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Coastal Wetland Ecosystems: The Example of Guadeloupe

Michelle DAHOME-DI RUGGIERO
Doctor in geography- University of the West Indies-BIORECA
Email: mimi.diru@orange.fr

Abstract* - Coastal wetland ecosystems comprising mangrove forests and their annexes: swamp forests, prairies and/or marshes are small green hinge spaces rich in biodiversity but fragile at the same time. Their exceptional benefits and values make them the true identity of our Caribbean island territories and of vital importance to humanity. Our 2008 study allowed us to show that their traditional uses have a low impact without overexploitation. Accordingly, it is clear that the dynamics of their habitats and their biodiversity is at risk due to modern activities that affect the planet. This is the problem: these environments so indispensable to the planet will disappear in time due to the environmental risks they are facing; can we reduce their vulnerability to preserve them by using sustainable development? As their many ecological processes are constantly increasing, such as the biocenosis-environment-physical competition and also the exchanges with the neighbouring ecosystems, they become vulnerable; If we no longer have to prove the value of the coastal wetlands, their ability to adapt requires that we make every effort to protect and preserve them. In this article we will present the structural and functional characteristics of these mangrove forest ecosystems which represent a vital world heritage. Then we will explain their vulnerability to coastal risks. Finally an analysis will highlight the likely solutions to facilitate their recovery.

***Keywords* - Plant succession, dynamics, ecology, vulnerability, function, protection, coastal risks.**

I. INTRODUCTION

The mangroves forest of the wetland coasts of the French West Indies, occupying 0.04% of the mangrove forests global area [1] are small spaces with important functions and numerous benefits [2],classified as major global issues. These specific, fragile, high biodiversity environments are determined by physical parameters, especially an unstable substrate and variable salinity [3]. They present an ecological heterogeneity whose factorial determinism are the geological history [4] or the climate [5] in the region, the evolution of the needs of human societies [6] and especially the system's adaptability capabilities[7]. Their adaptability and their benefits ensure a balance in the different island ecosystems both from the point of view of biodiversity maintenance and socio-economic development [1].These ecosystems represent the true environmental identity of the inter-tropical island territories of the Caribbean and especially of the Antilles. In general, we no longer have to prove their socio-economic importance at world scale, they cover 25% of the world alimentation [8].In Guadeloupe as elsewhere, they are also often put at risk due to their overexploitation, particularly by the modernity of the activities generated by industry, tourism, the proliferation of waste, sewage stations and other[9]. As a result, the spatio-temporal dynamics of these habitats and their biocenosis is the result of the risks they face due to the multiple ecological changes of the planet caused by anthropization.

The issue is clear: will these coastal wetlands, vital to our planet, disappear due to environmental risks and can a sustainable development reduce their vulnerability to preserve them?

Since we no longer have to prove their value, we will show that we must make all efforts to protect and preserve them.

In this article, we present the structural and functional characteristics of these coastal mangrove forests, a vital world heritage. Then we will show their vulnerability to environmental risks. Finally an analysis and discussion will highlight the current management difficulties regarding effective sustainability solutions.

II. STUDY CONTEXT AND METHODOLOGY

To address this problem, we chose Guadeloupe, an archipelago located at 61° West longitude and 16° North latitude in the middle of the Caribbean. It has great landscape diversity, with wetlands on 7500 hectares in 1998, 4/5 to be found around the Grand Cul-de-sac Marin lagoon. Sheltered by a reef circa 20 receiving material and energy both from the land and the sea. They are located mainly on the islets, coves and estuaries around the lagoon and sometimes along the south and east coasts.

Fig. 1. Distribution of wetlands in Guadeloupe

To learn about the structural and functional organisation of these mangrove coasts, we studied aerial photographs by photo-interpretation to identify the plant communities (Figure 2). We carried out an interpretative analysis on 2004 photographs (1/25000th) and the topographic data banks or BD-Topo and the orthophotos of the Grand Cul-de-Sac Marin. The space botanical organisation will allow us to create a typology for these ecosystems [10].

kilometres in length oriented East-West, the main vegetation of these coastal areas is the mangroves. Smaller and always green, they are an open system

Field observations, such as transect observations, botanical surveys [11], and traces of activities complement this cartographic work of species the anthropization, its impacts and highlight the vulnerability of these interpretation and recognition. They are accompanied by surveys among the residents of the study sites to record environments.

A bibliographical synthesis will result in an analysis of the relationship between man and nature, focusing on participatory management and the possibility of using these environments.

III. PLANT ORGANISATION OF THE COASTAL WETLAND ECOSYSTEMS

For this purpose, the photographs we used are in colour, they are numbered 302, 306, 308, 310, 331, 339, 348, and 485, taken from the GLP010-C-25000 mission. They were taken by the IGN (Institute Géographique National) on 28 March 2004, at 3935 m altitude. For the recognition of the units in the photographs we use a range of green (Figure 2). The red mangroves or *Rhizophora mangle* are dark green, the *Avicenia germinans* and *Laguncularia racemose* onesare much lighter. The swamp forest formed by mangle medaille (*Pterocarpus officinalis*) is a heterogeneous green (with a grainy-velvety texture). The marshes are a smooth and clear green; the prairies are a very pale green [12].

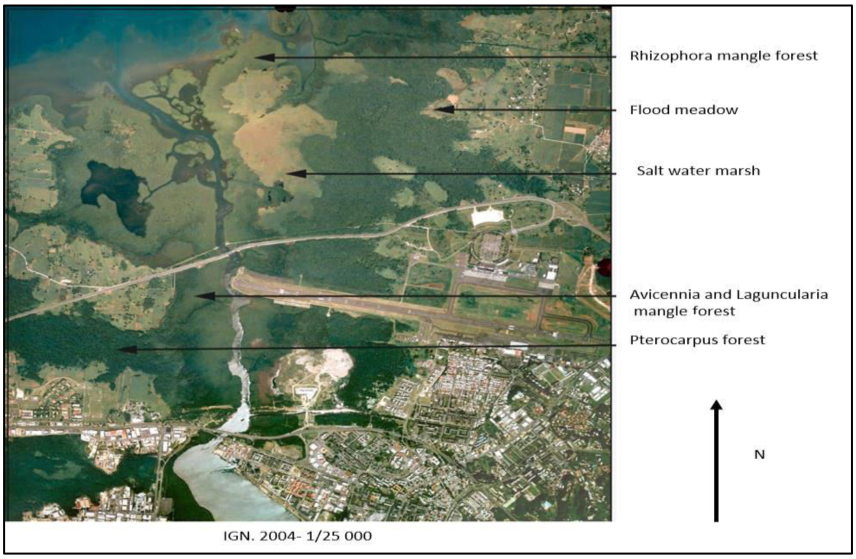


Fig. 2 Interpretation of the littoral wetland ecological units

A. *Typology*

In many areas of the island along the lower coasts under the influence of the tides we can see, from the sea to land, landscape units parallel to the sea in accordance with the overall diagram in Figure 3 [9]. It is a coastal wetland defined using the mangroves: a mangrove forest on salty soil on the sea border and a back mangrove forest. Depending on the water conditions, it is composed of an herbaceous swamp of brackish water, a swamp forest of fresh water, a freshwater prairie adjacent to crop lands or constructed areas. This succession of ecosystems permanently defined in contact with the sea is an open coastal wetland (Figure 3). If instead the area is protected by a sandy belt, called "captive mangrove forest" by Rousteauin 1996[13] due to the temporary contact with the sea, it is a coastal captive wetland. In both cases we can establish a typology based on the back mangrove forest which is where the landscape varies (Table I)

Among the open coastal wetlands, the partly halophilic alluvial open mangrove forests border the lagoon of Grand Cul-de-Sac Marin (Figure 4). We can distinguish four types numbered from 1 to 4, they are determined by the presence or absence of one or several back mangrove forest ecosystems: for example a swamp forest and/or swamp. The type 2 open coastal wetland including a mangrove swamp, a swamp forest and a prairie, can also be seen in some sectors of the Petit Cul-de-Sac Marin. This type is located in the commune of Petit-Bourg at the mouth of the river Lézarde and the territory of Goyave in the Bay of the town (from Pointe La Rose to Pointe de la Rivière to Goyave around l'Anse à Douville).

Sometimes, small mangrove wetland plant formations can also be seen in forest borders along the gullies and streams flowing into inlets of the Atlantic coast, example of riparian mangroves at Moule [14].

Captive mangroves are recorded from Port-Louis to Anse-Bertrand; separated from the sea by a sandy belt, they are also found in Northern Basse-Terre (Figure 4). These mangrove islets, called mangrove “pockets” by the NFB in 2012 [15], are located on the edge of a man-made aquatic basin at Deshaies and along the north coast of Sainte-Rose.

On the South and east coast of Grande-Terre, these small captive spaces (Table II) are defined by Portecop in 2009 [14] as basin or lagoon mangrove forests (in Saint-Félix-Gosier). The same year, they are named "colluvial mangroves" by PhilippeJoseph [16] who considers them *Rhizophora* pioneer fronts.

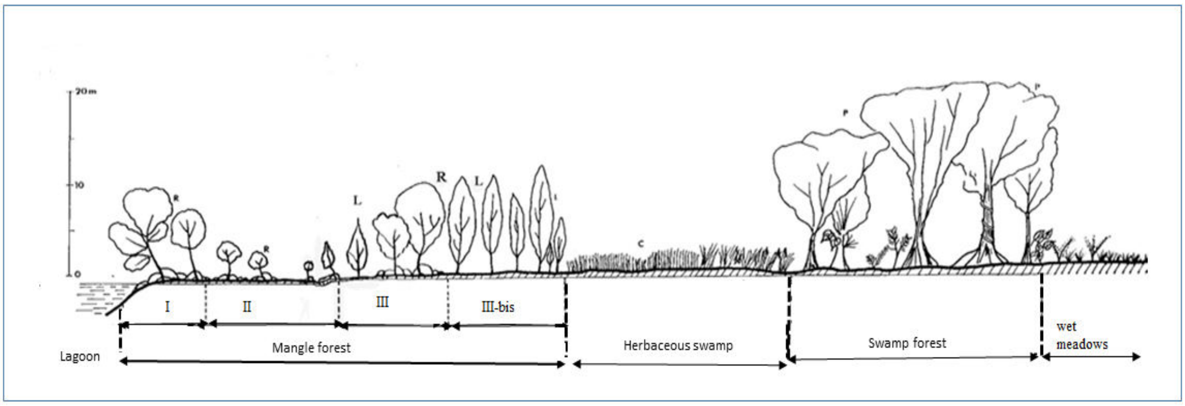


Fig. 3 Distribution of ecosystems in the littoral Wetlands – (1988, Imbert, Bland et Rusiier)

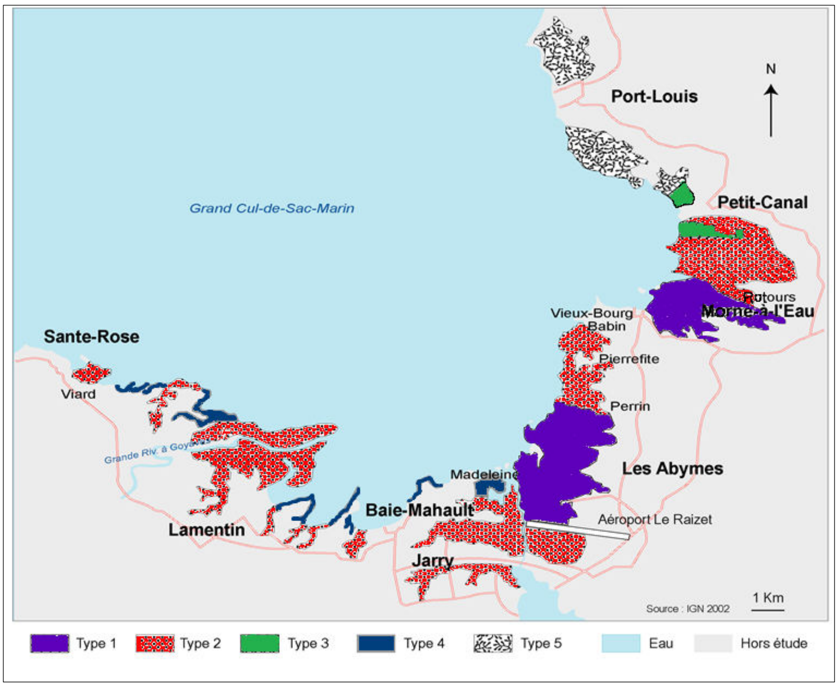


Fig. 4. Mapping of types of open coastal wetlands

TABLE I

Typology of coastal wetlands

Lagoon / coast sandy belt	**Mangrove**	**Marsh**	**Swamp forest**	**Meadow**	**Littoral wetland type**
Lagoon or sea					Open mangrove coast
«	x	x	x	x	Type 1
«	x		x	x	Type 2
«	x	x		x	Type 3
«	x			x	Type 4
Coast sandy belt	x	-	-	-	Captive Mangrove coast

TABLE II

Examples of localization of the "small" mangrove forests of Guadeloupe (from field observations: 2009-2016)

TYPES	**LOCATIONS**
Riparian	Moule: Damencourt, the Bay, Rivière d'Audoin. Marie-Galante: Rivière Vieux Fort St François: Anse à la Barque, Baie Olive
Basin	Gosier: Grand-Baie, Pointe de la Verdure, Saint Félix, Les Salines. Deshaies (near the Grande Anse beach)
Lagoon	Saint-Anne: the Lambi pond, la Helleux, Anse à Saints Saint-François: Anse Gros Boeuf, the salt mines of Pointe des Chateaux Nord Basse-Terre: Sainte-Rose, Deshaies
Channel	Anse-Bertrand: Anse Colas, Porte d'Enfer

The centre of these biocenotic communities supplied with colluvium [17] and water is a Rhizophoratum. The area is populated with *Laguncularia* or *Avicennia* according to the morphological nature of the surrounding environment.

In the Grand cul-de-sac Marin lagoon, the small mangrove forests of the islets exhibit four varieties of mangroves accompanied by a varied biocoenosis, consequence of past anthropization. In this case, they are open to the sea; however plant zonation is not present, the species are nested together, perhaps due to the small size of the islets.

B. Structural Aspects

The natural ecosystem diversity reflects the adaptability of the eco-complex coastal wetlands in relation to different environmental parameters: the nature of soils, water salinity, topography, proximity to peripheral environments, human impacts. We note a specific plant distribution within each ecosystem.

In the alluvial mangrove forests of Guadeloupe, [3], [9] D. Imbert en 1985 et en 1988 showed a structural zonation of phytocenosis from the sea to land along the Grand Cul-de-sac Marin. On the sea border, he distinguishes a red mangrove pioneer front or

In the colluvial mangroves, the plant structure is reversed (field observations), the black and white mangroves in the vicinity of the slopes or prairies surround the red mangroves. The plant community is enriched with various plants: grasses, vines, ferns...

For any plant grouping, each species develops its own adaptive phenomena that structure a habitat or a wet coastal ecological niche resulting in a rich and varied phytocenosis [19]. This evidence is highlighted in the interregional programme report for the protection and enhancement of coastal wetlands ecosystems carried out by the Guadeloupe NFB team in 2012 [15]. The mobility of the wildlife from one place to another allows many necessary and obvious interdependence relations between these ecosystems. It plays a particularly important role in the food chain. The faunal species occupy all levels: from the underground to the canopy, passing through the ground, the water of the marshes or the prairies, the roots, high on the trunks, branches, and stems [20]. The adaptation means of the

Rhizophora mangle followed by shrubby mangroves composed of black mangroves (*Avicenia germinans)* on occasionally flooded very salty soils. Then the high mangrove forest ranging between 10 to 20 metres in height, with a procession of all mangroves: red, black and the white *Laguncularia racemosa* colonizing the permanently flooded and slightly salty soils. With regard to the small mangroves and captive mangroves, not far from the sandy shores, the mixture of mangrove populations is enriched by a new species: the grey mangrove or *Conocarpus erecta.* It is very widespread, it particularly likes slightly flooded, drained and slightly salty soils.

Sometimes in the back mangrove forest we see the swamp forest dependent on freshwater with mostly *Pterocarpus officinalis trees,* laMangle Medaille, of the Fabaceae family [11]. The floristic richness depends on its temporal or spatial immersion [9], [14]. According to the species present in the understory (epiphytes, vines, ferns) we easily recognize the heavily flooded forest, a slightly flooded area and a non-flooded one. The marshes and prairies are specific for brackish or fresh water, since they are always flooded seasonally. In both cases, the varied herbaceous plant population is composed of Poaceae, Cyperaceae [18].

animal species which occupy these spaces are varied: the animals live free or fixed, they crawl, climb, walk, swim or fly. The flourishing of mobile species is permanent except in the presence of noise. Wetlands truly are protection spaces. All animal categories can be seen in these spaces: mammals (raccoons, bats), many birds (sedentary or migratory), amphibians (frogs, turtles, toads), reptiles, spiders, mollusks (shellfish: crab, conch.., snails: snails..., bivalves: oysters, clams, and chaubettes), worms (leeches), insects (butterflies, dragonflies, mosquitoes).

C. Functional Aspects of These Ecosystems

In order to carry out this study, we studied the forest biodiversity in 2005 and 2008 by using transects (40 m x 10 m) according to the following diagram (Table III). This transect sampling technique allows us to analyse the environment heterogeneity, advocated by Godron since 1966 and used by Imbert in 1988 [9] for the mangrove forests. Adapted for the structural study of the Guadeloupe swamp forest by J. Portecop, D. Imbert,

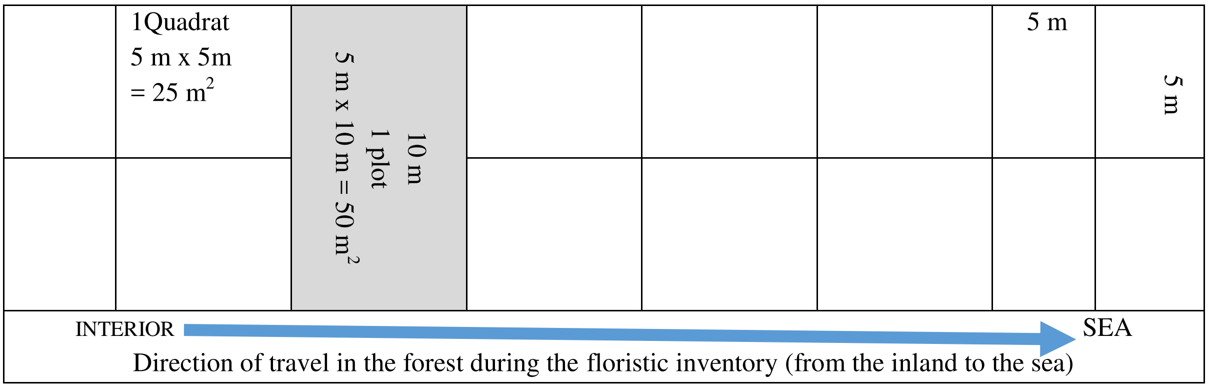
I. Bonhême and E. Saur [21]; it was also used by JP. Fiard in 1994 [22] and P. Joseph in 1997 [23] when analysing the forests of Martinique.

Our objective is to understand the traditional anthropization; the transects cover 400 m^2 corresponding to the smallest area for maximum support of the human activities (tree cutting, waste, crab capture), observed in the mangrove forests of Bois Ferme (Sainte-Rose) which we have deemed necessary and sufficient for our study (Figure 5). It starts at 10 or 20 meters from the forest edge and extends to the interior of the forest in the direction of the sea, in accordance with the users' direction of travel on the ground. Each transect consists of two rows of 25 m² quadrats (subplots, squares with 5 meter sides Table IV). These quadrats are the square elementary surfaces located on the site by using a compass, a wire and a decametre. Two quadrats form a plot.

Field surveys carried out according to the method applied in ecophysiology by P. Joseph in 1997, they are based on the measurements of the plant stratum height, on the identification of species, the individuals of the plot. The individuals are classed by height and diameter. The measurements were taken on the tree trunks at a height lower than 1.33 m for those whose diameter class ranged from 0.5 to 2.5 cm. For the classes with a diameter exceeding 2.5 cm, the measurements were taken at 1.33 meters, in accordance with the international standard. In this way we obtained the density of plant species as well as the species frequency for each transect.

TABLE III

Technical drawing for the sampling mechanism in the forest



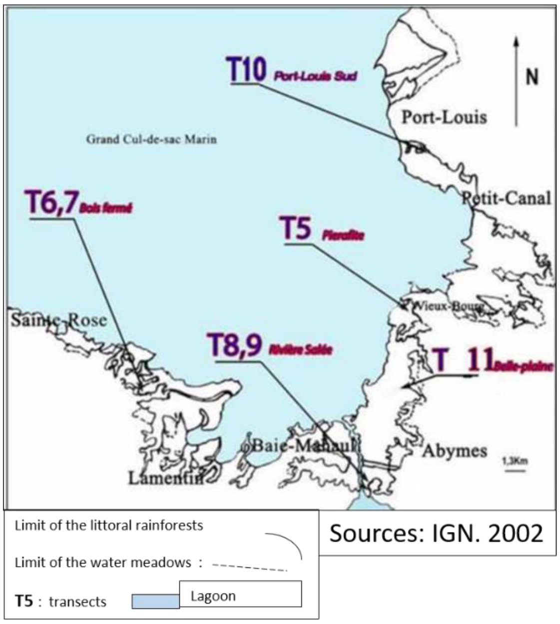


Fig.5. Location of the Mangrove transects in Guadeloupe (2003-2005)
(they do not reach up to the sea, the pioneer part on the sea edge does not exist)

These compared transect measures are necessary in order to verify the organization of the mangrove vegetation and to assess the impact of human interventions on the vegetation structure.

The choice of seven transects studied around the Grand Cul-de-sac Marin was based on the following anthropic indicators: the nearby natural environment (Forest T11, prairie T6 and T10, or hills T5), accessibility (nearby roads: T8 and T9), nearby activities (business, livestock) and the proximity or absence of habitats. This distribution of transects is designed to test the hypothesis that the vegetation dynamics in mangroves is conditioned by human impacts. In what regards the traditional activities, Table V also evaluates the floristic richness based on selected indicators. We note that plant diversity increases with the proximity of human activities: 12 species close to industrial areas. The mangrove populations are accompanied by epiphytes, ferns, vines, several preliminary observations had made us aware that the environmental impact depends on these determinants [10].

The examination of the survey results indicates that the *Rhizophora*s are more abundant in the last interior plots no. 7 and 8 of the T5, T8 and T11 transects where we do not find any *Avicennia*s. They have an average density in T6 and T7 (at Sainte-Rose) and a mere dozen individuals are present at Port-Louis T10. Noting the presence of *Laguncularias* in all transects and with a relatively constant size of the tree stratum, we can deduce that it is a mixed shrub mangrove.

edible species and other tree species, the anthropization modifies the vegetation enriching the flora. When the access is facilitated and the human activity involves foreign materials, the wet landscape diversifies with herbaceous or tree plant groups.

TABLE IV

Number of plant populations in the seven studied mangrove transects (Guadeloupe-2005-2008)

Sites / **Characteristics**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**
Height of the tree stratum (m)	12-15	10-15	10	10-15	10-15	10-15	15-20
Number of epiphytic individuals	24	0	0	80	29	1	2
Strength of Golden ferns	1	2	0	59	140	127	0
Number of vines (individuals)	0	0	0	7	22	0	0
Number of *Rhizophora*	181	0	0	24	21	0	18
Number of *Laguncularia*	106	40	2	36	45	332	142
Number *of Avidenia*	0	150	168	2	4	16	0
Total number of arboreal mangroves per transect	287	190	170	62	70	348	60

TABLE V

Plant species and genera other than mangroves observed in the mangrove transects of Guadeloupe - (+: shows the presence of the plant in the study transect -: means the absence of the plant)

Plant species and genera	**Type**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**
***Pterocarpus officinalis* (Fabaceae)**	Tree	-	-	-	-	-	-	+
***Annona glabra)*Annona)**	Tree	-	-	-	+	+	-	+
***Roystonea regia* (Araceae)**	Tree	-	-	-	+	+	-	-
***Ficus* (Moraceae)**	Tree	+	-	-	-	-	-	-
***Cecropia peltata)*Moraceae)**	Tree	-	-	-	-	-	-	+
***Ceiba pentandra*(Bombacacees)**	Tree	-	-	-	+	+	-	-
***Tabebuia pallidaheterophylla*(Bignoniaceae)**	Tree	-	-	-	+	+	+	-
***Terminalia catappa* (Combretaceae)**	Tree	-	-	-	+	+	-	-
***Myricia antillana* (Myrtaceae)**	Shrub	+	-	-	-	-	-	-
***Wittmackia lingulata* (Bromeliads)**	Epiphyte Grass	+	-	-	+	+	+	+
***Achrostichum aureum* (Ferns)**	Grass	+	+	-	+	+	+	+
Another ferns	Grass	-	-	-	+	+	-	-
***Dalbergia monetaria* (Fabaceae)**	Vine	-	-	-	+	+	-	-
Total of the different plants		**4**	**1**	**0**	**9**	**9**	**3**	**5**

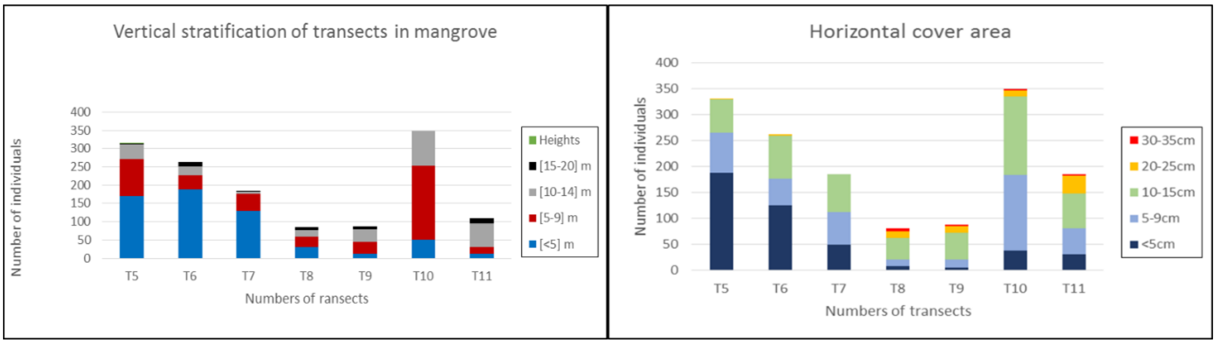


Fig. 6. Structural organization of vegetation in the studied mangrove transects of Guadeloupe

The study of mangrove horizontal recovery and vertical stratification in the seven study transects (Figure 6) reflects the population variability. A few tens of metres from the boundary of human activities, the density of young mangrove trees of small diameter and occupying a middle tree floor can be seen in five transects out of seven. These are the characteristics of a low biomass forest in a young stage, a forest in reconstruction.

This result shows a functional aspect of the mangrove: its enrichment in a spatially acquired biodiversity which develops along with the activities. This structural variability can be caused by the numerous cited indicators: roads, access, industry, and neighbouring ecosystems.

Beyond this adaptation dynamics, the mangrove areas have direct and indirect value which shows their potential.

IV. MULTIPLE POTENTIALITIES OF THE COASTAL WETLAND ECOSYSTEMS

They are specific for each territory and their environmental physical factors.

A. Ecological Functions

- Trapping the atmospheric carbon

These are areas whose functions in the manufacture of organic matter [24] and the absorption of greenhouse gas are vital [25]. By means of photosynthesis, the mangrove areas which are evergreen spaces function as carbon pits, they store 20% of the global Carbon. These environments help us to effectively combat global warming. In fact, Ringold et al. 2013 recognize in their study that the mangrove populations are as productive as the tropical rainforests in terms of carbon storage. In the mangrove forests soil this carbon storage process is 2 to 3 times greater than in other forest systems. It can reach 71-98% in the river mangrove forests and 40 to 90% for coastal mangroves. These figures include the roots, the dead biomass and the sediments. The evaluation of the mangrove underground biomass carried out by Giupponi et al, 2008 remains complex [1].

- Coastal protection

Due to a retention phenomenon of downstream-moving sediments, to sea swell and currents stopping, to the sheltered areas in coves, the wetlands protect the shorelines from erosion. The forest vegetation protects it from noise, it provides protection against the wind, against the cyclones. Wolanski's studies of 2006; Tanaka et al. in 2007 and Alongi in 2008 showed how the mangrove forests minimize the risks of average intensity tsunamis for the river populations [1].

- Air and water decontamination

The mangrove forests' role of sponges provides the wetlands with the hydrological functions necessary for the attached areas. The reserve water is redistributed in times of drought. The importance of the biogeochemical functions of this coastal wetland also consists in its role of biological filter extractor of pollutants. This biofiltration is assessed by studies of Lal, 2003 in the Fidji islands, Lin and Dushoff in 2004 in the Panama and Tam, 2006 in Japan cited by Spalding, Kainuma, et Collins, 2011[1]. This environment provides a barrier against pollution from the land or the sea. In addition, as in their soils, the organic matter decomposition is slow and the organic carbon is stored longer.

All of these functions that explain the effectiveness of these ecosystems to different geochemical cycles: water, air cycles (carbon and oxygen) matter and energy cycles, make the coastal wetland an open system depending on water and salinity in direct relation with the surrounding environments. It ensures water and air purification and as such it is a reservoir of biodiversity, hosting an abundant wildlife.

Therefore these complex chemical processes allow these areas to have multiple values for all populations [26].

B. Socio-Economic Values

The coastal mangrove forests are biocenotic reservoirs, opposing any landscaped coast by being in competition with them. In fact, the habitat determined by the vegetation of these areas structures them to ensure the food and protection of the numerous animal species. The resulting biocenotic richness allows us to classify our islands among the global biodiversity “hotspots”. It is an area of strong ecological richness subject to significant threats, one of the 34 defined by Conservation International and mapped by IUCN France in 2009. This biocenotic production has numerous benefits enjoyed by the local population. As a consequence they create economic wealth and have an invaluable social value.

- Economic value

Its biodiversity is accompanied by a production of food species favouring the fishing, hunting, agriculture activities (different livestock farms especially in the prairies: pig farms, henhouses, rabbit stock). The production of honey is rarer and the medicinal plants which start to be used are limited by the classification in protected species.

These traditional activities in relation to food (hunting, crab capture) are sources of income. This type of informal activity helps diminish the unemployment [10].

Nowadays, the boom in tourism with its modern forms: canoeing, pedal boats, boats paddle, electric or engine boats, hiking on plateaus, rallies in mangrove forest are all income-generating activities or they do not generate a profit. We counted at least 12 canoe-kayak recreation areas in the mangrove forests around the archipelago and three skeet shooting centres in Morne-À-L'eau, in Abymes (Sarcelle d’or) and at Baie-Mahault (la Madeleine).

- Social values

Beyond their economic value, they are places of meetings, of conviviality. These activities centered around fishing, hunting, trips in carts pulled by oxen, are designed to maintain the link between the generations and to ensure social peace. We can say the same with all the sports practised on these prairies, such as: skeet shooting, oxen pulling carts...The “winner” is identified in parties like the crab feast at Easter in Morne-À-L'eau.

We must also add the religious and spiritual values of these spaces resulting in pilgrimages, they are places of prayer (chapels in all the mangrove forests and the islets), liberation ablutions: “deep” bathing.

The well-being value of the wetlands must be taken into account: for health (mud baths in the mangrove forests of Babinorof Baie-Mahault), the heart (hiking and mountain biking), for leisure pastimes (walks, excursions in kayak, paddleboat or canoe)

The study of these environments has great value in environmental education, in the training of the young or in research. These ecosystems also have indirect value: they are a symbol of environmental identity and have natural heritage value. In literature, the mangrove was an inspiration theme for novelist Maryse CONDÉ or the creole text of Mirna BOLUS in 2009

In Psychology: The mangrove forests stand for “ill-being”. Among other things they represent a place where drugs are rampant, as they are a “no-man's land” belonging to no one or to everyone at the same time. They also provide shelter for many homeless persons.

C. Analysis-Discussion

The multiplicity of these values results in a permanent presence in these spaces which in general are not population housing areas. These natural mangrove coastlines allow the practice of various activities. Field surveys in different sites showed that with the increase in unemployment all the socio-professional categories temporarily used them to obtain raw material: trees for heating, crabs, mollusks: chaubettes, clams, birds, fodder or other. They represent a non-negligible income net of taxes which they refuse to declare. This questionnaire allowed us to know that 50% of respondents use these revenues to buy school supplies and clothes to go to school [10].

These spaces also allow the building of public housing to alleviate the housing shortage or mitigate the effects of the housing crisis. Particularly the adjacent prairies are used for sewage stations and "full sewage". In the past as well as today, they are "catch-all" areas confiscated for the achievements of major road infrastructures, airports, ports or hotel areas.

All these human activities with collective goals determined by society's needs result in dynamics that affect the biodiversity on these coastal wetlands and which may be irreversible.

V. VULNERABILITY AND COASTAL WETLANDS IN RELATION TO OUR SOCIETY

Nowadays, Man and his environmental space are often confronted with numerous disturbances which [27], [28] Lionel KUATE, 2010 considered hazards or risks. These environmental ecological risks may be natural (hurricanes, storms), or anthropogenic (results of human activities). Due to their random nature, these risks and the response of the biotope and biocenotic communities represent the determinants of an environment's vulnerability.

A. Vulnerability to Environmental Risks

The vulnerability of Guadeloupe's coastal wetlands is a reality that can be determined only by the impact or consequences of the exposure of these environments to disturbances varying in intensity.

The field observations allow us to note the traces of human activity, which accompanied by a bibliographical synthesis reflect the impacts of environmental disturbances (Table VI). The two types of risks: natural hazards and those due to anthropization have different consequences.

When it comes to ecological risk of the type of unpredictable natural disasters, such as tsunamis, storms and cyclones, the partly destroyed vegetation slowly renews itself after several years. If the impacts are low the environment reconstitutes itself gradually and spontaneously after the disturbance: this is its resilience at work. In the case of anthropic risks, such as urbanization, the environment disappears. Similarly, the introduction of invasive species [29] [30] or pollutants causes an ecological change in the characteristics of the wetlands site that might be described as “negative anthropic biodiversity”.

A typical example of total degradation of the mangrove forests to report: the mangrove forest of Gosier-Bourg to Pointe de la verdure. Tourist facilities and close urbanization cause a change in water networks. A dry forest pond (= mangrove disappearance state) resulted, a project to develop a marina is already envisioned to replace it.

Taking into account the consequences observed in the field, we can define a degree of sensitivity and the notion of reversibility to the natural state or irreversibility. These indices result in a classification of the impacts in the field which identifies the limits of the uses of these environments in Table VI.

TABLE VI
State of the effects of disturbances on the coastal ecosystems

	Risks	**Observed impacts**	**Reversibility**	**Littoral wetland sensitivity**
Natural risks	tsunamis, storms, cyclones	variable with the cataclysm	Possible, average, resilience	Low, Natural, reconstruction of the environment
Anthropic risks	Introduction of new species (invasive plants or invasive animals)	modified biodiversity- threatened environment, - loss of species	Irreversibility in the long term without searching for solutions	Average
	Tourism-Education	Variable with the respect for the areas	Possible Reversibility	Average
	Traditional uses	Dynamics Low:	Reversibility	Low
	Waste industrial pollutants, agricultural waste	Destruction and Risks, loss of environment function	Irreversibility	Strong
	Urbanization Roads... Housing, Facilities (sports fields), Tourism, port or airport infrastructures.	Habitat loss	Irreversibility	Very strong

This leads us to think that climate changes characterized by the increase in temperatures, floods, the intensity of the cataclysms and hydrological changes will result in the increase of the observed consequences [31] and especially in the irreversibility to the functional status. This irreversibility can spread if the anthropization increases due to an increase in needs. Some disturbances observed in the field can increase landscape diversity by forming mosaics of plant succession, they can even increase biodiversity. But in fact a subtle internal deterioration takes place endangering the wetland (the example of the Gosier). Which makes us wonder about the role of governance regarding the issue of the management of these areas.

B. Management

These coastal wetland ecosystems belong to many administrations: State, Region, Department, Communities and Public Lake and Maritime Areas [19], [32]. Throughout history, several regulatory legal tools (coastal law, landscape law) and Government agencies (NFB, PNG, DIREN and DDA today DEAL) were implemented by the State in the 1970s to protect these areas, avoid their suffering damages and loss. Protection decrees were also implemented, such as ZNIEFF 1 and 2, classifications as sites or even natural reserves in 1987; as well as the registration of the Grand Cul-de-Sac Marin on the RAMSAR list in 1993, the creation of the Biosphere Reserve in 1994 for the GCSM and the application of the MAB Programme. All these tools allow the global coastal wetlands to benefit from international labels that recognize their value and make them the object of specific protection projects [33], [34], [35].

Even today, the installation of populations is authorised to protect the electorate, the occupation remains anarchic and informal, they just “squat” the place until they obtain a deed of ownership.

In 1975, the Conservatoire du littoral (CDL) [36] was created to protect these areas. In 2010 the State assigned to it all the mangrove areas in Guadeloupe in other words circa 7500ha. The CDL is a public State institution that implements a land policy of protection of coast ecosystems and landscapes. It entrusts the management of sites to the communities, to associations or public institutions. The Grand Cul-de-Sac Marin is entrusted for management to the National Park of Guadeloupe [37] which turned it into the park's core with many restrictions and close monitoring. The management of other mangrove forests in Guadeloupe is incumbent to the National Forests Office with more flexible protection.

The recognised intrinsic value of the mangrove coastlines and the importance of mangroves in fighting global warming [31] [38], caused the creation of new tools at governmental level. A few years ago the State has decreed that the Wetlands management plan must be aligned with the Local Urbanism Plan and be included in the Regional Development Plan (SAR). Since 2013, the CDL and the Technical Office of Natural Spaces (Aten) implement for the State an action plan entitled mang meaning mangrove (the mangrove's Antillean creole name) which should ensure a better management of the coastal wetlands of the overseas European territories. Then in 2014, the Pôle-relais Mangroves and the Overseas Wetlands announced in 2012 were created in Guadeloupe[39].Its goal is to pool knowledge and good practices in order to disseminate them to the involved entities/managers to act more effectively for the preservation and restoration of coastal wetlands. Soon a Biodiversity Agency will be created. These measures give us hope for the sustainable protection of these environments.

VI ANALYSIS-CONCLUSION

The internal degradation of the coastal mangrove forests continues in some areas due to the arrival of filling materials, waste for example. In 2004 we could read that the Grand Cul-de-sac Marin coastal area remains intact or increases, it is no less true that within the coastal rainforests the biodiversity faces a regressive dynamics due to anthropization. In fact, in the vicinity of the La Gabarre waste site in les Abymes the littoral forests are damaged, in Jarry a sandpit installation causes the mutation of the mangrove forest to a mixed shrub formation with a thicket of thorny bushes. It represents a regressive evolution of the area, unsuited to the ecology of these environments, which in the end will have none of the characteristic of wet coastal areas.

In addition, with proven risks for the coastal mangrove forests due to global warming, the rise of the ocean waters, and the increase in the intensity of natural disasters; we truly have to efficiently protect all Guadeloupe's mangroves.

In the report of the National Observatory on the effects of Global Warming (ORNEC) of 2012[40], V. Duvat advocates the adaptation of the coastal development management, by reducing their vulnerability by controlling urbanization, implementing development strategies in different fields such as tourism, fishing and agriculture. The management of human activities must be strengthened using increased governance, particularly for the informal actions in these areas, an improvement of prevention, the development of new management tools to protect the habitats and resources. He also advocates that the adaptation of the local development to climate changes should be integrated in the policy of sustainable territory development.

It is clear that we must make information and prevention efforts towards the population through public conferences, sports etc. so that they become aware of these ecosystems. Similarly, associations for the protection of the environment as well as the managing bodies of these environments must continue to help the users to regulate their species predation.

VII. ACRONYMS

NFB: National Forests Office
PNG: National Park of Guadeloupe
DIREN: Regional Directorate for the Environment
DDA: Departmental Directorate for Agriculture
DEAL: Environment, Planning and Housing Directorate
ZNIEFF: Natural Area of Ecological, Fauna and Floristic Interest
MAB: Man And Biosphere
GCSM: Grand Cul-de-Sac Marin

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