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Niteroi, Brazil, 28-30 May 1992

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International Society for Mangrove Ecosystems

and

International Tropical Timber Organization

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Edited by

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International Society for Mangrove Ecosystems

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International Society for Mangrove Ecosystems (ISME)

ISME was inaugurated on 23 August 1990 and the seat of the Society is Okinawa, Japan. ISME takes over from the UNDP/UNESCO Regional Mangrove Ecosystems projects. ISME is affiliated to ICSU (International Council of Scientific Unions) and is part of IUBS (International Union of Biological Sciences) through IABO (International Association of Biological Oceanography). The Society was certified as a Foundation on 23 October 1992 in Japan.

FOREWORD

This publication is the first output of the project "**Conservation and Sustainable Utilization of Mangrove Forests in Latin America and Africa Regions**", sponsored by the International Tropical Timber Organization (ITTO) and the International Society for Mangrove Ecosystems (ISME). It contains the extended abstracts of the presentation of the participants at the workshop, which took place at the Universidade Federal Fluminense, Niteroi, Rio de Janeiro, in May 1992.

This publication presents a general but comprehensive view on the major aspects of mangrove ecosystems in Latin America, and will serve as a directory of mangrove researchers in that part of the world. Although far from complete, it shows the strong intention of Latin American scientists to participate in the project and the important contributions they can make to the project in the near future.

I would greatly thank the many people who have made this workshop possible, in particular ITTO and ISME for sponsoring the meeting for so many Latin American scientists; the President of the Universidade Federal Fluminense, Prof. José Raimundo Martins Romeo and his staff; the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for providing logistic facilities for the workshop and sponsoring the participation of many Brazilian scientists in the meeting. Many individuals have contributed to the success of the workshop and listing them here would mean forgetting some. However, I would like to express my special thanks to Drs. B. Kjerfve (U. South Carolina) and M. Steyaert (UNESCO) who, although not being formally asked, have provided intensive help in coordinating the workshop and its section.

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WELCOME ADDRESS AND OPENING REMARKS

Professor José Raymundo Martins Romêo

Universidade Federal Fluminense

I would like to welcome you at the Universidade Federal Fluminense for this opportune and important workshop supported by the International Tropical Timber organization and the International Society for Mangrove Ecosystems. It is opportune because for the next ten days the world will be focussed here, in Rio de Janeiro, for the UNCED' 1992 Conference on the environment. It is important because mangroves are unique in providing so many resources to coastal populations throughout the world tropics, though these ecosystems are being constantly threatened in many areas due to non-sustainable uses of their resources.

Our university had devoted considerable efforts in environmental research, including mangroves, and feels comfortable and honoured to host this workshop. I would like to offer all the required logistic support you may need from this University and wish you a productive and successful meeting. In a time when so many people speak of nature conservation and sustainable utilization of natural resources, it is very important to remember that before conservation, one needs to study Nature.

Thank you.

OPENING REMARKS

Prof. Dr. Sanga Sabhasri

International Society for Mangrove Ecosystems, Okinawa, Japan

Mangrove ecosystems are intertidal nature that exist primarily in tropical regions of the world. Habitats of approximately 90 species of plants and a great number of fauna as well as the microbial species of the soils, water and air have been found in these ecosystems. Mangrove is one of the most important sources of biodiversity that tremendously provides direct and indirect benefits to mankind. It is a rich nursery area for aquatic animals of economic importance such as fish, shrimp, crabs, oysters etc. In addition, mangrove forests supply forest resources such as fuel, charcoal, fodders, timber dyes and several chemical compounds.

Regarding environmental protection to the coastal areas, it can be said that mangrove forests play a significant role in coastal stabilization, dispersion of energy storms, reduction of soil erosion etc. It is estimated that the total worldwide mangrove areas is 170,000 km^2. To date, mangrove forests have supported and nourished human population living along coastal areas. Recently alarming rate of mangrove forest depletion has stimulated an increasing attention at global level. Now, time has come for us to protect and seek a better way to utilize mangroves resources. Conservation and sustainable development of the mangrove ecosystems are of urgent need.

In response to this scientists, and mangrove managers around the world agreed to establish the International Society for Mangrove Ecosystems (ISME) after several meetings, workshops, and regional projects on mangrove ecosystem management were organized. This Society was inaugurated on August 23rd, 1990 in Yokohama, Japan and the office of the Society is in Okinawa.

The aims of the Society are to promote and to coordinate studies of the mangrove ecosystem research on management and conservation aspects. The Society also intends to promote the public awareness of the importance of these ecosystems, as well as to support and implement results of researches. Trainings and exchanges of knowledge among scholars will be carried out through conferences, meetings and lectures.

The Workshop on Conservation and Sustainable of Mangrove Forests in the Latin America and Africa Regions today is one of the major activities of ISME. The Workshop will provide an opportunity for scientists and mangrove managers in experiences and to plan for regional projects in assessing the recent activities on regional mangrove ecosystems. The outcome of this workshop will eventually be of great benefit to the reforestation program of and management of mangrove forests in the Latin America and Africa regions.

This workshop is kindly given financial support by the International Tropical Timber Organization and is implemented by ISME. I have a high hope and firm belief that this workshop will surely provide a fruitful result in combining our knowledge and opinions together with our earnest endeavours in protecting mangrove forests of the region and the world as a whole.

FURTHER REMARKS: MANGROVE, A KEY ECOSYSTEM AT THE LAND-SEA INTERFACE IN THE TROPICS

Dr. Marc Steyaert

UNESCO-COMAR

Professor Raymundo Martins Romêo, Professor Sanga Sabhasri, Ladies and Gentlemen.

It is a great honour and pleasure for me to address your seminar as a colleague and as friend.

The mangrove is probably the most difficult forest to penetrate in. Until a recent past, it was considered by the majority of people and authorities in our modern society essentially as a nuisance for the health, only attracting the curiosity of the scientists due to its unique characteristics. However, there were and still are in all part of the tropics mangrove dwellers living in villages built on stilts. Traditionally, the mangrove ecosystem has a lot of goods to give the people, in terms of charcoal, pools, honey, etc... In their wisdom, the traditional societies have learned how to balance the utilization of the mangrove resources, while preserving the ecosystem stability.

We know how the modern society has forgotten the lessons of the past and has often the tendency to apply indusial methods to the exploitation of the mangroves, when it is not simply to suppress them for alternative uses, such as intensive artificial fishpond.

The International Society for Mangrove Ecosystems (ISME) is the outcome of a long effort, we have been proud and happy to be associated with, together with the United Nations Development Programme (UNDP) and the determining involvement of the Japanese scientific community and Japanese authorities.

It is a very great pleasure for me to see, as this workshop demonstrates again, that ISME, in addition of being a society of scientists, is also an active organization going into project implementation, only a couple of years after its creation.

I want also to recognize and welcome the most valuable participation of the International Tropical Timber Organization (ITTO) in supporting the series of regional workshops ISME is now engaged in, in Asia, Latin America and Africa.

In spite of the growing concern and awareness of the important role the mangrove ecosystem plays in the tropical coastal zone, this one continue to be under heavy pressure for wood cutting and clearing for alternative utilization. The challenge to remedy to this situation is still ahead of us and ISME is the cornerstone of this crusade.

Probably one of the most useful function ISME can perform is to maintain a permanent record of the status of the mangrove ecosystems and forests in the world. In this regards, the task ISME has undertaken with ITTO to review the present situation in the various regions of the globe and, in the meantime, to build through these regions a network of key contacts, is an essential step.

It is my deep hope that ISME will succeed in this venture. I wish you a most successful meeting.

INTRODUCTION

Dr. Marta Vannucci

International Society For Mangrove Ecosystems, Okinawa, Japan

A short introduction should be made to state the reasons why we are assembled at this Niteroi meeting, to indicate the purpose of this Workshop and the aims that we hope to fulfill.

What is ISME, the International Society for Mangrove Ecosystems? The realization of the need for an International Society for Mangrove Ecosystems arose from the UNDP/UNESCO Regional Projects in Asia and the Pacific that ran from 1983 to 1990. These projects of which I was Chief Technical Advisor, commissioned a number of research activities and studies relating to the nature and management of mangrove ecosystems. In December 1989 an International Conference on Mangroves was held in Okinawa under the auspices of UNDP/UNESCO and several Japanese Government agencies. In conjunction with these meetings there was a meeting of the Regional Mangrove Coordinating Committee for Asia and the Pacific (RMCC). It was the unanimous feeling of these meetings that an International Society for Mangrove Ecosystems should be established as a matter of urgency.

ISME is based in Okinawa, Japan. UNESCO, through its COMAR program gives active support to ISME in technical and scientific aspects of the study and management of mangrove ecosystems.

The present workshop is the first activity of an ITTO/ISME project entitled "Conservation and Sustainable Utilization of Mangrove Forests in Latin America and Africa Regions". This project was drafted and submitted to ITTO - International Tropical Timber Organization - by the Government of Japan who also funded the project. ISME is the specialized executing agency that implements the joint ITTO/ISME project.

The main objectives of the project are: 1) To complement and support the current activities being undertaken in the utilization, conservation and management of mangrove forests in ITTO member countries in Latin America and Africa. 2) To document and disseminate the current knowledge and the best practices for management, conservation and research with respect to mangrove ecosystems in Latin America and Africa. 3) To provide information for developing a regional program in Latin America and Africa respectively for management, conservation and research of the mangrove ecosystems of those regions and their resources.

The main objective of the project is to produce an account, as complete as possible of the current knowledge of mangroves of the western hemisphere and Africa. It is planned to achieve this goal mainly through three workshops to be held in Brazil, Africa and Okinawa. We hope that it will be possible to collect and review critically the data available on traditional and present uses and management of mangroves.

The present workshop is focused on:

1) Summary presentations by countries of the status, use and management of the mangroves in their respective countries;
2) Designate focal points for the preparation of detailed country reports;
3) Promote the formation of National Mangrove Committees, similarly to those in Asia, the Pacific and some African countries. These committees operate at government level and are responsible for all national matters related to mangroves, including legislation for the conservation and management of mangrove resources. Sustainable development of the tropical coastal zone should be a major objective.

Funds earmarked for the project fall significantly short of a conservative estimate of the amount needed to fulfill adequately all the objectives proposed. Nevertheless, ISME decided to go ahead with the implementation of the project and to accept the challenge of an almost impossible task, because of the far reaching significance of the project. The project and its findings are important for the countries of the Western Hemisphere and Africa1 were the mangroves are being wantonly destroyed at an alarming rate.

Dr. Luiz Drude de Lacerda has been selected Coordinator of the project and we all wish him well in his arduous task, one that cannot possibly be fulfilled unless we are all united in giving him support.

Awareness of the importance of mangroves as life sustaining ecosystems also provide a great number of hidden benefits, is now widespread throughout the world thanks to the untiring work of the COMAR programme of UNESCO, ably guided by Dr. Marc Steyaert. ISME is carrying on the work done during eight years of exhaustive work by the UNDP/UNESCO mangrove projects.

It is now left to our minds and hands to work for the materialization of our growing understanding of the structure and dynamics of mangrove ecosystems, each with its own peculiarities. We all need to work together, each in his own field of activity, to go as far as possible in fulfilling the high expectations that ITTO and ISME have of our work.

Last but not least, as Vice-President of ISME, I wish to thank UNESCO for its untiring support and guidance and the National Research Council of Brazil (CNPq), for its important contribution of funds for travel and living expenses of representatives of all "mangrove states" of Brazil that has enable them to participate in this Workshop. We are greatly indebted to the countries and institutions who have sent their representatives to this workshop. We wish to express our gratitude to the generous hospitality extended to us by Universidade Federal Fluminense represented by the Rector Professor José Raimundo Martins Romêo. We are also grateful to the Departamento de Geoquímica and Departamento de Linguística of this University who have offered this very suitable venue for our workshop.

1. MANGROVES OF BERMUDA AND THE CAYMAN ISLANDS

Joanna Ellison

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Bermuda and the Cayman Islands are both British territories, Bermuda in the Atlantic to the East of Cape Hatteras, and the Caymans Islands in the NW Caribbean to the West of Jamaica. Both have low island type mangroves, building peat, and with salinity regimes controlled by groundwater outflow.

The mangrove area in Bermuda is small, less than 20 ha, but the location is significant as the most northerly location of mangroves in the world. The largest ocean-connected area is at Hungry Bay on the South shore, and with unusual small areas of inland mangroves all over the islands.

Productivity is low and seasonal, there are only two species of mangroves; *Rhizophora mangle* and *Avicennia germinans*. Mangroves at Hungry Bay have been retreating in the last century, possibly due to impacts of rising sea level. The Bermuda Biological Station for Research, established since 1928 has been the location for a number of studies of mangrove fauna and root communities, but there is no mangrove scientist on the staff. More ongoing work starts this year with participation in CARICOMP productivity monitoring and the UNEP-IOC-WMO-IUCN long term monitoring of mangroves with respect to climatic change program. The latter project is designed to monitor changes in zonation, community structure and distribution, and allow comparison between sites.

The Cayman Islands has considerable mangrove areas, particularly Grand Cayman, where 50% of the island is mangrove, covering 10,000 ha. These largely fringe the shallow North Sound Lagoon, where the Central Mangrove Swamps extends some 5,000 ha into the center of the island. While this area is pristine, mangrove forests on the West Bay peninsula are in many places filled for commercial and residential development.

Mangrove communities show considerable structural complexity owing to the irregular Pleistocene sub-surface, but generally there is a seaward *Rhizophora mangle* margin, 5 to 15 m tall, with 15 m tall *Avicennia germinans* and *Laguncularia racemosa* landward. The Mosquito Research and Control Unit has carried out considerable mangrove research in the last few decades, mapping the swamp communities at 1:25,000, with studies on productivity, fauna and physical processes. Cayman also participates in CARICOMP monitoring, and will be established as a UNEP-IOC-WMO-IUCN long term monitoring site in early 1993.

2. MANGROVE ECOSYSTEMS OF MEXICO: ECOLOGICAL FUNCTION, ECONOMIC VALUE AND SUSTAINABLE DEVELOPMENT

A. Yáñez-Arancibia, A.L. Lara-Dominguez, G.J.V. Zapata, E.R. Arriaga & J.C. Seijo

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Mexico has a total mangrove area of about 524,600 ha, of those 60% are located along the Pacific coast and 40% along the Gulf of Mexico coast. The Southeastern forests are identified as the most important biodiversity reserve of aquatic plants in Middle America. Major areas of mangrove forests are located in the States of Tamaulipas (8%), Veracruz (9%), Tabasco (13%), Yucatan (31%) and Campeche (39%), this latter State with circa 204,000 ha of mangrove forests. The Laguna de Terminos, State of Comeche, is the most scientifically, economically and culturally important coastal ecosystem of Mexico.

The Laguna de Terminos is a complex and diversified ecosystem in terms of use and resource. It is located in Campeche State and is the largest coastal lagoon of Mexico. Its surface is approximately 170,000 ha or about 250,000 ha if one includes the associated swamps and other fluvio-lagoonal systems.

Mangrove forests, which cover over 120,000 ha, occur along most of the coastline of the lagoon. These forests are highly productive with productivity rates ranging from 16.07 to 24.58 $kg \cdot ha^{-1} \cdot yr^{-1}$ and a litter fall rate ranging from 8.35 to 12.52 $kg \cdot ha^{-1} \cdot yr^{-1}$, depending on mangrove forest type.

The adjacent continental platform is one of the most important for fisheries resources of the Central Occidental Atlantic Ocean. Presently however, the major economic activity of Campeche State is oil and natural gas production, which produces 70% and 30% of the total Mexican production respectively. Also, lowland agriculture is expanding in the area (20,000 ha of rice fields). These activities present serious risks to the environment and in particular to the mangrove forests due to the urban expansion associated with them.

Mangrove forests have important ecological functions and optimization of the state of the ecosystem depends on the preservation of water and habitat qualities. In ecology, a clear distinction between ecological function of an ecosystem and its structural components is often made. From the economic point of view, this distinction is useful since it allows us to visualize the available resource and understand how ecological functions work as a bridge between the resource value and the economic net benefit. This bridge is frequently the best indicator of parameters which have to be measured to economically evaluate the ecosystem. For example, to preserve mangrove areas as nursery ground and food source for fish and crustacea and to protect the coastline, influence habitat quality and sustain fisheries.

The economic analysis needs an adequate identification of relevant ecological functions and of the products (or resources) generated. This evaluation may be most important regarding its impact on sustainable economic activities in a given area, including commercial values and those which "value" is inexistent in the market. The balance between both types of uses determine the balance between destruction and conservation, between irreversible environmental impact and sustainable development.

The importance of economic evaluation of ecological functions of mangrove ecosystems and of its resources of economic importance, is a very advanced research line. Along tropical coasts it is an urgent necessity, in view of the intensive and non-planned utilization of tropical coastlines, and due to the exploitation and optimization pressure upon its natural resources. Notwithstanding the economic importance of ecological functions of mangroves, these forests are historically being destroyed in tropical countries. Preservation legislation is still of little effect and in general is not a priority. The important point to stress is that the economic value of the ecosystem is connected to its physical, chemical and biological integrity.

These recent advances in mangrove research show the necessity to measure the processes which link ecology and economy of the ecosystem. With this perspective, the EPOMEX Program started a project on "Economic Importance of Ecological Functions of Mangrove Ecosystems: Campeche a Study Case". The major objective of the project is to give value to indirect uses or ecological functions of mangrove ecosystems. And also to obtain the direct value of major uses and products or resources which depend on mangrove ecosystems.

3. STATUS AND MANAGEMENT OF MANGROVES OF CUBA

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Cuba is the largest island of the Antilles with 4,020 km of a coastline, characterized by hundreds of bays. Mangroves are the largest forest resource of the island with a total surface area of about 529,700 ha, representing 26% of all Cuban forests and 4.8% of the country's area. The forests have large socio-economic importance, deserving proper management and conservation.

Mangroves of Cuba are formed by four tree species: *Rhizophora mangle, Avicennia germinans, Laguncularia racemosa* and *Conocarpus erectus*. In general the forests show a zonation pattern with a seaward fringe of low (4-5m tall) *R. mangle*, where conditions of salinity, inundation and wind are extreme. Behind it, a mixed zone of taller *R. mangle* and *A. germinans* occurs.

Major environmental conditions in this inner fringe are similar to those found in the seaward fringe forest. However, soils are characteristically more stable, the trees are exposed to less wind intensity, and inundation is restricted to tidal movement. Landward, a mixed zone of *A. germinans* and *L. racemosa* occurs. This zone is under lower salinity but still submitted to permanent inundation. The two species generally form monospecific stands. However, mixed stands are also frequent. In this zone, *A. germinans* reaches 5 to 13m in height and 25cm in diameter.

Inland the *Avicennia-Laguncularia* zone, a monospecific fringe of *C. erectus*, with trees reaching 15-20m in height and 20-30cm in diameter, occurs. Outside the marine influenced area, *Bucida bucera* is also common. This fringe is on relatively dry soils. However, the saline or brackish ground water table is very close to the soil surface.

The zonation pattern however, can show variability in protected areas, with low salinity, where mangroves may attain their maximum development. These areas are generally associated with river deltas and the inner portions of embayment.

Timber reserves of Cuban mangroves represent 21.09% of the country's total. Preliminary estimates show these reserves to reach 19.44 million cubic meters, with $43m^3 \cdot ha^{-1}$. *C. erectus* corresponds to 38.74% of the total timber volume; *A. germinans* to 34.56%; *R. mangle* to 17.76% and *L. racemosa* to 8.94% of the total mangrove timber volume. Mangrove wood is extensively used as fuelwood for the sugar cane industry. Also coal and construction wood is produced. There is still the need for appropriate technology for utilization of large dimensions wood. R. mangle bark is used for tannin production, but this use has been decreasing due to high production costs and substitution by artificial tannin.

Other important uses of mangroves are related to fisheries. The totality of oyster production of Cuba comes from mangrove areas. Also most inshore fisheries are in mangrove areas and intense aquaculture has been started. Another important use of these forests is for honey production. In April, May and June, inland honey production decreases. During this period nearly 40,000 beehives are transported to mangrove areas, representing 25.8% of the country's total. Honey source is *A. germinans* which is particularly productive.

Most mangroves of Cuba (61% of the total mangrove area) are protected. The major function being shoreline protection against ′ erosion, hurricanes and gales. Also mangroves shelter fauna such as *Capromus* sp., the manatee *Trichechus manatus* L. and *Crocodylus rhombifer* Cuvier and a great number of endemic and migratory bird species. Mangroves are also used for recreation, tourism, sport hunting and fishing. They also provide numerous jobs for the local population involved in honey production, aquaculture and oyster culture.

Most impacts on the mangroves of Cuba are from anthropogenic sources, in particular environmental contamination, deforestation and residues of the agriculture and sugar cane industries. The industrial development has created serious problems of contamination. The characteristic narrow shape of the island results in the discharge of toxic substances directly to the coast. Mangroves therefore, are under intense pressure from contaminants that cause injuries to forest ecology and its biota.

Oyster culture has been seriously affected by industrial contamination. Natural oyster banks have disappeared in areas where wastes from sugar cane processing plants are released. These residues are the major sources of contamination in the country.

Deforestation has resulted in some areas, in increasing soil salinity of soils adjacent to mangroves with varying impacts on agriculture. Nursery grounds for some economic important fisheries have also been affected with decreasing recruitment of larvae and juveniles. Tree mortality has also been detected, mostly along the North shore, and was probably caused by the application of pesticides in the local agriculture.

Mangrove research in Cuba started in the late 40's with studies on the ordination of coastal areas of the North coast. In 1969, mangrove forests were surveyed and their area estimated. This work was followed by a comprehensive ordination and classification study of the woodlands of Cuba, including mangroves. Recently specific multidisciplinary projects related to the conservation and utilization of mangrove resources, have been developed in collaboration with FAO and have resulted in proposals for the sustainable management of mangroves in Cuba. The Research Station on the Ecology of Mangroves of the Academy of Sciences of Cuba, located on the south coast has developed ecological research on mangroves during the last two years.

4. CONSERVATION AND UTILIZATION OF MANGROVE FORESTS IN TRINIDAD AND TOBAGO AND THE LESSER ANTILLES

Peter Bacon

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Mangrove forests occur on all islands in the Eastern Caribbean, but the areal coverage is generally small and many of the sites are in degraded conditions. The largest areas occur in Trinidad, which has approximately 7,000 ha of well developed forests with good timber resources. In the Lesser Antilles the major part of the mangrove has poor tree development; often forming low coastal shrub in response to hypersaline conditions and frequent hurricane damage.

A report is given on a comprehensive mangrove site inventory conducted during 1991 in Trinidad and Tobago and other islands which are member states of the Caribbean Community (CARICOM); these include Antigua, Barbuda, Dominica, Grenada, Montserrat, St. Kitts, St. Lucia, St. Vicent and the Grenadines. This study identified and mapped all mangrove areas in each of the islands and described their vegetation and conservation status. A first attempt was made to record forest mensuration data; as no information had been available previously on mangrove timber resources or other forest products from the region. Previous studies had concentrated on the general ecology of a few larger sites or on wildlife, particularly the avifauna.

Seven species and one variety of mangroves occur in the Insular Caribbean. *Rhizophora mangle* is the most abundant throughout the region, with *R. harrisonii* and *R. racemosa* apparently restricted to Trinidad; *Avicennia germinans* is widespread, whereas *A. schaueriana* is present on most islands but rarely forms large stands and *Conocarpus erectus* is a common component of littoral woodlands and wetland margins; *C. erectus* var. *sericeous* appears to be restricted to the northern islands of the Caribbean.

Mangroves form a range of estuarine, coastal fringe, basin and shrub communities; frequently associated with salt marshes and salinas. The largest areas are found at river mouths, while communities fringing sheltered bays and lagoons are the most widespread.

Subsistence use of mangrove areas for charcoal, poles, fish, crabs and oysters is important in most islands. Good data is available only from Trinidad and St. Lucia, but it is thought that these resources provide full-time employment to a significant number of persons in some areas. St. Lucia appears to be the only island where an attempt is being made to manage mangrove charcoal production; otherwise there is little regulation of resource extraction. One site in Trinidad is an important visitor attraction because of its scenic mangrove waterways and rich wildlife and some attempts are being made to encourage tourists to mangrove sites in other islands; these efforts providing employment for tour guides and boatmen.

Conversely, the rapid expanding tourism industry in the Insular Caribbean has had a major impact on mangroves because of their coastal location. Many mangrove sites have been lost or reduced in size as a result of resort expansion, construction of airports, marinas and golf courses and filling of mangrove swamps for biting insect control has occurred on several islands. In Barbados, only one large mangrove site remains and even this is threatened with conversion to a golf course. Few attempts have been made to incorporate wetlands into resort design and landscaping and further mangrove losses can be expected if tourism continues to develop. In many islands, such as St. Kitts and Grenada, uncontrolled resource use, dumping of solid waste and general neglect have allowed sites to deteriorate to the point where public appreciation of their ecological or potential economic value is low. Consequently, such sites are easily sacrificed to make way for development activity.

In most islands, mangroves are the responsibility of the forestry departments; while in St. Lucia the Fisheries Division has control because of the acknowledged importance of mangroves to the support of inshore fisheries. No island specifically mentions mangrove forests in any piece of legislation; they enjoy legal protection only where they are included in established forest reserves, as in Trinidad, St. Lucia and Dominica. In Trinidad extensive areas of mangrove are included in wildlife reserves, but little attempt has been made to manage the mangrove vegetation to enhance wildlife or productivity. In some islands, such as Montserrat, NGO's have provided protection to mangroves through their inclusion in nature reserves and parks; NGO's are active also in the area of public education concerning the value of mangrove ecosystems and their potential role in economic development.

Identified needs for the conservation of mangroves in Trinidad and other Caribbean islands are:

a- To improve legislation for mangrove protection.
b- To undertake detailed mangrove forest structure mensuration.
c- To make an assessment of mangrove forest resources in all islands.
d- To investigate the potential for mangrove stand improvement.

Table 4.1 Mangrove sites and areas in the Eastern Caribbean

Country	Number of site	Approximate area (ha)
Antigua	36	559
Barbuda	9	616
Barbados	8	10
Dominica	10	10
Grenada	21	49
Grenada-Grenadines	4	67
Montserrat	4	4
St. Kitts	8	71
Nevis	8	8
St. Lucia	19	157
St. Vicent	4	2
St. Vic.-Grenadines	13	48
Trinidad	38	7,020
Tobago	9	130
Totals	191	8,851

e- To develop techniques for obtaining sustainable yields of mangrove charcoal and of site management for fuelwood production.
f- To investigate the feasibility of engineering mangrove systems for fisheries improvement and wildlife conservation.

5. STATUS OF MANGROVE ECOSYSTEMS IN CENTRAL AMERICA

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The Central American isthmus has one of the largest ratio of coastline per unit area in the world. Extensive mangrove forests are found on both coasts of the isthmus. Climatic and hydrological variations along both coasts influence the floristic composition, structure and dynamic processes in these forests.

The mangrove flora is dominated by three species of the *Rhizophora* genus (*R. mangle, R. racemosa* and *R. harrisonii*), and two species of the *Avicennia* genus (*A. germinans* and *A. bicolor*). Also the Combretaceae *Laguncularia racemosa* and the tree *Pelliciera rhizophorae* are found in these forests, the last one being dominant in the rainy areas of the Pacific coast. The lianas *Phryganocidia phellosperma* (Bignoniaceae) and *Rhabdadenia biflora* (Apocynaceae), the woody vine (*Dalbergia prawnei* and the Malvacea *Hibiscus tiliaceus* and *Pavonia spicata* are present in most of the large mangrove forests under rainy climates.

The shrubs *Clerodendrum pittieri* and *Tabebuia palustris* are abundant in many areas. The first is usually on elevated saline sites under dry seasonal climate, the second occurs in rainy regions on elevated brackish soils, usually near stands of *Muellera frutescens*. Under rainy areas large monospecific stands of *Mora oleifera* can be found. The scarce herbaceous component shows *Hymmenocalis pedalis, H. littoralis* and *Crinum erubescens.*

A great variation is found in the structural development of mangrove sites. Under rainy conditions trees may exceed heights of 35m and a total biomass of 280 $t \cdot ha^{-2}$. Stand volumes range from 35 to 420 $m^3 \cdot ha^{-1}$ with an average of 163 $m^3 \cdot ha^{-1}$. In dry seasonal areas, structural development is usually reduced. A clear zonation pattern is observed where *Rhizophora* species dominate the seaward part of the forest, and *A. germinans* the inland part. Extensive salt flats at the landward margin of the forest may reach over 13,000 ha in the Gulf of Fonseca alone. The common pattern is a landward reduction in height and basal area (as low as 4 $m^2 \cdot ha^{-1}$) due to increasing salinity. High structural development in some stands as a consequence of large localized discharge of freshwater may cause volume and basal area similar to those found in rainy areas. Under these conditions *A. bicolor* can show basal areas of 42 $m^2 \cdot ha^{-1}$.

Most mangrove forests on the isthmus are protected under government administration. Legislation covers the status of forest reserves and wildlife refugees. Still effective management has been impaired by inadequate technical knowledge, management policies and financial resources.

A large proportion of the Central American population is concentrated in the lowlands of the Pacific coast of the isthmus. Therefore, in areas with high population density the pressure on mangrove resources is high. This is the case for the Pacific coast of El Salvador, Honduras and Nicaragua, and sections of the pacific coast of Guatemala and Panama.

All of the countries of the region have protected their mangrove forests through some kind of control. Legislation for mangrove protection is, in most of the countries, specific and very strict. However, enforcement is occasional.

Main activities in most of the sites are: artisanal fisheries, salt and firewood extraction, bark collection, charcoal production, tourism, clams and crabs collection and shrimp culture. Firewood extraction in Nicaragua is around 9,000 $m^3 \cdot yr^{-1}$, and about 500,000 poles are extracted annually. Crab collecting in El Salvador averages 250,000 $kg \cdot yr^1$ and 60,000 to 100,000 $units \cdot yr^1$ in Nicaragua. Charcoal production in Costa Rica reaches over 2,000 $m^3 \cdot yr^1$ and 15,000 $m^3 \cdot yr^1$ in Panama.

Shrimp culture in Honduras for example, is very intensive with over 8,500 ha of ponds. In Panama

Table 5.1 Coverage estimates of mangroves in Central America (ha).

Country	Pacific Coast	Caribbean Coast	Total
Costa Rica	41,290	40	41,330
Nicaragua	39,310	Unknown	39,310(?)
Panama	164,990	2,890	167,880
Guatemala	15,400	640	16,040
Honduras	46,870	74,470	121,340
El Salvador	35,240	---	35,240
Total	343,100	78,040	421,140

this activity covers about 6,000 ha. Salt ponds in Honduras cover about 1,300 ha and about 700 ha in Costa Rica.

In some areas of the Pacific coast of Nicaragua, almost 30% of the coastal population depends exclusively on mangrove resources. Social conditions associated with these mangrove forests are precarious. Health problems are common. In some areas of El Salvador, 36% of houses do not have latrines. Unemployment can be as high as 73% in some areas of this country. Literacy is of only 46% and even lower in many areas.

Research in most areas is low and sporadic with some universities conducting small thesis research. Costa Rica and Panama are the only countries with a medium level research effort, associated with state universities. Some NGO's and development agencies are planning or initiating assistance projects in mangrove areas of the isthmus.

Coverage estimates for Central American mangroves are presented in table 5.1. Total estimated area is 350,800 ha, however the Caribbean coasts of Honduras and Nicaragua are expected to have considerable coverage of mangrove areas for which no estimates are available.

6. MANGROVE USES AND CONSERVATION IN PANAMA

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Panama has mangrove forests along both the Pacific and Caribbean coasts. Along the Pacific coast mangroves extend over 1,697 km of coastline whereas in the Caribbean they extend over 1,160 km of coastline. Recent estimates show that mangrove forests cover on both coasts circa 200,000 ha, this estimate is lower than an international accepted previous one of circa 500,000 ha. This difference is probably due to lack of exactness of surveys and although the most recent estimate seems more realistic, such a large difference makes necessary a confirmation survey to produce more definitive numbers.

Mangrove forests of both coasts present differences which are a result of different environmental conditions. The Pacific coast is characterized by irregular coastline, with many large rivers and affected by large tidal ranges (up to 6 meters). The Caribbean coastline is rather regular, with few smaller rivers and small tidal range (frequently smaller than 0.5 meters).

Mangrove forests cover 165,000 ha along the Pacific with associated salt plains of circa 20,000 ha, locally called "albinas". The major mangrove areas (46,500 ha) are concentrated along the oriental coast in the San Miguel Gulf. In general Pacific mangroves are composed of red mangrove *Rhizophora mangle* and *R. brevistyla*; black mangrove *Avicennia germinans* and *A. bicolor*; white mangrove *Laguncularia racemosa*; and "pinuelo" mangrove *Pelliciera rhizophorae*. Frequently other species such as the "alcornoque" *Mora oleifera* and the "castano" *Montrichardia arborescens*, also develop along the extensive salinity gradient typical of this coast. The most developed forests present tree densities of 300-400 trees·ha^{-1}, basal area of about 13.5 m^{2}·ha^{-1} and maximum tree height of 40 meters.

Along the Caribbean coast mangrove forests cover only 6,000 ha, mostly concentrated in Bahia Almirante, at the occidental end of the coast. Although some stands present a fairly good development, along most of this coast and in particular along its oriental side, mangrove forests are frequently narrow fringes of small red mangrove trees along the coast of bays and island close to the coast. These stands are generally monospecific, with maximum tree height of 5 meters and short aerial root system. More rarely taller stands of black mangrove occur in this coast.

In general mangrove utilization in Panama is limited. The primitive methods of extraction and production are responsible for the low level of utilization and profitability. Although the activity is basically of subsistence, a large number of rural people benefit directly from it. Species mostly used are black and red mangrove, and a major part of the resource is to produce fuelwood, since about 70% of the rural population depends on fuelwood as energy source. Apart from fuelwood, part of mangrove production is used for charcoal production, poles for agriculture and rural construction. There is also a annual production of 10,000 "quintales" of bark used for tanning in the local industries.

Mangrove forests in Panama seem to have an enormous importance for the local fisheries, particularly along the Pacific coast. Among the 10 species of shrimps of economic importance, only 2 or 3 have no links with mangroves. The others spends from 3 to 4 months in the estuaries covered by mangroves, or at river months where mangrove organic debris is abundant. The same link is probably true for the Engraulidae (*Cetengraulis mysticetus*), major source of fish flour in Panama. Mangrove litter production in the area ranges from 9.0 to 20.0 $t \cdot ha^{-1} \cdot yr^{-1}$. Most important fisheries in Panama occur in the Pacific with a production equivalent to US$ 100,000,000. Major commercial species appear to related to mangrove forests.

Notwithstanding the importance of mangrove forests in Panama, anthropogenic impacts are increasing. However, although evidence of mangrove destruction exists, its magnitude and evolution through time are difficult to obtain due to different results from mangrove area surveys. For example, according to Plan de Acción Forestal Tropical para la Repùblica de Panama (PAFT-PAN 1990), mangrove forest cover prior to 1960 was circa 300,000 ha. However, the most recent survey (1990) from the Intituto Nacional Geográfico Tomy Guardia (IGNTG) shows a cover of only 176,000 ha. Is this difference is due to deforestation? Although the analysis of IGNTG shows mangrove deforestation of only 5,000 ha during this period. Deforestation is most intense along the Pacific coast and reclaimed areas are normally used for pasture or agriculture. Recently, reclamation of mangrove areas for shrimp culture and pressure from urban development caused some deforestation.

The future of mangrove forests in Panama will depend on the fixation of the value for the resource by the State. Presently it is necessary to reinforce restrictive actions which are normally weakly applied. In more serious cases it is necessary to use politics to define the real interest in this resource by the society. Answers and alternatives will involve a radical change of attitude in exploitation models, education, the distribution of benefits generated by the exploitation of natural resources, and on the capacity to apply legislation which enhances the benefits of the resource utilization.

7. MANGROVE ECOSYSTEMS OF COLOMBIA: UTILIZATION, IMPACTS, CONSERVATION AND RECUPERATION

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Colombia has about 3,000 km of coastline along the Caribbean and the Pacific, and has large mangrove areas of approximately 358,000 ha, 90% of those along the Pacific coast and the rest along the Caribbean. These mangrove forests have been studied continuously since 1950.

Since pre-columbian times mangrove forests have been used with different intensities and purposes. Anthropogenic activities have resulted in negative effects on those forests close to urban, industrial, tourism and fisheries centers.

Different climatological conditions, such as rainfall, temperature and solar irradiation, have resulted in significant differences between the mangrove forests of the Pacific, considered as humid tropical forests, and the Caribbean, considered as dry tropical forests. Pacific mangroves show higher structural complexity and mean volume (43.3 m^3), whereas Caribbean mangroves are smaller, with dwarf, reduced crown and small mean volume (40.0 m^3).

Utilization of mangrove forests in both coasts has been different. Along the Pacific coast, from 1945 to 1970, industrial extraction of tannin, caused the loss of most of timber; along the Caribbean coast, between 1965 and 1985, mangroves were used to produce construction wood and charcoal, without the utilization of bark. Local populations along both coasts have traditionally used mangroves as a source of construction wood, poles, fuelwood and charcoal. They have also used bark for tannin extraction and leaves for medicine.

Among natural factors, earthquakes, hurricane and heavy seas have degraded mangrove forests. Major anthropogenic factors are forest exploitation, fisheries, construction of roads and airports, dredging, urban, industrial and agriculture contamination and shrimp farming.

Control polices, protection and conservation of mangrove forests has been partially achieved by the creation of specific legislation, Forest Reserves, Fauna and Flora Refugees and National Parks. Also silviculture practices, using propagation of seedlings and natural regeneration, have been implemented. Studies related to the successional dynamics of mangroves and a National Ordination and Management Plan is being formulated.

8. THE STATUS OF MANGROVES FROM THE COAST OF VENEZUELA

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This work presents mangrove areas of Venezuela and the location of major forests, including new mangrove stands from Falcón State, one of the States with a longer coastline. Also discussed is the present legislation for mangrove protection, major forest uses and products and environmental impacts and conflicts in the utilization of Venezuelan mangrove forests. Finally a short review of the present research lines on mangroves and associated ecosystems in Venezuela is presented.

Mangrove flora of Venezuela includes *Rhizophora harrisonii, R. mangle, R. racemosa, Avicennia germinans, A. schaueriana, Laguncularia racemosa* and *Conocarpus erectus*. Among these species, *R. mangle, A. germinans* and *Laguncularia racemosa* are the most common species.

According to earlier estimates, mangrove forests of Venezuela cover about 673,000 ha, which would be the fifth largest in the world. However, this number is probably wrong, since it includes as mangrove area the "paramancillo" *Symphonia globulifera*, a plant with a light spectrum and general form easily mistaken in remote photointerpretation of mangroves. More recent and reliable estimates are reported by the Venezuelan Ministry of the Environment and Natural Renewable Resources (MARNR), giving a total area of mangroves of about 250,000 ha. The major mangrove areas of Venezuela are located along the Orinoco River Delta, the San Juan, the Limón and the San Carlos Rivers estuaries; the lagoons la Restinga, Tacarigua, Cocinetas and Sinamaica, and the Gulf of Cuare-Morrocoy Bay (Table 8.1).

With the exception of mangrove forests along the San Juan and Orinoco Rivers, which are typically fluvial and can attain over 40 m in tree height, all other mangrove forests of Venezuela are located in arid and semi-arid regions.

An important fraction of mangroves are located in areas protected by special legislation, such as National Parks, Forest Reserves, Fisheries Reserves and Fauna Refugees, which give them special status. Additionally, up to 1990, the "Decreto 110" constituted a barrier to the irrational exploitation of mangroves. However, in October, 1992, a new law opened the possibility of discriminate utilization of mangrove resources. This could eventually threaten some important mangrove areas.

Mangroves from Venezuela are presently threatened mostly by urban development directed to the enhancement of top quality tourism and by indiscriminate tree harvesting. Small scale threats are due to aquaculture, dispersion of waterways, and salt ponds. In some mangrove areas the environmental impacts have been well documented, such as in the Lagoon of Tacarigua and the Orinoco River Delta.

Major products extracted from Venezuelan mangroves are Vitamin-B2, food for animals, tannin, poles, cellulose, fuelwood and charcoal. These products are used by private and state industries, such as the National Institute of Sanitary Works, telephone and electricity companies, the Ministry of Transport and Communications, pharmaceutical companies and leather factories.

Presently the studies of Venezuelan mangroves are not integrated, being mostly derived from academic theses. Major research groups are the IVIC, where the Marine Biology Laboratory has studied the biology and ecology of the mangrove tree crab Aratus pisonii, and some aspects of the ecology of fouling communities on mangrove roots. Additionally the Ecophysiology Laboratory of IVIC, has started a large multidisciplinary project in the Oriental region of Venezuela, including the San Juan River and the Orinoco River Delta.

In the recent past, major contributions to the study of Venezuelan mangroves were done by Dr. Federico Pannier and by a group, formed in the 80's, by the Ministry of the Environment and Renewable Natural Resources.

9. MANGROVE ECOSYSTEMS OF ZARUMILLA-TUMBES, PERU NORTHERN

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Peru is the Southern most limit of mangrove distribution along the Pacific coast of South America. The country has two major mangrove forests. The larger one, with 58.5 km^2, is located in the Zarumilla Province, between 03°24' and 03°34' S and 80°13' and 80°31' W, at the estuary of River Piura. The second, smaller one, with only 3 km^2, is located at 05°32' S, at the Tumbes River estuary.

These forests are under a semitropical climate, with annual precipitation ranging from 66 mm to 300 mm, and mean annual temperature of 25°C, ranging from 18°C to 32°C. Occasionally the poorly known "El Nino" phenomenon causes rapid increases in rainfall. "El Nino" occurs during summer months with variable duration and effect on the region.

The Tumbes River is the major freshwater discharge to the coast with mean discharge of 109 m^3/s, increasing to 4,000 m^3/s during the "El Nino". Sediments transported by the river have a great importance for the local coastal dynamics and for the sedimentation of low estuarine areas. During

Table 8.1 Conservation units where important mangrove areas are included.

Name	State	Type	Area (ha)
M. de Coro	Falcón	National Park	91,280
Morrocoy	Falcón	National Park	32,090
Los Roques	Federal St.	National Park	225,153
L. Tacarigua	Miranda	National Park	18,400
P. Paria	Sucre	National Park	37,500
Mochima	Sucre	National Park	94,935
L. Restinga	N. Esparta	National Park	10,700
Guarapiche	Monagas	Forest Reserve	370,000
L. Marites	N. Esparta	Natural Monument	3,674
T. Ma Guevara	N. Esparta	Natural Monument	1,670
Cuare	Falcón	Fauna Refugee	11,825
Boca de Cano	Falcón	Fauna Refugee	---
Los Olivitos	Zulia	Fauna Refugee	4,063
Higuerote	Miranda	Protection Zone	35,820

exceptional high discharges, hundreds of metric tonnes of sediments may be deposited over the mangrove forests in the area.

Mangrove flora is represented by five tree species: *Rhizophora mangle, R. harrisonii, Avicennia germinans, Laguncularia racemosa* and *Conocarpus erectus*. Mangrove associates include xerophytic species, grasses and some trees such as the "algarrobo" *Prosopis chilensis*.

Mangrove fauna of special conservation importance are the white "pava" and the American crocodile (*Crocodilus acutus*), which presently show very small populations. Among the economic important aquatic species are fish from the Mugilidae, Centropomidae, Scianidae and Ariidae. The bivalve *Anadara tuberosa, A. similis, Chione subrugosa, Donax asper* and various species of clams and oysters. Important crustacea are shrimps (*Penaeus* spp.) and crabs (*Ucides occidentalis*). Great diversity and densities of planktonic species are also typical of the area.

Peruvian mangroves are under high natural environmental pressure. Coastal erosion is frequent between the Tumbes River estuary and Punta Capones. Sediments transported by the Tumbes River are spread and deposited along the North littoral. The low rainfall results in high salt concentration. The intense rains during the "El Nino" result in large geomorphological changes in the coast with strong effects upon the mangroves.

Among the human activities, shrimp culture resulted in deforestation and decrease in post-larvae and juvenile populations.

Mangroves are legally protected although there is still a certain lack of enforcement. The organizations in charge of the mangrove protection are the Zarumilla Municipality, the University, the Central Peruana de Servicios, the Peruvian Foundation for Nature Conservation, Tumbes Silvestre and the Tourism Promotion Fund. Reforestation programs, detailed mapping of mangrove resources and cultivation of Crocodilus acutus has been started in the region.

10. BRAZILIAN MANGROVES

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Brazil has 7,400 km of coastline, and according to earlier estimates, about 2,500,000 ha of mangrove forests. This estimate is probably an overestimate. Mangroves are found from the Oiapoque River (04°30'N) to Laguna (28°30'S), under a wide range of environmental conditions. This great diversity in growing conditions is reflected in variable tree form, spatial arrangements of species and stand structural attributes. Some potential floristic variability is limited by the fact that western hemisphere mangrove forests are species poor (less than 10), while Old World forests have a very large number of species (over 40 species). Although these numbers may change, depending upon which are considered true mangroves or major species, certainly this difference is of great interest because of the many implications for research and management.

The Brazilian mangrove species are: *Rhizophora harrisonii, R. racemosa, R. mangle, Avicennia germinans, A. schaueriana, Laguncularia racemosa* and *Conocarpus erectus*. This apparent species simplicity is deceptive, since they are extraordinarily malleable in their adaptation to the environment. The varied responses of these few species to local tidal patterns and terrestrial drainage influence means that where mangrove stands share similar environmental conditions, they attain similar levels of structural development and function.

Brazilian tidal amplitudes decrease southward, from strongly macrotidal, with amplitudes greater than 4 meters, to mesotidal range (2 meters) and less (0.24 meters at Laguna). Mean annual rainfall varies strongly along the coast, attaining the highest values in the northern most state of Amapá (3,250 mm), and the lowest in the northeastern states, where potential evapotraspiration and precipitation values become similar. Most of these regions suffer droughts and hypersalinity that become a seasonal stressor. The mean annual temperature at Laguna is 19.6°C, with annual mean range of 8°C. Beyond this site mangroves eventually become limited by low temperatures and sporadic frost events.

Extraordinarily well developed black mangrove (*Avicennia germinans*) forests are typical of the northern Brazilian coast. Interestingly, mangrove development and coverage near the Amazon River delta is restricted because of the overwhelming fresh water discharge and intense tidal and wave energies. Mature red mangroves (*R. mangle*) at their latitudinal southern limit (Sonho Beach, 27°53'S) barely reach 1 meter tall, but black mangroves (*A. schaueriana*) still reach more than 8 meters in height at Laguna (28°30'S). The landscape here is dominated by herbaceous vegetation (*Spartina, Juncus* and *Paspalum*) with scattered and isolated white mangrove (*L. racemosa*) clumps.

Brazilian mangroves are threatened by diverse natural and anthropogenic disturbances. These contribute to the degradation of mangrove areas through physical fragmentation of landscape and the impoverishment or irreversible loss of genetic resources.

From earliest colonial times, mangrove forests captured the attention of New World explores, settlers and naturalists. Coming from temperate coastal landscapes dominated by herbaceous marshes, they were fascinated by these remarkable trees with ability to grow in seawater, forming impressive and often impenetrable mazes of aerial roots. They soon discovered that these plants yield useful products like timber, firewood and bark for tanning leather. In contrast to the indigenous populations that had lived, fished and made use of these forests for millennia without drastic alterations, New World settlers initiated dramatic changes that ultimately led to the depletion or degradation of the resource.

Recently, dredging and filling, industrial and urban pollution has resulted in large losses of mangrove areas. Low sheltered embayment often containing extensive mangroves are prime sites for the establishment of large industrial complexes, resorts and extensive mariculture projects.

Brazilian mangroves cannot be privately owned since they are public lands. This is a constitutional mandate reaffirmed by Brazil's new constitution (1988). Under the present legal framework mangroves must be administered for the welfare of the community.

The alarming rate at which mangroves are being destroyed in the region requires that prompt actions be taken to develop a regional program, capable of fostering and supporting ecosystem research, the development and compilation of management guidelines. The great malleability and accommodation to site factors exhibited by mangroves creates a requirement for management strategies that are site specific.

Brazil has many high quality scientific institutions that could contribute in significant ways to the protection of these resources. Thus, technical resources, manpower, and infrastructure are available. What is required is a great degree of liaison or coordination of efforts between existing institutions and supplemental financial support for specific activities, enforced by political will.

11. MANGROVE FORESTS OF PARÁ STATE, NORTH BRAZIL

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The State of Pará has an area of 124,802,400 ha, which is 25% of the area of Legal Amazon and 15% of the area of Brazil. It also has 598 km of coastline where mangrove forests are the dominant plant formation. These forests form a nearly continuous fringe along the coast penetrating landward up to 40 km. This penetration includes the larger rivers such as the Tocantins and the Amazon.

Typical species composition of Pará mangroves is: *Rhizophora harrisonii, R. mangle, R. racemosa, Avicennia germinans, A. shaueriana* and *Laguncularia racemosa*. Transition vegetation includes: *Conocarpus erectus, Acrosticum aureum* and *Hibiscus* sp. Other associates are frequently found in these mangroves: *Montrichardia arborescens, Pterocarpus rohrii, Bombax aquatica, Mauritia flexuosa, Euterpe oleracene, Drepanocarpus lunatus* and *Anona palustris*.

Various mangrove forests are being studied in the region. In general most of them are very well structurally developed. With trees reaching over 30m and high biomass. Over 45 species of animals are found in the mangroves of Pará. Of those Crustaceae and Mollusca are of particular economic importance to the local population.

Impacts on these forests are due to deforestation for housing, rice fields, road and aquaculture pond constructions; urban and industrial sewage effluent, small oil spills from boats in localized areas, changing waterways patterns; and overfishing. Major research in the area is carried on by the Federal University of Pará and the Emilio Goeldi Museum. Recently an environmental protection area of circa 23,800 ha, was established.

12. MANGROVES OF MARANHÃO STATE, NORTH BRAZIL

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The coast of Maranhão extends over 640 km, from 01°01' to 10°21'S and 41°48' and 48°40'W. Tide ranges between 4 to 8 m are typical of this coast. Annual precipitation averages 2,500 mm and air temperature has an annual range from 25 to 27°C. Along this coast mangrove forests may cover over 500,000 ha.

The western coast of Maranhão State has thirteen major bays, a hundred islands covered by mangroves and large mud flats areas. About 45 miles offshore, is one of the most extensive coral reef areas in South America (the Parcel Manuel Luís), which indirectly depends on the functioning of coastal mangroves to trap continental sediments.

The eastern coast of Maranhão has mangroves spread over five major embayments, seventy islands and large mudflats areas from the deltaic region of the Parnaíba River. A continuous ridge of sand dunes (Lençois Maranhenses) separates the bays from the delta. Between the eastern and western coast there is the Golfão Maranhense, a large estuarine Gulf area formed by the São José Bay and São Marcos Bay, where São Luís island is located. Mangroves cover almost all the gulf extension entering far inland up the rivers.

The mangrove flora of Maranhão is composed of *Rhizophora harrisonii, R. mangle, R. racemosa, Avicennia germinans, A. schaueriana, Laguncularia racemosa* and *Conocarpus erectus*. Riverine areas have the most developed mangroves with 30-40 meters tall trees. Mangroves in São Luís Island show little structural development due to urban and industrial impacts.

Transitional areas may show a variety of ecosystems as fresh water palm tree forests with *Euterpe* sp. and *Mauritia* sp., and other hypersaline habitats. Arid environments show *Batis maritima, Blutaparon* sp. and *Sesuvium portulacastrum*. In sandy areas *Sporobolus* sp. and other grasses and sedges occur. Freshwater marshes frequently located backward of mangroves contain *Eleocharis* spp., *Nymphea* spp. and *Neptunia* sp.. The salt marsh grass *Spartina* sp. may occur as seaward fringes in some sites.

Mangrove fauna present are crabs, oysters, clams and shrimps, which are used as an important food resource and support significant fisheries. Three species of vertebrates that occur in the Maranhão mangroves are in danger of extinction: the monkey, *Chipotes satanas*; a manatee: (*Trichechus manatus*) and the red bird: *Eudocimus ruber*. Of concern to public health is the discovery of the snail *Biomphalaria* sp., vector of schistosomiasis in oligohaline mangroves on parts of the coast.

Natural impacts on these forests are due to strong tidal currents, storms during the rainy season, hypersalinity and moving sands from aeolic dunes along the Eastern coast.

Human impacts are related to harvest for timber, charcoal and fuelwood, which can be very extensive in the São Luís area. Salt extraction also occurs in some areas. Pollution is restricted to mangrove areas closed to urban centers. Honey extraction in Maranhão is made in a predatory way and may represent an impact. Frequently, people cut the *A. germinans* trees to access beehives (*Melipora* sp.). No other use is made to the wood in this case and timber is often left inside the mangrove forest.

13. MANGROVES OF NORTHEASTERN BRAZIL

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The Northeast cost of Brazil includes the States of Piauí, Ceará, Rio Grande do Norte, Paraíba and Pernanbuco. It shows two distinct segments separated by the Calcanhar Cape in Rio Grande do Norte State. The first segment extends towards

NW-SE from the Cape to Maranhão State. The second extends towards N-S to the Bahia State coast. The differences in physiography, hydrology, hydrodynamics, geology and oceanography of the set two segments are the subject of an important integrated study of the whole coast.

The Northeast coast of Brazil is located between latitudes 3°S and 16°S and between longitudes 34°W and 46°W. Although in the tropics, its pluvimetric regimes make it unique and different from other tropical coasts in the country. The climate is semi-arid, with low precipitation throughout the coast and showing typical seasonality of arid regions. This seasonality is poorly understood and typically ranges from less than 50mm to over 300mm. Significant temperature variations do not occur in the region.

Mangrove forests along this coast are influenced by the different physical settings of the coast. In the first segment of the coast (the NW-SE segment) mangroves occur on more sandy soils, with dominance of silt in relation to clays, due to the occurrence of large sand dune fields along the entire coast. In the second segment (the N-S segment) mangroves occur on clay-silt sediments with very little sand. The dominant trees are those typical of Northern Brazil: *Rhizophora mangle*, *Avicennia* spp., *Laguncularia racemosa* and *Conocarpus erectus*. These forests are responsible for high aquatic productivity where they occur.

Major uses of Northeastern mangroves are related to artizanal fisheries. Fuelwood, timber for small constructions and fishing traps are also used in the region. Major impacts are the construction of real estate and marinas, salt pond construction and shrimp farming.

Table 13.1 shows the area of mangrove forests along the Northeastern coast of Brazil. The State of Piauí presents only 70km of coastline and circa 4,370 ha of mangrove forests located along estuarine areas. The larger mangrove forest is located in the Parnaíba River delta with about 271 ha. Salinity here ranges from 10 to 38 %., depending on the season. However, mangrove forests are limited by large dune fields typical of the region.

Ceará State, which has over 573 km of coastline, has the largest mangrove forests of the Northeast (22,940 ha). The climate is humid-tropical (AW') with a salinity range from 3%. to 38%. depending on the season. The largest forests are located along the estuary of the Timonha/Ubatuba River (10,100 ha). Rio Grande do Norte State presents the driest climate of the Northeastern coast, with precipitation smaller than 1,000 mm per year. Most of the salt production and shrimp farming occurs along this coast. Total mangrove area is 6,900 ha. The State of Paraíba although with a shorter coastline (130km) is under a more humid climate and therefore has larger mangrove areas (10,800 ha). Finally, along the State of Pernambuco which has a very short coastline, on high humidity (1,750 to 2,000 mm of rain per year), mangroves cover 7,810 ha.

Table 13.1 Mangrove areas of the Northeastern Brazilian coast.

State	Total area (ha)
Piauí	4,370
Ceará	22,940
Rio Grande do Norte	6,900
Paraíba	10,800
Pernambuco	7,810
Total	52,190

14. ENVIRONMENTAL STATUS OF MANGROVE FORESTS OF RIO DE JANEIRO STATE, S.E. BRAZIL

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The coast of Rio de Janeiro extends for 714 km, accounting for approximately 10% of the total Brazilian coast; between latitudes 21°37'S and 23°28'S. The littoral is limited by the pre-cambrian granitic shield of the "Serra do Mar" and "Serra Geral" mountain chains. This part of the Brazilian coast has a population of about 20 million inhabitants and harbors the second largest industrial development in Brazil including large petrochemical facilities, steel plants and chemical industries. Anthropogenic pressure is enormous, to a point that only 9% (about 390,000 ha) of the State's area is covered by natural vegetation. The deforestation rate in Rio de Janeiro State is estimated to be about 4,000 $ha \cdot yr^{-1}$.

The coast of Rio de Janeiro can be roughly divided in two different sections. The first, located south of Guanabara Bay and Rio de Janeiro city is dominated by the contact of the granitic shield with the sea. This section presents large semi-closed water bodies including the Guanbara, Sepetiba and Ilha Grande Bays and various islands. The second, north of Guanabara Bay, is dominated by extensive quaternary plains, formed during events of sea level change, between 8,000 and 3,000 years BP. It presents a number of coastal lagoons with varying salinities and is crossed by the four major rivers of the Southeastern Brazilian coast (the Itabapoana, Paraíba do Sul, Macaé and São João rivers).

Mangrove forests occur along the entire coast being dominant along the southern section, where they occur as large forests in the inner sections of bays and embayment and in protected shores of islands. Along the northern section, mangroves are restricted to river deltas, where they may form large stands, and in some coastal lagoons, where they typically occur as narrow fringes.

The mangrove flora is composed of true mangrove species (*Rhizophora mangle, Avicennia schaueriana, A. germinans* and *Laguncularia racemosa*) and mangrove associates, in particular the Malvacea *Hibiscus tiliaceus* and the fern *Acrosticum aureum* at the landward margin of mangrove forests. Since Rio de Janeiro is at the northern limit of typical warm temperate plant formations, belts of the grass *Spartina alterniflora* are common at the seaward margin of mangroves.

In areas where salt pans ("apicuns") occur, extreme halophytes such as *Salicornia* spp. and *Sesuvium portulacastrum* are frequent. Dense algal mats of *Rhizoclonium* spp., on the sediment, and of *Bostrichium* spp. on prop roots and pneumatophores, are typical of these mangroves. Along the southern section of the coast, due to the proximity of the Atlantic Forest, epiphytes typical of this formation can occur in mangroves, in particular bromeliads and orchids.

Local mangrove fauna is highly diverse. It includes many invertebrate species of economic importance. Among these the crabs, *Ucides cordatus, Callinectes danae* and *Cardisoma guanhumi*; the mussel, *Mytella guyanensis*; the clams, *Macoma constricta* and *Anomalocardia brasiliana*; and the oyster, *Crassostraea rhizophorae*, are of particular economic importance to the local population.

Major commercial fish and shrimp catches of Rio de Janeiro are based on mangrove associated species like the fish, *Mugil* sp., *Centropomus* sp., *Sardinella aurita* and *Brevoortia tyrannus* and the shrimps, *Penaeus* spp.. Nearly all of the 270ton per year of commercial shrimp caught in Sepetiba Bay, depend on mangroves either for nursery, shelter or food.

Many bird and mammal species are frequently found in mangrove areas where food abounds. Sixty seven bird species have been recorded for the large mangrove forest of Guanabara Bay. Among the mammals, marsupials are frequent in Rio de Janeiro mangroves.

Major mangrove areas (Table 14.1) occur along the southern section of the coast with a total of approximately 16,000 ha, 94% of total mangrove area of the Rio de Janeiro coast, whereas only 1,000 ha of mangroves occur along the northern section of the coast. The larger forest is located at Guanabara Bay, with circa 10,000 ha and Sepetiba Bay, with circa 3,500 ha. The northern section has its major forests along the Paraíba do Sul River Delta, with circa 7,600 ha. In this area *Avicennia germinans* presents its southern most limit in the Atlantic Ocean. The Itabapoana River estuary presents circa 100 ha. Coastal lagoon mangroves cover only about 300 ha.

The Sepetiba Bay forests are those better studied. They typically present above ground biomass of about 65 $t \cdot ha^{-1}$ and below ground biomass of about 16 $t \cdot ha^{-1}$. Tree density ranges from 4,000 to 5,000 $trees \cdot ha^{-1}$, with basal area of $22 m^2 \cdot ha^{-1}$, and mean height of 6.0 m. These characteristics are typical of sub-tropical mangrove forests and are probably similar to other Rio de Janeiro mangroves.

Utilization of mangrove resources, with the exception of mangrove associated fisheries, are very restricted. Fuelwood is only used in small bakeries and potteries along Guanabara Bay. Production of poles and construction wood is virtually non-existent, as is the extraction of mangrove bark for tannin production. Mangrove invertebrates in particular crabs and clams, are widely consumed by the local populations and frequently sold to tourists.

Anthropogenic and natural impacts on Rio de Janeiro mangroves are intense and very diverse. In the northern section, the forests in the Itabapoana and Paraíba do Sul rivers deltas are basically pristine. However, this latter area is suffering the effects of sea level rise which has caused constant alterations in shore dynamics with sand dunes moving onto mangrove areas. In the other mangrove areas, at the Macaé and São João rivers and in particular those inside coastal lagoons the urban development and coastal resort construction has caused intensive deforestation, to a point that in some lagoons (e.g. Itaipù Lagoon and Saquarema Lagoon) mangrove fringes have nearly disappeared.

Along the southern section of the coast industrial development has caused great impact on the mangroves, either directly through deforestation for land reclamation or indirectly through the contamination of mangrove resources with toxic substances. In Guanabara Bay large solid waste disposal sites are located in mangroves. Also, oil spills are a permanent threat to these forests due to the intensity of ship traffic to the two major oil terminals located inside the Bay. In Sepetiba Bay generalized heavy metal contamination is a constant threat to mangrove fauna and flora. Southwards along the Ilha Grande Bay, major threats to mangroves are caused by building of marinas, condominiums and other related tourism activities.

Notwithstanding the anthropogenic pressure presently threatening Rio de Janeiro mangroves, a strong conservation conscience has grown up among the government of the State and the general public. Environmental protection areas have been established in many parts of the coast. The most important is the Guapimirim Forest, in Guanabara Bay with nearly 4,300 ha of mangroves. Ecological reserves have also been established, protecting important mangrove sites, such as the Guaratiba Reserve (220 ha) and the Ilha Grande Reserve (60 ha). Military areas along the Sepetiba Bay have incidentally protected over 3,000 ha of mangrove forests and associated ecosystems.

Legal, management and conservation matters related to mangroves in the Rio de Janeiro State are carried out by three State authorities. The State Forests Institute; the State Environmental Engineering Foundation; and the State Authority for Rivers and Lagoons. All these institutions work under policy guidelines laid down by the State Secretary of the Environment. Also the Federal

Table 14.1 Major mangrove areas of Rio de Janeiro State, southeastern Brazil and theirconservation status (EPA-Environmental Protection Area; ER-Ecological Reserves;M-Military Area; MP-Municipality Park).

Site	Area (ha)	Status
Itaboapoana River Delta	101	no
Paraíba do Sul River Delta	760	none
Macaé River Estuary	43	none
São João River Estuary	41	none
Coastal lagoons	~300	none, MP
Guanabara Bay		
Guapimirim Forest	4,300	EPA
Others	5,700	none
Sepetiba Bay		
Marambaia	2,500	M
Guaratiba Reserve	215	ER
Others	700	none
Ilha Grande	60	ER
Cairucù	209	EPA
Tamoios	417	EPA
Other	~500	none
Total	15,846	

Institute for the Conservation of Nature and Natural Resources (IBAMA), control the mangrove forests of the State, since all mangrove forests in the country are protected under Federal law.

15. CURRENT KNOWLEDGE OF THE MANGROVES OF PARANÁ STATE, SOUTHERN BRAZIL

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The State of Paraná, Southern Brazil, has a coastline of only about 100km. It contains the best preserved mangrove forests of the Brazilian southeast coast. Major forests are located along the estuarine complexes of Paranaguá and Guaratuba Bays. Total area of mangrove forest along the Paraná coast is about 51,000 ha including saltmarsh communities which frequently occur as discontinuous belts in front of mangroves. Some debate still exists as to the total mangrove area of Paraná State.

The present state of conservation of mangrove forests in Paraná is an outcome of the historical colonization process, which contrary to most of other Brazilian littoral states, concentrated main human settlements and urban development in the highlands, the so called "primeiro planalto", up the Serra do Mar mountain range. Even today industrial and agricultural activities are rather incipient along the coastal plain, which has a maximum length of about 50 km. Paranaguá is the major urban concentration in the coastal zone, with approximately 120,000 inhabitants.

Species composition, forest structure, and distribution patterns are similar to those reported for other southeastern mangrove areas. Local mangrove trees are *R. mangle, L. racemosa* and *A. schaueriana*. Grasses, such as *Spartina alterniflora* and *S. densiflora* and sedges are frequently found associated with the mangrove forests. Notwithstanding their location near the southern limit of mangrove forests, the trees are well developed. *R. mangle* and *L. racemosa* height ranges from 8.0 to 15 and 13 m respectively, while *A. schaueriana* can attain up to 17m in height and a diameter of nearly 50 cm. No significant zonation pattern has been observed in these forests.

Detailed studies of forest structure, litter fall and leaf decomposition have been carried out in euhaline and oligohaline sites of Paranaguá Bay. Litter fall rates range from 223 $kg \cdot ha^{-1} \cdot day^{-1}$ under *L. racemosa* and *R. mangle* stands of average development, to 459 $kg \cdot ha^{-1} \cdot day^{-1}$ under *L. racemosa* and *A. schaueriana* stands of average development. Leaf litter is the dominant component corresponding to 79% of the total litter fall. Litter fall daily rates present significant seasonal distribution with summer values over six times higher than winter values. Litter decomposition rates estimated for the mangroves of Paranaguá were faster than many reported for other tropical and subtropical regions, probably due to active grazing macrofauna. Half-life decomposition rates ranged from 10.5 days, for *A. schaueriana* permanently immersed, to 249 days for *R. mangle* under supralittoral conditions.

Data on the seasonal variation of biomass and production dynamics of associated saltmarshes in the euhaline sector of Paranaguá Bay, besides typification and zonation of those systems, have also been studied. In general, below ground biomass of these marshes is seasonal (1.72 and 5.69 $t \cdot ha^{-1}$, in the end of summer and spring respectively). Below ground production reaches up to 3.58 $t \cdot ha^{-1} \cdot yr^{-1}$, exceeding above ground primary production which typically ranges from 1.01 to 1.79 $t \cdot ha^{-1} \cdot yr^{-1}$. In comparison with temperate *Spartina* marshes, the low productivity and low biomass of the high-energy sector of Paranaguá Bay are probably a result of different growth strategies, high salinities and fast sediment accretion, which usually lead to their ultimate replacement by mangroves.

An analysis of mangrove past evolution, present structure, and the impact of anthropogenic activities, through the use of field data, aerial photography and remote sensing (SPOT images), covering the whole of Paranaguá Bay has just been finished. There is also a extensive study of the evolution of the coastal plain as a whole during the quaternary, with a detailed analysis of sea level change, including information on plant formations and other biological indicators.

Other scientific outputs related to mangrove forests in the region concern benthic macrofaunal ecology of intertidal areas which includes not only mangroves, but also the associated saltmarshes and bare mud flats. The Southern Brazilian coast (mainly the state of Paraná and Santa Catarina) is a transitional zone between the tropical mangroves and the subtropical and warm temperate saltmarshes. Saltmarshes have been traditionally considered as a structural and functional part of mangroves in the tropics and sub-tropics. However, local studies on the structure and temporal variability of benthic macrofauna, do not support this view. In addition to obvious differences in plant architecture between mangroves and saltmarsh plants, seasonal cycles of detritus production are locally inverted in the Paraná littoral. *Spartina* marshes produce detritus mainly in winter, whereas mangrove litter fall is much higher in summer, which locally corresponds to the wet season. On a small scale, plant architecture and detritus availability seem to be the main source of macrofaunal variability, rather than sediment nature or its geochemical properties. On large scale, local macrofauna associations in mangroves, saltmarshes and mud flats respond primarily to environmental energy and salinity gradients.

Uses and misuses of Paraná mangroves are similar to those reported for other Brazilian coastal areas, being in a way very restricted. Subsistence use of mangrove shellfish (*Crassostrea rhizophorae, C. brasiliana, Mytella guyanensis* and *Anomalocardia brasiliana*) and of mangrove crabs (*Ucides cordatus* and *Callinectes* spp.) and fish (mullets during winter, and catfish and flat fish) is still important both in Paranaguá and Guaratuba Bays. This kind of artisanal exploitation, which has a strong seasonal component, is still a major source of income for a significant part of the coastal population.

Other important activities related to the local mangroves are shrimp fisheries, which are limited to the estuarine areas, and the production of "iriko", a "delicatessen" made of fried and salted juveniles of *Engraulis* sp. Iriko production is mainly concentrated in the Guaraquecaba region, and it may reach up to 40 tons per seasonal cycle. Iriko which is mainly utilized by the Japanese of Sao Paulo and Paraná, is by far the most highly priced marine resource in the whole region.

Shrimp and iriko exploitation is still artisanal. However, the use of special nets for shrimps "gerival" and of extremely fine-meshed nets for iriko capture can be very harmful to natural stocks. In this case it is a real myth to speak of an ideal balance between such activities of the local fishermen and the local marine systems.

Local use of mangroves as a source of wood and charcoal can be considered negligible, despite the lack of reliable data. The main impacts on mangroves in the area are deforestation and land-filling for low income housing, although restricted to the surroundings of Paranaguá and Antonina towns, and the rapidly expanding tourism industry, which affects mangroves and the coastal plain as a whole. Uses of mangroves for sewage disposal and sanitary sites are restricted to the town of Paranaguá and smaller human communities. No shrimp farm or silviculture programs are planned for the mangrove areas of Paraná state.

Federal and State environmental agencies have been efficient in preventing the developing of marinas and real estate in mangrove areas, and have achieved more success than other coastal states in Brazil.

16. MANGROVES IN SANTA CATARINA, SOUTH BRAZIL

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Santa Catarina State, South Brazil, is the southern most limit of the mangrove forests of the Southern Hemisphere. Mangroves along this coast reach up to 28°30'S. There are about 19 areas of mangrove forest along the State's littoral. However, their total area is poorly known. The three largest mangrove sites account for over 3,000 ha. Tidal amplitude ranges from 0.2 to 2.0 m, the mean annual temperature is about 20°C, and evaporation frequently exceeds precipitation.

Mangrove composition of Santa Catarina forests includes *Rhizophora mangle, Avicennia schaueriana* and *Laguncularia racemosa*. Extensive fringes of the salt marsh grass, *Spartina alterniflora* at the seaward margin, are also typical of these forests.

The status of conservation in Santa Catarina mangrove is variable, with many areas still pristine. Others present different degrees of degradation mostly due to deforestation for land reclamation for urban development, marinas, real estate and agriculture. In some areas disposal of solid wastes and urban and industrial pollution also occur.

Many studies are presently being developed in the mangroves of Santa Catarina, focusing on mapping, floristic composition, ecological parameters, and associated fauna and flora. Also social and economic aspects and mangrove regeneration experiments are presently taking place.

17. STRUCTURE AND FUNCTION OF OIL IMPACTED MANGROVE FORESTS: SÃO PAULO, BRAZIL

C.C. Lamparelli, F.O. Rodrigues & D.O. Moura

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The Brazilian coastline is 7,400 km long; it has a variety of estuaries, backwaters and coastal lagoons, most of them dominated by mangrove forests whose total surface is about 2.5 millions hectares. Along the coast, urban areas and industrial plants cause ecological disturbances to the coastal environment. One of the most harmful impacts is caused by oil pollution that affects particularly wetlands such as mangroves.

A long term survey has been carried out on the coast of São Paulo State, Southeastern Brazil since 1984, after a spill of 2,500 tons of crude oil reached the mangroves following a pipeline burst. The aims of this study are: to determine the effects of the oil spill on the mangrove ecosystem; to develop an impact evaluation methodology; to develop rehabilitation techniques under the environmental conditions prevailing in the study area.

The study is in progress and monitoring continues. Results so far show that the forest was seriously damaged. Reduction of the basal area was from 40% to 20% of the forest density. Loss of basal area was greatest for *Avicennia*, thus this appears to be the more vulnerable species of the three present in the area. The three species showed a continuous increase of leaf area after the event that caused an initial high rate of defoliation. Increase of leaf area was for *Rhizophora mangle*: 18.5%; for *Laguncularia racemosa*: 17.7% and for *Avicennia schaueriana*: 27.2%. There was a reduction of herbivory on the three species.

Propagule density was reduced and was accompanied by atrophy and malformations of the remaining propagules. The impacted area was rapidly colonized by new seedlings that grew up to about 1.0m high; 100% mortality followed when the nutrient reserves of the propagules were exhausted. The growth of seedlings into sapling could not take place, probably because of the presence of toxic residues in the water and soil of the impacted area.

Leaves showed chronic effects such as withering, necrosis, discoloration and malformations. Fissures in the epidermis, desiccation and necrosis of the stem were frequent. Anomalous shaped prop roots were formed and died off before reaching the sediment's surface.

These observations may be used to develop an impact assessment methodology in events of oil pollution in mangrove areas. First, basal area and forest density are the most reliable indicators of environmental quality. Second, high density of seedlings does not necessarily represent recovery. A better criterion to this is the presence of rooted saplings. Third, structural responses of mangrove forests to oil are slower than functional responses and can be divided in four post spill phases as follows: 1. Immediate effect; 2. Real structural damage; 3. Stabilization; 4. Recovery. At present, eight years after the pollution event, observations i indicate that the mangrove area under study is at the beginning of the recovery stage

Productivity studies may contribute to a quicker evaluation of the degree of negative impact. Productivity and decomposition rates data indicate in the first year survey, a litter fall production of 6.4 $t \cdot ha^{-1} \cdot year^{-1}$, with highest rates in December (26 $kg \cdot ha^{-1} \cdot day^{-1}$) and lowest rates in July (8 $kg \cdot ha^{-1} \cdot day^{-1}$). The leaf litter decomposition coefficients (k:$year^{-1}$)were: 3.55 for *A. schaueriana*, 2.92 for *L. racemosa* and 2.15 for *R. mangle*.

This approach enables us to understand and quantify some functional aspects of the mangrove ecosystem under stress in order to identify annual cyclic patterns, spontaneous recovery and helped us to establish a data base for comparative studies at other sites and for the purpose of rehabilitation oil spill impacted areas.

18. STATUS OF MANGROVE ECOSYSTEMS IN AFRICA

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Detailed studies of mangrove distribution along the African coast show limits to the extension of this ecosystem. Typically, mangroves occur from Northern Senegal to the Coast of Angola, in the Western part of Africa (Atlantic Ocean); and from the Northern part of Kenya to the south of Mozambique on the Eastern side of Africa (Indian Ocean), and in the west part of Madagascar island. Mangroves, are restricted in other Indian Ocean islands like Comores, Reunion and Mauritius.

Indeed, the most important distribution and extent of mangrove ecosystems along the African coast, are localized in three main areas, characterized by their quaternary formations and their very active and recent sedimentation. The first from Senegal to Sierra Leone; the second beginning in the Niger Delta until the Cameroun coast; and the third between Kenya and Mozambique, including Madagascar.

Thus, the importance and distribution of the mangrove forests and their resources varies from one area to another depending on rainfall, fresh water and nutrients supply, temperature and substrate. Because these last factors are most favorable in the Indian Ocean coast, the diversity of the species are more important than on the Atlantic coast of Africa. More than ten common species of mangrove trees can be distinguish in East Africa. Particularly important are: *Rhizophora, Avicennia, Ceriops, Sonneratia, Bruguiera, Xylocarpus,* and *Heritiera.* Along the Atlantic coast, common mangrove trees are restricted to 4 or 5 species, with the dominance of *Rhizophora, Avicennia* and *Laguncularia.* However, there is a need for more detailed systematic studies on the population variability among the species.

21 Western part of Africa, the standing volume show significant values, particularly in fairly well stocked areas such as the Niger Delta, with timber volume ranging between 100 to 250 $m^3 \cdot ha^{-1}$, with a mean of 184 $m^3 \cdot ha^{-1}$. The mean diameter and height in this area are respectively 90cm and 28m. But the disparity becomes greater when we compare, on the same Atlantic coast, the mangroves of the Niger delta (well extended and with high productivity) with the mangroves of Senegal, where the dominant heights are around 10m and the mean diameters between 20 and 40cm. The limiting factors in this last domain are mainly due to relatively recent climatic changes including the drought phenomena with a large natural degradation and reduction of the mangrove ecosystems.

Indeed, on the Senegalese coast, we are on the northern limit of the mangroves in West Africa where they used to be associated with large bare areas called "tannes", mainly induced by desertification phenomena. Here, the substrate is generally sandy and poor in clay content; the nutrient content is also low, while the salinity can be very high (from 35 to 90 ppm, upstream of certain

Table 18.1 Mangrove distribution in Africa and Madagascar (ha).

Country	Mangrove area	Country	Mangrove area
Senegal	440,000	Gambia	60,000
Guinee Bissau	243,000	Guinea	260,000
Sierra Leone	100,000	Liberia	40,000
Benin	3,000	Nigeria	973,000
Cameroon	272,000	Gabon	250,000
Zaire	20,000	Angola	50,000
Mazambiqu	85,000	Tanzania	96,000
Kenya	45,000	Madagascar	320,700

rivers). Of course, in this areas, the maximum measured heights, in this case for *Rhizophora*, are less than 5m and the diameters, less than 20cm.

In the eastern coast of Africa, the mean standing volume measured in one of the most productive mangrove area, in the Rufiji delta, Tanzania coast, is 127 $m^3 \cdot ha^{-1}$, reaching a maximum of 200 $m^3 \cdot ha^{-1}$ in certain almost pure mangrove stands.

Apart from the multiple uses to which the mangrove ecosystems are submitted in Africa, it is well know that the local populations contribute to the degradation of this ecosystem by creating a considerable pressure on it and mismanaging its resources (timber and charcoal production, soils exploitation for rice cultivation, mangrove wood extraction and others).

Nowadays, these local populations are more and more aware of the importance of this ecosystem and to different measures available for the conservation, protection and sustainable development of mangrove ecosystems which are undertaken in some countries. For example, natural reserves and parks have contributed in some countries, like Senegal, Guinee Bissau and Kenya, to the preservation of mangrove ecosystems. Even, some small scale mangroves replantation programs have been experienced in Sierra Leone in the past, in Benin and very locally in Casamance (South of Senegal).

Still, the large disappearance of pristine mangrove forests can be noticed everywhere along the African coasts because of soil destruction, the intensive exploitation of mangrove forests resources or pollution due to oil and gas production (Niger Delta), and also industrial waste.

Indeed, plans for better management of the mangrove ecosystem and its resources can be undertaken through a better knowledge of this environment, which means a multidisciplinary study such the UNESCO/COMAR Program and the suggested future ISME/ITTO project on Latin American and African mangrove forests.

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AGENDA

28 May 1992

0800-0900	Registration	
0900-1000	Opening Session	Welcome address by José Raymundo Martins Romêo, Reitor, Universidade Federal Fluminense Opening remarks by Sanga Sabhasri, ISME Vice President Further remarks by Marc Steyaert, UNESCO-COMAR Introductions by Luiz Drude de Lacerda, Project Coordinator
1000-1030	Election of officers	
1030-1100	Coffee Break	

1100-1200 Session I:
International Society for Mangrove Ecosystems (ISME)

Session Chairman: Sanga Sabhasri
Session Vice Chairman: Marta Vannucci
Session Rapporteur: Yara Shaeffer-Novelli

Welcome address by Yoshihiro Kohda
Presentation by Marta Vannucci

Discussion, questions and answers

1200-1330 Lunch Break

1330-1530 Session II:
Charter for Mangroves and other activities of ISME

Session Chairman: Marc Steyaert
Session Vice Chairman: E. Salif Diop
Session Rapporteur: Alejandro Yáñez-Arancibia

Presentation by Colin D. Field

Discussion, questions and answers

1530-1600 Coffee Break

1600-1800 Session III:
ISME-ITTO Latin America and Africa Project

Session Chairman: Luiz Drude de Lacerda
Session Vice Chairman: Salif Diop
Session Rapporteur: Björn Kjerfve

Presentation by Marta Vannucci

Discussion, questions, and answers

1900-2200 Cocktail Party at Bucsky Hotel by invitation of José Raymundo Martins Romêo, Reitor of Universidad Federal Fluminense

29 May 1992

0900-1030	Session IV: Mangrove Research and Resources in the Americas and Africa	
	Session Chairman: Marta Vannucci Session Vice Chairman: Shigeyuki Baba Session Rapporteur: Luiz Drude de Lacerda and Björn Kjerfve	
	Peru	Jorge Echeverria
	Colombia	Ricardo Alvarez-Leon
	Costa Rica	Jorge Jimenez
	Mexico	Alejandro Yáñez-Arancibia
	Brazil	Yara Shaeffer-Novelli
1030-1100	Coffee Break	
1100-1200	Trinidad-Tobago	Peter Bacon
	Cuba	Ciro Milian Padron
	Venezuela	Jesus Eloy Conde
1200-1330	Lunch Break	
1330-1500	Africa	E. Salif Diop
	Mangrove Forum	Presentations by participants and observers to the workshop
1550-1600	Coffee Break	
1600-1700	Mangrove Forum	Presentations by participants and observers to the workshop
1700-1800	Synthesis	Luiz Drude de Lacerda

30 May 1992

0900-1030	Session V: Planning for the Implementation of the ITTO-ISME Project for Latin America and Africa
	Session Chairman: Colin D. Field Session Vice Chairman: Marc Steyaert Session Rapporteur: Fabiola de Oliveira Rodriguez
	ISME's role in the Latin America and Africa regions mangrove project by Yoshihiro Kohda
	Discussion of project planning, project implementation, and preparation and production of the final report
1030-1100	Coffee Break
1100-1200	Continuation of discussion of project planning, project implementation, and preparation and production of the final report
1200-1330	Lunch break
1330-1530	Meeting of the workshop drafting committee
1530-1600	Coffee Break
1600-1800	Concluding session to approve the minutes and final report of the workshop

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