to a Secretariat position. The new duties are to plan, stimulate and coordinate the country's activities related to tourism. As a result of these recently expanded responsibilities the Tourism Secretariat appears understaffed, underbudgeted and only beginning to address the government mandate.

Existing or Potential problems and/or Needs: Inadequate administration to effectively control a rapidly developing tourism sector; potential for serious infrastructure and related ecological problems with the already approved concentration of densely inhabited structures on the coast; absence of a comprehensive coastal resource inventory and review process to determine degree of ecological impact of a proposed project; and absence of a permit process for coastal construction that would require an analysis of infrastructure needs, waste disposal and physical constraints.

Recreation

The presence of sport fish such as tuna, kingfish and marlin in the nearshore pelagic water provided the incentive for the establishment of three fishing clubs (Club Nauticos) on the south shore. Many sport fishing boats are available for charter and cater to winter tourists. Boca Chica, approximately 32 km east of Santo Domingo, La Romana and Boca de Yuma all have large recreational boating fleets. The richness of nearby waters and the proximity to the Mona Passage have contributed to an annual international billfish tournament in Boca de Yuma (Van Ost and Kline 1978).

Heavy urban use of the beaches east of Santo Domingo has contributed to the deterioration of some beaches such as at Boca Chica where litter is left and seagrape trees are used for firewood. The potential for conflict exists between increasing public use of the eastern beaches stretching to La Romana and the development of tourist hotels impeding access to public beaches.

High praise is to be given for the utilization of the coastal coral escarpment for urban parks in Santo Domingo and Puerto Plata. A beach-front park in Sosua is also very attractive.

Diving clubs exist but do not appear to be numerous. One club from Santo Domingo dives mainly among the Boca Chica reefs.

Present and/or Potential Problems and Needs: Initiate data collecting procedures for sport fishing; and plan tourist developments without impeding public access to beaches.

Natural Disasters

Tropical storms and hurricanes originating in the tropical Atlantic or Caribbean during August to October have repeatedly wreaked havoc and destruction on Hispaniola. Serious damage and loss of life are primarily due to high winds (greater than 230 kph) and storm surges, the latter ranging from 1 to 3 m (Poke 1977). In addition to direct damages caused by wind and surge, there is secondary damage associated with severe beach erosion and the undermining of near-shore structures. Between the period 1887-1975, 46 tropical storms or hurricanes have passed near or over the Dominican Republic (UNEP 1979c). In most cases they have entered the island on the sourthern coast, though occasionally storms originating to the east have affected the northern coast (de la Fuente 1975). Ten tropical storms or hurricanes have hit the country directly, the most recent being Hurricane David in 1979.

Hispaniola is also situated in an area of periodic seismic activity resulting from a series of fault systems that pass either adjacent to or through the country. This has resulted in a series of 25 recorded tremors ranging in magnitude on the Richter Scale between 5 and 6.5 during the period 1964-1976 (UNEP 1979c).

There are few precautions to protect an area from a "worst case" situation, except for advanced evacuation. In less severe cases safety precautions can significanlty lower property damage and life losses. In the Dominican Republic civil defense corps and facilities exist, though it is difficult to determine their effectiveness. However, building codes for even less than "worst case" conditions do not exist. Hurricane damage could be of major consequence to the rapidly developing tourist-oriented southeastern coast. Other factors than need to be considered before allowing the construction of near-shore facilities are the offshore platform characteristics that may aggravate storm surge, the presence or absence of natural coastal protection such as mangroves, a requirement for artificial breakwalls, and the land configuration as it relates to storm drainage.

Existing and/or Potential Problems and Needs: Incorporation of a variable stress level requirement in the building code based on size, location of structure, and frequency and magnitude of past storms or earthquakes.

Institutional Analysis

Research Center for Marine Biology (CIBIMA)

CIBIMA is a small research center operating semi-independently in the Department of Biology at UASD

(Autonomous University of Santo Domingo). In 1980 staff composition was 8 full time and 2 part time professionals. Distribution of professional degrees include 2 Ph.D., 1 M.S., and 4 B.S. CIMIBA's 1980 budget was RD$228,400, with more than half of the budget coming from funding sources outside the University (OAS and INDRHI).

CIBIMA was formed in 1962 with one biologist as the director of the Insitute of Marine Biology at UASD. The principal objectives of CIBIMA are education and scientific research. CIBIMA is the only educational institution (through the UASD Department of Biology) in the Dominican Republic that trains marine scientists. Several graduates of the CIBIMA program are currently in positions of responsibility in government institutions such as INDOTEC and the Fishery Resources Department. CIBIMA has participated in the PPA program through the professional education project. Four of the present staff have received some degree of foreign technical training through USAID sponsored fellowships.

Research projects include inventories of mangrove, coral reef and beach systems of the south coast and a study of the Lago Enriquillo ecosystem (Bonnelly 1978). In addition to these research projects CIBIMA hosted an international conference on conservation in 1978, the first of its kind in the country.

Current projects include a coastal lagoon survey with the intent to determine fishery potential, a study to determine the potential of crabs as a fishery resource, both funded by OAS, and the development of an aquaculture facility in collaboration with INDRHI.

Prior to 1979, the facilities of CIBIMA were located in a seaside converted casino on Santo Domingo's "Malecon". The spacious area included offices, laboratories, library, reference collections, student facilities and experimental marine tanks. The physical facility was irreparable damaged by Hurricane David (estimated cost of repair by UASD was RD$326,000) with associated damage to the equipment, library and boats estimated at RD$100,000. CIBIMA is temporarily located in a small house with inadequate facilities for either educational purposes or scientific investigation. A proposal to construct facilities in Boca Chica offers a sea-side location, proximity to high production areas such as mangroves and coral reefs, and ready access to Santo Domingo, but lacks funding.

Fishery Resources Department (DRP)

The DRP is a dependency of the Subsecretariat of Natural Resources within the Secretariat of Agriculture. DRP is the lead government agency in management of both fresh-water and marine fisheries. DRP is the lead government agency in management of both fresh-water and marine fisheries. DRP has recently been restructured removing the Hunting Section and creating new divisions of aquaculture and fishing. This restructuring prompted the hiring of 22 new technicans, which more than triples the size of the department. The present staff level is estimated at 120—the majority are enforcement inspectors. The 1980 budget is an estimated RD$3,000,000.

In addition to management of the country's marine and freshwater fishery resources, DRP plays a major role in both direct and indirect encouragement of aquaculture. The government aquaculture facility at Nigua provides fingerlings to stock public and private lakes and ponds as well as a facility for scientific investigation into polyculture and exotic species introduction. In addition to supplying the private sector with fish stock, technical advice is provided upon request. Future projects include the development of a mariculture facility and a regional approach to fingerling production with facilities planned for Azua and La Vega.

The Department appears to be suffering from the recent expansion to facilities inadequate to accommodate additional personnel and from an inadequate human resource base from which to draw talent necessary to efficient administration and technical competence.

Development and Cooperative Credit Institute (IDECOOP)

IDECOOP is an autonomous government organization created in 1963 to aid in the formation of cooperatives, coordinate the actions of cooperatives with the national Federation of Dominican Cooperatives and contribute to the improvement of existing cooperatives.

In 1974, through a loan from IDB, a fisheries project was initiated to provide the national consumer with lower priced fish while increasing the standard of living of the artisanal fisherman. The program consisted of the constuction of six facilities located in Monte Cristi, Puerto Plata, Miches, San Pedro de Macoris, Azua and Barahona, and a central facility in the capital. The central facility coordinates activities and serves as a commercial clearinghouse. The importation of 64 fiberglass boats complete with electronic fishing gear for the six cooperatives and two 22 meter steel hull boats to provide fish for the facility were included in the project.

An estimated 20% of the national fishermen participate in the fishing program (Lima dos Santos and Brownell 1978). Inadequate administration in the formative years of the program created a certain feeling of distrust among the fishermen. Lack of technical expertise at IDECOOP has been cited for the importation of fiberglass boats equipped with air-cooled engines rather than water-cooled engines. As air-cooled engines proved to run too hot for Dominican waters, they are now being replaced with the latter type.

Dominican Industrial Technology Institute (INDOTEC)

INDOTEC is a semi-autonomous institution associated with the Central Bank. Its primary function is to stimulate industrial development by providing technical capabilities. In 1978 an agreement was reached between IDB and INDOTEC to analyze the Dominican fisheries sector. IDB financed the project through a US$1.05 million non-reimbursable loan. The major objectives were to identify productive fishing zones, recommend methods, boats, ports, and processing and marketing facilities to assure the most efficient use of the resources, as well as institutional analysis with associated recommendations for a sector policy development. However, the INDOTEC report had not yet been released when the environmental profile was conducted. In addition to the above project, INDOTEC maintains a small aquaculture facility on the same grounds. Emphasis is directed towards culture of *Tilapia* and shrimp.

Conclusions

Ineffective management of the country's coastal and marine resources is due to five major causative factors: 1) Non-traditional utilization of the resources; 3) A rapidly growing and still inexperienced set of administrative organizations; 3) Absence of coordinating mechanisms between administrative agencies required for an integrated approach; 4) Shortage of skilled multidisciplinary professionals; and 5) Unclear legislative mandate.

The Dominican Republic has traditionally looked inland for development of natural resources, as indicated by its dependence on the sugar and mineral industries as principal sources of foreign exchange. This focus on development of the hinterland has, until recently, largely protected the coastal zone from many of the problems associated with development. Unfortunately this period of grace is rapidly coming to an end as development of marine fisheries and the tourist sectors become high priority areas.

As a holdover from the Trujillo era, many executive finctions were administered directly from the president's office during the Balaguer administration. Consequently, most administrative departments were small, understaffed, and largely ineffective. Only since 1978 have these offices started to expand. The Fishery Resources Department staff increased from four technicians to 22. The Tourism Office was elevated to a Secretariat position. The Mining Office increased from one office to an entire floor in the central government building. The Port Authority created by law in 1971, did not start functioning until early 1978. One of the consequences of such rapid expansions of many administrative bodies is that they are now struggling to meet legislative mandates.

Though several institutions have overlapping legislation, few mechanisms exist for integrated and ecologically sound development of the coastal zone. In some cases these mandates result in very nebulous areas of authority, hampering efforts for effective management and coordination; more commonly they produce adversary positions between administrators, usually at the expense of the environment (e.g. Nigua sand extraction).

There is a serious shortage of professionals trained in coastal zone and marine resource management. The only institution at the USAD preparing marine scientists suffers from professional and financial constraints, and since Hurricane David, infrastructure problems. This leaves the burden of integrated management largely with planners, who may lack the technical expertise to deal with the complex issues of coastal zone management.

Substantial increases in administrative staff have generated numerous interagency conflicts, largely because of unclear, poor or redundant legislation. The best example is the administration of aquaculture in the country. At present there are three government institutions working in parallel in aquaculture with little evidence of coordination. Few countries can afford the luxury of expending limited resources, both human and financial, on independent efforts to achieve a common objective.

There is urgent need to integrate the management of coastal zone and marine areas. The most significant impinging factors include the priority the government has givent o tourism, the priority that is expected to be given to development of marine fisheries and the threat of a major oil spill in the Mona Passage.

Despite the high priority the government has given to development of the tourism sector, the Tourism Secreatariat appears unable to examine the ramifications concentrated development will have on the environoment. In addition to the location of tourist developments on pristine beaches serious questions must be asked about public access to beaches, sewage treatment, solid waste disposal, hurricane protection, sources of food for the tourists, shell and coral collecting, and preservation of critical habitat for protecting endangered species.

At present the fishing sector is at an artesanal level, with imports accounting for 60% of all fish consumed. Results of a recent survey indicate that the potential exists in Dominican waters to meet local demand. The administrative body in the sector is not yet at the level capable of meeting the demand required of industrial level fishing efforts nor to maintain sustained yields.

Despite the responsibility of the Navy and Air Force for patrolling the country's waters and coasts, there is no emergency plan to handle toxic substance spills. This is especially critical in the easter portion of the country adjacent to the high traffic area of the Mona Passage. Ship traffic through the Mona Passage is likely to climb as recent cutoffs from some Mid-eastern oil field may result in greater hemispheric dependence on Venzuelan oil. In a recent Puerto Rican EPA-sponsored oil pollution conference a trajectory model of a theoretical oil spill of 6,000 barrels of crude to the east of Mona Island indicated that the oil would reach the eastern shore of the Dominican Republic in three days and spread as far as La Romana and Laguan Limon in five days. Emergency plans for toxic spills are also needed for each of the country's major ports.

Two existing agencies function to meet environmental emergencies. Presidential decree 2011 recently created a commission charged with the conservation of marine flora and fauna. The commission is composed of the directors of Civil Defense (president of the commission), customs, the Navy chief of staff, the director of migration, the administrator of the Las Americas International Airport and the director of Fishery Resources. The primary function of the commission is to facilitate the arrival of oil clean-up equipment from areas outside the country.

The Environmental Department, a dependency of the Technical Secreatariat of the Presidency, is to provide environmental evaluation of proposed projects. At present it is severely understaffed and may not have the technical expertise required to evaluate coastal zone management (see Arellano for an institutional analysis).

It may be necessary to create a commission that would function as a "review and permit institution" for development affecting the coastal zone. Its composition should include high level, qualified staff from the Navy, Fishery Resources, Civil Defense, Commerce and Industry, Tourism, CIBIMA, and the Enviornment Department. In the latter case the representative should serve as the primary liaison between the commission and other government institutions involved in upland activities with potential impact in the coastal zone. Review and approval would be required prior to any coastal development. In the same legislation to modify existing laws in order to create the new commission, there should be a requirement for an ecological assessment of projected activities in the coastal zone. The assessment should be completed "in house" and accompany the application document to the review committee. This committee should have the power to approve the project document, require modification in the proposed activity or reject it. In addition, the law should provide for inspection, review and interruption or termination of coastal projects which conflict with national goals.

Recommendations

CIBIMA is the only academic institution with a focus on basic marine research and the training of marine technicians and scientists. The government depends on CIBIMA's production of qualified marine scientists to fulfill the goals of marine legislation. Hurricane David damaged CIBIMA's educational facility which will provoke a shortage of people trained in marine sciences and resource management.

CIBIMA and the government recognize that the numerous fresh-water and brackish coastal lagoons and ponds are underutilized, and both have launched projects to undertake basic physical descriptions. To permit rational utilization, a thorough inventory must include salinity-termperature-oxygen fluctuations, both diurnal and seasonal, rate of overturn of waters, presence and status of native species, and solar radiation. Provided with a sound ecological baseline and knowledge of external factors, such as potential for local use or demand in the export market, pilot projects should be initiated to explore the feasibility of these resources for aquaculture/mariculture, e.g. raising *Artemia gualinas* for export, and potential for solar energy utilization.

As pressures continue to increase for development and use of resources in the coastal zone, guidelines are urgently needed for reviewing specific activities and projects and coordinating action between agenices. The review process should have two components: in-house assessment of a project's environmental impacts including endangered species, critical habitat, infrastructure needs and associated wastes; and a *required* review process at the level of ONAPLAN, the Environmental Department or newly created commission before action could be taken. This would

have the added advantage of integrating separate initiatives in administration of the coastal zone as well as providing a "watch dog" function. This would only succeed with clear legislation and adequate resources.

The Dominican Republic needs a national emergency plan to control toxic substance spills. The Marine Flora and Fauna Conservation Commission and the captain of the Port Authority could design the plan and regulations to facilitate arrival and use of spill clean-up equipment. The plan could be expanded to include coastal zone characterization and a coastal zone vulnerability index.

Due to parallel and rival administrations of the fishery sector, a national policy should be defined. The formation of a commission composed of heads of DRP/SEA, INDRHI, INDOTEC, INDECOOP and the Navy might be effective. The commission would set national priorities in the fishery sector, outline the most effective strategies to meet the objectives and coordinate efforts and share resources to attain those objectives.

Marine parks represent a priority area due to the fragility of many marine resources in the country. The creation of a park or parks would receive positive international publicity associated with the preservation of these areas. A marine resource inventory and criteria for park designation are needed. Three potential areas to be examined are the Siete Hermanos cays off Monte Cristi due to their pristine quality, isolation, and habitat for several endangered species; the offshore banks of Navidad and Plata due to their use as mating and calving grounds for the humpback whale; and the beaches extending approximately from Laguna Limon to Cabo Engano because of their importance as turtle nesting beaches.

VIII

Wildlands and Wildlife

In this report the term "wildlands" is used in a new broad sense. Our definition goes beyond the popular notion of wilderness which has come to mean an area basically unaltered by human intervention where man is a temporary visitor at most. Wildland as used here will include these areas, but will cover a much wider range of areas and land uses. In the development literature, wildlands traditionally have been those areas available for population expansion, agriculture, lumbering, and exploitation of natural resources. These areas have also been viewed as areas where landless peasants, driven from place to place by social and economic conditions, could acquire a piece of land (Miller 1978).

Much of the continuing problem with the human factor in wildlands management today is probably due to this confusion of wildlands with nonproductive lands. The failure to distinguish between wildlands and potentially exploitable but currently unexploited agricultural lands has resulted in serious problems both within the government and among the general public.

Wildlands in this report are defined as those areas that are not capable of maintaining permanent agriculture, livestock, or intensive forest production (Morell 1978) plus analogous aquatic areas, both freshwater and marine. This definition is broad enough to include areas that are managed for purposes of production or recuperation of natural biotic communtiies. A more restrictive definition used elsewhere (Freeman et al. 1980) included only "land and waters which have been little affected by modern man, where natural processes such as evolution, native plant and animal reproduction and natural nutrient cycling continue in dynamic equilibrium". For an island such as Hispaniola, where the Dominican Republic has less than 50,000 km² of territory and a history of almost 500 years of European settlements, this definition would be much too exclusive. We feel that the broader definition will better serve the needs of the Dominican Republic and the island of Hispaniola.

It is tempting to subdivide the wildlands management sector into flora, fauna, and geographic subunits, but one can quickly lose sight of the importance of considering wildlands as an interacting complex of necessary subparts. Flora, fauna, aquatic and terrestial subunits are arbitrary categories and give the impression that these characters exist separately. While they can be considered separately for the sake of analysis, they do not exist alone but rather they interact to form complex natural ecosystems. The wildland resource includes all of the characteristics and components of the natural ecosystem. Attempts to protect or manage only one aspect of the flora, fauna, or the territory, will not succeed. Wildlands must be protected and managed as interactive natural systems composed of diverse but necessary subunits.

Status of Native Wildlife

Of all the Greater and Lesser Antillean Islands, Hispaniola has perhaps the greatest variety of different environments. Pico Durate, the highest point in the Antilles (3,087 meters) and Lake Enriquillo, the lowest point (40 m below sea level) are both found within the Dominican Republic. Nine life zones exist within the national territory (see Chapter III), but this expands to 16 if the various transition zones are included (OAS 1967). Climate differences are impressive for such a limited land area (less than 50,000 km²). Dry, near desertic conditions are found in the southwest and northwest, while areas of heavy rainfall are located in the mountainous regions of the central and northern portions. In addition, a rich assortment of coastal, near-shore, reef and platform environments exists in the marine sector. An inventory of the coastal and near-shore marine environments is currently underway by the Museo Nacional de Historia Natural (Ottenwalder, pers. comm.).

In spite of its insular situation, relatively small size, and almost 500 year history of European settlement, the Dominican fauna is still only partially known. New species for the country, for the island, and for science continue to be found. A high degree of endemism exists which raises the prospects of discovering unique new species in any field trip to the remaining remnants of natural ecosystems. A total of 139 resident and 90 migratory bird species are known in the country, of which 34 are endemic. One family, the Dulidae, is represented by a single species *Dulus dominicus* which will be declared the national bird in the proposed Fauna Law.

Useful field guides to the ornithological fauna are published in English (Bond 1971) and in Spanish (Dod 1978). Both works are useful for identifications and general species distributions.

Beyond taxonomic identification of most of the native fauna, there has been little published in the way of ecological or behavioral monographs. Some species are now receiving a great deal of attention, but this interest seems to be associated with the actual or potential commercial value of the species. White crowned pigeon, *Columba leucocephalus*, American crocodile, *Crocodylus acutus*, and Hawksbill turtle, *Eretmochelys imbricata*, are some examples.

Some attention is also paid to rare or endangered species with no known commercial value, such as the hutia, *Plagiodontia aedium*, and the solenodonte, *Solenodon paradoxus*.

Basic information on populations, distributions, and food habits of fauna is not available. Human and financial resources have not been made available, in large part because the study and management of wildlife populations have never been a priority theme for the Dominican government. Only in the last decade have the major Dominican universities added biology with an emphasis on wildlife to their curricula. The field of wildlife biology is just now beginning to attract students as government positions are being generated.

Behavioral studies of captive animals have been made on several species of native fauna including two endangered mammals, *Platiodonita sedium* and *Solenodon paradoxus*. The Parque Zoologoco Nacional (ZOODOM) is conducting studies on these animals as well as raising captive iguanas *Cyclura cornuta* and *C. ricordi*. ZOODOM has also had success with reproducing *Crocodylus Acutus* (Duval, pers. comm.). These studies add to the growing base of knowledge about reproduction in these species and their behavior in captivity, but cannot substitute for field research on the behavior, reproduction, and ecological role of these animals in their natural habitat.

The Dominican Republic is not a signatory member of the CITES agreement (Convention on International Trade in Endangered Species), but final efforts are being made to have the nation subscribe to this international convention. The convention and supporting documentation are now in the office of the legal advisor to the Office of the Presidency. In anticipation of the eventual signing of this agreement, the Departamento de Vida Silvestre (DVS) has established close lines of cooperation with the Division for the Prevention of Commercialization of Protected Flora and Fauna of the U.S. Department of the Interior. For all practical purposes the DVS is proceeding as if the Dominican Republic were a signatory member to CITES.

Lists of endangered and threatened species officially recognized by the government do not exist, but the major wildlife research and management institutions have been compiling lists of species that they consider should be on such an official list (Table VIII-1). Comprehensive inventories to establish the presence or absence of these species in all areas of the national territory have not been made. The evaluations of population status represent professional estimates, but the data base is quite incomplete.

Status of Wildlands

Existing Uses of Wildland Resources

Quantitative data on current uses of wildland resources in the Dominican Republic are generally unavailable. Flora and fauna are both exploited in consumptive and non-consumptive ways. Live plants and plant products are harvested and collected for a variety of uses. Forest exploitation for timber production is dealt with elsewhere in this report (see Chapters III and IV). Other plant uses include food, medicines, beverages, ointments, ornamentals, dyes, perfumes and scents, flavors and teas (Liogier 1974). With the exception of fiber and charcoal production, most exploitation of wildlands flora appears to be for subsistence uses or by small-scale commercial concerns. Very little of what could be considered wildlands flora or its by-products finds its way into external markets with the exception of beeswax and honey. Over RD$800,000 worth of wax and RD$500,000 worth of honey were exported in 1979, with substantial amounts produced in areas of native vegetation (Marcano 1973, CEDOPEX 1980). Some ornamental plants and flowers are also reaching external markets, but in general the consumption of non-timber flora from wildlands areas is internal subsistence or small-scale and largely unrecorded. Socio-cultural uses, including medicinal and religious needs, are recognized but not quantified.

Faunal resources from wildlands appear to be exploited mainly for food. Native and introduced pigeons and doves, plus migratory ducks are hunted legally. Some ducks, pigeons, doves and other game birds are killed illegally. Eggs are regularly taken from the nests of many nesting birds, particularly social species like gulls or white-crowned pigeons. Exploitation by man in conjunction with habitat destruction is considered a main threat to the continued survival of certain species (Table VIII-1). Exotic species including rabbit, white-tailed deer, ring necked pheasant, quail, and wild pig are also hunted. The role these species play in the nutrition of the human population, however, is unknown. For some rural families, wild game may be a significant source of high-quality protein. Subsistence harvesting of terrestrial and aquatic fauna is common but no quantitative data exist. The dispersed nature of the practice and the marginal legality of some of the methods and prey make the acquisition of meaningful data very difficult. Many Dominicans, both urban and rural, have told the author of eating protected wildlife or out-of-season wildlife. Harvesting methods include the use of dynamite, poison, snares, illegal implements, poaching, failure to observe size or bag limits, failure to respect gravid females or resting areas, etc. The magnitude of the enforcement problem is not clearly known.

Except for a few products such as honey and beeswax, most wildlands products are consumed locally and may never be recorded in the marketplace. Consumption is difficult to estimate and reliable statistics are non-existent. Comprehensive nationwide surveys of wildlife have not been conducted. Basic data such as population, distribution, and annual harvest are unknown.

Non-consumptive uses which include recreation, study and appreciation, inspiration, and similar cultural and religious uses are also unquantified. Non-consumptive uses of non-national parks areas are unrecorded. The Dominican Republic has many fine beaches in its 1,500 km coastline and those near major poulation centers are heavily used, particularly on weekends and holidays.

Potential Uses of Wildland Resources

Outdoor recreation and tourism are two key non-consumptive uses of wildland resources that should gain importance in the future if conservation efforts continue. National Park use is expected to increase, particularly as the development of visitor facilities in the Parque Nacional del Este proceeds. Beach and coastal resources on the one hand and cool mountain resources on the other are also expected to receive greater use by visitors. (For a discussion of recreational uses of large water control facilities such as the lakes created by hydroelectric dams, see section on hydrological resources).

Research and other scientific uses which are generally non-consumptive are also expected to increase. The flora and fauna of the Dominican Republic are incompletely known and much work remains to be done concerning the complex interactions in natural ecosystems.

Consumptive uses will continue. While enforcement efforts are increasing, and some control over exploitation has been established, much harvesting of plant and animal products continues unchecked. Effective enforcement has been achieved only in the national parks and even there manpower shortages have limited the success of enforcement efforts.

As protection of the wildland resources in the national park system becomes more complete, repopulation of adjacent areas will become possible. The populations of white-crowned pigeons and other game birds are already showing signs of recovery due to extraordinary efforts by the Direccion Nacional de Parques to protect nesting sites in the national parks (Vargas, pers. comm.).

Table VIII-1. Status of selected fauna species in the Dominican Republic. Source data compiled from Bautista 1980, Belitsky and Belitsky 1980, C. Hernandez 1980, Hidalgo 1980, and Ottenwalder 1978. (Explanatory Notes: Population Status: E=endangered; R=rare; T=threatened; I=indeterminate; e=endemic; c=listed in CITES. Information Status: A=adequate; I=incomplete; U=unknown. Legal Status: P=protected; N=not protected. X=contributory factor.

	Population status	Information status	Legal Status	Habitat Destruction	Insecticide Poisoning	Traditions/superstitions	Hunting (meat, eggs)	Commercial Trade	Exotic Competition/Predation	Population Recovering
Turtles										
Caretta caretta	Ec	A	N				X			
Chelonia mydas	Ec	A	N				X	X		
Chrysemis decorata	I	U	N					X		
Chrysemis decussata	I	U	N					X		
Dermochelys coriacea	Ec	A	N				X			
Eretmochelys imbricata	Ec	A	N				X	X		
Reptiles										
Alsophis spp.	E	U	P							
Crocodylus acutus	Ec	A	P							
Cyclura spp.	Eec	I	P	X			X		X	
Darlingtonia haetiana	E	U	P							
Diploglossus spp.	E	U	P							
Epicrates spp.	Ec	I	P							
Mabuya mabouya	E	U	P							
Birds										
Ajaia ajaja	R	I	P	X			X		X	
Amazona ventralis	Ee	A	P	X			X	X		
Anas bahamensis	I	I	P	X	X		X			
Anous stolidus	I	I	N				X			
Aratinga chloroptera	Ee	A	P	X			X	X		
Asio stygius	E	I	P	X		X				
Burhinus bistriatus	I	I	P	X					X	
Buteo jamaicensis	T	U	N							
Buteo ridgwayi	Ee	I	P			X				
Calyptophilus frugivorus	Te	I	P	X						
Caprimulgus cubanensis	R	I	P	X					X	
Columba inornata	I	I	P	X			X			
Columba leucocephala	E	A	P	X			X			
Columba squamosa	E	I	P	X			X			
Corvus leucognaphalus	I	A	N	X			X			
Dendrocygna arborea	Ec	I	P	X	X		X			
Dichromanassa rufescens	E	A	P				X			
Geotrygon caniceps	E	I	P	X					X	
Geotrygon chrysia	R	I	N	X					X	
Geotrygon montana	E	I	P	X					X	X
Haematopus palliatus	R	A	N							
Hyetornis rufigularis	Re	I	P	X		X				
Loxia leucoptera	T	I	P	X						
Mycteria americana	E	I	P	X			X			
Nyctibeus griseus	E	U	N							
Nyctibeus jamaicensis	I	U	P							
Oxyura dominica	T	I	P	X			X			
Oxyura jamaicensis	T	I	P	X	X		X			
Pardirallus maculatus	R	U	N							
Pelecanus occidentalis	I	U	P				X			
Phaeton lepturus	I	U	N				X			
Phalacrocorax auritus	R	I	P				X			
Phoenicopterus ruber	Tc	A	P				X			
Pterodroma hasitata	E	U	P				X			
Podiceps dominicus	E	I	N	X						
Pdiolimnas flaviventer	R	U	P							
Porzana flaviventer	R	U	N							
Rallus longirostris	R	U	P				X			
Siphonorhis brewsteri	T	I	P	X					X	
Sterna fuscata	I	I	N				X			
Sula leucogaster	T	U	P				X			
Tachybaptus dominicus	E	A	P	X			X			
Temnotrogon roseigaster	Te	I	P	X						
Turdus swalesi	Re	I	P	X						
Mammals										
Eptesicus fuscus hispaniolae	I	I	N							
Lasiurus borealis minor	I	I	N							
Natalus major	I	I	N							
Noctilio leoporinus	I	I	N							
Plagiodontia aedium	E	I	P	X		X			X	
Plagiodontia hylaeum	E	I	P	X		X			X	
Solenodon paradoxus	E	I	P	X		X			X	
Stenoderma haitiensis	I	I	N	X						
Trichechus manatus manatus	Ec	A	P				X			

Plans are being developed to study the possibilities of commercial or semi-captive production of the American crocodile, *Crocodylus acutus*, for hides, oil and other products, and the local iguanas, *Cyclura* spp., for meat. These projects would have the double benefit of reducing pressure on endangered wild populations while at the same time encouraging rationally managed exploitation of a natural resource.

A great deal of interest exists in the Dominican Republic to introduce new species as free-roaming populations or for commercial propagation. Doves, pigeons, wild pigs, white-tail deer, rabbits, pheasants, quail, guinea hens, and some non-game species have been introduced. Aquatic systems are also involved. Tilapia, crayfish, carp, freshwater shrimp, and a host of other game and ornamental species are now found in Dominican streams, rivers and lakes. The introduction of exotic species is a precarious game of chance. The intentional introduction of the mongoose has devastated terrestrial vertebrate populations, particularly ground-nesting birds. Tilapia may have been responsible for the reduction in some native fish species. Particularly in insular situations, the introduction of exotics is unwise due to the high endemism in native flora and fauna.

Wildlands Management Categories

Existing Dominican laws establish at least nine categories of areas that would apparently form the units of a wildlands system. Law 67 (Parks) creates eight categories and the Forestry Law repeats the National Park category and adds Forest Reserve for a total of nine (Table VIII-2).

Law 67 creates some categories that are better left to other institutions since they now operate these areas or are better suited to manage them in the future. Zoological gardens, botanical gardens, and national aquariums can operate independently or can be attached to a research or educational institution. National monuments of a historical nature should be left to the Oficina de Patrimonio Cultural or to one of the museums dealing with these areas (Museo del Hombre Dominicano or Museo de las Casas Reales). Wildlands institutions should concentrate mainly on areas that are unaltered by man, not areas that are created or manipulated by man. Under this philosophy, recreation areas would be administered by the tourism office rather than the DNP.

The mission of the DNP should be narrowed to managing and protecting resource areas of national importance. The Director has expressed interest in a slightly expanded set of categories for the Dominican National Park System (Morell 1980, see Table VIII-2). This set greatly improves on the original categories created by Law 67. Major emphasis is placed on natural systems. Highly manipulated research and educational areas are excluded.

The proposed Fauna Law would create four categories under the administration of the DVS. Assuming continued emphasis on the production of exotic and native game species, it would seem more desirable to locate the functions of comprehensive resource and ecosystem protection in the DNP and place wildlife management functions in the DVS. This would suggest the need for only two categories for DVS administration, Wildlife Sanctuaries and the wildlife aspects of Multiple Use Management Areas. The distinction between Faunal Refuge and Faunal Sanctuary is unclear. There are two basic functions to be performed: the protection and study of native fauna and the production of wild game for harvest. A sanctuary satisfies the first need, and areas established for multiple use management would satisfy the second. The other areas that would be established by the Proposed Fauna Law are more global in scope and fall well within the mandate of the DNP instead of DVS.

No management categories for marine resources appear in the legislation. Categories could be created *de facto* by using broad definitions and not limiting the descriptions of existing categories to terrestrial environments. Parks, monuments, reserves, and management areas can be aquatic as easily as they can be terrestrial. It is advisable, however, to expand the legal mandates to include the creation, protection, and management of aquatic areas.

A list of suggested wildlands categories appears in Table VIII-2. This list should be considered a minimum but adequate starting point for a Comprehensive Wildlands System for the Dominican Republic. As currently envisioned, the System would include DNP, DRP, DVS, and DGF lands. National Parks, Scientific Reserves and National Monuments would be the responsibility of DNP and in some cases DRP. Wildlife Sanctuaries would be administered by DVS. Resource Reserves are essentially protected natural storehouses. They could be managed by any of the four agencies or by an outside institution, depending on the nature of the reserve. Forestry and fishery resources would be managed under the Multiple Use Management Area category. Biosphere Reserves frequently include several agencies working together, though a lead agency would need to be identified. World Heritage Sites would be managed according to the purpose of the individual sites. Scenic Corridors, whether highway or riverine, would be managed on an individual basis.

Under this system, cultural, historical and archaeological sites would be managed by the appropriate museum. In those instances where the sites are within or near larger wildlands areas, the agency with responsibility for the larger area could assume the protection of the smaller site, but the museum would remain as the expert agency and would retain final decision-making authority.

In a similar way, small Scientific Reserves might be located under DNP for protection services, but could be managed by another expert agency which might have a particular interest in the specific resource being conserved. These suggested modifications would entail changes in existing wildlands laws. Congressional and executive action would be required. Remedial legislation is rarely a popular issue. Interim management using these categories *de facto* would probably be adequate for years. The important objective is to develop cooperation among the four principal agencies. The first order of business is to agree on a system of categories for wildlands management in the Dominican Republic.

Table VIII-2. Wildlands categories used or proposed in the Dominican Republic.

I. Law 67 for the Dirección Nacional de Parques
- Recreation Areas
  - National Recreation Parks
  - National Zoological Gardens
  - Aquariums
  - Panoramic Highways
- Historical Areas
  - National Monuments
- Natural Areas
  - National Parks
  - Botanical Gardens
  - Natural Scientific Reserves

II. Proposed Fauna Law for the Departamento de Vida Silvestre
- Zones of Biological Interest
- Faunal Refuge
- Faunal Sanctuary
- Biological Reserve

III. Suggested by IUCN (1978)
- National Parks
- Scientific Reserves
- Natural Monuments
- Wildlife Sanctuaries
- Resource Reserves
- Multiple Use Management Areas
- Biosphere Reserves
- World Heritage Sites
- Scenic Corridors

IV. Proposed for the Dominican National Parks System (Morell 1980)
- National Parks
- Natural Monuments
- Cultural Monuments
- Scientific Reserves
- Wildlife Sanctuaries
- Wildlife Refuges
- Recreation Areas
- Scenic Highways
- Scenic Rivers
- Ecological Reserves

National Parks

J. Armando Bermudez and Jose del Carmen Ramirez

National Parks

Size (combined): 1,530 km²

Created: JAB 1956; JRC 1958

Staff: 2 administrators; 35 rangers

Vegetation: Extensive stands of native pines, *Pinus occidentalis*, with sheltered areas of broadleaf forest (Fig. VIII-1, also see Fig. II-2a).

Important fauna: Very poorly known. 51 birds have been identified in the park, including 13 endemics to Hispaniola and 11

Figure VIII-1. *Sabana Vieja Valley surrounded by beautiful pine forests in the Jose del Carmen Rodriguez National Park. The cabin (lower center) is one of several FORESTA guard stations in the Cordillera Central. (Hand-held aerial photo, Carlos Quesada.)*

endemics to the Caribbean. Unconfirmed reports of *Solenodon, Plagiodontia,* and many of the 18 Dominican bats have been made.

Important resources: The two parks are the headwaters of almost a dozen of the country's major rivers. Water for industrial, domestic, and agricultural uses comes from these mountains. The hydroelectric potential of many of these streams can only be realized if the watersheds are properly managed. The stands of pine and the broadleaf forests are important genetic resources for reforestation in other parts of the mountains.

Facilities: 17 ranger cabins are located in the eastern portions of the two parks where enforcement is currently concentrated. All are short of household items like bedding and raincoats, and some are in need of repairs. Equipment includes a four wheel-drive truck and a string of old pack mules. DGF supplies fire-fighting hand equipment. Visitor facilities include a shelter and a cabin on the trail to Pico Durate, and a camping area that is under construction.

Past Uses: Many areas of the parks have been significantly altered by human use. Coffee plantations exist inside the parks along some of the borders. Slash and burn agriculture has cleared the natural vegetation off many of the slopes at lower elevations. Deliberate burning and vandalism has damaged vast expanses of the forests. In the past, DGF has placed more emphasis on protecting the pine trees to the point of ignoring the rest of the system of which the trees are only a part. Hunting and grazing occurred in many areas of the parks.

Existing problems: The problem of shared authority in the parks by both DGF and DNP personnel must be resolved. Control must be established over the entire area of both parks. Resettlement of settlers must proceed as soon as possible. The proposed trans-mountain highway could set back park protection significantly. More than 90% of all forest fires are deliberately set by local people. Until the park is seen as a beneficial reserve, this problem will continue.

Los Haitises Naitonal Park

Area: old 208 km²; new 120 km²

Created: 1968; new boundary modification proposed 1980

Staff: 1 administrator; 1 boat captain, 1 deckhand, 1 carpenter, 2 area supervisors, 13 park rangers

Vegetation: Lowland broadleaf forest developed on karst formations; plus coastal mangroves

Important fauna: *Solenodon, Plagiodontia,* many bats, avifauna poorly studied, but at least 50 species identified, frigate bird and pelican nesting areas on off-shore islands, marine near-shore environments shelter a wide variety of fauna from Samana Bay.

Important Resources: Outstanding example of karst formations. Caves in abundance, possessing geological, ecological and archaeological importance.

Facilities: Three ranger cabins with an additional one under construction. Equipment consists of a four-wheel-drive truck, a 7.38 m inboard cabin cruiser, and a woodworking shop where signs and materials are prepared for all units in the park system.

Past Uses: Nearly all of the original park area has been grossly altered by rural invasions of landless peasants seeking agricultural lands. Slash and burn clearing practices and indiscriminate use of fire have destroyed much of the value of the older park area. The boundary modification will return to park status the sole remaining area with adequate natural areas or the potential to recover.

Existing Problems: New boundary must by approved so the DNP may establish firm control over the area. Banco Agricola continues to provide loans to settlers invading park lands. Mobility within area is very difficult given the rough terrain. Sediment load carried by Barracote River disturbs the near-shore areas of the park.

Isla Cabritos National Park

Size: 26 km²

Created: 1974

Staff: 1 administrator, 1 area chief, 6 park rangers

Vegetation: Semi-desertic dry forest (Fig. VIII-2a)

Important fauna: *Crocodylus acutus, Cyclura cornuta, C. ricordii, Phoenicopterus ruber,* total of approximately 50 resident and migratory birds

Important Resources: Lacustrine saltwater environment below sea-level; insular semi-desertic environment; crocodile nesting areas; flamingo nesting areas; protected habitat of endemic rock iguanas

Facilities: Administrative compound plus pickup truck and inflatable boat

Past Uses: Extensive grazing on the island by domestic livestock has severely affected the native vegetation. Recovery has been good since the removal of dogs, cats, goats, burros, and cattle. Heavy hunting pressure on crocodiles and egg collection has reduced the population. *Tilapia* introduced to lake may have hastened extinction of native fish population. Diversion of water for irrigation means salinity of lake increases, possibly endangering even the introduced *Tilapia* upon which the crocodiles depend for food. Hurricanes in 1960's and recently in 1978 and 1979 brought enough water into the watershed to delay this problem at least for the moment.

Existing problems: Irrigation development in the Neiba Valley continues, meaning further withdrawals of water from streams and wells that would have supplied the lake with water for dilution. Park area is too small to protect the nesting and rearing areas for young crocodiles. Adequate water to assure salinity control in the lake must be guaranteed to the park ecosystem.

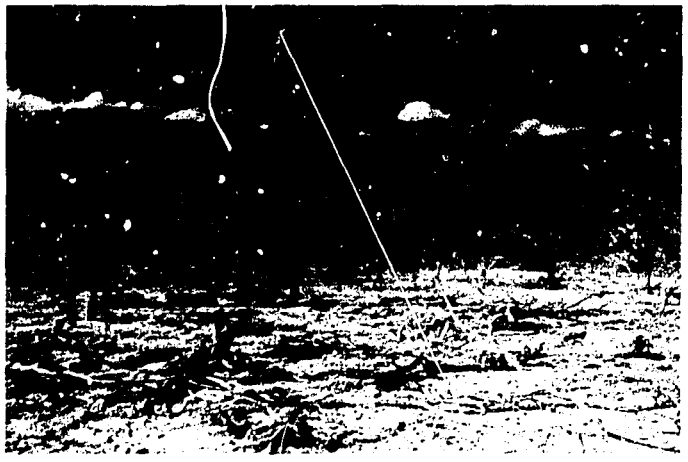


Figure VIII-2a. *Isla Cabritas National Park severely degraded (1977) by charcoal-making and goat browsing. Strict control by DNP has eliminated feral livestock, allowing the natural vegetation to recover. (Photo John Shores.)*

Parque Nacional Del Este
Size: 434 km²
Created: 1975
Staff: 1 administrator, 1 supervisor, 6 area supervisors, 10 park rangers
Vegetation: Lowland broadleaf forest, mangrove swamps (Fig. VIII-2b).
Important fauna: *Solenodon paradoxus, Plagiodontia aedium, Cyclura cornuta, Columba leucocephala,* visiting manatee and sea turtles, 112 bird species, including 8 endemics to Hispaniola and 11 endemics to the Caribbean.
Important Resources: Manatee feed areas, turtle nesting beaches, white-crowned pigeon nesting areas, coastal lagoons, marine ecosystems, numerous caves with archaeological sites.
Facilities: At the present time, facilities are limited to administrative and protection facilities, consisting of three ranger cabins. Equipment includes a four-wheel-drive truck, two launches, and three pack mules. The first park managment plan in the Dominican Republic has been written for the PNE (DNP 1980). Visitor facilities are expected in the near future.
Past Use: In the past many valuable tropical hardwood trees were cut from the lands of the park in a selective-cutting or high-grading process. Small agricultural plots were scattered throughout the park, but the thinness of the soil meant that shifting agriculture had to be used. Free-roaming goats and burros and feral pigs wandered throughout the area. Large-scale coconut plantations are still operated along the west coast of the mainland.
Existing Problems: A large settlement exists on Saona Island as part of the Marina de Guerra outpost there (Mano Juan, pop. approx. 350). Marine areas not included in original declaration of park limits. Resettlement of remaining families from southeast portion of mainland has been delayed. Park lacks surface drainage, water a critical resource. Conflicts with fishing interests likely.

Resource Management

Wildland management is divided among three principal institutions, each in a separate superlevel of government. The Direccion Nacional de Parques (DNP) is a semi-autonomous agency directly under the Presidency. The Direccion General Forestal (DGF) is located in the Secretaria de Estado de las Fuerzas Armadas y Policia Nacional. The Departamento de Vida Silvestre (DVS) is part of the Subsecretaria de Recursos Naturales (SURENA) of the Secretaria de Estado de Agricultura (SEA).

The Departmento de Recursos Pesqueros (DRP) is a sister agency to DVS in SURENA. The Museo del Hombre Dominicano (MHD) and Museo Nacional de Historia Natural (MNHN) are both under the umbrella of the Presidency. The Parque Zoologico Nacional, usually called ZOODOM, is now under the administrative control of the Universidad Nacional Pedro Henriquez Urena (UNPHU), while the Jardin Botanico is an autonomous institution but receives major funding from the government.

Legal and Historical Bases

The legal basis for resource management in the Dominican Republic is relatively ambiguous. Legislation has been created to deal with problems on a piece-by-piece basis, resulting in overlaps, gaps, and moderate confusion among and within institutions.

The first piece of institutional legislation was the Hunting Law, dating from 1931 and desperately in need of modification or replacement. Although a new Fauna Law has been proposed and is expected to pass both houses of the Congress and to receive presidential approval without any problems, it has apparently not received priority status at the legislative level. The new DVS is forced to operate under a law almost 50 years old, created in a time of major economic depression worldwide, and clearly meant to encourage sport and commercial hunting. As its name implies, it is a hunting law, not wildlife management legislation. The existing wildlife law is outdated. It lacks any mention of endangered species or the need to control the introduction of exotic species to the island. A detailed analysis of the law is not warranted here. The Dominican government has demonstrated its awareness of the inadequacy of the old law by proposing the new legislation.

The proposed wildlife legislation takes a much-needed global approach to the problems of protecting and exploiting native fauna; recognition of the need to control faunal imports as well as exports; regulation of captive reproduction with exotic and native species; control of all types of hunting, including subsistence, commercial, sport, and research. Categories for wildlife refuges and management areas are also established. The proposed law will be the first attempt to establish wildlife management as a legally recognized national goal. Unfortunately, it is not yet law.

In chronological order, the next major piece of wildland legislation is Law 5856 (1962) which is called the Forestry Law. This law created the Direccion General Forestal (DGF or FORESTA). (For a discussion of this legislation and of the institution, see the sections on natural vegetation and on plantation forestry.) Rather surprisingly, the Forestry Law does not mention native fauna. Its

Figure VIII-2b. *Subtropical moist forest in Parque Nacional del Este. (Photo, John Shores.)*

stated objective is to regulate the concentration, restoration, development and exploitation of forest vegetation (Law 5856, Title I, Article I, 1962). Provisions are made for Forestry Reserves and National Parks, both of which will be managed by DGF, but no reference to wildlife is made, nor is much notice given to plant species not exploited for wood or other major forest products such as resins, gums, etc. The focus of the legislation is on commercial forest production and watershed protection. The Direccion Nacional de Parques (DNP) was created by Law 67 (1974). Three groupings of areas and reserves were established, including eight specific categories for protected areas. This was the first piece of comprehensive wildlands legislation because it acknowledges the importance of all the factors that interact to form a functioning natural system instead of concentrating on just the timber or just the wildlife, as in the case of the two preceeding laws.

None of the three laws (or four if we include the proposed Fauna Law) includes the power of expropriation of land for the purposes of implementing the legislation. The DGF and DNP are given land management responsibilities, in the first case for Forestry Reserves and National Parks, of which National Parks would be a part. An apparent conflict exists between the Parks Law and the Forestry Law. Both laws charge their respective institutions with the administration of national parks. Article 12 of Law 67, however, states that institutions holding state lands that become parks or reserves should transfer those lands to the DNP without any remuneration of any kind. This would seem to imply that the national parks currently under joint DGF/DNP administration should pass to DNP. The cooperation between these two institutions, particularly with respect to prevention of forest fires in the Cordillera Central, is laudable. It is to be hoped that this close cooperation continues as each institution develops independent programs in its own management specialty.

A potential conflict also exists between the DNP legislation and the proposed DVS legislation. Both institutions will have the responsibility to limit research projects which include collecting and harvesting of wildlife for scientific purposes. Chapter III, Article 10 of the proposed Fauna Law states that all types of hunting licenses will be issued by DVS/SEA. Article 13, Section 2 of Law 67 states that the hunting or capture of animals in parks or reserves can only be done for scientific purposes, with DNP authorization. The problem could arise that the DNP, to conduct its own research within a national park, must first apply for permission from DVS. While it is proper that DNP personnel should have valid collecting licenses, there should be no confusion as to which institution is responsible for research and management within the National Parks System. This responsibility should belong to the DNP alone.

The greatest problem with respect to fauna is not legal, but rather an institutional problem. The Departamento de Recursos Pesqueros was formed from the fisheries division of Caza y Pesca (See discussion in the Marine Resource Section). The DVS took over the responsibility of the hunting division. The DRP has emphasized fish and shellfish in their programs, while the DVS has concentrated mainly on terrestrial fauna. Endangered marine fauna such as the manatee, *Trichechus manatus*, and four species of marine turtles have been largely ignored. Their populations are extremely low, yet neither institution has been able to come to grips with the problem. The DVS has a strong interest in these species, but lacks the mandate and the resources to develop anything other than a small program to protect one turtle nesting beach. The DRP has a clearer mandate, but that institution is oriented more toward production than to protection of endangered species.

Institutional Framework

Four Dominican institutions have major responsibilities in the wildlands sector: the Direccion Nacional de Parques; the Departamento de Vida Silvestre; the Departamento de Recursos Pesqueros, and the Direccion General Forestal. The former two, DNP and DVS, are treated here. DGF is discussed in chapter IV and the DRP in chapter VII.

Secondary institutions in the wildlands sector are considered to be those with significant impacts on wildlands through activities, programs, or projects directed at the wildlands resources. Not included here are the institutions that affect wildlands through their activities, but which are not mandated by law to recognize wildlands as part of their concerns (Table VII-3). Secondary institutions fall into three basic categories, policy, registration, and research/education.

Table VIII-3. Government institutions affecting wildlands in the Dominican Republic.

Primary Institutions (management)
- Dirección Nacional de Parques (DNP)
- Departamento de Vida Silvestre (DVS/SEA)
- Dirección General Forestal (DGF)
- Departamento de Recursos Pesqueros (DRP/SEA)

Secondary Institutions (policy)
- Congreso
- Presidencia
- Cancillería

Secondary Institutions (research/education)
- Museo Nacional de Historia Natural (MNHN)
- Museo del Hombre Dominicano (MHD)
- Parque Zoológico Nacional (ZOODOM)
- Jardín Botánico Nacional (JBN)
- Universidad Autonoma de Santo Domingo (UASD)
- Universidad Nacional Pedro Henríquez Urena (UNPHU)
- Universidad Católica Madre y Maestra (UCMM)
- Centro de Investigaciones de Biologia Marina (CIBIMA)

Secondary Institutions (registration)
- Centro Dominicano de Promoción de Exportaciones (CEDOPEX)
- Departamento de Ganadería (SEA)
- Departamento de Sanidad Vegetal (DSV/SEA)

Wildlands policies at the national level are established by the Congress, the Presidency, and on international affairs, by the Chancery. Actual management responsibilities, however, are delegated to the individual agencies. Registration responsibilities are the task of CEDOPEX, Departamento de Sanidad Vegetal, and Departamento de Ganadería. Their functions to date have been much more in the realm of registering introductions and exports of fauna and their products rather than examining the advisability of trade in a species itself. Little control has been exercised. CEDOPEX is charged with registering all exports of Dominican products. While this offers the potential to control the international trade of threatened or endangered species, to date it has been less than effective. The mechanism exists, but the Dominican government has not moved to restrict trade in these species. Agreements to protect certain species only exist as memoranda between the heads of these agencies, and do not carry the weight of law. Greatly needed is the passage of the proposed Fauna Law and subscription to the CITES international agreement.

Research and education functions are performed by a large number of institutions. The museums, zoo, botanical garden and universities are traditional research institutions. The universities have major responsibilities for biological sciences education, but wildlands management training has not been offered. Expansion of wildlands training at these institutions is necessary if professional needs are to be met in the future.

Important support functions in research and education could be carried out by secondary wildlands institutions. Currently,

however, the activities of each of these institutions have been conducted independently and with only minimal cooperation.

In addition, the three national universities play a major role in training the students who become agency staff. Close linkages are maintained between each agency and the two universities in Santo Domingo. The DGF is also tied to UCMM programs. Most of these linkages are due to the sharing of personnel. Top agency officials are also professors at the various universities. While somewhat effective at keeping the various officials informed as to what current activities each institution is pursuing, this system depends to a great deal on the individual holding the position. A great need exists for institutionalizing this kind of communication. It could raise the overall level of effectiveness of all the agencies and reduce duplication of efforts.

Wildlife Department (DVS) is composed of five divisions plus an administrative unit. The Department was formed in 1978 with an original staff of six. It has grown rapidly to a current staff of 41, not counting honorary inspectors. The emphasis of existing and future programs is clearly on wildlife production and control of vertebrate pests (Table VIII-4). Threatened and endangered species are receiving less attention.

Table VIII-4. Completed and planned programs of the Departamento de Vida Silvestre.

Programs Completed

1. Ecological baseline study of bio-physical factors of the Lake Enriquillo watershed.
2. Ecological baseline study of bio-physical factors in the Rincon Lake watershed.
3. Ecological baseline study of flora and fauna in the area of the Bao hydroelectric project.
4. National survey of damages caused by vertebrate pests to agriculture.
5. Construction of a nursery to supply plants used by wildlife.
6. Preparation of the proposed Fauna Law.
7. Study of 11 potentially commercial species for food production including doves, pigeons, quail, and other game birds.

Future Programs Proposed

1. Inventory and evaluation of selected ecosystems in the country. Designed for international funding at RD $1,159,812 covering two years.
2. Mongoose control program in suburban and rural areas. This is a cooperative project and would involve the anti-rabies center as well as DVS.
3. Proposal to bring two German volunteers to work in the ecosystem evaluation program.
4. Proposal to study the raising of frogs, *Rana catesbiana*, for commercial uses.
5. Proposal to study ways to raise Japanese quail for rural consumption and commercial sale, cooperating with ALCOA and Partners of Michigan.
6. Proposal to study damage to cacao by endemic woodpecker, *Melanerpes striatus*.
7. Proposal to begin acquiring equipment and establishing laboratory for use in the vertebrate control program in cooperation with Denver Wildlife Center of U.S. Fish & Wildlife Service and USAID/DR.
8. Quail production program by rural youth on a national level.
9. Proposal to develop a conference entitled Seminar on the Study, Management, and Conservation of *Columbidae* in the West Indies.

The DVS has remained a centralized agency in spite of the Director's stated goal of delegating authority and responsibility to the Section heads (Pena, pers. comm.). In part, this is a result of the confined office space and the small staff. The close proximity of one office to the next, and the Director's office to all the rest, imposes a certain amount of centralization and control. The small staff size facilitates the exchange of ideas and a strict separation of functions among Sections is the focus of all Department activities. Once the DVS becomes a land management agency with responsibility for administering wildlife sanctuaries and management areas, a certain amount of decentralization will by necessity take place.

A common problem for new or reorganized agencies is a lack of public identity. The DVS has not been immune to this problem, but has recognized it and designed a series of public education programs to remedy it while at the same time explaining the mission of the DVS and the existing wildlife laws to the public. Daily newspapers, weekly supplements, and other printed materials such as posters are used to reach a broad audience. Radio and television are used to reach other sectors of the population as well.

In part because of this need to build public support, and in response to deliberate SEA emphasis on food production, the DVS has moved heavily into the production of gamebirds as sources of meat and eggs for rural populations. While programs using pigeons, quail, and partridges do increase public awareness of the Department and are legitimate efforts aimed at increasing rural incomes and consumption of protein, their placement within DVS is questionable. Building a public image as an action agency is one goal, but creating a wildlife institution with an identity closely linked to introduced and exotic species could be a mistake.

The mission of the Departmento de Vida Silvestre should be redefined to be the conservation and production of native fauna with top priority on the preservation of existing genetic resources. The restoration and management of native wildlife, the preservation of threatened and endangered species, and the control of vertebrate pests should be the major goals for the DVS.

Training has been an integral part of DVS staff development from the beginning. Seminars, short courses, and workshops have been used to broaden staff expertise. Most of the training programs have been in-country, but an effort has been made to have DVS personnel attend regional and Caribbean meetings. In general the approach has been to organize workshops or short courses in Santo Domingo and bring in expert help from an international agency to conduct the program. Most of this training has been of a practical, field-oriented nature.

Most of the advanced wildlife training must come from abroad. Local universities do not have the faculty nor facilities to offer courses beyond the standard biological sciences curriculum. The goal of much of the international assistance received to date has been to boost the technical level of DVS programs. Information, consulting, and training have been the principal inputs. To develop its programs and achieve its goals, the DVS maintains direct contacts with a broad range of foreign institutions. The institutions and the nature of their contacts with DVS are shown in Table VIII-5. It is important to note that the DVS is attempting to rebuild interest in the Man and the Biosphere (MAB) Committee that was set up in the Dominican Republic but is not currently operating. The MAB program can be another important link between national and international efforts to reintegrate economic development and wildlands management in regional ecodevelopment.

Foreign technical assistance has involved the Denver Wildlife Research Center in vertebrate pest control, the United States Peace Corps in quail production, and a plan to use German Volunteer Services in the ecosystem evaluation program. Partners of Michigan have backed a major expansion of the quail production scheme. OAS, RARE, WWF, and CCA funds are being sought for the expansion of programs addressing the problems of threatened and endangered species, but these sources for funds have not been developed to date.

National Parks Directorate (DNP) was created by Law 67 (1974) as a dependency of the President's office and actually began functioning in 1976. Its principal objective is the conservation and study of the biota and environment in areas termed "national parks" located in rural, urban and recreational areas as well as historic sites. The most important functions of DNP are: (a) to guarantee the public access to recreational areas and the opportunity to enjoy contact with nature in its pristine state; (b)

Table VIII-5. Institutions in contact with the Departamento de Vida Silvestre, Secretaria de Estado de Agricultura, Dominican Republic.

	Information Exchange	Consulting	Training	Equipment	Funding
Partners of Michigan	X	F	X	X	X
Denver Wildlife Research Center	X	X	X	X	X
International Affairs/USDI	X	F			
Migratory Species/USDI	X				
Endangered Species/USDI	X				
Enforcement/USDI	X				
German Volunteer Services	X	F	F	F	F
United States Peace Corps	X	X			
Organization of American States	X				F
RARE	X				F
IUCN	X				
CITES	X				
World Wildlife Fund	X				F
Caribbean Conservation Association	X				F
ICBP	X				
MAB	N				
New York Zoological Society	X				
National Audubon Society	X				
CATIE/Turrialba, Costa Rica	X				
Dept. of Natural Resources/Puerto Rico	X	F			
Instituto Mexicano de Recursos Naturales	X				

Notes: X = operating N = not functioning, F = future plans.

to provide study areas where management techniques can be tested and directed to achieve stability in natural ecosystems; and (c) to set aside areas where the populace can participate in direct observations of nature and complement those observations with environmental education—both directed to increasing public awareness of their relationship with the environment and their responsibilities to nature.

Early emphasis was on urban and historical areas, but with a change in priorities since 1978, the immediate goals of the DNP have been to establish protection of the five existing national parks and to begin the task of explaining the importance of national parks to the public. The agency has four departments, but the largest by far is the Department of National Parks with a staff of approximately 82 in five national parks, plus the department chief and a staff biologist in the national office. The remaining three departments have a total professional-technical staff of five. The priority of the DNP in the last two years has clearly been to establish an effective presence in the national parks.

Decentralization is a primary objective in the DNP. Considerable responsibility for decision-making has been delegated to the individual park administrators. All park administrators meet once a month with the national director and the financial administrator to stimulate interchange of ideas and to coordinte activities.

Six or seven field managers have received special training overseas in national park planning or administration. Because the national university system does not offer specialization in national parks, recruitment has been from agronomy and forestry degree programs. Though one might expect graduates to be more interested in working within their curriculum areas, the DNP has not experienced a high turnover rate at the upper levels. Delegation of authority and responsibility has been effective in fostering a high level of interest in the job. In spite of rustic conditions in the parks, the administrator lives in the park and there have been few resignations. The DNP has expanded rapidly with most of the growth occurring in the last two years. Between 60-70% of the total DNP budget is allocated to the national parks. The 1980 budget is roughly RD$600,000 but this is expected to increase to nearly RD$900,000 for 1981 (Morell, pers. comm.). The problem facing the DNP now is how to raise the experience level of the field personnel. It is the hope of the Director that eventually all park guards will have completed their secondary education. His goal for the second stage of staff development is to have a ranger corps composed of unmarried high school graduates from outside the region in which they are patrolling. Currently, most park guards are local peasants without diplomas (Morell, pers. comm.), but low salaries deter involvement of educated persons. International financial institutions may be asked to supply interim grants to support DNP operational expenses while the parks are being developed. Once better facilities are available to park staff and visitors, the problem of maintaining mid-level staff should decrease.

Training requirements are considerable. Putney (1980) states that parks alone will need 12 professionals and 48 technicians. Local universities do not have wildlife or wildlands management degree programs. Current estimates are 12 biologists and 90 agronomists graduated per year, with perhaps four having specializations in forestry. The biologists tend to have a stronger laboratory orientation than field orientation (Putney 1980). Clearly if DNP and other wildlands programs (DVS, DGF, DRP) are to expand and develop, foreign training will have to continue. Seminars, short courses, workshops, and advanced degree programs must be included in any training program.

Current DNP projects include the management and protection of five national parks; environmental education through publications, media articles, interviews, and other means; maintenance of urban parks under DNP supervision; and staff training. Projects include the modification of the boundaries of Los Haitises National Park, the protection of pigeon nesting areas within the parks (not a shot was fired in the Parque Nacional del Este this year—Morell, pers. comm.), an inventory of national wildland areas, and the development of infrastructure in the National Park of the East. This last area has been chosen as a pilot project for training DNP staff.

Equipment is barely adequate to provide minimal support to DNP efforts. Ranger cabins are sorely needed to establish a permanent presence of the DNP in all regions of the parks.

Foreign assistance at the present time is mostly in the form of cooperation and information exchange. Recent collaborative efforts have involved Alvaro Ugalde, Director of the National Park Service of Costa Rica (1978), Craig MacFarland from CATIE Wildlands Management Unit, Turrialba, Costa Rica (1980), and Allen Putney from the Eastern Caribbean Natural Area Management Program, St. Croix, Vigin Islands. A longer-term consultancy in 1979 by Edmundo Fahrenkrog, OAS, led the management planning effort for the National Park of the East. A wildlife biologist currently works as advisor to the Chief of the National Parks Department. The biologist is a United States Peace Corps Volunteer completing his tour of service. From 1976 to the present, a total of six Peace Corps Volunteers have worked in the DNP.

Future consulting needs include a park management specialist to train the park staff, a marine ecologist to guide the inventory of potential marine parks, and an advisor for the national wildlands inventory.

The DNP maintains close contacts with CATIE, WWF, IUCN, TNC, University of Michigan Wildlands Program, Caribbean Conservation Association, and other groups and individuals with conservation interests.

National Zoological Park (ZOODOM) was created in January 1975 by law 114, as a dependency of the administrative secretariat of the Presidency. (Flora and fauna in the area surrounding the zoological park received protection ten days earlier by Decree 451.) Its principal functions are (a) to study the ecology and behavior of indigenous species of vertebrates in the different habitats of the island: (b) to develop biological research on indigenous species and use that knowledge to promote public awareness of the importance of conserving native biological resources; (c) to maintain adequate numbers of native and exotic species in captivity to facilitate scientific research to help preserve endangered species; (d) to contribute to the establishment of ecological reserves suitable for basic research on natural populations; (e) to contribute to the appropriate administration of the faunal resources of Hispaniola and the Caribbean; (f) to prepare publications on native and exotic fauna exhibited in the zoo; (g) to serve as a practical laboratory for research and educational programs (ONAP 1980).

The zoo's major activities focus on education and research, including captive breeding of native fauna, reintroduction of progeny to native habitats, and field studies on wild populations of rare, threatened, or endangered species. Newly constructed, modern facilities permit ZOODOM to develop program activities. ZOODOM receives adequate budgetary support from the Presidency, as well as close collaboration with the local universities.

Anthropological Museum (MHD) was created in 1972 by Law 318 as a dependency of the administrative secretariat of the Presidency. Its principal functions are: (a) to conduct research on Pre-Colombian anthropology, enthnology and archaeology; (b) to maintain and conserve exhibitions of representative artifacts; (c) to maintain an inventory of museum collections; (d) to advise the government on the purchase of artifacts from private collections; (e) to publish research results. Major emphasis is given to prehistoric man. MHD collaborates closely with DNP on speleological studies in or near national parks. A major effort is urgently needed to determine the best methods for protecting important cave resources, particularly cave art.

National History Museum (MNHN) is also a dependency of the administrative secretariat of the Presidency. Its major goal is to conduct basic research, especially on birds, molluscs, and crocodiles. MNHN is nearing completion of a detailed inventory of the entire coastline. Though housed in a large and impressive building, it is not yet open to the public as displays are still being prepared. Serious pest problems are damaging some of the reference collections maintained by the MNHN. Unless the collections are adequately curated and protected, the MNHN cannot function as a national repository.

Principal Problems and Needs

Several problems exist at the legal level which impede adequate wildlands conservation and management efforts: 1) Management categories are not unified but very fragmented; 2) Management responsibility is sometimes unclear and lacks the proper emphasis that should be placed on threatened and endangered resources and their critical habitats; 3) Control of exotics is not firm enough (this will improve with proposed Fauna Law); and 4) Exports are not controlled by international convention (GODR is *not* a signatory member of CITES).

Institutional problems are of two types, inter- and intra-. Interinstitutional cooperation is sadly lacking. A few projects (e.g. management plan for Parque Nacional del Este) are carried out by interinstitutional, interdisciplinary groups. The traditional accounting system used by the government makes projects with shared budgets almost impossible, thus reducing the incentive to work with an outside institution. Some individuals and their institutions do manage to conduct cooperative projects, but these succeed in spite of institutional structures, not because of them. Usually a person with charisma is responsible for much of the success. Interinstitutional interfaces are also problematic fronts. Fortunately most of these are bi-institutional interactions and should therefore be easier to solve than multi-institution problems. The man problems are between DGF and DNP over ultimate control of the national parks in the Cordillera Central, and between DVS and DRP over the agency to manage and protect sea turtle, manatee, and other seemingly forgotten species.

A major problem is developing between DVS and DNP over the methods and criteria to use in a nationwide survey. Because of the broader mandate given to the DNP, it is suggested that the national wildlands survey be managed with DNP as the lead agency, and that a parallel national wildlife survey be managed with DVS as the lead agency. The DNP orientation should be toward complete, functioning ecosystems largely unaltered by man. The DVS orientation should be to identify critical areas for individual species of wildlife. Once the DNP program has selected appropriate areas in the national park and wildland system, the DVS program should be ready to select wildlife refuges, sanctuaries and management areas from the remainder. That way a needless duplication of effort is avoided, and in addition first priority is given to functioning natural ecosystems. Because of the management inherent in the wildlife approach, it seems logical to select candidate parks first on the basis of naturalness, and select range and management areas from the remaining areas that can then be manipulated to favor certain species.

A major institutional need is to develop mechanisms and structures for encouraging multi-institutional cooperation. An incentive and reward system is needed to facilitate coordinated interrelations. An authority structure is needed to guide the efforts of various collaborating institutions so that a common goal or objective is achieved.

Currently, the best cooperative efforts occur when funding and guidance come from an exogenous source. An expert consultant with external funding can often get higher levels of cooperation on multi-institutional projects than can an internal coordinator using national funds. Apparent sources of difficulty include: 1) Administrative/accounting procedures that inhibit sharing funds and budgets; 2) Institutional jealousy with respect to territory, control, and credit for efforts; 3) Reward/incentive system that tends to ignore non-traditional achievements; and 4) Reluctance to divert resources from traditional projects to new, untested, or innovative projects.

Foreign expert consultants with external funding can avoid many of these pitfalls, but what is needed is the institutionalization of inter-agency cooperation. This problem area is important enough to warrant careful study.

Educational capacities for advanced wildlands training are essentially non-existent in the Dominican Republic. The source of both expert consultants and advanced education must be external (Putney 1980). A two-pronged approach is suggested where consultants should be brought in to train host country nationals in a learn-by-doing context, and selected Dominicans should be sent to foreign training facilities, including institutions of higher learning where they can pursue advanced degrees.

It might be also possible to arrange exchange programs or visiting professor programs to strengthen certain curricula in the national universities. As the demand for wildlands personnel is felt in the market, the shortage in supply may bring out competition among agencies for qualified personnel. It would be more productive to have training programs planned and in progress to supply adequately trained resource professionals as they are needed.

Conflicts between wildlands and essentially all other land uses will increase as development proceeds. Even with an adequate system of wildland reserves the future of the living natural resources of the Dominican Republic would still be in jeopardy

from spillover effects generated in adjacent or even distant areas. The effects of an oil tanker accident in the Mona Passage could be devastating to some wildlands resources (see chapter VII). Wildlands cannot be left to stand alone. An integrated system of wildlands, forest production lands, watershed protection areas, agricultural lands, and more developed land use areas must be devised if the country is to minimize the irrevocable loss of wildlands and natural resources.

Recommendations

Highest Levels of Government

1.1 Develop comprehensive legislation establishing GODR's dedication to the conservation and management of natural resources and the environment. While not a subsector of wildlands, comprehensive, uniform environmental legislation is of critical importance to the effective protection for the natural resource base of the Dominican Republic.

1.2 Become a signatory nation to the Convention on International Trade in Endangered Species (CITES). The Departamento de Vida Silvestre (DVS) currently cooperates on CITES matters, but the legal mandate is lacking. This should be considered a top priority for congressional and presidential action.

1.3 Approve and implement the proposed Fauna Law. The effectiveness of the DVS is seriously compromised by the outdated Hunting Law. The proposed new law would add needed force to the programs which aim to protect and conserve endangered species, among other needed modifications.

1.4 Declare all islands and keys in the Dominican territorial waters to be Natural Resource Reserves, and establish interim protection for local flora and fauna. The importance of the coastal islands and keys is so high that an immediate step is warranted to protect the populations on these small land areas, particularly nesting birds and turtles. Protection should be established as soon as possible, and studies begun to determine the proper resource management category for each area.

1.5 Revise and modify existing laws which create wildlands managment categories. Existing laws have created a jumble of categories, groupings, and agency responsibilities. A uniform set of categories and selection criteria is needed with clear determination as to the management priorities in each area, plus an unambiguous assignment of each category to an agency or institution.

1.6 Continue supporting environmental education. The Government of the Dominican Republic is to be congratulated on its efforts to establish environmental education as an integral part of the national education system. These efforts must be continued and expanded.

Inter-Institutional Level

2.1 Clarify borders between DVS and the Departamento de Recursos Pesqueros (DRP) with respect to marine fauna. Certain threatened or endangered marine fauna have not received proper attention. The DRP should either increase emphasis on sea turtles and marine mammals, or pass this responsibility to the DVS.

2.2 Define role of the Direccion General Forestal (DGF) with respect to National Parks. Article 12 of Law 67 charges all other institutions with the responsibility to transfer National Park lands to the Direccion Nacional de Parques (DNP). Complete control of the National Park System should rest in this institution. The cooperating arrangement between DGF and DNP should continue with regard to forest fire prevention and control.

2.3 Establish a clear mandate for one institution to be responsible for protecting caves and caverns. Effective protection of the rich cave resources of the Dominican Republic does not exist. While Law 492 (1969) declares a large number of caves throughout the country to be National Monuments under the control or protection of the Oficina de Patrimonio Cultural, Law 67 would appear to assign this responsibility to the DNP. Current cave research efforts are carried out by the Museo del Hombre Dominicano and the private Sociedad Dominicana de Espeleologia.

2.4 Expand environmental education programs at all levels. Every institution interviewed in the wildlands sector has some sort of environmental education program. These should be encouraged. A careful evaluation of the different programs might reveal some key characteristics that help determine the success or failure of a particular method or media. An evaluation of experiences gained to date should be made.

2.5 Encourage integrated development schemes applying ecodevelopment priciples. Carefully integrated, multi-disciplinary programs to develop land use techniques applicable to hillside farming must be assembled. By developing productive resource exploitation methods, the government can help relieve the pressure on national parks and equivalent reserves while at the same time stemming the rural-to-urban migrations.

2.6 Establish guidelines and effective controls over the introduction of exotic species. The proposed Fauna Law would establish this as a responsibility of the DVS, but clear cooperative agreements will be needed among the various agencies involved including DVS, Departamento de Sanidad Vegetal, Departamento de Ganaderia, and DRP. At the present time, international organizations are able to bring exotic fauna, both terrestrial and aquatic, into the country with apparently no restrictions or even inspections. Published guidelines would greatly facilitate cooperation in and control of exotic introductions.

2.7 Modify accounting and evaluation procedures to encourage inter-institutional cooperation and project sharing.

2.8 Develop national data base for natural resources. A comprehensive data base of natural resources would be a great planning aid and would help identify potential impacts at an early stage in project formulation. Special emphasis should be placed on threatened and endangered species.

Departamento de Vida Silvestre (DVS)

3.1 Increase emphasis on the protection and management of threatened and endangered species. Too much emphasis is placed on commercial production. While control of pest species is important, the top priority should be research and management efforts aimed at preserving the existing genetic resources. A separate section in the Department should be created for this purpose. It is difficult to accept the argument that a wildlife department should be involved in the study of exotic species for commercial applications. These tasks could better be handled by departments experienced in raising chickens, turkeys, and other fowl and small livestock. It would be more logical to dedicate wildlife department resources to conservation and repopulation with native species and to the control of vertebtate pests.

3.2 Establish the DVS as a land management agency. Wildlife management areas, sanctuaries, and refuges do not exist under the DVS control. These areas should be established to permit a directed management program by the responsible agency.

3.3 Conduct comprehensive national wildlife surveys. It is of prime importance that coordinated national surveys of wildlife populations be begun. Compilation of baseline population and distribution data is the first step in establishing an accurate picture of the faunal resource and its condition.

Direccion Nacional de Parques (DNP)

4.1 Conduct a nationwide wildlands survey. This is the first step in evaluating the appropriateness of existing units of the national park system, and also the first step in identifying new areas that should be evaluated for possible inclusion. Useful aerial photography may be forthcoming from the SIEDRA/CRIES project. This would supply an effective way of determining the level of hu-

man impact on selected areas as a first-cut approximation of wildness.

4.2 Adjust boundaries of Los Haitises National Park. It is of extreme importance that the boundaries of this park be clarified so that effective control of the area can be established.

4.3 Conduct a coastal survey to identify marine park candidates. The Museo de Historia Natural is currently conducting a program of coastal inventories and their experience should be included in a comprehensive marine park survey. Lead agency responsibility, however, must remain with the DNP.

4.4 Expand Isla Cabritos Naticnal Park. While the goal of a complete self-regulating ecosystem may never be possible for Isla Cabritos National Park, at the very least the park area should be expanded to include crocodile nesting areas and other critical habitat areas.

4.5 Include marine areas in the Parque Nacional del Este. The management plan (DNP 1980) contemplates a 500 m marine zone around the park plus the canal between the mainland and Isla Saona. All of this area should be included in the park.

IX

Small Farmers

Introduction

This chapter deals with some of the environmental problems and agrarian trends concerning small farmers in the Dominican Republic. In any study of the relationship between man and natural resources, the role of the small farmer is extremely important for he is a food producer. Moreover, he constitutes the bulk of the rural population of what essentially still is an agrarian country. It is the small farmer with simple technology who produces the bulk of the food for national consumption.

A survey of official government literature leads to the conclusion that it is the small farmer who is implicitly viewed as the main agent of irrational use of such resources as soils and forests. Regardless of the validity of the accusations, the small farmer is an important agent in ecological transformations, a part of the problem, and a necessary component of any solution.

Although the main concern of this chapter is the specific ways in which the peasant's productive systems affect natural resources, first we must consider some broader societal issues that are deemed crucial to the resolution of the ecological problems existing at the level of peasant society. These societal issues will confront Dominican society during the 1980's with some of its most trying challenges. These challenges can only be met successfully by a concerted national effort involving the manner of dealing with the issues, a massive marshalling of resources, and strong political determination. The Dominican people must determine how they will meet these important challenges.

Some Trends of the Agrarian Structure and their Ecological Implications

Land Tenure

There is an ongoing dual trend toward fragmentation and concentration of land, the key resource in agriculture. Fragmentation brings about a continuous rise in the number of "minifundios" or small farm units. According to the Agrarian Reform Institute (IAD 1979), out of 495,000 farms in 1970, some 300,000 had less than two hectares (also see Table VI-3). Furthermore, within this broad strata of minifundia a substantial number of landholder's plots are as small as ½ or even ¼ hectare. These two latter types of tiny land holdings are termed "microfundios". During the 1980's the numbers of minifundia and landless peasants are expected to increase (S. Moquete, pers. comm.), though considerable efforts to provide land to the landless will continue under the agrarian reform programs. Minifundia are particularly widespread in the Cibao, while in La Vega and San Francisco de Macoris, minifundia coexist with latifundia. The eastern coastal plain is dominated by latifundia in sugarcane and cattle production.

The reasons behind the fragmentation of property have not been clearly identified. However, laws of property inheritance of the Dominican peasantry give siblings equal shares of the parents' property upon their deaths. A generation ago, when mortality rates were high, the number of surviving descendants was much smaller and life expectancy was shorter.

Socio-economic and ecological issues logically spring from an increase in minifundia. What is the relationship between the very small landholder and natural resources? To answer this question we need to study the production systems of the farmers of small landholdings. While farmers from the Cibao and the Central Cordillera have been studied to learn their agricultural and economic techniques, the peasants of the southwest remain largely a socio-economic unknown.

Small farmers and agribusiness operations have divergent productive orientations. The small farmer has small plots for fruits and staples including plantains, dry beans, yucca, sweet potatoes, pigeon peas, and in some areas, tomatoes. Very few small farmers grow rice, a crop grown by farmers with more capital and machinery. Most larger farms have a concentration of the more profitable export cash products such as sugarcane, tobacco, cacao or beef.

The small farmer still relies on rudimentary agricultural technology. He uses basic tools and little if any mechanization or fertilizer. In the Dominican Republic fertilizers are used primarily by the cash crop export sector (SEA/IICA 1977). At the same time several studies have shown a positive and open attitude of small farmers to modern technology, including fertilizer, but they do not use it because they cannot afford it (Tejada and de Moya 1977). Loaning institutions generally consider the small farmers a risky credit subject; hence they have a hard time acquiring credit for production.

With his rudimentary technology the small farmer is forced to extract as much as possible from his land; this can easily lead to overutilization and soil degradation and as soils deteriorate productivity decreases. The rudimentary technology the peasants use

does not necessarily lead to a deterioration of the soil and/or other natural resources. The regions where peasant technology is causing the greatest ecological damage are the steep slopes of the Cordillera Central unsuitable for seasonal crops, particularly beans (M. Paulet and B. Santos, pers. comm.). Even if a peasant is in a position to take soil conservation measures, his individual effort is lost when the problems are widespread and affect whole regions (Moquete 1979). In areas such as the watersheds of Sabana-yegua, San Jose de Ocoa and Tavera, the solution to the deterioration of natural resources requires intersectorial planning that transcends the level of the family farmer.

The concentration of land into larger farms is another significant aspect of the agrarian structure. Serious socio-political as well as ecological issues must be considered. Though latifundia can be productive, large farms in the Dominican Republic tend to be inefficient and their practices frequently lead to natural resources degradation, especially for beef cattle ranching and sugarcane production, specifically in the case of the government lands.

Concentration of the land usually involves peasants selling their land to mass producers. Agricultural real estate value in the Dominican Republic is amongst the highest in Latin America. In the Cibao, the cost of a hectare of agricultural land is DR$2,000 to 4,000 or more (A. Abreu, pers. comm.).

"Professional cattlemen" purchase a significant portion of the land sold by small farmers. City dwelling professionals (lawyers, doctors, dentists, engineers, military officers, etc.) make up a new sociological strata investing in land and cattle. This represents sound economic behavior as well as prestige. These entrepreneurs prefer to rear cattle because, unlike modern mechanized crops, livestock does not require their continuous physical presence; a manager can be hired to run the farm.

Total cattle stock stands at 1.9 million head grazing on about 1.4 million hectares of land, roughly 55% of the land in agricultural use (Ecol. Cons. 1980). The ecological problems associated with ranching are well known in the country: overgrazing is common. Cattlemen remove most trees because they believe cattle prefer sunlight to shade; the elimination of trees from the pasturelands contributes to the desertification of the countryside (Ecologia 1979).

The Dominican Government is a very large landholder and land user. Currently it runs 11 sugar mills and it owns about 187,000 hectares dedicated to sugarcane and pasture. The State Sugar Council (CEA) has a poor record for land use and is a money losing enterprize. According to knowledgeable Dominican technicians, the CEA has severe administrative and planning limitations.

In a visit to a CEA sugar mill the first impression one has is of general decay of the infrastructure and the equipment: the mill appears old and deteriorated, the workers' housing is in poor condition and the raillines, irrigation and drainage canals unkempt, etc. In the case of Central Barahona, the CEA's largest mill, the poor maintenance of the irrigation canals has led to widespread loss of good agricultural soils due to salinization. Obviously, if the government is going to be a fundamental institution in the struggle to preserve and manage the natural resources it would do well to start by putting its own house in order.

Employment and Income

Another feature of the agrarian structure is the scarcity of employment opportunities and the concentration of income. Unemployment is not so much a threat as is underemployment. Official figures usually report that underemployment affects 40% of the rural labor force. More recent studies, however, indicate that these official statistics may be underestimating underemployment in the countryside. Juan Diaz (1978) found that even in places like Moca, one of the most productive sectors of the Cibao, underemployment stands at 46%

Given the low productivity of small farms and widespread phenomenon of underemployment, rural income is very low. According to IAD (1979) the number of families below the "poverty line" is increasing. This same report concludes, pessimistically, that the present trend is towards a greater concentration of income rather than towards a fairer distribution of it.

The Rural Exodus

The combination of forces acting upon the peasantry has led to a significant rural exodus. This exodus away from the countryside is visible in all rural areas but it is more intense in the Cibao and in the southwest (Breton et al 1977).

The migratory movement is in fact made of several currents, the widest running toward large urban centers such as Santo Domingo and Satiago de Los Caballeros. Peasants sometimes migrate directly from their areas of origin to these large cities, other times they migrate in stages, moving first to small cities or large towns, then to Santo Domingo or Santiago.

Ramirez (1981) found that in Santiago and Santo Domingo half the population is made up of immigrants. Furthermore, 80% of the people over 35 years old are immigrants from rural areas. Twenty-five percent of the immigrants interviewed said that they were looking for employment, while another 23% wanted to improve their economic condition. Needless to say, the massive arrival of thousands of peasant households into these and other cities has strained the capacity of the municipalities to provide basic public services as electricity, water, sewage, etc. (see Chapter X).

During the last 20 years peasants have also migrated abroad. There are no reliable statistics on the number of Dominicans living abroad as figures fluctuate quite widely. Researchers of the National Population Council (CNVP) believe that a minimum of 400,000 Dominicans live in New York City, at least 50,000 are in Puerto Rico, and several thousands live in Venezuela. Severe unemployment problems and strong internal pressures within the aforementioned countries will probably stop or substantially reduce the arrival of more Dominican immigrants.

Problems in rural areas have brought about an increase of squatters to both national and private lands (IAD 1980). While in 1979 there were only five invasions of private property, 30 invasions had taken place in the first nine months of 1980. Invasion of land is not a minor disorder, but an organized confrontation involving hundreds of squatter families; some 5000 peasant households were involved in 1980. The invasion of private land raises serious socio-political issues. The government must inevitably take sides—it can either remove the squatters or it can expropriate the land from its owner to allow the squatters to keep the land. Either way, serious conflict always ensues with one of the parties in dispute. If the present trend in land invasions continues, it will pose a serious potential for political confrontation within Dominican society.

The Production System of the Small Farmers in the Southwest

Given the limited time available, it was only feasible to look with some degree of detail at the production systems of the peasantry of two ecologically critical areas: those of the southwest and the Cordillera Central. While the small farmers of the Cordillera Central have been the subject of several sociological studies, those of the southwest have been largely ignored. For this reason our attention will be focused on the latter.

Both the Cordillera Central and the southwest are critical regions because the struggle to transform the country into a self-sufficient food producer will be largely determined by what occurs in these regions. While the battle for food production will

be fought in the dry and fertile but still largely uncultivated plains of Azua, the war will be won in the Cordillera Central where all of the country's major river systems are born. Thus the destiny of the lowland plains and the highlands is intimately linked by the major rivers.

In the last 30 years the Dominican peasantry has undergone substantial changes. Although they might not agree upon the causes of these changes, Dominican writers who have explored the subject tend to agree on the broad pattern of these changes (e.g. Bosch 1980; ISA 1979). Until the recent past peasant households were largely self sufficient in food staples; their participation in the market economy was peripheral so they hardly needed any cash. Three decades ago the countryside had half the population it has now and the natural resources base had not been seriously depleted. Today the peasant has been largely integrated into the market economy as both producer and consumer. He has become a consumer of a wide variety of manufactured goods and services that require cash. He acquires by selling his product or labor.

As their cash needs have grown, peasants have had to intensify their productive efforts but higher productivity can only be achieved with the introduction of expensive modern inputs like machinery, fertilizers, weed killers, etc. The majority still rely on traditional production systems such as slash and burn agriculture; however, these can very easily degrade the natural resources base, particularly if the expanding need for cash is accompanied by a population explosion.

How do peasants of the southwest make a living? What technology do they employ, and what effect does this technology have on the local natural resources are some of the questions we shall address next.

The Southwest is formed by seven provinces: Azua, Baoruco, Barahona, Independencia, Elias Pina, Pedernales and San Juan de la Maguana. This large area covers 14,500 km² or 30% of the national territory. In 1989 its population was estimated at 692,000 or 13% of the nation's total (ONAP 1980). Its population density is 38/km², much lower than the national average of 100/km².

The Southwest is the poorest area of the country and least developed agriculturally. Nonetheless, the Southwest has the potential to become the main agricultural frontier of the Dominican Republic. Only 27% of the region is distributed into farms (see Table VI-2). A substantial amount of the land is still government or community owned. If water is made available through irrigation projects under construction or being planned, as much as 78% of the region could be put to agricultural use (ONAP 1978). However, SIEDRA (1977) reporst only 49% of the Southwest has soils of moderate or high agricultural potential (see Table VI-9).

The natural resources of the dry Southwest are being rapidly depleted by deforestation for charcoal, the destruction of the dry forest, salinization of the soil, and desertification. Although not all these changes can be attributed to the small farmers, they are an important agent because they constitute the bulk of the agricultural producers and their productive system remains largely unchanged.

The economic base of most peasant households is sustained by three main activities: slash and burn agriculture, the making of charcoal, and the rearing of goats. Each of these activities is important for the sustenance of the household economy, but all of them, given the rudimentary methods employed, strain the existing natural resources particularly with increasing monetary inflation.

Slash and Burn Agriculture

According to the 1971 census there were 54,300 farms in the Southwest. Of these farms, 76% or 41,400 had less than five hectares. Small farmers grow numerous crops because of the range of microclimates found in this generally dry area, which has, nonetheless, marked differences in precipitation and altitude. Coffee is cultivated in the higher areas, plantains are grown on the plains where irrigation is available, and beans, chick peas, and yucca seem to be grown everywhere. Rice and sugarcane are also grown but usually on the large farms.

In the parched Southwest where water determines agriculture, those peasants who have access to it can successfully cultivate a crop. Most small farmers, however, depend on the vagaries of the weather and rudimentary farming skills for dry-land farming.

Families raise most of their yearly food needs by slash and burn agriculture (Fig. IX-1). The tools and techniques of this type of productive system in the Southwest are remarkably similar to those used by the peasants of the Cordillera Central (Werge 1974). Of all the different activities carried out by the peasants of the Southwest it is slash and burn agriculture that has the broadest negative impact on local resources. Damage is particularly noticeable on the steep hillsides of the Sierra de Martin Grande, Sierra de Baoruco and the southern slopes of the Cordillera Central, and also in crucial watersheds such as the Rio Yaque del Sur, Rio del Medio and Rio Ocoa.

During the year a peasant cultivates several types of crops in a number of plots that are usually widely separated from one another and distant from the household site. As peasants frequently state, this production is for household consumption and for sale. The manner in which household production is split between home consumption and the market varies widely. There are no reliable figures that would allow one to place a small farmer along the continuum ranging from those who hardly market any produce to those who sell most of their production. Nonetheless, the fact that in the Southwest the small farmers tend to market very small amounts reflects not their desires or attitudes but that low productivity barely provides the yearly sustenance for their families.

In the Southwest, as in the case of the Cordillera Central (FAO 1971), the peasant does not normally own all the different plots he cultivates. He gains access to them using a variety of land tenure arrangements varying from full ownership to rent and sharecropping.

Elpidio Ramierez is a typical "conuquero" from Las Yayas, near Padre Las Casas, who cultivated two plots under different tenure arrangements in 1980. On the steep hillsides with thin, rocky soil that surround his community he cultivates a two hectare plot that he owns. He plants yearly crops of beans and yucca for household consumption, plus corn for his chickens. Since his children are too small to help with field chores and he does not have money to pay for laborers, Elpidio has incorporated a partner, his brother, to share in the risks and the costs. Elpidio contributes with the land and the seed while his brother supplies

Figure IX-1a. *Slash and burn agriculture opening the subtropical dry forest near Padre las Casas. Small farmers are now entering the dry lowlands where the vagaries of rainfall reduce the probability of a successful harvest. (Photo, Gary Hartshorn.)*

Figure IX-1b. *Slash and burn agriculture on shallow, rocky soil in degraded subtropical dry forest in the lower Sabana Yegua watershed. (Photo, Gary Harsthorn.)*

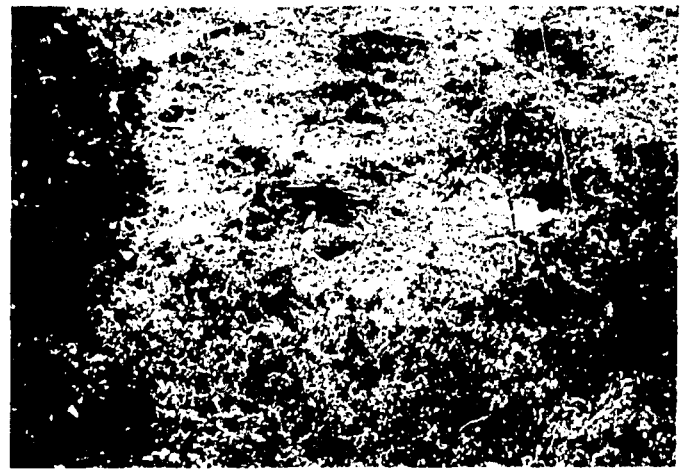


Figure IX-2a. *Carrying branches and small stems to make charcoal. (Photo, John Shores.)*

most of the labor. This tenure arrangement is known as "halves" because at harvest the crop will be spiit into two shares, not necessarily equal. From his share Elpidio first sets aside 136 kg of beans to cover the annual family needs, plus an additional 91 kg as seed for next year's crop. Any remaining beans from his share are sold in the market.

Four years ago Elpidio became the physical owner of this plot by clearing the dry forest on the government land. He cleared the land by relying on another widespread peasant labor exchange known as "el convite". In this particular case, Elpidio repayed the labor contributed by his neighbors, relatives and friends by offering them food on the day of the "convite" and later with his own labor. "Convites" seem to be called also for the heavier agricultural tasks such as weeding and harvesting. It is interesting to note the Elpidio did not abandon his plot after cultivating it for one year; rather, he has planted crops for four years and manifests that he has not noticed a significant decrease in yields. The common assumption is that peasants abandon their plots after only one year of cultivation.

In the fertile valley Elpidio cultivates a 1.0 hectare plot that he rents for DR$10 for a two-crop agricultural year. In this plot he produces commercial crops that can find a ready market: tobacco, peanuts, and, if the price is right, beans. To prepare the land he rents a pair of oxen at DR$5 per day. It is in this plot where he uses whatever modern inputs he can afford such as fertilizers and weed killers.

Besides cultivating his own plot for household consumption and a rented one for commercial purposes, Elpidio also engages in another occupation common among the small farmers of the Southwest. He makes charcoal in his spare time as a cash supplement. The demand of Azua truckers for charcoal is good and the truckers haul it to the main market in Santo Domingo. Elpidio makes charcoal about once every two or three months. In the Southwest most of the peasants occasionally make charcoal but only the very poor do it as a full time occupation.

The Making of Charcoal

Charcoal production is one of the most widespread and important sources of cash for the poorer economic strata of the arid Southwest (Fig. IX-2). Virtually all charcoal produced by the poor peasants goes to the cities and small towns where it is the main cooking fuel of the poor, who cannot afford liquified gas or electricity.

It is difficult to establish how many households are engaged either full or part time in the charcoal industry. One can infer that the number of households involved in the charcoal business must run into the thousands by the fact that in the town of Azua there are 100 trucks working full time hauling charcoal to the markets. These truckers make a formidable political pressure group as shown by their threats to block the main highway of the Southwest if FORESTA proceeds to reduce their charcoal hauling permits from the present level of two trips per week.

The Southwest is the largest charcoal producing region in the Dominican Republic. Jennings and Ferreira (1979) estimated the region's output at an average of 200,00 sacks per month. This would represent a early total of 2.4 million sacks, about half the estimated national production. The sack is a large hemp bag which is not a standard measure: all sacks vary and the average weight of one of these fully-loaded sacks is unknown. Charcoal sacks, like goats, are sold on sight without weighing the product. Truckers currently pay producers about DR$3 per sack.

Charcoal, as previously mentioned, is basically consumed in the towns and cities by the poor, but the middle income strata use it as well. It is used not only for cooking but also for the very energy wasteful practice of boiling clothes. For some mysterious cultural reason the people consider that garments have not been washed properly if they have not been boiled. Wood is too precious to be consumed in such a manner. The Dominican government should carry out a widespread campaign to discourage such a wasteful practice particularly now when there are many cold water detergents on the market.

All three daily meals are cooked with charcoal but it is the midday meal when the greatest amount of charcoal is consumed. A family of five or six members requires about one five gallon

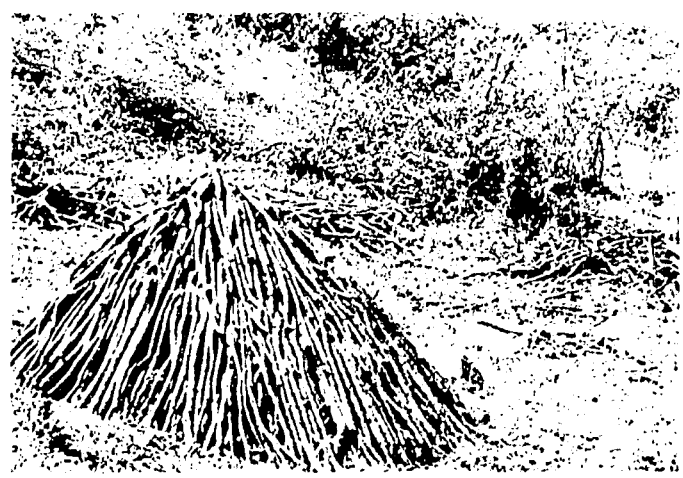


Figure IX-2b. *Stack of sticks ready to be converted into charcoal. (Photo, Stanley Heckadon.)*

can of charcoal per day, which is worth DR$0.70. The major midday meal requres a half tin can. Of the different foods prepared, beans require the greatest amount of energy. Native beans, according to housewives, are notoriously hard and require long cooking. American beans, on the contrary, are softer and cook faster. A natural suggestion which comes to mind is the need for further research within the Dominican Republic's research centers to produce several varieties of beans that will cook with less energy than those now available in the market.

Characteristic circular patches of burned ground mark the site where a temporary charcoal kiln has been constructed and fired. Most peasants of the Southwest prefer to construct kilns that will produce 20 to 25 sacks of charcoal. Making a kiln is strictly a family or household activity. Sr. Conce near Neyba makes charcoal of a full time basis. It takes his six young sons and himself five days to cut the wood and make the 25 sack kiln covered with earth. Next comes the firing of the kiln and the delicate process of burning the wood—a process that takes about five days. Then it takes another two days to sack the charcoal and transport it on burros to their house. The distance between the charcoal making areas and inhabited areas is progressively greater. As the "charcoal front" advances the prime woods bayahonda (*Prosopis juliflora*) and cambron (*Acacia farnesiana*) become scarcer. Sr. Conce, like many other charcoal makers, also faces serious problems due to erosion of the soft loose topsoil necessary to cover the kilns. In the areas where charcoal is being intensively produced, the destruction of the dry forest has led to erosion of the thin soil leaving it barren and rocky.

Charcoal demand increases every time the price of fossil fuels increases. This perhaps accounts for the rapid expansion of the "charcoal front" in the Southwest and in the Southeast; many peasant families now find it a profitable commercial activity. Roads facilitate the movement of the product to the market. Dry forests are being seriously depleted (Fig. IX-3). There is no reforestation, the trees that have been cut for charcoal are either totally destroyed or left as short stumps that will take a long time to regenerate. Stump sprouts face a further threat: the thousands of voracious goats browsing freely across the disappearing dry forests of the region.

The Rearing of Goats

The third important component of the peasant's production system is the rearing of goats. Peasants refer to goats as the poor man's cow. In the Southwest most families raise goats because they do not have the economic capacity to have cattle.

Many households have between four and five goats that are an occasional source of milk and meat, but mainly function as a

Figure IX-3a. *Subtropical dry forest seriously depleted by cutting for charcoal. The few emergent trees (right skyline) give an indication of the former height of the forest. (Photo, Italo Russo.)*

Figure IX-3b. *Woodcutter in the Parque Nacional del Este. (Photo, John Shores.)*

hedge against economic insecurity. In an emergency they can easily be sold for cash because of the significant (780 m ton) gap between production and demand (SEA 1978). The tendency is for the gap to widen with the elimination of pigs due to swine fever.

If it were not for its backwardness, the goat industry could make a much greater economic contribution to the peasant economy and cause less environmental damage. Goat production has not changed in generations. Peasants give their goats minimal care; goats survive by foraging on extensive communal and government lands. Goats will eat practically any type of vegetation; it is common to see bark peeled from trees. Allowing goats to roam freely is quite detrimental to the animal's development: no control or care can be given to the young born in the bush, resulting in as much as a 40% juvenile mortality rate (Jose Alvarez, pers. comm.), due to disease, dog attacks and accidents. Peasants do not vaccinate the animals or take measures to control parasites. There is no supplementary feeding with minerals or vitamins and consequently the creole goats take up to two years to reach a marketable weight of 20 to 25 kg. Improved breeds of goats reach 50 kg in the same time span. Most peasants, however, cannot afford to wait and generally sell their goats when they are 6-12 months old.

Creole goats have low milk output, seldom surpassing one liter per day. Though peasants should increase their milk consumption, they prefer not to milk the female goats so that the young kids can reach a marketable size faster. Creole goats are hardy animals capable of surviving with minimal care under adverse conditions. However, peasant-reared goats destroy the dry forests of the Southwest. Goats not only chew on the bark of trees but uproot the thin grasses and chew on the tender sprouts of trees that have been cut by man to produce charcoal.

Though creole goats have a negative impact on the Southwest's natural resources, the goat could become a dynamic pillar of the peasant economy by increasing their income and protein nutrition. A growing unfulfilled demand exists for goat meat. The generations of rearing goats make the peasants of the Southwest the most viable source of manpower to be trained in efficient resourceful modern techniques. Though credit has not been available for raising goats, especially to peasants, responsible government agencies must facilitate the transition into a more modern and efficient industry, especially with education and financial aid.

Slash and burn agriculture, charcoal and goat rearing all contribute to the deterioration of the Southwest's natural resources, particularly under the present context of a rapidly expanding population and a growing need for cash. Of the different natural resources threatened by the intensification of the traditional sub-

sistence systems it is the dry forests and the fragile, loose and erosion-prone soils that are most affected by man's activities. In the case of slash and burn agriculture, the main agent of erosion is the short cycle crop (e.g. beans) planted on the steepest terrain.

As a final note it is necessary to mention the recent blow sustained by the small producers. African swine fever caused the elimination of all pigs from the Dominican Republic. According to the SEA the number of pigs in the country was about 800,000 before the disease and the subsequent elimination of the animals. This industry was predominantly in the hands of small peasant producers for whom it represented "the poor man's money box". The rearing of pigs was more profitable than goats for the peasants. A study of the effects of the elimination of pigs on the peasant economy is sorely needed.

The Impact of Natural Catastrophoes on the Peasants

In the last two years peasants of the Southwest have been stricken by hurricanes David, Frederic and Allen. In a matter of hours thousands of peasants saw their houses shattered, crops destroyed and animals drowned. Many human lives also were lost. Those who began to rebuild did so in vain because the following catastrophe destroyed their efforts.

Material damages in the Southwest were enormous. ONAPLAN, in a patent underestimation, calculated the economic costs of David and Frederic at DR$130 million in the Southwest. The psychological costs of these disasters have not been taken into consideration but they seem to be substantial and will influence future attitudes of these rural communities.

Psychologists and sociologists have pointed out that people who survive great catastrophes (wars, earthquakes, hurricanes, etc.) undergo subtle changes in their personalities and attitudes towards the future. When one speaks to peasants of the Southwest, one senses the presence of a strong undercurrent of insecurity. Peasants feel unsure about tomorrow and that agriculture is becoming too unpredictable as a livelihood. In the immediate aftermath of hurricane David, Dominican psychologists stated that peasants in the shattered communities were dazed, afraid of the future, and somewhat unable to plan ahead. Today these attitudes continue, albeit somewhat attenuated by the passage of time. Nevertheless, memory of these disasters affects their planning and attitudes toward agriculture.

Before the hurricanes many peasants were abandoning the countryside for the cities because agriculture is a hard, demanding and marginally profitable endeavor. City life, on the other hand, seems more exciting and somewhat easier. As a result of these natural disasters the peasants' mistrust of agriculture has risen and many have decided to leave their farms because they do not have resources to rebuild and are afraid to rebuild because they fear the next catastrophe.

Institutional Analysis

Agriculture Bank (Banco Agricola)

After the Secretariat of Agriculture, the official institution that reaches the largest number of small farmers is the Agriculture Bank (Reinoso and Hidalgo 1978; Castillo et al 1977). For the small farmers the Agriculture Bank is the main source of credit for crop production. Therefore, it is relevant to look at the credit policies of the bank in the light of their environmental impact.

Although the Agriculture Bank loans money for a wide range of agricultural activities, ecological considerations are seldom taken into account when a line of credit is being extended. The Bank gives priority to insuring a safe return for the capital invested, just like any other bank.

Bank officials are aware of the ecological consequences of the Bank's actions; they have known for quite a while that they are in many cases financing productive activities that are not the most suitable for the soils in which they are being carried out. This happens, for example, in the case of ranching which occupies steep terrain leading to overgrazing and soil erosion. The same applies to rice, beans and sugarcane.

For many years bank technicians have discussed the need to employ credit as a tool to zone land in the Dominican Republic, that is, to use land according to its optimal capabilities by growing only those crops it is best suited to produce. Regionalization, however, has proven a very difficult concept to implement, due to administrative, cultural and political reasons. The Agriculture Bank depends upon SEA mandate but the SEA has not taken a firm stand on regionalization of credit availability. Interest in improving the quality of Dominican export tobacco stimulated the National Tobacco Institute to define land use parameters for determining access to credit. The Agriculture Bank has negligible control over the two largest uses of land in the country, sugarcane and ranching. For example, cattlemen go directly to the private banking sector to finance their operations. Private banks do not have ecological guidelines to follow and they can loan money in accordance with their own rules. Since ranching occupies slightly over half of the agricultural land and the credit used by this industry comes from private banks, it is of utmost importance for the government to institute some ecological guidelines to be used by the private banking sector. However, it may not be easy to introduce these ecological guidelines into the actions of private banks.

Private banks are reticent toward any attempt to change the productive orientation of the farmers. Banks consider that it is very risky to make a producer shift from an activity he has been performing well for years to one with which he is unfamiliar.

There are also powerful cultural reasons against zoning. In traditional ranching areas, such as the Cibao and the eastern coastal plains, ranching is a centuries old occupation with great social prestige attached to the industry.

Given the previously discussed considerations it would seem that the use of credit as a means of zoning the country's agricultural activities would be easier to implement first in the large irrigation projects planned for the Southwest especially since the government owns most of the land and provides both credit *and* water. In the dry southwest water is a more powerful zoning tool than credit will ever be (Fco. Checo, pers. comm.).

The Dominican Agrarian Institute (IAD)

The IAD is in charge of government agrarian reform programs. This institutional analysis reviews IAD's activities from an ecological viewpoint. The goals of the IAD are very broad. Besides providing land for the landless peasants and helping them become efficient food producers, IAD also attempts to increase rural employment. Raising the productivity of new landholders has preoccupied IAD's technicians while trying to meet national food demands. Ecological considerations have received little if any attention. The low priority given to IAD agrarian reform can be ascertained from the different activities of colonization programs and farmer organizations.

Colonies of individual farmers were the first stage in the agrarian reform process during the 1950's and 1960's. Land was distributed on an individual basis and little support was given to the farmers who employed traditional subsistence techniques. The relationship of the new landholders to their land differed little with traditional slash and burn agriculturalists. Traditional farming techniques contributed to deterioration of natural resources.

The more recent farm colonies, especially with better soils and guidance, have been more successful with their land. The prosperous irrigated rice projects of Bonao are an example where farmers have actively participated in the application of good crop production and conservation techniques. Unlike individual colonists, the cooperative farmers have had access to technology, fer-

tilizer, etc. The outright granting of land to landless farmer does not motivate him to induce sound land management techniques because he does not have that knowledge; he has to be supplied with other types of inputs including eduction,credit, water, marketing and technical assistance, especially in a community atmosphere.

Community Development Office (ODC)

This institution reaches many rural communities via its community development workers. Altogether the ODC has some 400 social promoters throughout the country; 25 are currently assigned to the Southwest.

The task of the community development workers is essentially political, i.e. to orgnaize the community so that local goals can be achieved. Community organization has a two stage process whereby the people first identify their principal socio-economic problems and then the people are organized to solve the identified problems. A school, bridge, sports field, water supply system, etc., may be among the objectives of the community. It is assumed that when the community acts together, with some governmental help, to solve one of these problems, it will learn to organize itself more effectively to tackle other local problems.

Ecological principles play no role whatsoever in the Community Development Office. When officials of the ODC were queried about what ecological message was being delivered to the communities or if the social promoters received any training in ecological principles, the answer was always negative. Indeed, it would seem that a very good opportunity to create some degree of ecological awareness at community level is being neglected by not using the mechanism already existing here in the form of several hundred community development workers throughout the nation.

Crucial Challenges for Dominican Society During the 1980's

> "The tragedy of the Regina Express caused great commotion in the conscience of the Dominicans. If 22 persons die asphyxiated in a ship's bilge trying to leave their own country, the country itself is subject to judgement. What occurs that so many people try to leave their own country at great risk, great cost and deceiving the law?"
>
> —El Listin Diario, Santo Domingo 1X 1980

Today in the Dominican Republic one senses a growing awareness that the country is standing at a historical crossroad. It faces daunting interrelated challenges of almost unprecedented magnitude concerning population, food and energy.

Population

As one of the smallest countries in Latin American (barely 48,000 km²) and already one of the most densely populated (100 persons per km²), one of the critical problems of the Dominican Republic is its fast rate of population growth. The country's present population is estimated at 5.6 million with an annual increase near 3.0%—one of the highest growth rates in the world. If present growth trends continue it is likely the population will double within the next two decades. Substantial and irreversible damage to the natural resources base has occurred with the present population; doubling the population in the near future has alarmed some members of the local scientific and technical community. Pena Franjul (1979) has recently pointed out: "Neither the country nor the land can afford the luxury of a doubling of the population before the end of the present century." Franjul believes uncontrolled population growth is the country's principal socio-economic problem, that will have serious negative consequences on the quality of life of the Dominican people. Though the alarm has been voiced by a few local scientists most government policy makers do not yet seem aware of the repercussions of uncontrolled population growth. The voluminous planning literature produced by the government does not include substantive consideration for family planning or a population policy. It is perhaps to these upper level policy makers that Fernando Russell (1980) recently and somberly warned: ". . .it is not true that the country can continue to increase its population indefinitely and at the same time supply it with its basic needs without provoking negative ecological damage."

Food Production

The Dominican Republic is a net food importer. The country produces about 260,000 m tons of food but requires an additional 100,000 tons of food (World Bank 1978). The urgency to achieve food self-sufficiency is fueled by the fact that malnutrition has become a chronic national problem. The diet of 75% of the people has calorie and protein deficiencies (B. Defillo, pers. comm.). Moreover, child mortality seems to be increasing (El Caribe 1980)—a fact Defillo links to a downturn in agricultural production with a concomitant steep rise in the cost of essential foods and the general decrease in the purchasing power of the Dominican peso due to inflation.

The Dominican Government has adopted a food policy to quickly raise the nutritional standards of the lower income groups (ONAP 1976). It has been estimated that 65% of the population is below the 'poverty level'. If a food policy is to be successful, a massive production effort including a program to minimize damage to the natural resources base will be required. According to Lopez (1980) the poor performance of Dominican agriculture is closely connected to the "quantitative and qualitative degradation of our non-renewable resources".

While the task of producing cash exports (i.e. sugarcane, coffee, cacao, cattle, etc.) will largely remain in the hands of large private and government farms, the burden of providing the nation with food will be mainly dependent upon the farmers of small and medium-sized landholdings.

Energy

Like many developing nations, the Dominican Republic is a net importer of fossil fuels. Seventy percent of the energy demands come from increasingly more expensive fossil fuels. In 1978 the country's main cash export, sugarcane, was barely sufficient to pay for imported fuel.

The energy crisis has deep seated ecological implications: to pay for fossil fuels the country will have to intensify the production of traditional cash crops at a time when more land will also have to be dedicated to food crops to feed a rapidly expanding population. Thus one can envision in the near future a serious potential for conflict in the allocation of land for export and for food crops, while placing unprecedented demands on the natural resources of the island. Some of these natural resources have already been severely degraded where they are no longer capable of sustained productivity (see Chapter VI). Thus, the success of meeting the food and energy challenges is inescapably linked to a judicious use of the remaining non-renewable resources.

One of the many disturbing results of dearer energy is that wood from the dry forests of the parched southwest and northwest regions of the country will be extracted for charcoal production. Charcoal is the principal cooking fuel of the urban poor. The rural poor, on the other hand, rely almost exclusively on firewood. Dominican households have recently had to face steep cost increases for liquified gas and electricity. It is likely the cost of liquid gas and electricity will continue to rise which will intensify the demand for charcoal and firewood.

If the "charcoal front", that is to say the wood charcoal industry, is allowed to expand in its present rudimentary form, the existence of the remaining dry forests of the Dominican Republic will be seriously threatened. Already, the extraction of charcoal, with the existing level of demand, is placing substantial stress on the reserves of dry forest. According to Jennings and Ferreira (1979), charcoal production is 4.8 million sacks per year, equivalent to 168,229 metric tons. To produce this amount of charcoal required the burning of 622,900 tons of wood. Almost the whole of this production comes from the driest regions of the country: the southwest (Azua, Barahona, Bahoruco, Pedernales, Independencia, etc.) and the northwest (Dajabon, Monte Cristi), where the removal of the thin cover of dry forests is contributing to desertification of the land. Obviously, the process of desertification can only accelerate in the immediate future with the rise in the demand for charcoal in the cities.

Given the importance of charcoal, both for the rural poor who produce it and the urban poor who consume it, the industry cannot be banned altogether but the centuries old techniques will have to be modified substantially.

Summary of Problems and Solutions

During the present decade the Dominican Republic will have to accomplish what it has not been able to do in the recent past: become a self-sufficient food producer, expand its agricultural export output, generate more energy from local renewable resources and, especially, establish an effective population policy. These goals must be met while minimizing the damage to natural resources by wise conservation and management. During the 1980's, a new and qualitatively different relationship between the Dominican people and their ecological patrimony must occur in order for these goals to be met.

Ecologically minded people, both within the technical ranks of government agencies and among the general public as well, are aware that the nation's development plans and natural resources are inextricably related. Fortunately, the number of interested people is growing, and this increased interest may help bring about solutions to the population, food and energy problems in an ecologically beneficial manner.

X

Pollution

Introduction

General Description

This chapter reviews environmental problems and the human health consequences of pollution in urban, rural, agricultural and mining areas. Water supplies, air quality, solid wastes, sewer and sewage treatment, storm water drainage, industrial mining and agricultural pollution, disease vectors, pesticides, accidents and other problems are reviewed and the impact of each is examined. Also, the response of the government to the various problems is evaluated.

Legal Basis

Three institutions control municipal pollution but none controls industrial or agricultural pollution. Legislation to create INAPA, the National Water and Sewage Institute (Law 5994, 1962) mandated the provision of potable water and sewage systems for the nation except in the National District (Santo Domingo) and in Santiago. Potable water and sewage systems are provided to these two metropolitan areas under Law 498 (1969) by CAASD (Water and Sewage Corp. of Santo Domingo) and CORAASAN (Water and Sewage Corp. of Santiago). Municipal solid waste collection and disposal services are provided for each city by its Public Works Department, in addition to storm drains, road and street repair, traffic control and similar services. For example, ADN (Municipality of the National District) provides solid waste management for Santo Domingo. These water and sewer authorities are mandated to set use tariffs to cover operating and maintenance costs.

The mining industry is currently the only industry subject to environmental controls as defined in Law 146 (1971). Articles 133-138 state that air, water and land may be changed in mining and/or processing operations, but they must be returned to their original states. Furthermore, contaminants harmful to fauna, flora or humans must not be used or released. Any government ministry finding such pollution shall have the Ministry of Mining close the concession until corrections have been made. Finally, the mining concession is liable for any damages caused by pollution. There have been recent instances of alleged pollution damage from mining to which the concessionnaire responded with corrective measures for damages.

Law 5914 (1962), covering Fisheries (Article 29), requires that industry control wastewater discharge, yet industrial pollution is apparently not legally controlled at this time. This situation probably results from the limited amount of industry in the nation, the nature of those industries and their tendency to be geographically dispersed. Nearly 70% of the manufacturing dollar value relates to agriculture, including sugar, furfural, molasses, tobacco, food and beverages. The only heavy industries are mining (bauxite, ferronickel, gold and silver), cement and steelmaking, petroleum refining and electric power generation. With few exceptions the individual plants are widely separated from one another, discharge waste waters to different bodies and are remote from population centers.

Legislative mandate is basically a response to a perceived need by the public for the protection of their general well-being which in this case includes the natural resources, air, water, land, and public health.

Institutional Framework and Capabilities

The Administrative Secretariat of the Office of the President controls the Office of the Executive Director of INAPA. In addition to the Executive Director's staff, six Regional Offices and two central support divisions, one Technical and the other Administrative, carry out planning, design, construction, operating and maintaining all potable water and sewage systems in the nation except those for the National District and for Santiago. The Regional Offices report to the Executive Subdirector whereas the Technical and Administration Divisions report to their respective Subdirectors. The Technical Division is divided into departments of Engineering, Operations and Maintenance, and Construction and Supervision. The Administrative Division is divided into departments of General Services, Finances and Accounting, and Users and Tariffs. The counterpart organizations for the National District (CAASD), and Santiago (CORAASAN), are organized along the same lines.

The total manpower and support budget for INAPA are respectively 400 people and RD$300,000 per year (pers. comm.). The mandate requires that user charges generate sufficient revenues to cover investment in all potable water and sewer systems, their operating and maintenance costs and all administrative and coordination services performed by INAPA; thus INAPA is supposed to be a financially self-supporting organization. Facilities planning calls for potable water services to private homes and community centers for both urban and rural populations, as well as sewer connections only for urban populations. Provisions for rural latrines or similar facilities are not covered by INAPA plans

and hence are judged to be the responsibility of the Ministry of Health.

Current INAPA planned potable water and sewer services are shown in Table X-1 in terms of percent of population served. It can be seen that total potable water service is to be increased from the present 59% to 82% by 1990. Sewer service will be expanded from 12% in 1979 to 26% in 1990 but with no credit assistance for private latrines, septic tank/drain fields or other acceptable sanitary systems in the rural areas. These figures illustrate the heavy work load carried by INAPA where the population is growing rapidly, urban immigration is substantial, personal income and concern about personal hygiene are low, and the existing sanitary infrastructure is limited and in a poor state of operation and maintenance. Potable water supply and sewer service represent serious environmental problems.

Table X-1. Percentage of national population served by potable water and sanitary sewerage systems. Source: B. González, INAPA.

	1960	1970	1979	1985	1990
Potable Water to Residences					
Rural	1	5	10	18	24
Urban	23	60	54	52	50
Potable Water to Community Centers					
Rural	3	11	23	38	52
Urban	57	25	32	33	35
National	27	43	59	72	82
Sanitary Sewers for Residences					
Rural	—	—	—	--	—
Urban	13	16	25	38	44
National	4	6	12	20	26

Environmental Monitoring

INAPA has a central water purity laboratory with analytical capabilities for physical, chemical and bacteriological testing by a staff of four technicians. Technical duties include testing services for 11 sewage treatment plants and many potable water facilities. The only other operational environmental monitoring systems are operated by multinational corporations.

The multinational environmental monitoring systems are basically designed to meet the requirements of the parent company. As such the multinational plant will often adapt the emission limitations of the corporation's country headquarters, e.g. ALCOA would monitor and control emissions to United States standards, Falconbridge to Canadian standards and Rosario Dominicana might have adopted the standards of their design engineers. This monitoring has important implications and benefits. Of particular importance, however, is that private sector environmental monitoring is a valuable resource to the Dominican Republic since it represents technical expertise, operational instruments and laboratories, trained technical personnel and an environmental data base.

Great care should be exercised in setting up an environmental monitoring system. The United States Environmental Protection Agency wasted hundreds of millions of dollars over the last decade failing to apply quality assurance planning, specifications and protocols to environmental monitoring of air, water hazardous and toxic waste streams. When the Dominican Republic undertakes a national, multi-media (air, water, solids) environmental monitoring program, the technical resources of the multinational industrial sector can be of substantial assistance in developing cost-effective environmental data.

Water Supplies and Water Related Diseases

Rainfall ranges from 500 to 2700 mm/year, which results in stream flows in excess of 19 billion m^3. In addition to this substantial surface resource, high ground water yields in each of the 14 hydrographic zones (see Fig. V-3) are potentially available. The quality of surface and ground waters is generally adequate for agriculture but seawater intrusion in wells in the Azua area limits productivity of some wells, and salt content in the lower reaches of the Yaque del Norte and Yaque del Sur rivers create use limitations.

Types, Statistics, Trends and Developments

Water supplies may be broadly grouped as surface flowing, surface impounded (lakes, reservoirs), and ground waters. The broad water uses for surface impoundments are hydroelectric power (CDE, Electricity Institute) and irrigation (INDRHI, Water Resources Institute). Flowing surface waters are largely used for stock or animal water, potable water supply; industrial, mining and commercial uses; personal laundry and hygiene, etc. Ground waters are used for potable water; industrial, mining and commercial uses, some irrigation, personal hygiene, and sundry other uses.

The INAPA program for potable water will expand service and, where modern sewage collection and treatment is feasible, will increase the quality and degree of protection of those surface waters receiving treatment plant effluents. CAASD is requesting engineering proposals on a potable water reservoir project to serve the short-term needs of Santo Domingo.

The trends in water use should be relatively clear: as increasingly expensive energy drives up the cost of water, users will be forced to use water more efficiently. This should start with the big user, the government. Bacterial contamination of urban and rural surface waters (though no current data is available), may be bringing about widespread use of filtered drinking water to avoid water-borne diseases. This situation will not improve significantly until more adequate potable water facilities become available. Salinity of irrigation waters in several lower river valley areas and siltation of reservoirs decrease the irrigation and potable water supplies. The increasing lack of concern on the part of the consumer society for the value of water, minerals and topsoil, and the rising cost of energy and labor, will become apparent when the tariffs, as required by law in this nation, must be paid.

Problems and Issues

The main potable water supply problems are currently in the water quality and water cost categories. It would appear that water quantity problems will not appear in the near term except in certain isolated areas. The perceived problems are as follows:

- Potable water is bacterially contaminated periodically or continuously across the nation.
- Surface waters are reported to be bacterially contaminated.
- Surface waters are reported to be heavily contaminated with sediments under a range of flow conditions.
- Sewage collection and treatment is available only to about 15% (25% reported by INAPA) of the urban population.
- Water quality monitoring of both potable supplies and natural surface water appear to be incipient, hence a general data base is non-existent.
- Water and sewer use charges were not investigated in detail, but appear low and based on volume, without adjustment for pollutant loading.
- Bacterially contaminated water causes human alimentary diseases especially among the poor in rural and urban areas.

Based on the potable water quality problems, the following are offered as recommendations:

- Quality of potable water delivered to urban and rural people should be given priority status.
- Educational programs must be undertaken to improve personal hygiene and sanitary facilities for the rural and urban poor.
- A program to manage watersheds and thereby reduce soil losses and siltation is needed.
- Water quality must be monitored to gather data to support better natural resource planning and management.
- Citizens must pay full user charges for potable water and sewer services and thereby become aware of conservation measures; subsidized water to the poor will be necessary.

Industrial Pollution

It is traditional to look at large corporate industry with its usual smokestack and probable wastewater outfall and to focus one's attention on correcting a large "pollution problem." In the Dominican Republic the highly visible multinational corporations, ALCOA, Falconbridge, Rosario Dominicana and Gulf & Western, have received such particular attention in the past. There have been alleged pollution problems from one or another of these firms in the past which were unfounded or have in turn been corrected. There may be problems in the future because men and machines fail. However, it should be stressed that these multinational corporations use headquarters-generated policies aimed at good management, energy and resource conservation, as well as good public relations.

It should be noted that industry supplies only about 9% of the national employment compared with 55% for agriculture and 36% for services. Average worker salary in industry is high ($3,883 in 1970) compared with agriculture ($575.20) and services ($1880.30). The manufacturing productivity stimulates higher industrial wages and taxes. As a result the Dominican Republic provides incentives for industries to locate and operate in the country.

Preliminary Industrial Inventory

The following partial inventory has been assembled to help quantify the industrial pollution problem. It is basically a sampling but has the virtue that it illustrates the nature of the problem. There are slightly over 1,000 industrial plants in the nation employing over 40,000 people. Some 475 are food and beverage processors that employ about 12,000. Those industries with higher pollution potential are sugar, mining, steam electric power generation, cement, steel, chemicals, and paper. Hence, there has been an effort to include examples of these industries in this review.

Industries in the Dominican Republic (Table X-2) are generally diverse in products, capital intensive, generate substantial sales, offer 120,000 jobs when sugar is included (44,000 jobs without sugar), generate minor water and air pollution, have minor industrial safety problems, and have few noise problems. Many have dust problems but only a few involve short-term hazards (e.g. explosions).

There are several pollution problems widely recognized by the public: Particulate or smoke emissions from the FDC cement plant and the smoke emissions from Metaldom in Santo Domingo; suspended solids and sulfur oxide emissions from steam electric power generation using Bunker C fuel oil with 2.5% sulfur content; and the majority of waste waters from food processing, soap and detergent production and similar operations are subject to minimal waste recovery operations before discharge, without further treatment, to sanitary or storm sewers.

Government-owned Industry

The GODR owns a wide variety of industries including sugar, cement, oil refining, electricity generation (steam and hydroelectric) and gold and silver mining. Pollution control in these industries ranges widely in performance. The FDC cement plant's electrostatic precipitators are reported to be inoperative due to lack of maintenance. The CEA sugar refinery has not yet adopted the full recycling of wastewaters as have the other two major sugar operations. Electric power generation is currently constrained to the use of high sulfur content (2.5% sulfur or more) Bunker C fuel oil which results in substantial stack emissions. Heavy demands as well as operational and maintenance problems make emissions control improvement a low priority.

Multinational Industries

Multinational corporations operate sugar refining, furfural production, ferronickel mining and smelting, bauxite mining, oil exploration, gold and silver ore mining, extraction and smelting (government owned) and petroleum refining (also half owned by the GODR). These plants are rated as good to excellent performers in multimedia emissions control. Their standards of emissions control are basically derived from headquarters' companies along with their design engineers or management personnel. Technological design, function and operation, maintenance of emissions monitoring systems are "state-of-the-art", and cost effective.

Of particular importance in the list of multinationals' capabilities is their policy to be able to rapidly and expertly respond to emergency situations. Fire-fighting, spill control, storm and flood protection and first aid are only a few of the capabilities that are more or less standard policies with these multinational firms. Their standards for operation and maintenance personnel training and performance are essential elements in safe, efficient and trouble-free plant production as well as emission control. This capability should be recognized and utilized by the government.

Private Industrial Sector

The private industrial sector includes the food industry—both domestic and export, animal foods, textiles, paper, steel, cement, drugs, soaps and detergents, batteries, chemicals, etc. The food industry includes sugar, vegetables, fruits, meats, milk, carbonated beverages, beer and distilled liquors, grains and cereals, coffee, cacao, salt and spices. Generally speaking, these operations are using imported machinery, processing equipment and technology. Therefore, most of the processes tend to be efficient and generate minimal emissions; there are, of course, a few exceptions, but pollution control often awaits public concern and concomitant government action.

The majority of private sector industries recognize that emissions mean material and energy losses. Hence emission controls, particularly when incorporated in the process, represent opportunities to make money through cost saving. The brewery, Cerveceria Nacional Dominicana, recovers its spent beet products for sale as animal food. The sugar refinery, Central Romana, does not buy nor discharge water; it gets its water from the sugarcane through evaporation/condensation and then reuses it for cooling, washing, etc., recycling it until evaporation losses consume it.

The rise in energy costs, the depressed market, competition and other forces will lead the efficient plant manager to process improvements that will lower emissions to cost effective levels. The inefficient processor will be forced out of business if he doesn't or can't adapt improved technologies. However, where a profitable and hence otherwise efficient processing plant is emitting excessive smoke causing environmental hardship to a number of citizens living downwind and cost-effective control technology exists, that company should take steps to voluntarily control the emission. An example of this situation is the steelmaker Metaldom in the western part of the National District.

Table X-2. Characterization of the major industries in the Dominican Republic. * Rough estimates.

Name/Location	Product/Capacity	Value/year $	Employees	Water Use	Fuel Use	Impacts
CEA	Sugar 810,000 MT/yr	360,000,000	50,000	Minor Discharge	27,000 BBL/mo	Soil management
Gulf Western Central Romana	Sugar/Furfural 350,000 MT/yr	160,000,000	18,000	Closed recycle	12,000 BBL/mo	
Vicini	Sugar 90,000 MT/yr	40,000,000	5,000	Closed recycle	3,000 BBL/mo	
Falconbridge Bonao	Ferronickel 68,000 MT/yr	110,000,000	2,000	23,700,000 l/d	150,000 BBL/mo	Water
ALCOA Pedernales	Bauxite 1,470,000 MT/yr	22,000,000	1,000	Dry	17,000 BBL/mo	Dust
Rosario Dominicana Cotui	Gold-Silver	72,800,000	740	Closed recycle	9,000 BBL/mo	Water hazard
Metaldom S. D.	Steel 60,000 MT/yr	30,000,000	1,000	2000,000 l/d	2,800 BBL/mo	Smoke
Refineria Dominicana de Petroleo, Haina	Petroleum Products 30,000 BBL/day	550,000,000	120	100,000 l/d	23,000 BBL/mo	Stack sulfur emissions
Fabrica Dominicana de Cemento, S.D.	Cement 1,800 MT/day	45,000,000	1,300	100,000 l/d	40,000 BBL/mo	Stack particulates (smoke) Oil spill controls in place
Industrias Lavador S.D.	Soaps	14,000,000*	300	800,000 l/d*	—	Untreated waste-water
Industrias de Asbestos Cementos, S.D.	Asbestos-Cement 96 tons/day	9,000.000	120	200,000 l/d	100,000 KWH/mo	Untreated waste-water Breathing in mixing room
Carnes Dominicanas S. D.	Meat Packing 350 animals/day	35,000,000	150	200,000 l/d		Direct discharge of blood
Acromax Dominicana S.D.	Pharmaceuticals	6,000,000*	150*	200,000 l/d	230 BBL/mo	
Proteinas Nacionales	Animal Feeds 1000 MT/day	88,000,000*	160	50,000 l/d		Dust explosion hazard
Cerveceria Nacional Dominicana, S.D.	Beer 63,000 BBL/mo	38,000,000	850	3,000,000 l/d	8,400 BBL/mo	
Industria Nacional del Papel, Bonao	Reclaimed Paper 40 MT/day	4,000,000*	250	1,500,000 l/d	4,300 BBL/mo	Untreated waste-water

Smaller private sector industries use more water and fuel (or energy) than necessary because of technical limitations of their staff and equipment, but some companies lack the capital to make recognized and needed improvements. These smaller firms discharge wastes to the sanitary or storm sewer or to a drainage ditch or stream. Relatively small discharges with only moderate pollutant loads are tolerable in local rivers until stream quality standards are developed to protect the water resource.

Problems and Issues

The main industrial sector pollution problems are in the visible air pollution category. Where water pollution problems exist they are masked by high sediment loads, high B.O.D. (Biological Oxygen Demand) and bacterial contamination. It would be illogical to bring a portion of 44,000 jobs into jeopardy by imposing wastewater discharge limitations on industry until improved watershed management techniques are utilized. Water quality monitoring efforts will not be of much value (except for baseline establishment and personnel training) until the stream sediments problem has been partially corrected. Finally, it will probably be found that most of the moderate to small urban industries will become sewer users as these services become available where their plants are located. This capacity will have to be designed into new sewer treatment plants if this practice is accepted as public policy.

The main industrial pollution issues which will need to be addressed are as follows:

- The government must repair its electrostatic precipitators at its cement plants to control cement dust and smoke.
- The government steel plant needs smoke control equipment for their electric furnaces.
- The Corporation Dominicana de Electricidad is currently

discharging sulfur oxides and particulates when they are firing Bunker C fuel oil, but since conversion to coal is under consideration, emission controls for pulverized, cleaned coal should be evaluated.

- Falconbridge Dominicana Corporation (Fig. X-1) is a major Bunker C fuel oil user but careful monitoring shows that good natural ventilation has prevented any demonstrable environmental damage. Their water uses and treatments have resulted in discharged effluent quality meeting Canadian standards and showing no deleterious effects on surface water quality in the Rio Yuna.
- Rosario Dominicana, S.A., which uses sodium cyanide leaching for processing gold and silver ores is a zero-discharge operation, wasting all effluents to their tailings pond. Groundwater seepage below the dam is minimal but monitored regularly. Consideration may be warranted to develop a "danger-reach" analysis of the valley below the dam to develop the types and extents of hazards in the event that the dam ruptured or was overtopped, e.g. in a major hurricane.
- Meat packing plants were found to be sewering wash waters and blood to the surface waters or to the sanitary sewers while recovering other values. Consideration should be given to these practices and their several impacts. One major meat packer plans to recover blood for animal feed.
- The government sugar industry, CEA, is using older technology and therefore has some wastewaters containing product and resource losses. The modernization of these processes will correct this problem and improve yields. It is understood that this modernization project is in the planning and financing stages.
- The beer and rum processors are currently recovering spent grains for animals feeds, but certain wastewaters are still discharged to sewers or surface waters. These industries plus the beverage and food processors should be reviewed for potential savings in energy, water and products, along with effluent limitations.

Rural Environmental Problems

All too often the dispersed and remote locations of rural families and communities have made their problems difficult to determine, quantify and resolve. Rural environmental problems in the Dominican Republic have a common factor—limited personal information. The large proportion of poor rural people apparently know little about personal hygiene, have limited access to health care services, have nutritional problems and almost no training in modern farming techniques. Whereas these conditions are being improved with an outreaching school system, rural environmental health and sanitation programs and an agricultural extension effort, rural environmental problems will not be resolved in a short time.

Figure X-1. *Falconbridge open pit mining and smelting operations for ferronickel in the Sierra de Yamasa. Falconbridge is successfully reclaiming mining spoils with African star grass* (Cynodon plectostachyus) *followed by* Pinus caribaea *plantations. (Hand-held aerial photo, Gary Hartshorn.)*

The small farmer is faced with an expanding population of hill farmers and decreasing thickness of soil mantle and concomitant crop productivity. Clean cultivation of hillsides increases soil erosion into reservoirs, as well as contaminating potable water supplies. Pressures to increase farm production to meet local and export needs compound the problems of the undereducated peasant farmer, forcing him to use pesticides and fertilizers.

Burgeoning population, declining farm productivity, limited educational background and the variety of governmental programs aimed at their improvement have resulted in increasing congregation in rural communities. In these rural towns and villages the lack of knowledge of the need for personal hygiene, the lack of clean water and sanitation facilities, poor nutrition and crowding have led to problems with disease. The human ecology of rural groups, both familial and communal, in this developing nation, is changing from the traditional remote family-trained slope farmer to that of the school educated village farmer or farm worker who is being integrated into the national economy.

Pesticides

The abuse of pesticides by untrained small farmers has resulted in several problems. Some farmers and farm workers exposed to chemicals suffer from chronic or acute poisoning. Farm produce has been found to have excessive pesticide residues, which endangers consumers who do not adequately rinse their fresh produce before use. Excessive amounts of pesticides appear to remain in farm environments as unused pesticides in unmarked containers and as applied residuals that contaminate surface waters and accumulate in wildlife. Pesticide resistant species of insects, weeds and fungi and the accidental ingestion by children or other persons using pesticide containers for water are other problems.

Of the estimated 1979 pesticide consumption totaling $14.9 million, 47% is in herbicides, 36% in insecticides, 14% in fungicides, 1% in industrial insecticides and 1% in miscellaneous pesticides (Table X-3). The general problem in pesticide use is that only 30% of these chemicals are applied by trained personnel (R. Bisono, pers. comm.). The small farmer has minimal knowledge about pesticide hazards, and personal family hygiene and health care are also poor. Adding to the problem is the large number of poor farmers and workers involved with pesticides, their low level of literacy and their probable lack of concern about pesticide exposure until they are ill or see someone ill from pesticide poisoning (if it can be deduced as such through their available medical care).

Coordinated efforts are needed to prevent misuse or abuse of pesticide applications. The government has enacted pesticide registration and labeling legislation. Manufacturers and compounders of pesticides have produced and are distributing written and pictorial training materials. Safety equipment is available but expensive. Responsible companies have their employees who handle (compound, transport or apply) pesticides regularly medically monitored for pesticide levels in their bodies. A pesticide laboratory program has been undertaken in San Cristobal with German technical assistance to test for pesticide levels in farm workers, residuals in soils and contamination levels on agricultural products. Refractory pesticides, which resist chemical decomposition in the environment, are highly toxic or have high potentials for bioaccumulation and whose general use is prohibited, and cannot receive registration for use in the United States, must be so de-

Table X-3. Estimates of amounts of active ingredients and value of pesticides used in the Dominican Republic in 1979. (Data provided by R. Bisono, Compañía Química Dominicana.)

	Active Ingredient (kg)	Value (RD$)
I. INSECTICIDES		
Monocrotophos	109,000	1,900,000
Insecticides/Nematicides	36,000	650,000
Pirethroids	32,000	550,000
Parathions	27,000	500,000
Methomyl	23,000	400,000
Metamidofos	18,000	300,000
Chlorinated Hydrocarbons	14,000	220,000
Other Organophosphates, Carbamates	50,000	900,000
Subtotal	(309,000)	(5,420,000)
II. HERBICIDES		
for Rice	155,000	2,700,000
for Sugarcane	114,000	1,960,000
Hormone (2,4-D, Dicamba, etc.)	64,000	1,100,000
Contact (Paraquat, Diquat)	41,000	700,000
for Cotton (Surflan, Karmex, etc.)	7,000	120,000
Other (Monuron, Atrazine, etc.)	23,000	420,000
Subtotal	(404,000)	(7,000,000)
III. FUNGICIDES		
Mancozeb	41,000	720,000
General Organics	36,000	640,000
for Rice (Bim, Caconil, etc.)	18,000	320,000
Seed Dressings	9,000	150,000
Banana Spray Oil	7,000	100,000
Copper	5,000	90,000
Other	7,000	100,000
Subtotal	(123,000)	(2,120,000)
IV. MISCELLANEOUS		
Rodenticides	4,000	70,000
PGRs (Ethrel, MH-30)	4,000	60,000
Molluscicides	3,000	50,000
Subtotal	(11,000)	(180,000)
V. INDUSTRIAL		
DDBP	3,000	50,000
Malathion	5,000	100,000
Pirethrins	8,000	50,000
Subtotal	(16,000)	(200,000)
TOTAL	863,000	14,920,000

scribed to the government pesticide registration review agency before they can be used in the Dominican Republic; this is intended to resist dumping of banned pesticides in this nation.

Functionally, the government, the chemical industry and the farmers must cooperate in training efforts to insure that pesticides can be used safely and their benefits to agricultural production and quality enjoyed for the general good of the country. A balanced program of safe user training, clinical testing to prevent toxic levels in body tissues and testing of agricultural products, soils, and water must be undertaken. These efforts should be targeted at those sectors of maximum hazard, high usage, high toxicity, least training, least health care, etc. This problem is solvable but it will take time and dedication. It will in fact become more complex as the nation diversifies its cropping patterns to decrease dependence on imported food and to improve nutrition. Hence it is very important to this agriculturally oriented country that a functional, cooperative and fully objective program for the safe and efficient use of pesticides be organized and implemented rapidly. The key element in this type of program is cost. Whereas a training program will take time and money, the lack of a training program will be much more costly in the long run. In the long term, integrated pest control using chemicals, pest resistant species, natural predators, sterile insect mating, etc. offer an improved system of pest control over the purely chemical route.

Fertilizers

The excessive application of fertilizers wastes agricultural capital or credit and contaminates surface and ground waters. Fertilizer enriches surface waters to stimulate algae and aquatic plant and fish growth, but does not benefit the farmer who applied it. Excessive nitrogen and other chemicals diminish the potability of surface and ground waters. Though no reports of excessive fertilizer use were found, numerous small farmers with limited training create the potential for a problem in this area. However, until water quality is improved by better management practices, fertilizer runoff and ground water contamination will receive lower priority.

One would suspect that the rising costs of fertilizer will focus small farmer attention on efficient application methods, amounts, frequencies and timing. Later, potable water sampling and analysis can be used to find problem areas and serve as the basis for improvement.

Water Supplies

Rural water supplies from surface-riverine sources and reservoirs face problems. Surface waters require sediment removal and decontamination. Where riverine sources are used, impoundments are often required to assure quality supplies during floods and droughts. Contamination by livestock and humans, pesticides and fertililzers "up-stream" of the potable source and sediments must be kept to a minimum. The cleaner the water source the less treatment required to process it to drinking standards.

Rural water may be supplied by wells in areas where adequate quality ground water is present. The advantage of this type of water supply system is that it usually requires little or no treatment, but a disadvantage is that it requires storage and energy to operate a pump. Electricity is preferred if available, but diesel or gasoline engines (with or without electric motor) are economical; windpower, if available, may be best. Care must be exercised in the well design and construction to prevent surface water contamination of the ground water. In coastal areas or in proximity to saline lakes, pumping rates may need to be controlled to avoid saltwater intrusion into the groundwater supply zone.

Data (see Table X-1) indicate that only 10% of rural populations and 23% of rural communities had potable water service in 1979. The forecast showed increases to 24% for rural residential and 52% for rural community potable water services by 1990. From informal comments, it appears that a monitoring program for potable water exists but is very limited by lack of resources. These resources are analytical laboratories, trained analysts and sampling technicians, sampling team vehicles and supportive financial budgets. The basic physical, chemical and bacteriological testing of routine samples is costly. When the apportioned cost of sampling, sample preservation and retrieval is added to the analysis of a water sample, it can cost $25 or more. The problem arises deciding who must pay the costs and how they are to be collected. Note also that prudent testing for fertilizers, pesticides, heavy metals from ore bodies (with or without mining) can double or triple testing costs. Responsible officials should seek a practical and cost-effective policy for the supply of potable water to rural communities with its quality control responsibilities and costs.

The ability to maintain a functional and expanding labor-intensive agriculture might in part rely on the ability of INAPA to supply and assure the quality of rural potable water supplies.

Diseases

The Ministry of Health is beginning to assemble a modern data base of health information (O. Rivera, pers. comm.). The data re-

covery system is aimed at institutional data sources, which have limited access to rural poor. An AID sponsored pilot project to place "health record keeping" technicians in small villages should correct this data gap. The pharmaceutical industry states that alimentary diseases and respiratory infections appear to be the primary medical problems in rural areas. The poorer rural people tend to seek clinical help for only acute illnesses; but apparently temporary wellness does not eliminate the disease organisms and recurrences are common. Infant and juvenile mortality appear to be major problems.

Obviously, improvement in personal hygiene and sanitation facilities as well as availability of clinical facilities and nutrition information are needed. The control of insect vectors and understanding of the relation between sanitation and disease are important in any community health program.

Urban Environmental Problems

Urban environmental problems in developing countries seem to derive from the slums which are populated by the very poor, recent immigrants. The combination of normal urban population growth plus recruitment from the hinterland is more than expanding urban service facilities can handle. The poor immigrant finds some unoccupied land to set up a hut. These uncontrolled settlements often expand rapidly and totally lack utilities and services; there are no potable water supplies, sanitary facilities, streets, storm drains, solid waste collection, fire or police protection, etc. Potable water must be carried in and stored. Personal hygiene and toilet facilities are initially absent and are brought in slowly. Food sanitation, storage and preparation is marginal. Storm drainage follows the natural land contours in many cases, removing some of the various wastes. Part of the slum is likely to be in a flood plain subject to damage or loss of human life. The combination of having poor housing, lack of sanitation facilities, the presence of insect vectors, poor diet and human crowding result in disease and mortality.

Fortunately, the government recognizes these problems and is working to solve and prevent future slums. Potable water is brought to community centers. Latrine use instruction and construction help contain wastes. Solid waste is collected from central locations which are accessible by road. Insect vector erradication services are provided where disease problems are recognized or suspected. But resources which can be applied to these problems are limited. Slums face service deficiencies considered essential for the rest of the urban population.

The following discussion attempts to treat those more important problem areas in practical terms as well as cost effective resolution. The government should be careful to select environmental codes and standards developed by other nations which will meet the needs of the human sector and remain cost effective.

Potable Water

The potable water problem appears to be pervasive in that it cuts across all sectors of society but harms the poor in the slums most. For example, a variety of surface and ground water sources serve the Capital District through a variety of distribution systems, some new and some very old. Bacterial contamination of these systems is apparently widespread. Episodes of low pressure and no service are frequent and often aggravated by daily electric power outages. Many affluent residents use silver chloride disinfection filters to improve potability. Residential cisterns supplied with public water are commonplace as a means of improving service, but many residents of the "old city" must rig temporary pumps to pull water to their cisterns when pressure is low.

In the slums community water systems allow poor people to draw supplies and carry the water to their respective houses. The migration of the poor into the urban areas continuously expands the problems of potable water service. Simultaneously, large tracts of subsidized housing are being built with water and sewer service to provide upward mobility and relief to excessive crowding in the slums.

The combination of factors attributing to potable water problems include lack of quality protection and reliable distribution, expanding demand, equitable cost distribution and resource conservation.

Potable water quality is usually accomplished by protecting the source, supplying adequate treatment with bacterial controls, pressurizing the distribution system to both provide transport and insure only outward or exfiltration leaking so that groundwater contamination of the potable water cannot occur. Unfortunately, there are apparent problems in each of these three critical areas. Reliable distribution entails a relatively leakproof system, continuity of electric power and adequate planning to anticipate and thereby be prepared to meet new slum subdivisions, commercial and industrial needs with reliable, good quality water. The expanding demand for potable water reflects increased population, improved standard of living and increased industrial and commerical uses.

The problem of equitable cost distribution is particularly vexing in a developing nation. The poor people must have potable water, but are the least able to pay for it. The cost of collecting water service fees is in itself a deterrent, hence subsidy is the frequent answer. In subdivisions, however, potable water charges are facilitated by metering and integration with sewer use and garbage collection charges. These charges also become the incentives for resource conservation. It is difficult to envision a water conservation ethic in the slums served by the community center faucet.

Sanitary (closed) Sewage

The sanitary sewage problem in urban areas is widespread since only 25% of urban populations were reported to have been served in 1979 (see Table X-1). It also has two forms, collection and treatment. Collection is aimed at protecting the local population from their wastes, whereas treatment is employed to protect the surface water resource for subsequent use. Since many cities in the Dominican Republic are coastal (Santiago, San Juan, La Vega and San Frandisco de Macoris excepted), the sewage discharge to the sea has been accepted without concern. Increasing concern for public health, the potential sensitivities of the expanding tourist industry and emerging recognition of the numerous public benefits to be derived from a thoughtfully planned program of natural resource protection and management have started to accelerate the installation of sewage treatment systems.

Since about half of the present National District's potable water supply is groundwater, sewage collection will improve groundwater quality. Groundwater near the earth's surface in the same district are thought to be responsible for contaminating some piped potable water supplies by infiltration through pipe leaks during periods of low internal pipe pressure. Improved sewers will also help alleviate this suspected problem. Relatively complete sewage collection and treatment will enhance the surface water sources, permitting the cost-effective use of these waters for needed potable water supplies in the near future.

The existence and effective operation and maintenance of sewers and treatment plants should be an important asset to both industrial expansion and cost-effective wastewater treatment and control of industrial effluents. Where publicly-owned sewers and treatment plants are available and have unused capacity, industry should be encouraged to pretreat wastewaters prior to discharge into the sewer for the completion of the needed processing at the sewage treatment plant. The industry should pay for this service and will find it more economical than most alternatives. The publicly-owned treatment works thereby provide a service, re-

ceive a fee, utilize unused capacity and can charge other private users less.

Finally, sewage collection and treatment, coupled with modern storm drainage and effective watershed management, will permit contact water uses such as swimming, fishing whether sport or commercial, and similar public benefits. This should contribute to improved national pride and significantly reduce the need for remote or segregated facilities as the means for enhancing the tourist business.

It should be noted that large quantities of fish, shellfish and/or dried algae meal can be harvested from suitably designed and operated sewage treatment plants, creating financially attractive resource recovery potential. The polishing pond that follows the extended aeration lagoon in many sewage treatment plants can produce over 100 metric tons of dried unicellular algae per year per hectare, worth about $250/m ton locally. Where this algae is recovered as food for fish culture, about $22,000 worth of fish can be produced per year at $0.45/kg whole. Here is the potential for making sewage treatment plants financially self-sufficient and possibly even profitable. The algae recovery equipment can take the form of thickening by DAF (dissolved air flotation), dewatering with a vacumm filter and solar drying.

Stormwater

Intense rainfalls create a variety of problems, possibly most commonly flooding. An important collateral urban benefit is street and sidewalk flushing. But the damage to road pavements, sheet and gully erosion losses of inadequately protected soils, inflows/infiltration damage to sewage systems and their operational control, leachate damage to groundwater from sanitary landfills and failure to recharge the groundwater resources are the major problems. Local flooding is the first apparent result of urban development as rain cannot infiltrate soils but must run off impermeable surfaces. Adequte storm drain designs will control the problem in most cases, but as urban areas grow, more topographic trouble spots appear, previously adequate storm drains become overloaded, drainage ditches become clogged with debris, ponds develop which become breeding grounds for insects and in low steep valley areas which have been settled by rural farmers there is the ever-present danger of loss of human life due to flash flooding.

There is a general lack of awareness of the need for the expense of storm drains in an urban setting. Surface drainage is required for areas that are paved or have a tight or non-porous soils, and it tends to be expensive, often $200 to $600 per capita. Consider the National District which receives about 1400 mm rainfall per year on relatively porous soils. It also recovers about half of its potable water from groundwater which is overused in certain areas as evidenced by saltwater intrusions. Two technologies to improve storm drainage while controlling costs are available. Porous pavement as a porous macadam or interlocking ceramic or concrete bricks which will pass 250 mm of rainfall per hour and sand-topped concrete cisterns designed and sited to filter storm water, retain it and allow it to recharge the local aquifers.

Solid Waste Collection and Disposal

This important urban service is performed by the municipal government in each major city using modern packer trucks operating on regular collection routes. The solid waste is largely from food preparation and contains a minor amount of paper and relatively little glass, metal, plastics or rubber. In the National District this largely biodegradeable waste is currently being delivered to two sites, one a sanitary landfill and the other an uncovered dump. Study and design programs are reported to be underway to implement a Mexican composting process as the means for managing the long-term solid waste disposal requirements of these subtropical urban areas.

The major solid waste problem will remain the collection function. Considering the crowding, lack of roadways and inadequate environmental sanitation/personal sanitation awareness of the very poor in the slums, garbage collection efficiency will be the lowest where the need is probably the greatest. Visits to several slums confirmed that the residents were generally discarding wastes in the nearest convenient open space. It is possible that the use of a central garbage pickup station (which can be serviced by packer truck) can be added to improve the sanitation of slums.

The solid waste sites observed exhibit the traditional problems of such operations: There appeared to be no leachate control measures, sites were not fenced to exclude persons and animals, vector controls (insects, birds, etc.) appeared absent, waste cell compaction and cover soil controls appeared minimal and short-term disposal utility appeared to be the controlling factor. The institution of conventional sanitary landfill design criteria and operational controls are definitely needed. On the other hand large amounts of paper, glass and metal are already being recycled which reduces significantly the municipal solid waste volume and tonnage. Compania Anonima Desperdicio recovers about 150 tons/week of paper for the National Paper Industry. The Dominican National Brewery recovers about two truck loads of broken glass bottles per day, for return to the Dominican National Glass Company. The Dominican Metalurgical Complex recovers scrap iron and steel to supplement its steel imports.

Whereas composting of municipal solid waste with a high (75% or more) biodegradeable component is an attractive alternative to sanitary landfilling, the nonbiodegradeable component (glass, metal, plastics, rubber, ceramic and earth) is increasing. This will require either source separation or central separation facilities to be added with the consequence that a sanitary landfill will have to remain in operation to receive those non-recyclable residuals.

A second concern is that of leachate control in existing and future sanitary landfills. In areas where soils are porous and groundwaters are used for potable water supply, consideration should be given to placing an impenetrable layer between the waste cells and the groundwaters to protect the latter from any leachate that may be generated by surface waters percolating through the waste. Leachate contamination of groundwater may only be a minimal hazard at this time, but can be expected to increase with time, income and population growth.

Air Pollution

The general perception is that minor air pollution in the Dominican Republic is industrially generated and that noise pollution is non-existent. These matters are developed below and do represent significant if incipient problems.

Numerous comments were received on smoke and particulate emissions from the Dominican Cement Factory and a few about the smoke and dust from the Dominican Metalurgical Complex (Metaldom) or likewise a few comments were voiced about the smoke from the steam electric power plants of CDE in Haina, Puerto Plata and Santo Domingo that burn Bunker C fuel oils. Other large fuel burning installations such as Falconbridge, CEA, Central Romano, Casa Vincinin and the Dominican Petroleum Refinery received very minor comment. The only remaining large industries where air pollution questions were raised were ALCOA and Rosario.

The Dominican Cement Factory operates four kilns with individual capacities of 250, 250, 500 and 650 tons/day. In 1975 two large electrostatic precipitators were installed in the kiln stack breechings to give 99.5 and 99.9% recovery of cement fines (particulates) being lost with the stack gases. These emission control devices are now apparently almost inoperative due to equipment corrosion and lack of maintenance. Hence particulate emissions are again a problem and are estimated to be about 20 tons/day

when the plant is running at full capacity. This amounts to a product sales loss of $2000/day.

The Dominican Metalurgical Complex (Metaldom) has three electric furnaces with daily capacities of 18, 20, and 40 tons, for a nominal annual capacity of 60,000 tons. The dust emissions are estimated to be about 3 tons/day, assuming no emissions controls are in place and operating. Air washers, bag house or electrostatic precipitators can be used for control of these emissions, which will largely be a community service although plant working conditions will also be improved. Unless combined with other conservation efforts this emission control will not be self-amortizing.

The steam electric plants of CDE burn Bunker C fuel oil at a nominal rate of 12,000 BBL/day, inclusive of purchased power. Since Bunker C fuel oil contains in excess of 2.5% sulfur, sulfur oxide emissions can be estimated to be about 94 tons/day. Fortunately these emissions occur largely at three different coastal urban locations which assists in their dispersion. Controls for this problem are expensive, e.g. up to 10% of the plant investment and would be inappropriate at this time. CDE mounting fuel bills and service interruption problems require high priority attention. Later, attention should be given to burning carefully washed pulverized coal as a means of controlling fuel costs and lowering sulfur oxide emissions. The use of puliverized coal allows maximum coal cleaning, avoids loss of rated steam generating when boilers are converted and requires minimal burner conversion expenses.

Another source of power plant air emissions are Falconbridge and the 16 or so sugar mills. Falconbridge, which burns Bunker C, is reported to emit about 45 tons/day of sulfur oxides, but sulfation plate monitoring data over a number of years plus visual inspection of vegetation and tree plantations in and around the plant site fail to show any signs of sulfur oxide damages. The sugar mills burn both fuel oil and bagasse (waste sugarcane pulp) which characteristically gives episodes of black smoke due to combustion control problems. Fortunately those mills are geographically dispersed and like Falconbridge generally enjoy good regional ventilation and therefore pose only minor local or temporary problems.

A specific urban air pollution problem comes from vehicle emissions. Automobiles, buses and trucks operating on busy thoroughfares with traffic loadings of more than 3,000 vehicles/hour during peak flow periods emit an estimated 12.4 gms per km per vehicle including hydrocarbons, carbon monoxide and nitrogen oxides. This relatively high emission rate is estimated on the basis of the poor mechanical condition of many vehicles (as evidenced by excessive exhaust smoke and odor) and the significant proportion of larger vehicles, principally buses, which are generally loaded. The vehicles that appear to be the major polluters are the "publicos" or low-cost, route-serving taxis. Fortunately these vehicles characteristically have good passenger loadings thereby decreasing the "effective" grams/mile/passenger emission rate. There is a program underway to replace gasoline "publicos" with larger diesel buses, which will help by decreasing fuel use, substituting cheaper diesel for gasoline and decrease the number of engines to keep tuned for fuel economy and emission reduction reasons. It would appear that the high cost of automotive fuels ($2.35/gal. for gasoline and $0.99/gal. for diesel) could be used to provide incentives for vehicular emissions reduction programs.

Hazardous Waste Disposal

Hazardous wastes are those materials which by their nature are inherently dangerous to handle, store, transport or dispose. These include old explosives, radioactive materials, some chemicals such as pesticides, some biological wastes and some fuels. These wastes are usually produced by industrial operations, but some can derive from mining, farm operations, hospitals and military functions. Fortunately, there appears to be only a limited problem with hazardous wastes in the Dominican Republic.

The safe disposal of pesticide wastes and empty containers requires special incineration equipment. However, where descriptive labeling is used, empty containers can be returned for reuse thereby removing this potential hazard from the rural areas where untrained persons may subject themselves to contamination and injury. Biological wastes from hospitals are usually incinerated. Used explosives and exotic fuels from the military should be disposed by well-trained and suitably equipped experts.

The key to protecting the public and the environment from hazardous wastes is first, their prohibition from normal waste streams both industrial and municipal and second, their careful disposal by trained personnel using technically appropriate equipment with suitable emission controls and personnel safety devices. Technology is currently under development for the use of cement kilns and blast furnaces for the incineration of injectable hazardous chemicals. These processes have the high temperatures and residence times needed to chemically dissociate complex chemicals to their basic elements which are emitted or combine to form harmless compounds. Should the need arise it would appear possible that one of the three Dominican cement plants could modify one of its kilns to incinerate injectable hazardous wastes.

Summary

Contamination of water supplies is the most serious pollution problem in the Dominican Republic. Sanitary sewers serve only 15-25% of the urban population; potable water reaches 54% of the urban areas. Rural surface waters are generally contaminated by sediments and fecal coliform bacteria, while fertilizers, pesticides and irrigation-delivered solids and salts are less extensive contaminants. Urban surface and groundwater resources are largely contaminated by inadequate sanitary facilities, with inadequate storm drains and untreated industrial effluents contributing to a lesser extent.

More appropriate land use and management, expanded rural sanitation systems and continued public instruction in personal hygiene could significantly lessen the contamination of rural surface waters. Urban water resources contamination could be lessened by improvements in delivery systems, water use conservation, equitable user fees, and technical capability. The development of industrial waste water discharge limitations (both qualitative and quantitative) and community planning for energy and resource efficiency are also needed mechanisms to reduce urban pollution.

Public health problems are largely due to waterborne diseases and poor personal hygiene. Inadequate nutrition due to poverty, burgeoning population, migration, and persistent deficiencies in public education all contribute to the serious health problems of both urban and rural poor in the Dominican Republic.

From a national perspective industrial pollution is not a serious environmental problem. Government-owned industries are pollution sources due to antiquated or inoperative technology and under-capitalization. Multinational industries cause minor pollution problems and should be used as sources for pollution control standards and technology. The development of a close cooperative relationship between public and private sectors could maximize environmental progress in pollution control and set the stage for cooperative rule-making.

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XI

Institutional Aspects

There are approximately twenty-six institutions involved with environmental and natural resources-related matters in the Dominican Republic. Of these, 18 are public sector agencies. Some agencies, such as DNP, FORESTA, ZOODOM, BOTANICO, and the dam corporations, were created and function as special entities directly under the President's Office; another agency type, such as PLAN SIERRA, is a mixed unit with public as well as private sector participation.

Institutions in the private sector that have some relationship with natural resources and the environment are the following: UCMM; UNPHU; UCE; the vocational agricultural schools, LOYOLA, SALESIANA, and DAJABON; the Dominican Ornithological Society; the Dominican Conservation Society; and the Caribbean Ecological Society. Of the nine private institutions, six are educational and carry out some research; three are small conservation organizations devoted to preserving the flora and fauna of the country.

Public institutions specifically involved in a particular sector are analyzed in the appropriate chapter of this CEP:

Chapter IV FORESTA
Chapter V INDRHI and CDE
Chapter VI DTA and PLAN SIERRA
Chapter VII CIBIMA, DRP, IDECOOP and INDOTEC
Chapter VIII DVS, DNP, ZOODOM, MHD and MNHN
Chapter IX Banco Agricola, IAD and ODC
Chapter X INAPA and CAASD

Major Institutions

Agriculture Secretariat (SEA)

SEA is governed by Law 8 (1965) and Statute 1142 (1966). Though this legislation remains in force, SEA's internal structure has varied significantly and is very different from its originally conceived form.

SEA contains six undersecretariats, 36 departments and eight regional offices. SURENA is the unit within SEA that deals with natural resources; SEICA has some activities in this field, mostly through the Soil Testing Laboratory in San Cristobal. The regional offices are operational units charged with carrying out programs and projects.

SEA's responsibilities are: (a) to formulate and direct the Republic's agricultural policies in accordance with national development goals and in coordination with other public agencies in the sector; (b) to study and monitor the socioeconomic aspects of agricultural production, distribution and consumption; (c) to manage the use of renewable natural resources; (d) to rationalize present with potential land use by promoting improvements in agricultural technology and upgrading the training of farmers and technicians; (e) to promote agricultural production and protect such production from pests and diseases; (f) to review and approve annual budgets of institutions in the agricultural sector; and (g) to monitor, participate in and regulate all matters related to the nation's agricultural development (ONAP 1980).

SURENA is responsible for managing renewable natural resource use in the Dominican Republic. The laws and statutes in force that assign to it such a mandate are: Law 8 (1965) management and conservation of land resources and the environment; Law 85 (1931) hunting; Law 5914 (1962) fishing; and Law 8 (1965) weather forecasting. The key functions of each department in SURENA are listed below.

The Meteorological Service has the following responsibilities: (a) to maintain climatological stations throughout the country, analyze station data and periodically report short as well as long-term trends in weather and climate; (b) provide synoptic daily weather forecasts for marine and air navigation; (c) offer training in the field of meteorology; (d) conduct studies of the atmosphere; and (e) establish guidelines and control mechanisms to detect any activities that may induce air pollution. The Deparment recently acquired new equipment to improve its service. The importance of the Meteorological Service was highlighted in 1979 by increased public awareness after Hurricane David (A. F. Deno, pers. comm.).

The Department of Inventory and Evaluation is a research unit responsible for conducting studies on the potentialities of natural resource use in the Republic. It was recently created and is an outgrowth of the GODR-USDA-Michigan State University Comprehensive Resource Inventory and Evaluation System (CRIES). The Department has two key functions, the first of which is to carry out, update and maintain an inventory of renewable natural resources of the country. The objective of such an inventory is to provide precise information concerning the quantity and quality of each natural resource factor input. This inventory is being carried out in coordination with other SURENA departments as well as other public and private institutions that generate primary information concerning all natural resources factors. The Department has a specialized remote sensing

unit. The other important function is to establish and maintain an archive of published documents concerning the topic (G Tirado, pers. comm.).

In addition to the five principal departments, SURENA has an Office of Technical Coordination and an Environmental Education Unit. The Office is responsible for the overall elaboration of policies and development of inter-institutional collaborative efforts at the local and international levels; it also is in charge of program development and provides technical backstopping to the Undersecretary of Natural Resources. The Environmental Education Unit is responsible for promoting a public awareness for natural resources management. It attempts to achieve this goal by developing short courses for teachers, technicians and farmers. The Unit also is charged with providing materials for public information purposes (I. Russo, pers. comm.).

Environmental Department (MEDIO AMBIENTE)

The Department of Environment and Natural Resources (MEDIO AMBIENTE) of the President's Technical Secretariat was created in 1977 to monitor national policies as well as to develop normative plans in the area. Though handicapped by limited staff and resources, the Department has actively pursued the introduction of natural resources management elements into national development planning (G. Dastellanos, pers. comm.). The Department is an executive unit within the Office of the Technical Undersecretary; as such, it is outside the formal national planning framework, though its personnel actively collaborate with ONAPLAN on a need basis.

MEDIO AMBIENTE has been most active in working on the establishment of an inter-institutional coordinating Council for Natural Resources Management (CONARENA) in the Republic (P. Bona Prandy, pers comm.). It has also collaborated with ONAPLAN in the preparing multi-sector regionalization plans for the Southwest and Eastern Cibao; and it has been involved in preparing reports on the environmental impact of various development schemes.

Dam Construction Corporations

Five autonomous corporations have been created by Presidential Decree and made responsible for the construction of hydropower facilities. These agencies were established because of the inherent weakness in existing governmental institutions and because of the greater ease with which political control and fiscal restraints could be exercised.

The following corporations have been established and the costs of the corresponding works are as follows: Hatillo ($85 million); Valdesia ($52 million); Rincon ($26 million); Sabaneta ($45 million); and Sabana Yegua ($82 million). In reality, the administration of these corporations is delegated by the President to a small group of trusted, responsible individuals. The agencies function with minuscule staff and cease to exist with the completion of the project. The works are then turned over to INDRHI or CDE (L. Guzman, pers. comm.).

Inter-institutional Linkages

Public Sector

There exist an ample range of public institutions that carry out activities related to environmental and natural resources management. These institutions have an incredibly complex and heterogeneous character since each is charged with specific and unique missions.

That there are problems of division of interest and institutional conflicts is due as much to the diverse responsibilities assigned each of the different public agencies as it is to the absence of a natural resources policy. The ADP calls for passage of enabling legislation to define specific policies for soil, water and forest resources. The plan also recognizes the importance of strengthening SURENA as the principal normative-operational unit in the natural resources sector. Another specific recommendation in the plan is the call for creating a Council for Natural Resources Management (CONARENA) as the instrument needed to harmonize and coordinate policy formulation and implementation among the various public and private institutions (SEA 1980).

Land Resources. Though positive steps very recently have been taken by integrating IAD's Soils Department and the Agroforestry Division of CDE into SEA, there still persist some problems with INDRHI's Agrological Division and the parallel functions that this Division possesses with SURENA. Greater coordination needs to be achieved between CATASTRO and SEA since their functions are closely related.

Water Resources. This problem is more complex since there are a larger number of institutions involved. There are conflicts between INDRHI and SEA with regard to a water resources management policy as well as in the activities that each carries out; steps are being taken at the field level to mollify these problems.

The management of dams and reservoirs poses a classic confrontation between CDE's interest to devote such infrastructure to intensive energy use and INDRHI's efforts to use water downstream for irrigation purposes. Both institutions have very different priorities and these conflicts will continue to arise if no overall national policy is adopted. Recently, the executives of both institutions signed an inter-institutional agreement to form a technical commission to study the problem and present viable solutions.

The creation of corporations to construct dams and reservoirs is an obvious parallelism with functions that were mandated under law to INDRHI. It has been argued that these corporations were created out of a lack of faith in INDRHI's ability, as much by the government as by international lending agencies, to carry out these very costly projects. However, had an opportunity been given to INDRHI in the first place, and if resources provided to the corporations had been directed to INDRHI to upgrade personnel, equipment and materials, it is possible that this institution probably would now be much more efficient technically and administratively.

INAPA and CAASD have very specific functions and it is recommended that they coordinate closely, especially in the rural areas with respect to the treatment of potable water. Such coordination can be established at the normative level between SEA, SESPAS and INDRHI.

Wildlife Resources. The responsibilities related to wildlife are concentrated in SEA's Wildlife Department. Other SEA departments that relate to this activity are Plant Breeding, Livestock and Coffee and Cacao. There is adequate coordination since they are dependencies of the same institution. There is no formal coordination between ZOODOM, BOTANICO and SEA; the first two agencies are considered very independent.

Forest Resources. FORESTA is the agency responsible for setting and carrying out forest-related policies and programs in the republic. Notwithstanding, its internal structure is weak and it does not have sufficient technically qualified personnel to carry out its work. There is little coordination with SEA and DNP.

In 1978, the President ordered (Decree 301) that both FORESTA and DNP coordinate their activities with SEA through SURENA. A Coordinating Commission was created and the Commission was charged with avoiding the duplication of functions and efforts among these three agencies. This Commission is presided by the Secretary of Agriculture and includes the Technical Secretary of the Presidency, the Director of FORESTA and the Director of DNP.

The law being considered by Congress to integrate the public agricultural sector calls for moving both agencies to SEA in order to assure that the policies established in the natural resources

management area are concordant with national development policies and in particular with agricultural development policies.

Fisheries Resources. The Department of Fisheries Resources within SURENA is charged with a broad array of functions and responsibilities. It has been strengthened in the last two years and it carries out a number of important projects. Examples are: IDECOOP, which since 1977 is carrying out a program to expand marine fisheries production; INDOTEC, which is just now completing a study to determine marine fisheries potential; and CIBIMA, which orients its activities towards research.

SEA and CIBIMA have signed inter-institutional agreements that have significantly stimulated research. With respect to IDECOOP, though ties have been broadened, one cannot say that adequate coordination exists. In general, the existent institutional structure is weak and too dispersed to stimulate a broad program of fisheries exploitation.

Public-Private Sector Links

The coordination between the public and private sectors is relatively recent and generally informal. With the exception of agreements that SEA has signed with the universities and some of the vocational schools, through the Professional Training Project (PPA II), to train technical personnel in different disciplines related to agriculture, the participation of the private sector in the public arena and the mechanism of existing coordination are quite limited. It is important to take into consideration this problem and to realize that the public sector must make an effort not only to intensify this coordination but also to stimulate other private organizations to fight for environmental concerns. CONARENA can be an important means for amplifying the coordination between both sectors.

Public Sector-International Agencies

The relationship between the public sector and international lending agencies or technical assistance missions of foreign governments is concentrated in the following areas.

The Inter-American Institute of Agricultural Cooperation (IICA) in collaboration with SEA has carried out research principally in the areas of soil and water resources. This collaboration was initiated in 1973 under PIDAGRO I and through SEICA (A. Perez Luna, pers. comm.).

The Organization of American States has collaborated with SEA and FORESTA. The most important collaborative effort was the natural resources inventory of the Dominican Republic published in 1967 and considered the classic baseline environmental work of the country.

The Food and Agricultural Organization of the United Nations has offered technical assistance in the areas of forest, soils and water use for several years.

The Nationalist Republic of China through its Mission to the Dominican Republic is offering technical assistance in both rice cultivation and fisheries. Israel is another country that has an agreement with SEA to stimulate fisheries; it also collaborates in the rice research programs. The government of the Federal Republic of Germany is initiating a broad technical assistance program that includes conservation of natural resources (J. E. Lois, pers. comm.).

USAID has offered technical assistance and loans for development of natural resources It has sponsored numerous studies in the areas of forest, soils and water resources. Through its loan program, PPA I and PPA II, it has aided in implementing various projects in the natural resources area, principally in land and water (S. Grullon, pers. comm.).

USDA has sponsored research in forest and soils areas. It was instrumental in helping to carry out the CRIES Project.

IDB has financed hydroelectric projects, and under the auspices of PIDAGRO I, II, III, various projects in soils, fisheries and forestry. The World Bank has concentrated its efforts in the construction of hydroelectric works, especially dams and irrigation canals.

Human Resources

Surveys were undertaken of twenty-six public, semi-autonomous and private agencies involved in training, research, planning and program implementation in the natural resources and environmental management fields. The purposes of the surveys were to determine the levels and disciplinary orientation of training currently available in the Dominican Republic, to identify present manpower levels, to relate fields of training with current areas of work, and based on the proposed program of activities for each institution, to identify institutional needs for additional numbers of professionals and technicians over the next five years. The agencies surveyed include: Training—UASD, UNPHU, UCMM, ISA, LOYOLA, SALESIANA, and DAJABON; Research—BOTANICO, ZOODOM, CIBIMA, INDOTEC, CENDA, and CIAZA; Planning—MEDIO AMBIENTE, and OSISA; and Project Implementation—SURENA, FORESTA, DNP, IDECOOP, CAASD, INAPA, IAD, INDRHI, PLAN SIERRA, PRYN, and INDESUR.

Training

The centers of higher education in the Dominican Republic are UASD, UNPHU, UCMM, UCE, and INTEC. They provide Licenciate (Lic.) and Engineer (Eng.) level professional training with the exception of INTEC, which also offers a one-year advanced course of study in Agricultural Economics. Aside from the above exception, post-baccalaureate training is not available in the Dominican Republic in any of the fields related to natural resources management.

It should be recognized that over 80 percent of the present professional staff in the nineteen agencies concerned with planning, project implementation and research solely have a Lic. or Eng. degree. This type of training at a Dominican university is pursued through an Engineering degree program with a major concentration in Agriculture or Civil Engineering. Programs leading to an Agricultural Engineering degree are offered by ISA-UCMM, UNPHU, UASD and UCE. Civil Engineering studies are pursued through UASD and UNPHU. Recently, UASD instituted a program with a minor concentration in Soils, and ISA-UCMM now offers one with a minor in Forest Management and Administration (R. Martinez Richiez, pers. comm.).

In most cases, while foundation courses in Soils, Hydrology, Forestry and Botany may be taken, emphasis is placed on agronomic or engineering-design aspects and little advanced training is possible in these subject fields. Exceptions to the rule are studies in Marine Biology through the cooperative CIBIMA-UASD program and in Geology at the UCMM. The latter program, however, is heavily oriented towards mining and engineering applications and less toward Geomorphology. The recently established Department of Natural Resources in UNPHU's School of Agronomy should offer very important service courses in Ecology and related subjects in the coming years and thus help provide agronomists with a greater awareness of environmental and natural resources issues.

Due to the current absence of more advanced studies in natural resources at Dominican universities, the increased demand for such specialized training has led many individuals to obtain "skills-instruction" by attending short intensive courses abroad. The two most cited examples are: airphoto interpretation skills through the Inter-American Center of Photo Interpretation under the Ministry of Public Works in Medellin, Colombia; and cartographic training at the Pan American School operated by the Inter-American Geodetic Service in Panama. In addition, attendance at conferences and workshops abroad in the respective fields of interest is often used as a "refresher" mechanism.

While social scientists represent only 4 percent of the current work force in natural resources management fields, it is important to note that a more diversified training base is available in this area in the Republic. There is Lic. training in Economics at UASD, UNPHU, UCMM. UCE and INTEC. Sociologists are trained at UASD and UNPHU; while UCMM offers a Lic. in Social Work. The UASD recently established a Lic. program in Geography and UCMM offers a minor concentration in this field.

Public Administration also represents 4 percent of the present labor force in the natural resources sector. Lic. training was made available through the UASD in the mid-1960s, but due to low enrollments, it was suspended for several years. Recently, this program was re-established but enrollments remain low and the program's future is somewhat in doubt.

Technical level training in the field of Agronomy is available through the following vocational schools: ISA (Santiago); LOYOLA (San Cristobal); SALESIANA (La Vega), and the Agricultural School (Dajabon). These schools draw their student population from farm families; their geographical location at different points in the Republic helps to build a cadre of agronomists that reflects the country's varied ecological and social conditions. FORESTA operates a technical vocational school at Jarabacoa, but to date only in-service, short courses have been offered in matters related to forest conservation.

Present Labor Force

Table XI-1 presents a summary listing of current staff levels as well as projected increases. There are 448 individuals who work as professionals and technicians in natural resources and environmental management programs in the 19 surveyed planning, research and program implementing agencies. Eighty-two percent (263) of all professionals are at the Lic. Eng. level. Finally, 28% (127) of the entire staff is at the technical level.

Table XI-2 presents the levels of professional and technical staffing by work-related activities in the nineteen Dominican institutions. Because of the importance of SURENA in the scope of activities under review, this institution's personnel has been disaggregated and staffing is examined by each respective department. The four major activities pursued by these agencies are Planning, combined Planning and Projects Implementation, solely Project Implementation, and Research. Each institution is categorized by its prevailing scope of activities and the sum of professional and technical staff in each work-related sphere indicates both strengths and weaknesses in the sector's capacity to carry out natural resources and environmental management programs.

The work areas of Planning combined with Project Implementation (246 individuals) and Project Implementation (52) account for 67 percent of the work force. One hundred and forty individuals make up the research staff, and 10 persons are engaged in Planning.

The principal implementing institutions, based on numbers of professional-technical staff, are FORESTA (53), INDRHI (47), Land and Water (34), Fisheries (30), and the Meteorological Service (21). Over half of the personnel in this work-related activity are at the Lic.-Eng. level; close to 40 percent are technicians.

The research institution with the largest professional-technical staff is IDOTEC (47); followed by CENDA (39), Inventory and Evaluation (14), BOTANICO (12) and ZOODOM (12). Close to three-quarters of these agencies' staff are at the Lic.-Eng. level; another 10 percent each can be found at the Ph.D. and technician levels; the MA-MS category accounts for the least number of individuals.

Only three units are concerned with Planning on a full-time basis. These are MEDIO AMBIENTE, Technical Coordination and OSISA. They reflect only 7 percent (10 individuals) of all current staffing. Though the Lic.-Eng. level continues as the principal staff component, the MA-MS makes up a significant third.

Projected Manpower Needs

Five year projections of proposed staff additions (Table XI-1) are based on information obtained through interviews with agency heads; in some cases, the proposed staff additions have been adjusted either in level or number of individuals requested, to reflect more accurately both project program development and the ability of a unit to absorb additional staff. Personnel projections should reflect both anticipated staffing needs at the executive-administrative, professional and technical levels, as well as the institution's respective function either as a planning, project implementing or research unit. As a general rule, Ph.D. staff should be reserved for the research institutions.

The greatest proposed proportional increase is at the MA-MS level. It is here that the greatest present as well as future professional and administrative demands in all agencies rest. Given that eleven out of the total nineteen institutions in the sector are program implementing agencies, there is an urgent need to intro-

Table XI-1. Summary listing of current levels and projected increases in professional-technical staffing by field of specialization.

	Training Level									
Fields of Specialization	**Ph.D.**		**MA-MS**		**Lic-Eng**		**Tech**		**Subtotal**	
Agronomy					43	6	13	10	56	16
Botany	1	2		3	3		1		5	5
Biological Sciences	2	1	4	9	33	4	7		46	14
Chemistry	3		2		14		1		20	
Computer & Information Sciences			1	3	12	3	27	10	40	16
Ecology		1	4	20	23	2	6		33	23
Education				5	7	3	1	5	8	13
Engineering Sciences			1		33	6	9		43	6
Forestry			4	8	5	13	25	30	34	51
Geology			1	2		2			1	4
Hydrology	1		12	8	22	25			35	33
Meteorology-Climatology				5	7		8	20	15	25
Fisheries			4	2	4		8	22	16	24
Planning & Project Administration	2		2	3	8	1	5		17	4
Social Sciences			1		15	3	1		17	3
Soil Science	4		7	4	13	12	4		28	16
Professionals, Unspecified	1	5	1	10	21				23	15
Technicians, Unspecified						5	11	75	11	80
Present Staff	14		44		263		127		448	
Future Additions		9		82		85		172		348

Table XI-2. Levels of professional and technical staffing by work-related activities in Dominican institutions. ( ) = Institutional total

Agencies:		Planning				Planning and Project Impelementation				Project Implementation				Research			
		Ph.D.	MA/MS	Lic-Eng	Tech	Ph.D	MA/MS	Lic-Eng	Tech	Ph.D.	MA/MS	Lic-Eng	Tech	Ph.D.	MA/MS	Lic-Eng	Tech
SURENA:	Technical Coordination	—	1	—	1(1)												
	Wildlife					—	3	6	3(12)								
	Fisheries Resources					—	6	13	11(30)								
	Water and Land					—	5	17	12(34)								
	Meteorological Service									—	1	11	9(21)				
	Inventory & Evaluation													—	1	12	1(14)
	Environmental Education									—	1	2	1(4)				
FORESTA																	
DNP						—	—	13	40(53)								
BONTANICO						—	1	9	3(13)					1	2	7	2(12)
ZOODOM														2	2	8	–(12)
CIBIMA														2	2	5	1(10)
IDECOOP										—	—	—	3(3)				
INDOTEC														5	1	39	2(47)
CAASD																	
INAPA						—	2	14	–(16)								
INDRHI						—	1	10	8(19)								
IAD						1	9	34	3(47)								
MEDIO AMBIENTE		—	1	5	–(6)	—	—	4	12(16)								
PLAN SIERRA										—	1	6	4(11)				
CENDA														—	2	27	10(39)
PRYN										—	1	11	1(13)				
CIAZA														2	—	4	–(6)
OSISA		1	1	—	1(3)												
INDESUR																	
CESDA*						—	—	6	–(6)								
Totals		1	3	5	1(10)	1	27	126	92(246)	—	4	30	18(52)	12	10	102	16(140)

* Centro Sur de Desarrollo Agropecuario was not surveyed.

duce quickly professional skills and managerial techniques that will enhance the successful completion of program activities. The advanced skill level and the nature of the subject matter, juxtaposed with the relatively short period (21-24 months) required for completion of MA-MS training, are all factors which prompt such a heavy investment at this level.

While the prospective 82 additional MA-MS professional should serve the demands within the nineteen service agencies, every effort should be made to incorporate some of them, at least on a part-time basis, into the academic programs of the local universities. This would appear to be the most feasible and economical manner of broadening instruction at the national level to include more substantive training in the fields of natural resources.

Of the total 85 proposed additional Lic.-Engs., by far the largest number will be Agricultural and Civil Engineers. This projection assumes continued availability of the UASD program with a minor in Soils, the ISA-UCMM program in Forest Management and Administration and the future establishment of a much needed concentration in Hydrology within Civil Engineering either at UASD or UNPHU. As a general rule, training at this level should be carried out in the country.

The five-year personnel projections show a 35% increase in the present number of technicians. The consensus of heads of departments and agencies is that the greatest bottleneck to program implementation currently rests at this operative level. Past experiences of Dominican professionals, who returned from MA-MS training abroad and did not find relatively-trained, supportive, technical staff to assist in program implementation, has been disheartening; in many instances, such highly skilled individuals quickly become frustrated and after a short period of time, have left government service. The greatest numbers of technicians are needed in SURENA by Fisheries Resources (22), Water and Land (20), Meteorological Service (20), Inventory Evaluation (25), as well as in other agencies such as FORESTA (30), and INDRHI (20).

The short intensive course of two to three months duration, offered in the country and in Spanish, is a well-tested method of transmitting skills and job techniques. The SEA-UNPHU link through the School of Agronomy's Department of Natural Resources could provide the institutional base; requisite technical back-stopping from outside the Republic could be provided on a need basis to offer a series of short courses on relevant themes or skills. One such course, of potential value to SURENA, would be oriented to improve techniques for inventorying, evaluating and managing natural resources; this course should include laboratory as well as field techniques in land use methods and conservation practices, as well as work in thematic cartography and interpretation of air photo and remote sensed data.

Budgeting and Financing

The financial analysis presented below is an initial attempt at characterizing recent public expenditures in the natural resources management field. It has two basic shortcomings. First, a financial analysis ideally should be based on proposed as well as actual budgetary expenditures. This report only includes actual expenditures for 1978; it was not possible to obtain similar data for subsequent years. Second, though an active search was carried out in Santo Domingo, it was not possible to obtain financial information for any of the autonomous government agencies nor the private sector. As a result, no global figures can be given at this time for the natural resources sector expenditures. This analysis, due to data limitations, is restricted to the programs of SEA and the Armed Forces based on information found in ONAPRES (1979).

Table XI-3. Comparison of expenditures by programs in SEA for the 1978-80 period.

	FUNDS		
	Spent 1978	Estimated 1979	Proposed 1980
National Sources	22,030,510	95,810,276	131,400,000
Programs			
1. Administration	5,822,234	9,374,359	17,926,285
2. Production, Credit & Marketing	2,718,784	22,469,078	70,441,590
3. National Resources	505,701	1,837,985	3,851,190
4. Rural Development	2,233,359	8,800,033	8,316,325
5. Livestock	1,170,366	4,493,382	6,825,125
6. Institutional Financing	9,580,066	46,835,439	74,039,485
External Sources			28,359,125
	22,030,510	95,810,276	159,759,125

Over the past three years, SURENA received the least amount of financing of any of SEA's programs (Table XI-3). Notwithstanding the proportionally low funding level, one can observe a significant, comparative annual increase over the three-year period. Only two SURENA activities, Meteorological Services and Fisheries Resources, existed in 1978; the Wildlife, Land and Water, as well as Inventory and Evaluation programs were created in 1979. Fisheries has received most of the funding; in contrast, Land and Water has received the least amount (Table XI-4).

The Armed Forces Forest Protection and Control Program shows an annual increase of 63% for 1978-79 and 30% during 1979-80 (Table XI-5). This program is financed exclusively with local funds (ONAPRES 1979).

Conclusions and Recommendations

Conclusions

Environmental policy. Though a defined national policy exists for intermediate-term agricultural development planning in the Dominican Republic, at this time there is no explicit policy for natural resources management. Solutions are sought for environmental problems on an ex-post-facto basis.

Institutions. There are sixteen public institutions directly related to natural resources management in the Dominican Republic. Some of these agencies have distinct responsibilities and others have parallel functions. This situation has resulted in frequent conflicts and what is worse, an underutilization of human, institutional and financial resources. There is little coordination between public and private sectors. Informal arrangements are the rule rather than the exception.

Decision-makers have demonstrated genuine interest to resolve structural bottlenecks and organizational problems. In some cases,

Table XI-4. Comparison of expenditures by program in SURENA for the 1978-80 period.

	FUNDS		
	Spent 1978	Estimated 1979	Proposed 1980
Activities			
1. Meteorological Services	376,651	979,234	1,669,695
2. Wildlife		96,045	360,145
3. Fisheries	129,050	453,534	1,229,240
4. Land and Water		211,137	327,790*
5. Inventory and Evaluation		98,035	318,320
Totals	505,701	1,837,985	3,905,190

*$54,000 external funds provided by AID-517-T-029 (PPA) loan.

Table XI-5. Expenditures for the forest protection and control program of the Armed Forces during the 1978-80 period.

	FUNDS		
	Spent 1978	Estimated 1979	Proposed 1980
National Sources	1,830,079	2,770,895	3,544 720
Operating Expenses	1,830,079	2,770,895	3,544,720
Capital Expenditures	9,027	234,470	354,780
	1,839,106	3,005,365	3,899,500

legislation has been proposed as a corrective mechanism; in others, simple informal working agreements are used. The law before Congress to integrate the agricultural sector is an example of the former, while the INDRHI-CDE memorandum of understanding is an example of the latter. In any case, a fundamental governmental objective since 1978 has been institutionalizing the managment and the decision-making process in the public sector.

Budget. The basic problem is the lack of standardized procedures to evaluate all agency budgets and sector expenditures. The situation in the private sector is even worse since very little budgetary information is made available.

Human Resources. Training in the natural resources management fields is not available in the Dominican Republic. Most professionals have an Engineering degree with a major concentration in Agriculture or Civil Engineering. Technical, vocational school training is available solely in Agronomy; FORESTA periodically offers short courses.

There are 448 individuals working in twenty-six public and private agencies in natural resources management: 321 are considered professionals and 127 technicians. Five-year demand projections for nineteen institutions estimate a need for an additional 348 individuals; 176 professionals and 172 technicians. Greatest demand is at the technical level; this followed by the baccalaureate (85), masters (82) and doctoral (9) levels.

Recommendations

Environmental Policy. An urgent need exists to formulate a natural resources policy and relate such policy to the development goals of the country.

Planing. A Natural Resources Management Plan is needed, one that contemplates discrete actions and programs to be taken singly or in combination in the areas of water, soils, forest, wildlife, fisheries resources and environmental pollution. Such a Plan should provide the frame of reference for identifying, planning and executing field and laboratory-based programs over the short and long-term.

More rigorous planning is required in the agricultural areas to improve productivity and protect the ecosystem. This is especially true for marginal upland areas which have been placed under more intensive shifting cultivation. Many of these areas, such as the Sierra, coincide with catchment zones of the multi-purpose hydroelectric projects. Only adherence to such planning will maintain the viability and prolong the lifespan of these projects.

Institution. Mechanisms that bolster greater inter-institutional collaboration need to be established. An important mechanism in this regard will be the National Council of Natural Resources (CONARENA); it will be a step forward in irradicating traditional problems of diffusion of effort and duplication of function that in the past have led to inefficient use of personnel and financial resources.

SURENA must continue to be strengthened. It should develop more fully its mandate to plan, implement and supervise national policy in the natural resources management fields. It is necessary, furthermore, to strengthen other key institutions, such as INDRHI, FORESTA, and DNP. Care must be taken to see that all coordinate more closely their activities with SURENA.

Budget. An effort should be made to begin to unify and standardize accounting procedures so that a more rigorous analysis of the expenditures in natural resources can be made in the future. Such normalized accounting procedures would greatly aid in improving the use of national and external funds.

Human Resources. There is an urgent need to establish instructional programs for natural resources management in the republic. It is important to provide support for the newly established Department of Natural Resources at UNPHU. This Department needs to build a teaching and research staff. Such a Department should offer formal professional training within the Lic.-Eng. curricula as well as topically-focused or skill-oriented "refresher courses" for technical, professional and administrative staff.

A professional training program should be initiated as soon as possible and scholarships created to satisfy the projected middle management and intermediate professional staff needs. Care should be exercised in defining specific job requirements within each agency and using such job descriptions as the basis for screening scholarship applicants. The job descriptions should serve as points of reference in developing academic curricula.

Since many individuals will be called upon to exercise their professional skills as members of interdisciplinary problem-solving teams, it is important that they be given opportunities to develop these special team skills within the supportive environment of their university studies. Furthermore, all who pursue MA-MS and Ph.D. training abroad should be required to prepare theses or dissertations on relevant environmental problems in the Dominican Republic. It is important that research priorities be established a priori and related as much as possible to on-going field projects in the sector so that the large number of projected academic studies have a definite impact on environmental problems of greatest concern.

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