Status and Uses of Mangroves in the Republic of Panamá

Luis D'Croz

Centro de Ciências del Mar y Limnologia, Universidad de Panamá, Estafeta Universitaria, Panamá

1. Historical Background

The Republic of Panamá has mangrove forests on both the Pacific and Caribbean coasts. There are 1,697 km of coastline in the Pacific and 1,160 km in the Caribbean.

Resources derived from mangroves have been utilized from pre-colombian times to the present. Presently, some forest products from mangroves are widely utilized in rural constructions, also as sticks in horticultural crops and they are still used for the extraction of tannin. Also, an increasing scientific literature documents the importance that had the fishing of euryhaline species from mangrove bordered estuaries and channels for pre-colombian human settlements located at or near the central coast of Panamá, probably 5,000 years ago (Cook and Ranere, 1992). The existing archaeological data reveal that people from these settlements fished estuarine and coastal species such as Ariidae, Carangidae, Clupeidae, Sciaenidae, and Batrachoididae using fences, harpoons, fishhooks and other primitive devices.

Presently, fishing activities derived from species related to mangrove bordered estuaries range from artisanal fisheries based on euryhaline species fished near the coast, to the fishing industry that exploits the penaeid shrimps resource that include several species with life cycles related to the mangroves (D'Croz and Kwiecinski, 1980), they represent nearly 90% of the fishing income of the country.

In spite of all the historic, archaeologic and biologic evidence that focus on the importance of mangroves for the Panamanian society these forests continue to be one of the biological communities subject to the strongest anthropogenic pressure. There are historical records of mangrove deforestation, mostly for reclamation of land for agriculture, cattle raising, urban development, and most recently for penaeid shrimp farming. The extraction of forest products is somehow disordered and with little or no technical orientation. Nevertheless, in spite of this there are some promising signs, including a few concrete actions from the governmental side and also from non-government organizations, that are concerned with the fate of mangroves in Panamá.

2. Extent and Distribution

Although most studies indicate that Panamá has near 5,000 km² of mangrove forests (Saenger *et al.*, 1983; Letourneau and Dixon, 1984; Rollet, 1986), the evaluation of the national mangrove surface by remote sensing carried out by the Instituto Geografico Nacional Tomy Guardia (IGNTG) (Anguizola and Cedeño 1988, Anguizola *et al.*, 1989), suggests that mangrove surface in the country is significantly smaller than the values reported earlier. The results from the surveys carried out by the IGNTG, are summarized in Table 1 and the location of major mangrove areas of the country is shown on Fig. 1.

The inventory from the IGNTG indicates that there are approximately 2,000 km² of mangrove in the country, including nearly 200 km² of salt-flats, known as "albinas". This evaluation, seems to be more accurate than the previously published ones. Most mangroves are located in the Pacific coast, in particular in the Gulfs of San Miguel and Chiriqui where they cover 464.89 and 446.88 km² respectively. In the Caribbean coast the mangroves cover 60 km², and half of this is concentrated at the Province of Bocas del Toro. Mangroves are the principal forests in the brackish areas in the Pacific coast of Panamá and are mainly composed by the red mangrove (*Rhizophora mangle* and *R. brevistyla*) whose trees are among the tallest (30-40 meters). Almost monospecific stands of red mangrove are formed along the deltas and river's mouths where semidaily tides fluctuate between 2 to 6 meters. Stands of black mangrove (*Avicennia germinans* and *A. bicolor*), white mangrove (*Laguncularia racemosa*), mora (*Mora oleifera*), and "castaño" (*Montrichardia arborescens*) develop along the gradient of salinity at the mouth of rivers. Other species are also important within the structure of the forest on the Pacific side, such as the "mangle piñuelo" *Pelliciera rhizophorae*. Along most of the Caribbean red mangrove predominates with trees less than 5m tall, arranged into a slender fringe. Less abundant are the white mangrove (*L. racemosa*)

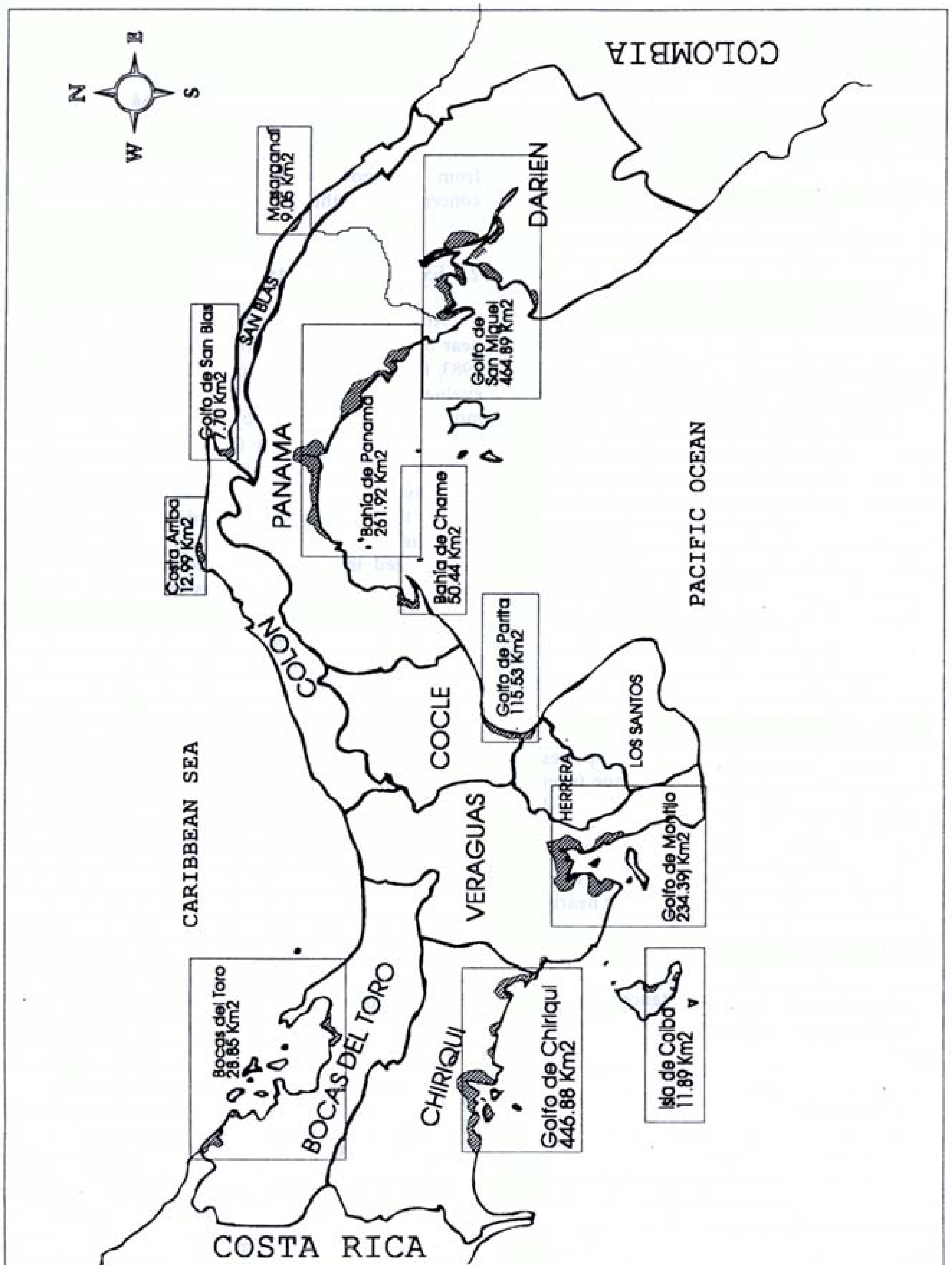

Fig. 1. Mangrove distribution in the Republic of Panamá

Table 1. Mangrove areas (km²) in the Republic of Panamá according to Instituto Geográfico Nacional Tomy Guardia (1988).

Site	Present surface	Converted surface	Salt flats
Chiriquí Gulf	446.88	17.48	0.0
Coiba Island	11.89	0.0	0.0
Montijo Gulf	234.39	12.82	0.0
Azuero Peninsula	62.13	0.34	4.77
Parita Bay	115.53	4.01	166.18
Chame Bay	50.44	3.48	9.56
Panamá Bay	261.92	5.77	0.0
Las Perlas Archipelago	1.61	0.0	0.0
San Miguel Gulf	464.89	0.0	7.12
Total Pacific coast	1,649.68	43.90	187.63
Bocas del Toro	28.85	0.0	0.0
Coast North of Colón	12.99	1.23	0.0
San Blas Gulf	7.70	0.0	0.0
South of San Blas Gulf	9.05	0.0	0.0
Total Caribbean coast	58.59	1.23	0.0
Total	1,708.27	45.13	187.63

"Converted areas" refers to former mangrove areas presently used for other purposes; see section 8 for details.

with canopies higher than the red mangrove. However, mangrove forests at the western extreme of the Caribbean coast of Panamá are much more developed.

3. Physical Setting

According to the National Atlas of the Republic of Panamá (IGNTG, 1988), the position of the Intertropical Convergence Zone (ITCZ) is one of the factors that influences more strongly the rainfall on the Isthmus of Panamá. The ITCZ is formed by the convergence of winds from both hemispheres. A strip of weak and variable winds, masses of cumuliform clouds and frequent and intense rains are generally associated to the ITCZ. Rainfall pattern on the isthmus is related to the position of the ITCZ, which is determined by the direction and intensity of the winds. In general, the ITCZ covers the isthmus between May and December, leading to the rainy season. Between January and April, the northern winds move the ITCZ southward, producing the dry season. This seasonality on the rains is highly marked in the coast of the Pacific. However, the Caribbean coast stands out for a greater uniformity in rainfall throughout the year, although maxima and minima rainfall coincide with the general pattern of the isthmus.

The precipitation over the country varies between 1,000 to 7,000 mm per year (Fig. 2). In the west coast of the Gulf of Panamá the annual precipitation is around 1,070 mm. In the eastern section, and in particular in the area of Chimán where extensive mangrove forests exist, the precipitation is almost 3,000 mm. In the Gulf of Montijo, where a large mangrove cover also exists, the precipitation is over 3,000 mm while in the coast of the Gulf of Chiriquí, rainfall fluctuates between 2,500 and 3,000 mm. In the Caribbean coast, maximum rainfall is nearly 6,000 mm and particularly in the area of Bocas del Toro, coincident with a significant mangrove cover. However, most of the coastal rainfall ranges between 2,000 and 4,000 mm.

The continental runoff from the isthmus flows toward both the Pacific and the Caribbean coasts. The division line is formed by a mountain chain that spreads from the east to the west. The Pacific side occupies 70% of the surface of the country, while the Caribbean accounts for 30% (IGNTG, 1988). Rivers are short, on average they are 106 km long on the Pacific and 56 km on the Caribbean watershed respectively, and their courses are generally perpendicular to the coast. Total annual runoff for the isthmus of Panamá is 4,570 $m^3.s^{-1}$ and approximately the 60% of this value drains toward the Pacific coast (Fig. 3).

Runoff that affects the mangroves on the Pacific side is highly variable. According to the National Atlas, the mangroves in the Bay of Parita and at Chame receive the least runoff of the Pacific side (less than 500 mm/year and 500-700 mm/year respectively). Large formations of mangroves on the Pacific coast, as those in Chiriquí and Darién, receive between 1,000 and 2,000 mm/year. The largest runoff that affects mangroves on the Pacific coast of Panamá occurs in the Gulf of Montijo (2,000-3,200 mm/year). Mangroves of Bocas del Toro, in the Caribbean, also receive high annual runoff (2,000-3,200 mm).

The mangroves of the isthmus are subject to tidal oscillations that are very different between the coasts of the Pacific and the Caribbean. In the Pacific coast tides are semi-diurnal, with wide amplitude (6 m) and predictable. This tidal amplitude generates estuaries where the tidal effect is evident for several kilometers upstream. On the contrary, tides in the Caribbean coast are diurnal, with narrow amplitude (0.5 m), irregular and thoroughly influenced by meteorological conditions.

Other environmental factors affecting the distribution of the mangroves are coastal currents. In the Caribbean eastward currents predominate whereas in the Pacific they are mostly westward. The marine sediments which prevail in the Pacific coast are composed of sand and mud whereas the Caribbean coast exhibits abundant coral formations.

4. Biological and Ecological Characteristics

The available information on the characteristics of the mangrove forests of Panamá is scattered. Among the available information is that by Mayo (1965) and Golley *et al.* (1975) on the mangroves of Darién. The following description of the Panamanian mangroves is summarized from this later work.

Golley *et al.* (1975) indicate that the principal forest community in the brackish areas of the Pacific side of Panamá are formed by the red mangrove (*Rhizophora* spp.) with trees among the tallest in the world (30-40 m). Almost pure stands of this mangrove species are formed along deltas and rivers, where tides oscillate between 2 and 6 meters. Communities of the black mangrove (*Avicennia germinans*), "alcornoque" (*Mora oleifera*) and "castaño" (*Montrichardia arborescens*) develop along the gradient of salinity in rivers and estuaries in Darién.

The canopy of the forest is relatively open and only 50% of the surface is covered by branches and leaves. Tree density in Darién, with DBH greater than 10 cm ranges from 300 to 400 $trees.ha^{-1}$. The reported basal area reaches 13.5 $m^2.ha^{-1}$. The maximum tree height encountered for mangroves was 41 meters.

In the Caribbean, the islands near to the coast and the bays support a thin fringe of red mangrove (*Rhizophora mangle*) of little growth. The stands are in general shorter than 5 meters tall and with short aerial roots. Less abundant are the stands of white mangrove (*Laguncularia racemosa*), although they are taller than the red mangrove (Golley *et al.*, 1975). Exceptions are the mangrove forests at the other extreme of the Caribbean of Panamá (Bocas del Toro) which are much more developed. A FAO report prepared by Letourneau and Dixon (1984) describes the Chame and Chepo mangroves. According to these authors the mangroves of Chame are of "low quality" due to unfavorable conditions of rain and runoff. Nevertheless, Letourneau and Dixon (1984) indicate that the forest is ecologically stable. The area of Chepo has large stands of red mangrove "which spreads several kilometers to the back of the Chepo River".

Concerning the mangroves from Chiriquí, a report by D'Croz and Del Rosario (1986) pointed out that there are near 10,000 ha of halophyte vegetation, mainly mangroves, in the lower basin of the Chiriquí River. Most of this cover is composed by mangrove trees, predominantly the red mangrove *Rhizophora mangle* and the "mangle piñuelo" *Pelliciera rhizophorae*. Also present are the "alcornoque" *Mora oleifera*, the black mangrove *Avicennia germinans*, the white mangrove *Laguncularia racemosa* and the giant fern *Acrostichum aureum*. Approximately 3,000 ha are red

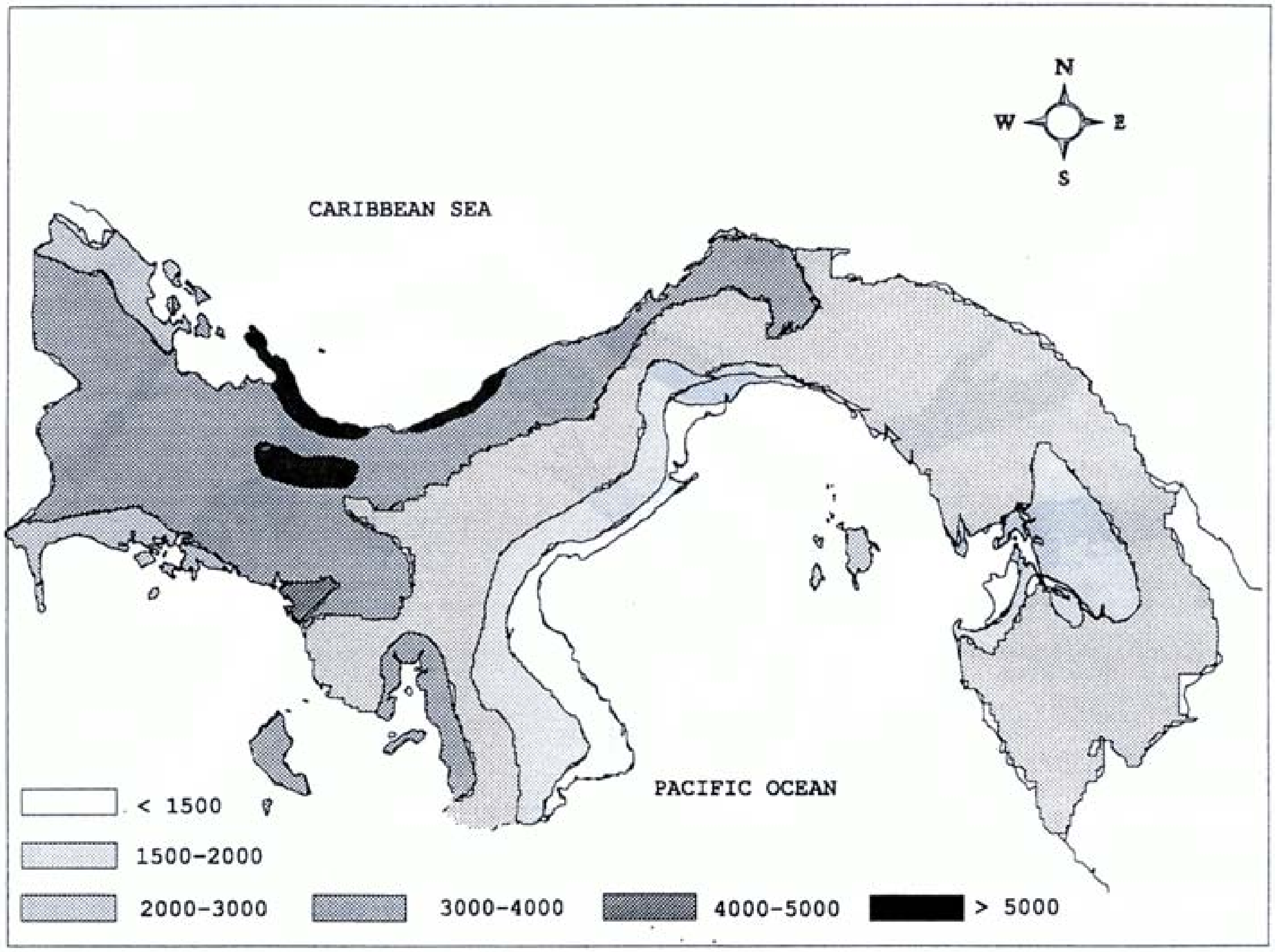

Fig. 2. Annual rainfall (mm) in the Republic of Panamá (IGNTG, 1988).

mangrove with canopy heights ranging from 10 to 20 meters. The stands of *Pelliciera* generally have canopies ranging from 5 to 15 meters in height and frequently encircled by red mangrove trees. These stands cover almost 3,000 ha and the highest canopies are predominantly adjoining the terrestrial vegetation. Nearly 3,500 ha are mixed stands of *Rhizophora* and *Pelliciera*. The structure of the forest is of riverine type. Since there is no topographical barrier, high tides flood all the area, which probably explains the absence of species zonation.

The major Panamanian experience on the ecological value of the mangroves is related to their function as nursery sites for animal species of commercial value and to their contribution to the organic output into the coast. It is well-known that the coasts bordered with mangrove have populations of juvenile stages of aquatic marine and brackish water species which spend part of their life among the mangrove roots, searching for food and protection. These organisms are protected by the great quantity of roots from the red mangrove (*Rhizophora* spp.) that provides efficient shelter.

Numerous species of penaeid shrimps from the Pacific coast of Panamá are found in the mangrove channels and estuaries as juveniles (Table 2). The three species of white shrimps (*P. occidentalis, P. stylirostris* and *P. vannamei*) are the most abundant in tidal mangroves (D'Croz and Kwiecinski, 1980). These shrimps were spawned offshore and reach the coast as post-larvae (approximately 12 mm long). They live in the mangroves for a period of 4 to 5

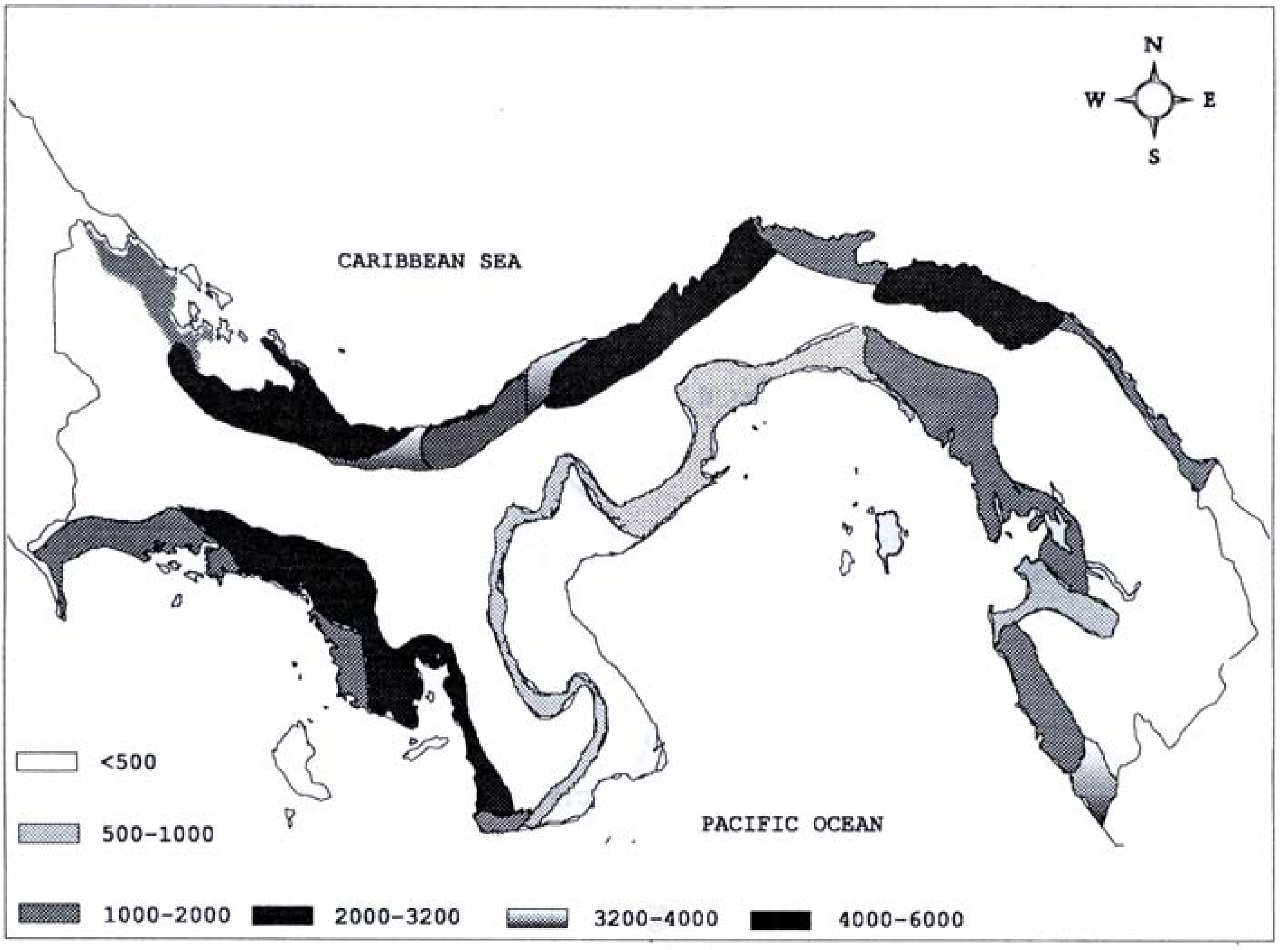

Fig. 3. Annual runoff (mm) to the coastal areas of the Republic of Panamá (IGNTG, 1988).

months. After which they migrate toward the ocean where they complete their life cycles. When they leave the estuary they are between 50 to 80 mm long.

Presently numerous small farms that cultivate shrimps along the Pacific coast, obtain their "seed" (postlarvae) from adjacent estuaries and mangroves.

Over 30 fish species have been reported to be associated to mangroves from the Pacific coast during their juvenile stages. The most common are *Mugil curema, Eucinostomus californiensis, Centropomus armatus, C. nigrescens, C. robalito* and *C. uninensis, Lutjanus aratus* and *L. argentiventris* and *Micropogon altipinnis*. A detailed discussion on the fish species using mangroves and estuaries along the Pacific coast has already been published (D'Croz and Kwiecinski, 1980; D'Croz, 1985).

Information regarding the Caribbean coast is more scarce. Cubit *et al.* (1975) reported the pink shrimp *Penaeus duorarum* to inhabit tidal creeks and small bays of the mangroves of Colón. This study reported that artisanal fishermen find along the mangrove fringe of brackish lagoons; sardines, mullets, anchovies and sharks among others. These reports suggest that mangroves have a similar ecological role along both coasts. In addition to the fish, Cubit *et al.*, (1985) also reported crocodile species (*Crocodilus acutus* and *Caiman crocodilus fuscus*) and iguanas (*Iguana iguana*) inhabiting the Caribbean mangroves of Panamá.

Preliminary studies on mangrove productivity in Panamá showed that annual litter production varies from 900 g.m^{-2} for the mangroves of Chame, to 2,000 g.m^{-2} for the highly developed mangroves of the Chiquirí River (D'Croz, 1985; D'Croz and Del Rosario, 1986). Mangrove litter is transformed in the soil and water into food material by microorganisms and small invertebrates and is eventually consumed by adjacent marine and estuarine fauna. This transformation process has been studied in Panamá by Golley *et al.* (1975) and D'Croz *et al.* (1989). These studies showed that under biological action, mangrove litter loses fibers, lignin, tannic acids which are undigestible to the marine fauna and shows an increase in nitrogen and phosphorus associated with proteins, resulting in a progressive increase of its nutritional value (Fig. 4).

5. Associated Ecosystems

Panamá has coral reefs along both coasts. However, only along the Caribbean they are associated with mangroves. Along the Pacific, coral reefs develop offshore, close to islands far from the influence of the heavy load of terrestrial sediments.

Along the Caribbean coast of Panamá over 250km of reefs occur parallel to the coastline. These reefs are at a post-climax stage and are frequently associated with mangroves forming a typical *Rhizophora-Thallassia*-coral association. Coral reefs are best developed along the Colón region, between Margarita Island and Minas Bay, in Bocas del Toro and San Blas. The reefs are composed of about 50 species of hermatipic corals, 16 species of anhermatipics and 4 species of *Millepora*.

6. Human Settlements and Traditional Uses

There is little information on human settlements in the mangroves of Panamá. However, the Action Plan for Tropical Forests of the Republic of Panamá (PAFT-PAN, 1990) reports the existence of nearly 1,000 families which depend solely on mangrove resources. These families are located mostly along the Pacific coast.

7. Commercial Exploitation

The major importance of mangroves in Panamá is related to their value in forestry and fishery. According to Letourneau and Dixon (1984), under optimal conditions, natural red mangrove stands have 200-300 m^3.ha^{-1} of timber. Whereas regenerated stands can produce from 8 to 10m^3.ha^{-1}.y^{-1}, with annual diameter growth of 0.5 to 0.6 cm in the first 25 years. Major mangrove products are: fuelwood and charcoal of very good quality, dense, fine grained wood for planks, posts, poles and high quality tannin.

In general however, utilization of mangroves as a source of raw materials is somewhat limited in Panamá. Primitive extraction and production methods seem to be responsible for the low utilization, production and profitability of mangrove products. Forest production of mangroves of Panamá is shown

Table 2. Penaeid shrimp species commercially fished in the Pacific coast of Panamá, according to D'Croz y Kwiecinski (1980).

Species	Depth of catches (ft)	% of total catches	Estuarine stage
Penaeus occidentalis	3-15	34.0-40.5	+
Penaeus stylirostris	3-15	1.9-2.25	+
Penaeus vannamei	3-15	1.9-2.25	+
Penaeus brevirostris	30-45	25.00	+
Xiphopenaeus rivetti	**	27.50	-
Protrachypene precipua	**	?	-
Trachypenaeus byrdi	**	2.70	+
Trachypenaeus faoea	**	?	+
Solenocera agassizi	45-60	0.18 - 1.86	-

(** in brackish waters close to estuaries) on Table 3. Although the activity is considered as of subsistence, it does support an important portion of the population living in rural areas. The most used mangrove species are red and black mangroves. Trees are felled and cut in 4 to 12m pieces. Roots are also cut to help securing mangrove poles during the transport to the estuary where the timber is loaded in small boats and transported to adjacent human settlements for sale.

Bark is generally extracted only from large trees of *Rhizophora* (DBH >40cm) and is mainly located at the Chiriquí Province. Until June, 1983 Panamá exported over 720 tons of bark yearly to Costa Rica. In 1986, average bark production for local consumption was over 430 tons, delivered to 14 tanneries located in the Provinces of Chiriquí, Herrera and Los Santos.

It is estimated that about 70% of the rural population in Panamá depends on fuel wood as the major energy source. Mangroves of Chiriquí produce from 2 to 3 million wood piles for fuel (Table 4). Using trees with diameter between 6 to 14 cm and height from 3 to 8 m. According to INRENARE (1988) demand for this product was 2.1 million in 1983, equivalent to 1,000 m^3 of mangrove wood. Charcoal production in mangroves occurs mainly in the regions of Azuero, la Chame and Chepo. The most used species are red and white mangroves. Production in 1986 reached 118,200 bags, equivalent to 1,087,440 kg (INRENARE, 1988).

Poles production for use in agriculture occurs mostly in Azuero, Capira and Chame and is approximately of 8,780 units per year. In recent years this production is on the decrease.

Table 4 summarizes major subsistence products from the mangroves of Panamá as well as the number of people involved in the production.

Regarding the inter-dependence of fisheries resources with mangroves, it is known that out of 9 or 10 species of shrimps, forming the shrimp resource of the Pacific coast, six of them are found as juveniles in mangroves and estuaries; the white shrimps *Penaeus occidentalis*, *P. stylirostris* and *P. vannamei*; the red shrimp *P. brevirostris* and the "carabali" shrimps *Trachypenaeus byrdi* and *T. faoea*. Additionally, two species of seabob shrimps (*Xiphopenaeus riveti* and *Protrachypene precipua*) are commonly found in coastal waters in front of mangroves and close to estuaries bordered by mangroves. Therefore, nearly all shrimp species of economic importance along the Pacific coast of Panamá are to some extent associated with mangroves. Only one species, *Solenocera* spp., which represents less than 10% of the total catches, is not associated with mangroves. Shrimp fisheries in Panamá is the most important fishery activity and produces incomes varying from 60 to 70 million dollars per year.

Another important fishery of Panamá is the anchovies (*Centengraulis mysticetus*). This species is used in the production of fish meal. According to Bayliff (1966) juvenile anchovies are pelagic being found in deeper waters from January to March. In April, as an adult, they approach the coast, in particular in the muddy and shallow (< 10m) areas. The areas of largest anchovies catches in the Gulf of Panamá, correspond to the coast with most mangrove cover and mangrove bordered estuaries (D'Croz and Kwiecinski, 1980). Largest catches are from Chame, Bayano and Gulf of San Miguel, areas of extensive mangroves with large detritus input which may be important as food to the detritivorous adult anchovies. These observations suggest that organic debris from mangroves may be of great importance to the life cycle of anchovies. Bayliff (1986) reports that reproduction of anchovies occurs in shallow, sometimes brackish waters, in particular along the coast of Juan Diaz and Panamá Viejo. Economical benefits from this important fishery may reach up to 20 million dollars per year.

Apart from these commercially exploited species, an important fraction of the artisanal fisheries are associated with estuarine and mangrove species, in particular snappers (*Lutjanus* spp.), corvinas (*Micropogon altipinnis*) and robalos (*Centropomus spp.*). Estimates for the year 1980, showed that each kilometer of coastline covered by mangroves along the Panamá Bay, produced benefits of nearly US$ 100,000 per year (D'Croz and Kwiecinski, 1980).

8. Conversion to Other Uses

Mangrove areas converted to other uses in Panamá have been estimated by Anguizola and Cedeño (1988) to reach 5,647 ha. Major converted areas are located in the Sona District, Veraguas Province (1,345 ha) and in the Chiriquí Province (2,157 ha). These areas are presently used for agriculture and cattle growing (Table 5).

Although the dominant trend is a reduction of mangrove cover, in some areas small increases of

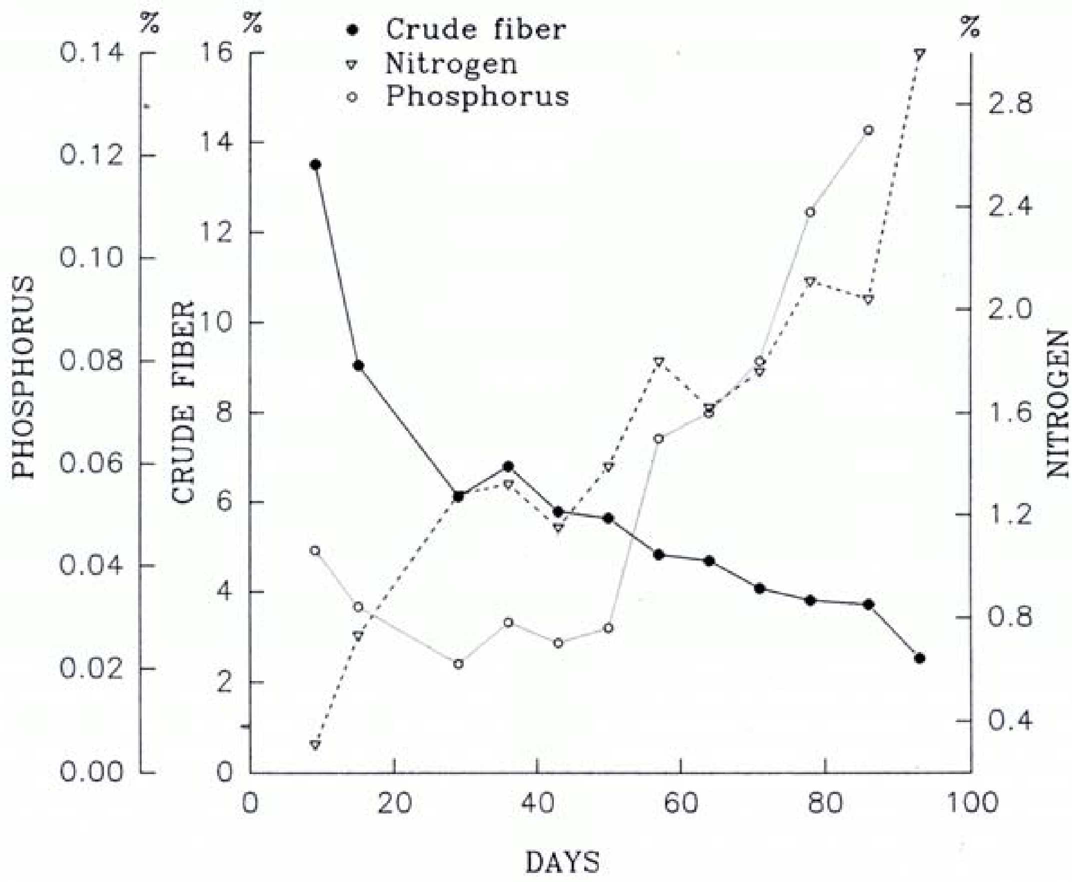

Fig. 4. Chemical Changes of *Rhizophora mangle* leaves during decomposition in the Bay of Panamá

mangrove forests have been documented. A survey done by IGNTG (1988) showed an increase of 135 ha of mangroves in Parita Bay, close to the estuary of the Boca Estero de Palo Blanco River, and between the mouth of the Anton River (La Uva estuary) and the Charco Los Camarones Bay (70 ha).

Approximately 47% of the converted mangrove areas are presently used for agriculture, notwithstanding the low fertility of the mangrove soils. An important fraction of these converted areas remain as non-vegetated lands subject to inundation and approximately 22% of converted mangrove areas are used for extensive cattle growing of very low productivity (Anguizola *et al.*, 1989).

Regarding pressure from urbanization, the mostly affected mangroves were those located close to Panamá City, converted to urban settlements, in particular the mangroves of Juan Diaz, located west of the city. However, the Ministry of Housing, with the help of the Institute of Renewable Natural Resources (INRENARE) and other institutions, had established an effective policy for the conservation of mangrove stands in the City's surrounding area.

9. Environmental Impacts

Some developmental activities have resulted in negative impacts on mangroves. According to the Action Plan for Tropical Forests of the Republic of Panamá (PFT-PAN, 1990), mangrove cover prior to 1960 reached approximately 300,000 ha. Presently however, most recent estimates (IGNTG, 1988) show a total mangrove cover of approximately 176,000 ha. These estimates suggest that mangrove deforestation caused the decrease. However, it is important to confirm this information.

The decrease in mangrove cover seems to be restricted to the Pacific coast, in particular along the

Table 3. Volume and surface of mangroves affected by forestry activities in the Republic of Panamá, according to INRENARE, (1988).

Product	Site	Annual production	Required timber	Surface
Charcoal	Chame	75,000 bags	4,726,071	26.3
	Azuero	43,200 bags	2,722,217	15.1
	Total	118,200 bags	7,448,288	41.4
Fuel wood	Chiriquí	2,100,000 to 3,411,792 units	1,766 to 1,087	14.3-23.2
Bark	Chiriquí Montijo Gulf and Parita	9,600 kg	954.1 (wood) 143.1 (bark)	66.7
Sticks	Azuero	266,000 units	16,125.695	211.6
Poles	Chame			
	Azuero	8,780 units	1,895.983	38.2

oriental margin of the Chiriquí Gulf. Half of deforested mangrove areas are presently being used for agriculture and cattle farming, notwithstanding the low fertility of such soils. More recently, increasing pressure from the shrimp farming industry resulted in deforestation of mangroves close to saline areas, where there are the best sites for this activity. This is particularly important in Cocle and Azuero peninsula in the Pacific. Some deforestation was caused by urban expansion of the metropolitan area of Panamá city in Juan Diaz area. Although regulation exists to avoid deforestation in the area some stands continue to be deforested, suggesting lack of enforcement of the law.

Oil spills are another important impact upon mangroves in Panamá. Although public environmental authorities make efforts to control these incidents, their efforts seem to be insufficient or inadequate. Breaking the law regarding protection of mangroves results in such small penalties that lawbreakers rather pay fines than avoid doing the damage. Until when the Government will not consider mangroves as an important part of the Nation's natural heritage, attempts to stop degradation will continue to be ineffective.

Although contamination of mangrove areas has not been reported as a serious impact on mangroves, the enormous quantity of oil transported through the Panamá Isthmus is a constant threat to natural systems. Approximately 70 million tons of oil are transported yearly from one ocean to the other, either through the Panamá Canal itself or through pipelines. The large volume transported is rather from international oil commerce than for Panamá's utilization. Among the consequences of the transport and stock of such large oil quantities, there was a large oil spill in April, 1986, involving 50,000 barrels of crude oil from the only oil refinery of the country, located in the Colon Province at the Caribbean coast. The spill seriously affected coral reefs, mangroves and seagrass beds (Jackson *et al.*, 1989). Approximately 27 km of coastline bordered by mangroves were affected. Considerable tree mortality occurred and complete destruction of the epibiota of mangrove roots followed the spill. Also, mangrove seedlings replanted in the area failed to produce leaves.

10. Research and Training Programs

The most significant effort for the conservation and sustainable utilization of mangroves of Panamá was the Action Plan for Tropical Forests of the Republic of Panamá (PAFT-PAN, 1990), with support from the United Nations Developmental Program (UNDP) and Food and Agriculture Organization (FAO). This Government plan is coordinated by the National Institute of Renewable Natural Resources (INRENARE) and includes the national policy and strategy for the management of mangroves in Panamá. Its major objectives are: to protect and manage the stands to maintain biodiversity; to ordinate and manage the forest for its sustainable utilization; to rehabilitate degraded soils; to manage watershed; to

Table 4. Major subsistence forest products from the mangroves of Panamá, according to INRENARE (1988).

Product	Site	Species	Tree DBH (cm)	Annual production	Annual demand	Users
Fuelwood	Chiriquí Azuero	*L. racemosa* *P. rizophorae*	5-15 cm	2.8 million	2.1 million	350
Charcoal	Azuero Chame, Capira	*Rhizophora spp.* *L. racemosa*	5-30 cm	1,087,440 kg	150 kg/person	2,060
Bark	Azuero, Chiriquí	*Rhizophora sp.* *Rhizophora sp.*	40-70 cm	430,909 kg 718,182 kg	454,545 kg 727,272 kg(*)	107
Sticks	Azuero	*Rhizophora sp.*	5-10 cm	266,000 units	-	375
Poles	Chame, Capira, Azuero	*Rhizophora* sp.	10-20 cm	8,780 units	-	120

(*) Exported to Costa Rica

enhance environmental education, capability and extension in forestry; to promote alternatives for sustainable production to reduce deforestation.

Additionally, some important research and training programs have been initiated through international collaboration. Among them the Regional Wetlands Program for Central America of the International Union for the Conservation of Nature and Natural Resources (IUCN) and the Central America Program for Fisheries Development (PRADEPESCA).

11. Management Policies and Legislation

The Constitution of the Republic includes the Ecological Act. The State is responsible for the protection, conservation and improvement of the environment and natural resources. The Constitution also establishes as a State duty to involve the population in the process of nature protection. Additionally the Republic has turned most Regional and International agreement into National Laws regarding disposal of toxic substances in the oceans. On the 10th June 1991, the National Congress approved the law to support the protocol of conservation and management of coastal and marine areas of the Southeastern Pacific. Regarding fisheries resources, the Act 225 of the Constitution regulates the fisheries activities to preserve its benefits.

Although levels of contamination and degradation of coastal resources are still not critical, some local cases create preoccupation of potential degradation and destruction of coastal and marine ecosystems of Panamá, including mangroves. This is due to several reasons, including:

- there is no specific policy for the management and conservation of coastal and marine ecosystems, notwithstanding their enormous social and economic importance for the country.
- the existing legislation is inadequate, when regarding water and environmental quality, since laws developed for sanitary control and/or related to agriculture activities are still in force.
- although the INRENARE is responsible for the management of mangroves, there is inadequate interinstitutional interaction. Frequently the regulation of a resource, as the mangroves, is shared by various state authorities, which have different views. In some cases these views are even opposed. In the case of mangroves, fisheries, harbor, forestry, agriculture and urban interests are involved, resulting in inefficient management of the resource. This frequently results in over exploitation of the resource and a certain degree of passivity regarding the constructions which negatively affect the environment.
- economical constraints are permanent in the controlling institution, resulting in inefficient enforcement of legislation.
- the increasing marginal population finds diverse resources at the coastal zone for their subsistence, resulting in increasing pressure on the natural ecosystems.

Table 5. Converted mangrove areas in Panama (km^2), according to Anguizola *et al.* (1989).

Conversion uses	Chiriqui	Montijo	Parita	Chame	Panamá	Total
Salt flats	0.0	0.0	1.61	0.26	0.0	1.87
Shrimp ponds	0.0	0.0	2.56	1.40	0.0	3.96
Tidally flooded	0.0	3.47	0.41	0.0	1.57	5.45
Crops	15.92	1.36	3.94	0.0	4.38	25.60
Cattle farming	3.87	5.50	1.91	0.81	0.0	12.09
Non-vegetated	1.78	0.0	0.14	0.75	1.71	4.38
Agriculture	0.0	3.12	0.0	0.0	0.0	3.12
Totals	21.57	13.45	10.57	3.22	7.66	56.47

Mangroves, coral reefs, and other biological communities that are the rich biodiversity of the country are justification enough for the establishment of a coastal zone policy in Panamá. Currently, the general principles for such a policy are already approved and executed by several of the government agencies, although on an institutional base rather than in a comprehensive way. In addition, several laws of the republic, including the Constitution, deal with the environment and natural resources. In order to make coherent all of these laws and regulations some future action will be necessary such as:

- the formulation of a national policy on the coastal resources and the environment.
- the updating of the laws in respect to the importance of the coastal resources and environment.
- to adequate the institutional framework from which is performed the management of the coastal resources and environment. This should imply the centralization of actions and decisions at a high level commission from the executive, including the National Commission for Mangrove sponsored by INRENARE.
- to reformulate the education policy to include an important component on natural resources, the environment and its relevance for the country.
- to create a national council on science and technology to plan the development of the scientific and technological knowledge necessary to straighten and promote the conservation, development and use of natural resources and the environment. This will allow a better knowledge of the environment and its resources through scientific research and its effective utilization through the application of new technologies delivered through the universities, technical institutes and professional associations, and any other organization of interest in mangroves.

12. References

Anguizola, R.M.; Cedeño, V.J. and Sopalda, G,. 1989. Uso actual de antiguos manglares de la República de Panamá. XVI Reunión de Cartografía. Inst. Panamericano de Geografía e Historia. San José, Costa Rica. 26 febrero-2 marzo de 1990. Mimeo.

Anguizola, R.M. and Cedeño, V.J., 1988. Inventario de manglares de la República de Panamá. Instituto Geográfico Nacional "Tomy Guardia", Panamá R. de Panamá. Nov. 1988.

Cook, R.G. and Ranere, A.J., 1992. The relation of fish resources to the location, diet breadth, and procurement technology of a preceramic and a ceramic site in an estuarine embayment on the Pacific coast of Panamá. In: The evolution of archaic and formative societies on the Pacific coast of Latin America (ed. M.Blake). Washington University Press.

Cubit, J.; G. Batista, G.; Roman, A. and Batista, V., 1985. El valor de los manglares y arrecifes en la costa de Colón. In: Agonía de la naturaleza, eds. S. Heckadon y J. Espinosa. Inst. Invest. Agrop. Panamá/Smithsonian Trop. Res. Inst. Panamá. pp. 183-199.

Bayliff, W.H., 1966. Population dynamics of the anchoveta, *Cetengraulis mysticetus*, in the Gulf of Panamá, as determined by tagging experiments. Inter-Amer. Trop. Tuna Comm., Bull. 11(4): 173-352.

D'Croz, L., 1985. Manglares: su importancia para la zona costera tropical. In: Agonía de la naturaleza, eds. S.

Heckadon y J. Espinosa. Inst. Investig. Agrop./Smithsonian Trop. Res. Inst. Panamá. pp. 167-181.

D'Croz, L.; Del Rosario, J. and Holness, R., 1989.
Degradation of red mangrove (*Rhizophora mangle* L.) leaves in the Bay of Panamá. Rev. Biol. Trop., 37(1): 101-104.

D'Croz, L. and Del Rosario, J., 1986.
Ecología de la vegetación de la cuenca inferior del Río Chiriquí: su posible relación con las obras hidroeléctricas. In: Evaluación ecológica del Río Chiriquí en relación a la construcción de la represa hidroeléctrica Edwin Fábrega. Inst. Rec. Hidráulicos y Elect./Univ. Panamá, eds. D. Hernández y L. D'Croz. Panamá. Informe Técnico. pp. 66-95.

D'Croz, L. and Kwiecinski, B., 1980.
Contribución de los manglares a las pesquerías de la Bahía de Panamá. Rev. Biol. Trop., 28(1):13-29.

Golley, F.B.; McGinnis, J.T.; Clements, R.G.; Child, G.I; Duever, J., 1975.
Mineral cycling in a tropical moist forest ecosystem. Univ. Georgia Press. Athens, GA. 248 pp.

IGNTG, 1988.
Atlas geográfico nacional de la República de Panamá. Inst. Geogr. Nac."Tommy Guardia". 3a Ed. Panamá. 222 pp.

Jackson, J.B.C.; Cubit, J.D.; Keller, B.D.; Batista, V.; Burns, K.; Caffey, H.M.; Caldwell, R.L.; Garrity, S.D.; Getter, C.D.; Gonzalez, C.; Guzman, H.; Kaufmann, K.W.; Knap, A.H.; Levings, S.C.; Marshall, M.J.; Steger, R.; Thompson, R.C. and Weil, E., 1989.
Ecological effects of a major oil spill on Panamanian coastal marine communities. Science (243): 37-44.

Letourneau, L.R. and Dixon, R.G., 1984.
Ordenación y cosecha de los manglares. Panamá, resultados y recomendaciones del proyecto. Informe para el Gobierno de Panamá. F.A.O., Roma. 35 pp.

Mayo, E., 1965.
Algunas características ecológicas de los bosques inundables de Darién, Panamá, con miras a su posible utilización. Turrialba 15:336-347.

PAFT-PAN. 1990.
Plan de acción forestal de Panamá. Proyecto de ordenación, conservación y desarrollo de los manglares de Panamá. Instituto Nacional de Recursos Naturales Renovables. Rep. de Panamá.

Rollet, B., 1986.
Ordenación integrada de los manglares. Síntesis de siete seminarios nacionales en América Latina. MISC/86/4 F.A.O., Roma. 100 pp.

Saenger, P.; Hegerl, E.J.; Davie, J.D.S. (eds.), 1983.
Global status of mangrove ecosystems. The Environmentalist 3:1-88.

Snedaker, S.C., 1981.
Mangrove forest management in Chiriquí, Panamá. Forest Industries Development Project for Latin America FAO/UNDP-RLA/77/019. Tegucigalpa. 18 pp.