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STRUCTURAL COMPARISONS OF MANGROVE FORESTS NEAR SHRIMP PONDS IN SOUTHERN ECUADOR

ABSTRACT

Coastal salitrales and mixed-species mangrove-basin forests are preferred sites for the construction of shrimp grow-out ponds in Ecuador. Because the forest habitats are dominated by Avicennia *and* Laguncularia, *large scale land clearing for ponds has reduced the relative coverage and abundance of mangrove species in these genera. Unlike the leaf detritus exporting* Rhizophora*-dominated habitats, the infrequently inundated basin forests produced large quantities of dissolved organic matter which form a food resource for crustaceans including shrimp. The differential loss of this habitat type in southern Ecuador could be a reason for the decline in wild shrimp postlarva.*

Introduction

Tropical mangrove forests have a number of ecologically-important functions (Saenger, *et al.*, 1983) and economic values (cf. Hamilton and Snedaker, 1984) of which the support of nearshore marine life may be one of the most widely appreciated. This is based on the fact that mangroves form an intertidal habitat and continually produce large quantities of mangrove leaf detritus that is a basis for nearshore and estuarine food webs (Odum and Heald, 1975). In particular, the yield of shrimp fisheries around the world have been closely correlated with the abundance of coastal mangrove forests (Martosubroto and Naamin, 1977; Turner, 1977).

In spite of the recognized importance of mangroves, these highly productive forests have undergone deleterious modifications in many places for a variety of purposes (Saenger, *et al.*, 1983). At the present time, the conversion of mangrove habitats to ponds for shrimp mariculture may be the most ubiquitous worldwide mangrove-related problem (Rabanal, 1978; Velasco, 1980; Ong, 1982). This practice involves the complete removal of mangroves over extensive areas and their replacement by activities that do not perpetuate the natural values. In Ecuador, for example, Terchunian, *et al.*, (1986) have estimated a 16% reduction in the area of mangrove forest between 1966 and 1982 in one study area in the southern Gulf of Guayaquil. Although conversion to shrimp growout ponds does not necessarily destroy all of the mangroves in a regional setting, pond siting preferences in Ecuador focus the greatest impacts on salitrales (*i.e.*, salt flats) and associated mixed-species basin mangrove forests (see Lugo and Snedaker, 1974, for definitions of the mangrove forest types). This raises two major questions: (1) what might be the probable consequences of the loss of habitat diversity in the mangrove ecosystem, and (2) what is the ecological status of the remaining mangrove forest habitats? The purpose of this study was to make an initial ecological assessment of the remaining mangrove forests contiguous to large shrimp farms to determine whether or not these questions are valid and therefore worthy of further investigation.

Materials and Methods

Six different mangrove forests, representing a range of environmental conditions, adjacent to commercial shrimp growout ponds were selected for study (Fig. 1). The point-center quarter method (Cottam and Curtis, 1956) was used to measure structural parameters of the mangrove forests along two parallel transects established at each of the study sites. At each site, a total of 80 trees having a diameter at breast height (DBH) greater than 2.5 cm were identified to genus, and their height and DBH were measured. Complexity indices (Holdridge, 1967) were calculated on a 0.1 ha basis for each of the forest sites. This index is traditionally used to compare structural patterns and relative vigor of different mangrove forests (cf. Pool *et al.*, 1977). In addition, the importance value (Curtis, 1959) was estimated for each genus within each study forest.

Generic identifications were used because, at present, there is no agreement with respect

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to the number and the correct identity of the mangrove species in Ecuador, particularly among the *Rhizophora*. Horna, *et al.*, (1980) report the presence of four species of *Rhizophora: R. harrisonii, R. mangle, R. racemosa*, and *R. samoensis*. Horna, *et al.*, (op. cit.) cites Cintrón, *et al.*, (1979) and Horna (1980) as first reporting the presence of the two latter species in Ecuador. However, Cintrón (1981) reports only the presence of *R. mangle* and *R. brevistyla*, whereas Tomlinson (1978) considers *R. harrisonii* to be a synonym for *R. brevistyla* (see also Breteler, 1977).

Results and Discussion

Table 1 summarizes the most important structural characteristics of the six mangrove forests. The forest complexity indices, with the exception of the Balao Grande site, are low compared to mangrove forests in other regions (cf. Pool, *et al.*, 1977, Jiménez, 1981). However, the low values are comparable to stressed dwarf-mangrove environments in south Florida and to *Avicennia* forests in dry environments (cf. Pool, *et al.*, 1977, Martínez, Cintrón and Encarnación 1979). Two main factors seem to be responsible for the low values: (1) human intervention in the form of mangrove habitat modification, and (2) the alteration of surface water flushing patterns.

Of the two causative factors, human intervention seems to play the greatest role in explaining the low complexity indices in the remaining mangrove forest areas. Because the nearby growout ponds had been constructed in the salitral and basin forest habitats, the study transects necessarily did not include representative numbers of *Avicennia* and *Laguncularia*. The reduction in abundance of these two genera is also reflected in the corresponding high importance value for *Rhizophora*. Since *Avicennia* and *Laguncularia* tend to be found closer to the salitrales, the preferred sites for ponds, than *Rhizophora*, the destructive impact has been greatest on these two genera and the habitats they dominate.

The low basal area (BA) is also notable, especially when compared to other values reported for Ecuador by Acosta-Solís (1957) (BA = 62.4 + 13 m²/ha) and Cañadas and Torres (sin fecha) (17.6 + 1.99 m²/ha), both of which are cited in Cintrón (1981); our values are up to one order of magnitude lower. The low basal area determined in this study is mainly attributable to human intervention through the widespread selective felling of large mangrove trees (greater height and DBH) for such uses as construction material for piers, bridges, electric poles and housing. A secondary factor, particularly over the longer term, is the altered surface water flushing patterns resulting from the barrier dikes around the growout ponds, which could reduce the energy subsidy to the forests.

Summary and Conclusions

This preliminary assessment indicates that *Avicennia* and *Laguncularia* forests are the most heavily impacted by the construction of shrimp farms in salitral and basin-forest habitats. This translates into a direct loss of habitat diversity of an unknown magnitude. In addition, the selective harvesting of the largest trees in the remaining forests results in a relatively low basal area which reduces the calculated value of complexity index. This preliminary finding may be highly significant for the following reason.

Regional mangrove forest ecosystems typically consist of a mosaic of forest types with differing functions (Lu-

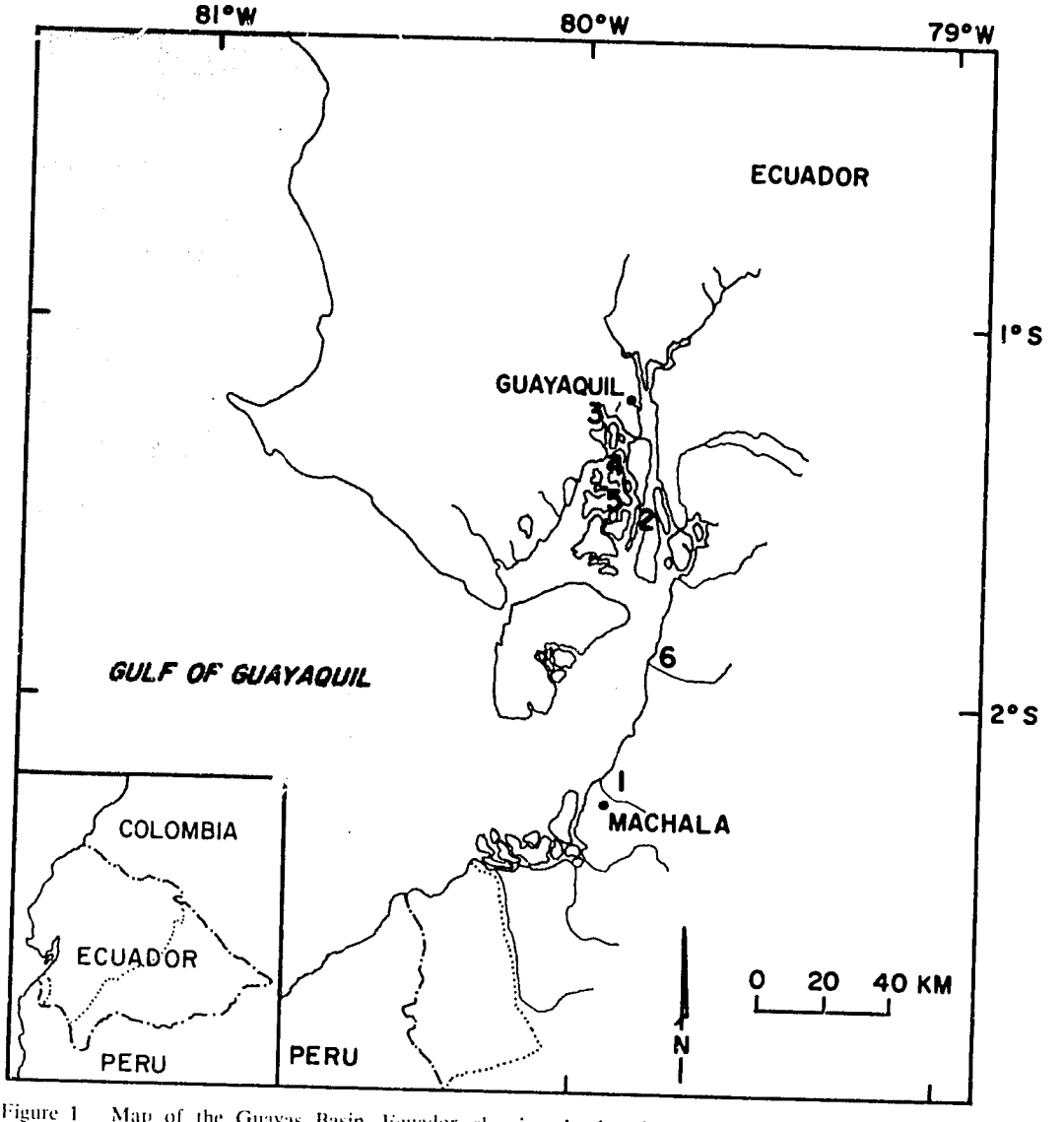

Figure 1 Map of the Guayas Basin, Ecuador, showing the location of the sampling sites: 1). Machala, 2). Puerto de Roma, 3). Chongón, 4). Isla de las Conchitas, 5). Estero Santa Ana, and 6). Balao Grande. Sampling site names refer to closest known geographic location.

TABLE I

STRUCTURAL COMPARISON OF MANGROVE FORESTS NEAR SHRIMP PONDS IN SOUTHERN ECUADOR. COMPLEXITY COMPONENTS ARE EXPRESSED ON A 0.1 ha BASIS

Site	Genus Present	Genus Density (Trees/0.1 ha)	Forest Type	Relative Density (%)	Genus Basal Area (m^2)	Rank	Canopy Height (m)	Rel. Dom. a (%)	Rel. Freq. b (%)	I.V. c (%)	CI d
Machala	*Rhizophora*	58.8	Basin	100.00	0.718	1	26.16	100.00	100.00	300.00	1.10
Puerto de Roma (Río Guayas)	*Rhizophora*	21.4	Riverine	97.37	0.867	1		99.92	95.24	292.52	
	Laguncularia	0.6		2.63	0.001	2		0.08	4.76	7.48	
	Totals	22.0			0.868		35.00				1.34
Chongón	*Rhizophora*	132.9	Riverine	93.75	0.378	1		86.65	80.00	260.40	
	Avicennia	7.1		5.00	0.011	3		2.42	16.00	23.42	
	Laguncularia	1.8		1.25	0.048	2		10.93	4.00	16.18	
	Totals	141.8			0.437		9.43				1.75
Isle de las Conchitas	*Rhizophora*	221.2	Overwash	100.00	1.056	1	11.60	100.00	100.00	300.00	2.71
Estero Santa Ana	*Rhizophora*	279.0	Basin	93.75	0.740	1		97.48	86 36	277.59	
	Avicennia	7.4		2.50	0.002	3		0.24	9.09	11.83	
	Laguncularia	11.2		3.75	0.017	2		2.28	4.55	10.58	
	Totals	297.6			0.759		8.30				5.62
Balao Grande	*Rhizophora*	111.6	Basin	55.00	0.892	1		76.44	54.55	185.98	
	Avicennia	86.2		42.50	0.249	2		21.30	39.39	103.19	
	Laguncularia	5.1		2.50	0.026	3		2.26	6.06	10.83	
	Totals	202.9			1.167		19.17				13.62

a Relative dominance; b Relative frequency; c Importance value; d Complexity index

go and Snedaker, 1974). Fringe and overwash forest dominated by *Rhizophora* produce detritus in the form of particulate organic matter. This material is exported on every tide and is the basis of the marine foodweb concept established by Odum and Heald (1975). In contrast, less frequently inundated forests, such as basin forests dominated by *Avicennia* and *Laguncularia*, produce very fine particulate and dissolved organic matter which is exported only when the forests are flushed during storms and neap tides (cf. Twilley, *et al.*, 1986). This dissolved organic matter has a number of ecological roles, such as forming a basis for heterotrophic microorganism foodwebs, triggering chemosensory responses in marine fauna (cf. Alongi, 1978), and when aggregated into "flakes", forming a major food resource for crustaceans such as amphipods, isopods, crabs and shrimp (cf. Camilliari and Ribi, 1986). Obviously, the preferential elimination of these particular genera and habitat types would necessarily limit the quantity of dissolved organic matter entering the nearshore environment.

The declining abundance of shrimp postlarva in Ecuadorean estuaries is well documented and has been a major concern of shrimp farm owners who rely on wild postlarva for stocking growout ponds. Although all mangroves have not been eliminated in the major production region, we hypothesize that the disproportionate elimination of sources of dissolved organic matter, may be the dominant cause of the reduction in wild shrimp postlarva stocks.

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