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The management of Insular Caribbean mangroves in relation to site location and community type

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Abstract

Mangrove ecosystems occupy different locations on Caribbean island coasts, ranging from open bays (fringe mangals) to totally enclosed salt ponds and salinas. On geomorphologically active coastlines, such as south Jamaica, systems are at varying degrees of maturity and productivity. Furthermore, because of system variability, the interactions between mangroves and associated marine systems, such as coral reefs and seagrass beds, are developed to different degrees.

Community structure and productivity of a range of mangals on different islands of the Greater and Lesser Antilles are discussed. Forcing functions and levels of interaction with the marine environment are identified.

The rational choice of management options must be based on the range of goods and services provided by the different systems; and a good understanding of their ecology is essential when choosing sites for protection, waste disposal, landfill, marina development and fisheries enhancement. Examples are given from current studies in Jamaica, St. Lucia, the British Virgin Islands and Trinidad, of a flexible management response to mangrove ecosystem diversity.

Introduction

The importance of wetland conservation is widely recognised and Caribbean island governments are working to produce inventories and management plans. Mangrove dominated wetlands, or mangals, are the most common type in the Insular Caribbean, particularly in the Lesser Antilles. Mangroves are threatened and impacted by development activity, particularly because of their coastal location and the importance of coastal economies in the Caribbean (Hudson, 1983; Bacon, 1987). In most coastal areas the mangals contain only three species of mangrove trees, which in order of importance are *Rhizophora mangle* L., *Avicennia germinans* (L.) Stearn and *Laguncularia racemosa* (L.) Gaertn.; with *R. harrisonii* Leechman, *R. racemosa* G. F. W. Meyer and *A. schaueriana* Stapf & Leechman at scattered locations in the Southeastern Caribbean. The buttonwood, *Conocarpus erectus* L., is common throughout the region on the drier wetland margins. The invertebrate, fish and waterfowl faunas show a high degree of commonality and Caribbean mangals carry out the classic roles of coastal protection, organic matter production, provision of fish nursery area and wildlife habitat. This suggests that a uniform mangrove management strategy can be applied and that this might follow the globally applicable principles laid down by Hamilton & Snedaker (1984).

However, as Lugo & Snedaker (1974) demonstrated, a range of mangrove types occurs in the Neotropics; the riverine, fringe, basin and scrub types, which have different ecological attributes. Furthermore, Bacon (1986) pointed out that these mangals were associated with a variety of coastal ecosystems whose geographic characteristics determined their ecology and productivity. This paper examines the influence of site location on the ecological and economic attributes of mangals in selected Caribbean islands and discusses how these features can be incorporated into the management decision-making process.

Description of sites studied

Mangrove systems were surveyed on a 50 km stretch of coastline near Kingston, south Jamaica; these ranged from open bay fringe mangal to enclosed salina with scrub mangroves (see Fig. 1). On this geomorphologically active coast, barrier and lagoon development has influenced mangrove distribution and successional processes; so that there are pioneering, mature and senile mangal communities (Bacon, 1986). Site aspect also influences the degree of hurricane impact, which is a further factor controlling mangrove forest structure and productivity (Alleng, 1990).

Mangrove areas studied in St. Lucia showed a similar site variability on both east and west coasts of this geomorphologically different island (see Fig. 2). The generally small mangrove stands occupied open bay fringes or were isolated from the sea behind beach barriers which breach only in times of heavy flooding. Site characteristics influence plant distribution, tidal exchanges, salinity range, groundwater and riverine inputs, sediment grain size and composition and nutrient status.

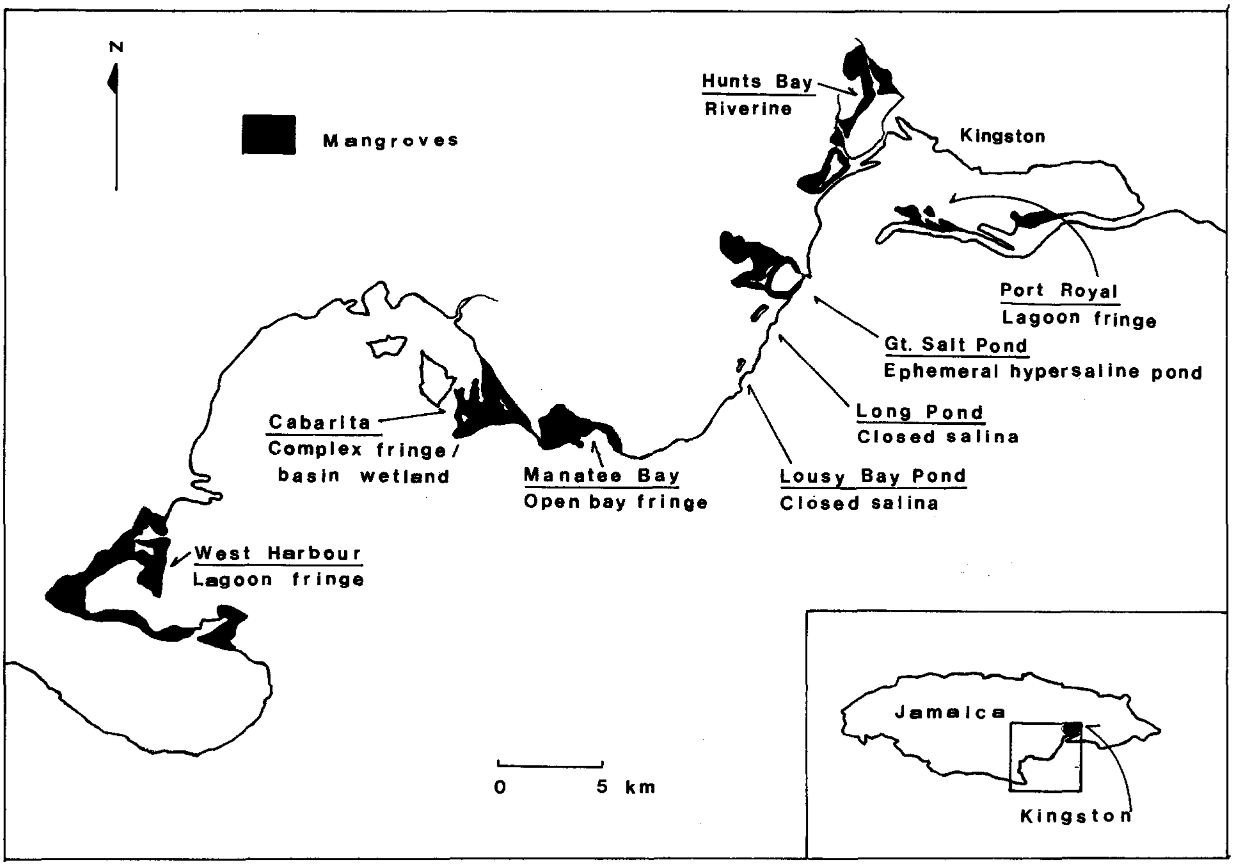

Fig. 1. Selected mangrove sites in south Jamaica.

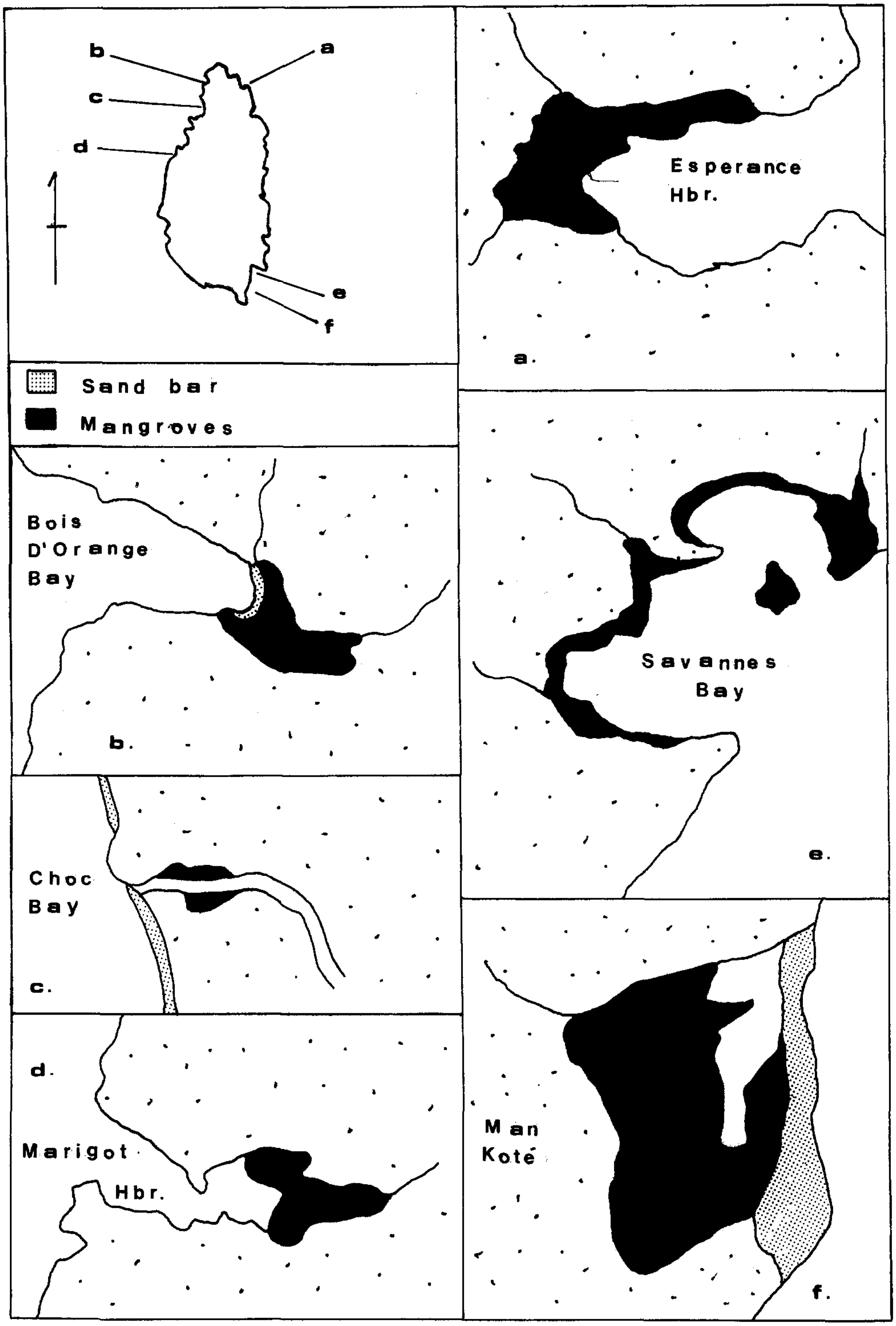

Fig. 2. Selected mangrove sites in St. Lucia. Scale for a–c, & f = 1:10 000; Scale for d & e = 1:25 000.

Methodology for mangrove area assessment

The ecological and socioeconomic values of these two groups of mangals were assessed using a methodology adapted from Adamus (1983). The method assigns a rating to attributes and functions of these wetlands in order to obtain a ranking that can be used for management decision-making (see Table 1). The rating system used was simple, scoring High (3), Medium (2), Low (1) and None (0), because of the relative paucity of data for some categories. Field observation and mapping by the senior author and reports on the Jamaican sites (Chow, 1989; McCain & Bacon, 1989; Alleng, 1990) and St. Lucian sites (Portecop & Benito-Espinal, 1985) provided detailed infirmation on areal extent, plant distribution and use of the habitats by wildlife, but assignments under the socioeconomic categories (such as, importance to fisheries, education value) were based largely on informed opinion.

Results and discussion

The danger of generalizing about mangrove management is apparent when this assessment methodology permits the ranking of systems according to their respective values. All the sites were positive for some values, but the ranking identified areas of priority for conservation while singling out sites with lower value that might be available for use as marinas, dump sites or landfill. All isolated and semi-isolated sites scored low values for wildlife habitat and fisheries, and the potential for mariculture, educational and recreational use (see the WH, EC & RE categories in Table 1). Embayment and Lagoon-type sites also received the highest rankings when this evaluation system was used in the British Virgin Islands (Blok-Meeuwig, 1990); in Tortola, for example, top priority sites for conservation were Paraquita (lagoon fringe), Witches Brew (lagoon fringe) and Hodges Creek (embayment fringe).

Table 1. Assessment of ecological & socioeconomic values of selected mangrove sites in Jamaica & St. Lucia.

Site	SZ	CD	VD	OW	SD	SL	WH	EC	RE	Value index
A. Jamaica										
Kingston Hbr.	3	3	2	3	3	3	2	2	2	2.3
West Hbr.	3	3	2	3	3	3	2	2	2	2.3
GSP/Flashes	3	3	2	2	3	3	2	2	2	2.2
Cabarita	3	2	2	3	2	2	2	2	2	2.0
Manatee Bay	3	1	2	1	3	2	1	1	1	1.5
Long Pond	2	2	2	1	3	1	1	0	1	1.3
Lousy Bay	1	1	1	1	1	1	1	0	0	0.7
B. St. Lucia										
Savannes Bay	3	1	2	1	3	2	2	2	2	1.8
Esperance Hbr.	3	2	2	1	3	2	2	1	1	1.7
Marigot Hbr.	2	1	2	1	2	2	2	1	1	1.4
Man Kote	3	2	3	1	0	1	1	1	1	1.3
Bois d'Orange	2	2	2	1	0	1	1	0	1	1.0
Choc	1	1	1	1	3	1	1	0	0	0.9

Key: SZ = size of mangal
VD = vegetation dispersion
SD = species dominance
WH = wildlife habitat
RE = recreational/educational value
CD = community diversity
OW = open water dispersion
SL = sytem linkages
EC = economic values

Score: High = 3, Medium = 2, Low = 1, None = 0.

Open mangals permit movement of marine and estuarine organisms in and out of the system and export of organic matter. Ogden & Gladfelter (1983) noted that interaction between mangals, seagrass beds and coral reefs was a common feature of Caribbean coasts, but did not comment on the degree of variability which exists in such linkages. The nature of the association between three of the south coast Jamaica mangals and neighbouring marine ecosystems is shown in Fig. 3, to illustrate this point. The communities at these locations are fringe mangroves dominated by *Rhizophora*. In Port Royal they occupy approximately 6 ha, with mean canopy height 4.6 m (Alleng, 1990), while in the Great Salt Pond/Flashes area they occupy approximately 25 ha, with mean canopy height 5.4 m. Fringe mangroves in West Harbour occupy approximately 260 ha, with mean canopy height at 6.0 m. Apart from variations in areal extent, other structural parameters are within the same order of magnitude and accord well with the description of fringe mangroves given by Lugo & Snedaker (1974).

However, the geographic setting and hydrography influence the fate of the organic matter and nutrients generated within the three systems, with implications for the nature of their linkages with contiguous ecosystems. Site geography indicates that the impacts of exported materials are probably in inverse relation to the area of mangroves at each site. Port Royal mangroves are functionally part of the Kingston Harbour system, which has strong fluviatile influences, wind-driven and tidal circulation patterns. Kingston Harbour is a major exporter of nutrients and organic matter to the inshore environment and its effluent strongly influences the neighbouring reefs and seagrass beds (Head & Hendry, 1986; Bacon *et al.*, 1989). Furthermore, this system is an open, continuously exporting system. In contrast, the Great Salt Pond/Flashes mangroves developed around an hypersaline pond closed by an ephemeral sand bar. A lagoon formed briefly during the wet season when flood water breached the barrier permitting entry of sea water. Now that there is a permanent artificial channel stable, more marine conditions have been established in the pond. However, it still acts as a source of nitrite and phosphorus to the inshore waters when there is positive net discharge only during the wet season and particularly after storms (McCain & Bacon, 1989). This situation is similar to the Nariva mangrove lagoon, Trinidad, where discharge to the Atlantic Ocean occurs only during two to three months of the wet season, when the effluent stream can carry up to 100 t org.C day^{-1} from the 90 km^2 wetland (Bacon, 1981). Such pulses of nutrient-rich, brackish water have a seasonal, or intermittent impact on neighbouring marine habitats.

As West Harbour lacks riverine inputs, has prevailing onshore winds, a weak circulation pattern, and experiences a high evaporation rate because it is located in one of the driest areas of Jamaica, a net outflow of water containing dissolved and particulate organic matter has not been detected. This mangal probably has little direct influence on the ecology of the adjacent Portland Bight, but functions as a net accumulator of organic matter. Such lagoonal systems which act as sinks for organic matter occur in several parts of the Jamaican coast, but are poorly described. Mangrove production appears to be available to consumers only if they enter the system, hence West Harbour's importance as fish habitat and nursery environment and its potential for mariculture.

The relative roles of the three fringe mangals shown in Fig. 3 have been assessed as indicated in Table 1 using differences in community structure and ecological forcing functions (Lugo & Snedaker, 1974) and degree of site variability (Bacon, 1986). This allows these ecologically and economically important systems to be rated for management purposes.

What has not been done is to include in the assessment methodology criteria which express the value of the mangals *to* associated marine habitats. Although the value of the mangal itself has been assessed, the relationship between particular mangrove sites and the continued health and productivity of an island's fisheries, seagrass beds or coral reefs is a critical factor in coastal resources management. If this dimension can be

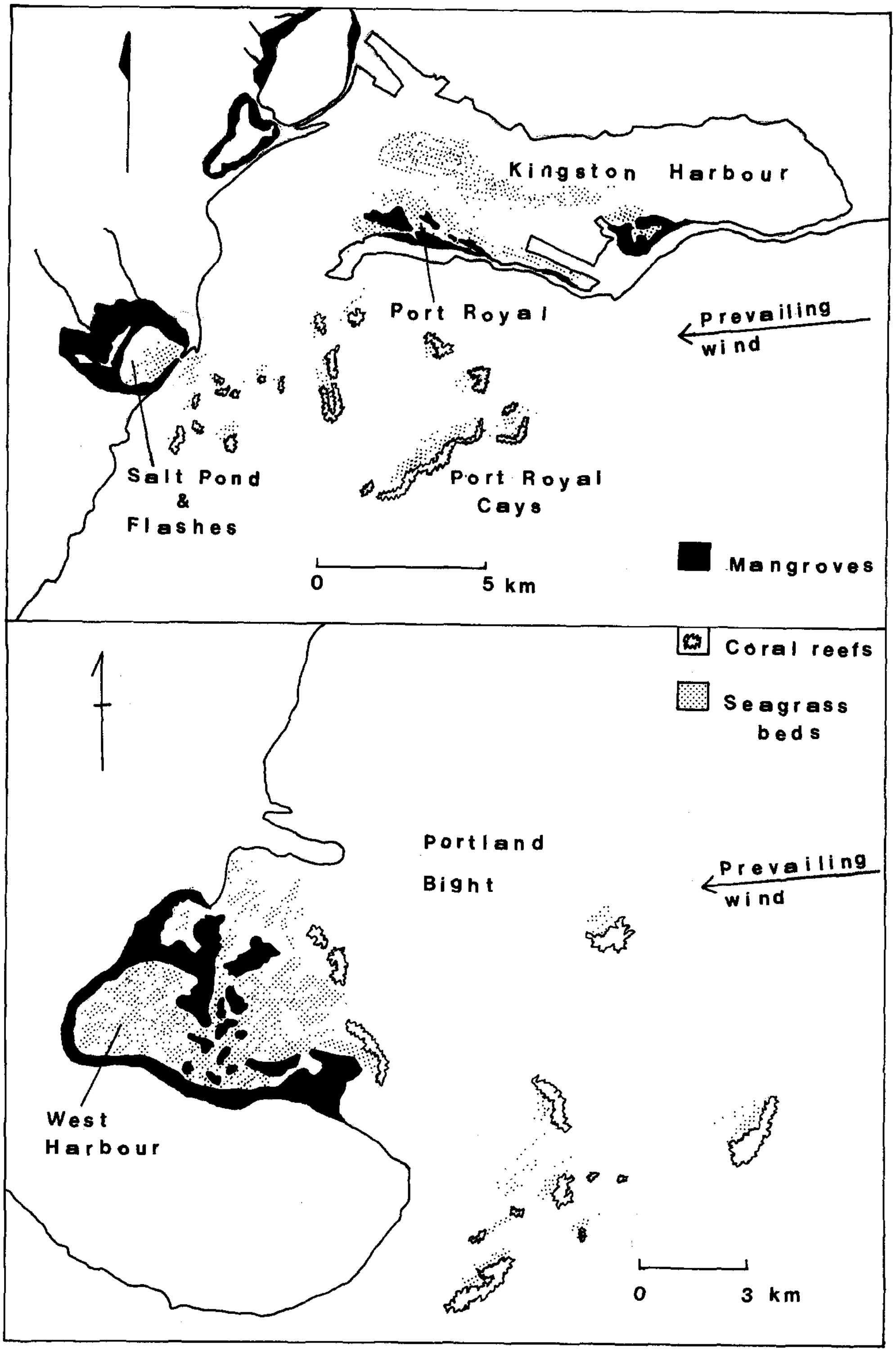

Fig. 3. Associations of three Jamaican mangals with neighbouring coastal ecosystems.

Table 2. Role of mangals in interactions with neighbouring coastal and marine ecosystems.

1. Physical interactions
   1.1. Filtering terrestrially derived sediment
   Reduction in sediment load reaching the sea
   1.2. Buffering salinity changes
   Reduction in volume of freshwater reaching the sea
2. Nutrient interactions
   2.1. Export of dissolved & particulate organic matter
   2.2. Sinks for particulate organic matter
3. Biotic interactions
   3.1. Export of meroplanktonic larvae to marine food chains
   3.2. provision of feeding habitat
   - marine invertebrates & fin fish (diurnal & seasonal migrations)
   - seabirds, shorebirds, marine mammals
   3.3. Provision of juvenile (nursery) habitat
   - crustacea (shrimp, lobster) & molluscs (conch)
   - fin fish (reef fish, seagrass bed fish, pelagics)
   - seabirds & shorebirds nesting (also roosting)
   - marine mammals (dolphins)

added, a more flexible system of mangrove site assessment would be produced which could respond to conservation requirements in other sectors of the economy. Table 2 lists some of the identified interactions with associated ecosystems which influence the value that should be attached to mangrove sites.

The nature of interactions between these systems is understood (Ogden & Gladfelter, 1983), but insufficient data is available on which to base evaluations. Further research is needed to quantify (a) the interactive physical forcing functions, (b) the magnitude of nutrient and biotic exchanges and (c) the degree of nursery dependence between key Caribbean ecosystems, in order to improve the mangrove site assessment methodologies currently in use.

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