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Threatened halophytic communities on sandy coasts of three Caribbean islands

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Three tropical islands — Trinidad, Dominica and St. Lucia — in the British Caribbean were surveyed for location of coastal herbaceous halophytic plant communities native to upper, intertidal sandy beaches. Comparisons of earlier and later drawn topographical maps displayed marked urban expansion indicating the disappearance of native beach vegetation. Hierarchial cluster analysis revealed marked similarities among sites on these islands. Studies of alpha and gamma diversity of the few, viable communities located along back beaches revealed that, like temperate sandy communities, these communities were generally characterized by a small number of perennial halophytic species. At most locations, the community was dominated by only one species — *Ipomea pes-caprae* — accompanied by a few sub-dominant species. Governments of these islands should consider preserving the few remaining native beach plant communities for future scientific studies.

Keywords: biodiversity, coastal plants, coastal pollution, halophytes, nature conservation

Introduction

Loss in biodiversity is a world-wide problem for many of the world's major ecosystems and is frequently accompanied with habitat degredation (Hansen *et al.* 2001, Symstad & Tilman 2001). Global oceanic pollution and forests destruction have been well documented (Armantrout & Wolotira 1995, Livingston 2000). Although much effort has been put into restoring and preserving tropical ecosystems such as rain forests, mangrove swamps, and coral reefs, preservation of tropical, coastal sandy plant communities has been largely ignored (Condit 1995, Mulkey *et al.* 1996, Sheil & May 1996, Kennish 2001).

The halophytic plant communities at these tropical sandy sites are subject to some of the same climatic and physical environmental stresses known to be present in halophytic communities worldwide. Natural geomorphologic processes also occur at these marine boundaries, resulting in seasonal beach erosion (Viles & Spencer 1995). These beaches are frequently affected by hurricanes that repeatedly alter shorelines, depositing and removing sand and, thereby, destroy native plant communities (Hughes 1994). In addition to the complex dynamics of sand removal and deposition, the substrata continuously receive high levels of salts from aerosol spray and oceanic waters and are typically distinguished by low water-holding capacities and nutrient levels (Shoulders 1981). These environmental stresses are further magnified by the prevalence of constant winds and high levels of solar radiation, which result in decreasing plant water contents (Jefferies *et al*. 1979).

These tropical coastal communities have been especially vulnerable because of human attraction to such areas for recreational purposes. Some of the most commonly used recreational areas in the world are tropical coastal beach environments (Laevastu *et al*. 1996). Beach plant populations are often deliberately removed to beautify hotel beach-fronts. Other human activities that contribute to degradation of beach communities include processes such as sand removal from beach inter-tidal zones for use in housing construction and lining of shores with protective physical barriers, both of which invariably interfere with natural sand movements and result in loss of beach fronts (Cambers 1991, Preu 1991).

Preliminary geographic investigations of distribution patterns of sandy coasts on the islands indicated marked reductions in beach vegetation as compared with distribution patterns recorded on much earlier topographical maps (Fig. 1). Many of the areas originally covered with coastal beach vegetation are now devoid of plant material and are now supporting new urban constructions including hotels for tourism (Fig. 1). To implement conservation activities, studies documenting the biotic components of viable beach communities must first be carried out to provide the necessary data for planning and directing these activities.

The study addressed two questions: (1) What are the geographic locations (survey of islands) of sandy coasts that support sustainable, herbaceous plant communities on three Caribbean islands in the West Indies — Dominica, St. Lucia, and Trinidad? (2) What halophytic plant species characterize these communities at their specific locations?

Materials and methods

Location

The study was carried out on three tropical Caribbean islands, which form part of a larger group of islands, collectively called the West Indies. The three islands chosen were: (1) Dominica (located between 15°12´ and 15°38´N and between 61°15´ and 61°30´W; area 290 square miles, 752 km^2). (2) St. Lucia (located between 13°42´ and 14°06´N and between 60°52´ and 61°05´W; area 238 square miles, 616 km^2). (3) Trinidad (located between 10°03´ and 10°44´N; between 60°55´ and 61°44´W; area 1754 square miles, 4543 km^2). Both Trinidad and Dominica, as compared with St. Lucia, are large islands devoid of much of the tourism responsible for economic enhancement in the latter. However, Dominica is not as industrially advanced as Trinidad, and inter-tidal areas in Dominica are generally much less disturbed.

Survey sites visited on three islands

After consulting geographical maps of the three islands, beach locations were visited on each island (British West Indies Sheet Series, 1958–1986). Names represent towns and villages along coastlines, listed on topographical maps. Dominica: Cabrits, Calibishie, Castle Bruce, Hampstead, Lagon, Londonderry, Mahaut, Marigot Melville Hall, Portsmouth, Roseau, Salibia, Salisbury, St. Joseph, Woodford Hill. St. Lucia: Cap Point, Chock, Choiseul, Cul de Sac, Dennery, Laborie, La Toc, Marigot, Marquis, Micoud, Pigeon Point, Point Gautier, Pointe Sable, Reduit, Soufriere, Vieux-Fort, Vigie. Trinidad: Bonasse, Coral Point, Galfa Point, Guayaguayare, Guyama, Icacos Point, Las Cuevas, Los Blanquizales, Los Gallos, Manzanilla, Matura Point, Punta de Arenal, Salybea, St. Marie Point, Toco.

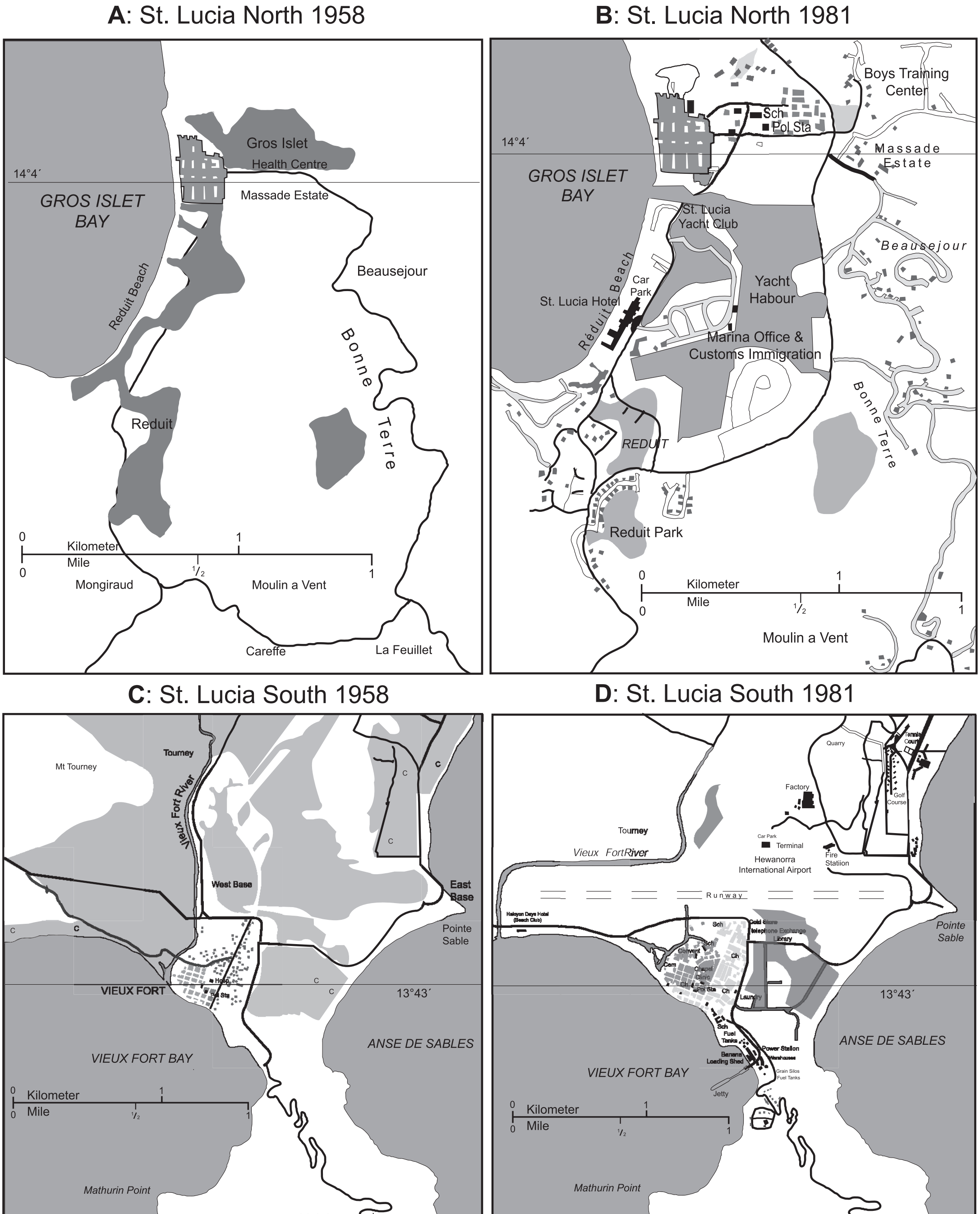

Fig. 1. Early (1958; **A** and **C**) and later (1981; **B** and **D**) topographical maps of northern and southern regions of the island St. Lucia, indicating urban expansion on sandy coastal areas.

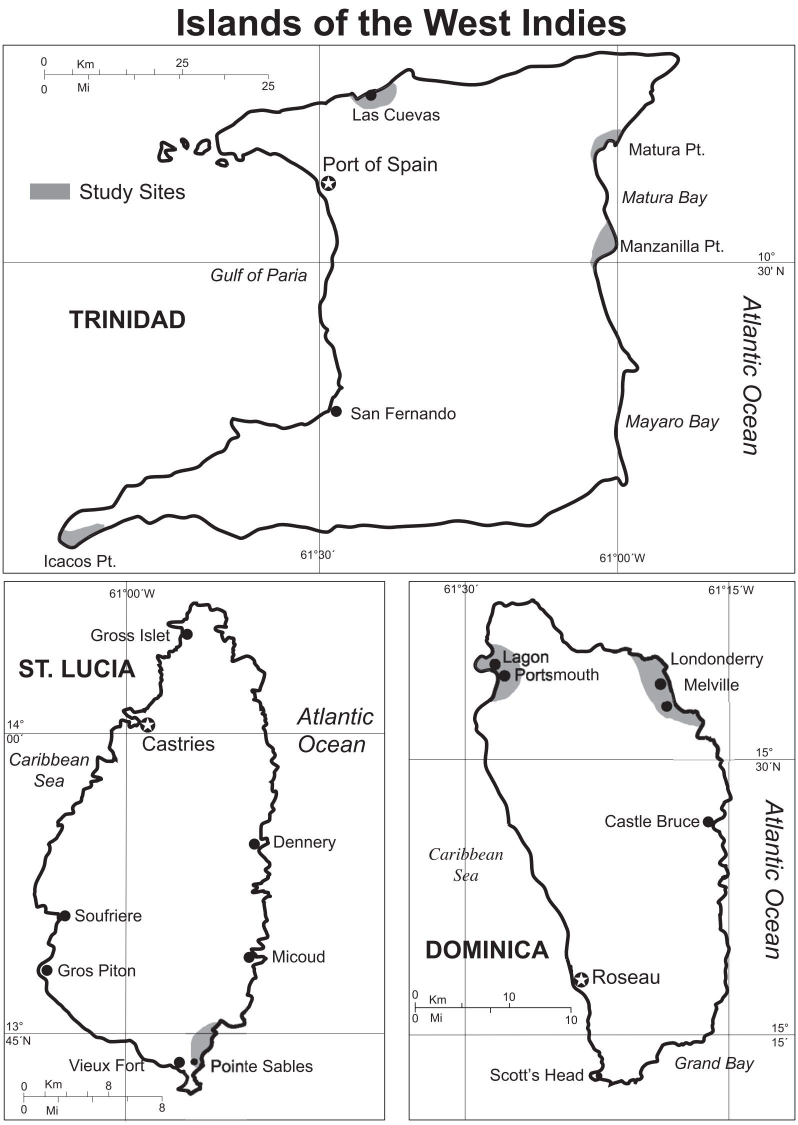

Fig. 2. Three Caribbean islands, Dominica, St. Lucia and Trinidad, marking locations (shaded) of herbaceous sandy communities.

All sandy beach areas were visited, except for those beaches, which were inaccessible due to natural barriers such as volcanoes, pitch lakes and precipitous cliffs. Access to beach sites was achieved through the use of vehicles followed by hikes down beach paths or by excursions in row-boats to secluded inlets. Sampling times were during the months of April–July 1995 (Trinidad and St. Lucia), and June 1998 (Dominica and St. Lucia).

Data collection included records of beach locations devoid of native halophytic communities as well as locations supporting large (> 25 m × 10 m patches) sandy plant communities on back beaches. Sites listed above that were devoid of native vegetation were not marked for further studies. Only large areas of native plant communities devoid of human destruction and disturbances (roads, huts and hotels) were chosen for further study of plant species composition and relative cover. The size of each randomly chosen study area, at each location, was 25 m long (parallel to coast) and 10 m wide (perpendicular to the shore).

Hierarchical cluster analysis (Euclidean distance, single method; SYSTAT 2000) was carried out to examine relationships among vegetation sites on the three islands, Dominica, St. Lucia, and Trinidad, based on the species composition at each site. Alpha diversity (mean number of species per site) and gamma diversity (total number of species per island) were calculated for each island. Studies of community plant species composition and relative plant cover were carried out for each site. Relative plant cover data (area occupied by each species) for each plant species were randomly collected using quadrats (1 m^2) along transects perpendicular to the shore. Within each quadrat, estimates of each plant species occupying a quadrat (plant cover) were determined visually and estimates were then categorized: high ≥ 40%, moderate = 20%–40%, and low ≤ 20%. Plant samples of native halophytes, consisting of vegetative shoots and flowers when available, were collected for examination and identification. All native, halophytic herbaceous plants present at each of the sites chosen for study were identified and confirmations made with the help of plant taxonomists at central university herbaria (National Herbarium of Trinidad and Tobago, UWI, St. Augustine; Herbarium, Department of Plant Sciences, UWI, Kingston, Jamaica; Institute of Jamaica, Kingston, Jamaica). Species lists were prepared using nomenclatures of Beard (1946, 1949), Hitchcock (1936), Howard (1979) and Nicolson (1991).

Results

Among all sites visited during the survey of the three islands, only nine sites — Dominica: Lagon (15°35´N/61°28´W); Londonderry (15°33´N/61°18´W); Melville Hall (15°32´N/61°18´W); Portsmouth (15°35´N/61°28´W). St. Lucia: Pointe Sable (13°44´N/60°5´W). Trinidad: Icacos Point (10°03´N/61°56´W); Las Cuevas (10°47´N/61°24´W); Manzanilla (10°31´N/61°01´W); Matura Point (10°41´N/61°02´W) (Fig. 2 and Table 1) — supported viable, undisturbed communities deserving of floristic studies (Table 1).

Considerations of community patch size (> 25 m × 10 m) and lack of disturbances to the plant community and its surrounding were the main factors used for choosing sites (Fig. 2). Several of the sandy coastal sites visited (listed above) were devoid of vegetation or were sparsely covered with roadside grasses that had invaded the regions (Fig. 1). This was a direct result of human disturbances such as dumping, footpaths and urban structures. In several instances, vehicular and pedestrian traffic, as well as construction of large hotels bordering beachfronts, had effectively removed all natural

Table 1. Plant species and cover (H = high, M = moderate, L = low) for: Dominica, D1 = Lagon; D2 = Londonderry; D3 = Melville; D4 = Portsmouth; Trinidad, T1 = Icacos Pt; T2 = Las Cuevas; T3 = Manzanilla; T4 = Matura Pt; St. Lucia, S1 = Pointe Sable.

Family	Species	D1	D2	D3	D4	T1	T2	T3	T4	S1
Aizoaceae	*Sesuvium portulacastrum*							M	M	M
Amaranthaceae	*Blutaparon vermiculare*					M	L			
Asteraceae	*Wedelia trilobata*		M	M			L	L		
	Melanthera nivea							L		
Boraginaceae	*Heliotropium curassavicum*									L
Convolvulaceae	*Ipomoea pes-caprae*	H	H	H	H	H	H	H	H	H
	Ipomoea stolonifera							L		
Cyperaceae	*Remirea maritima*							L	L	
Euphorbiaceae	*Jatropha gossypifolia*					L				
Fabaceae	*Crotalaria falcata*				L					
	Crotalaria pallida		M	L	L					
	Crotalaria retusa				L					
	Vigna luteola			L			L	L		
Poaceae	*Paspalum distichum*					L		L		
	Sporobolus virginicus		L	L			M		L	L
Verbanaceae	*Lippia nodiflora*						L			

seashore vegetation (Fig. 1). In general, sandy herbaceous halophytic communities were much more frequently encountered at sites visited on Dominica, although vegetation sites on the island of Trinidad were considerably greater in extent along coastlines. Dominica, as compared with St. Lucia, had much fewer construction sites and less urban development on coastal sites (Fig. 2).

As shown in the hierarchical analysis, similarity in plant species composition among sites present on the three islands was registered (Table 2). The St. Lucia site clustered with sites from both Dominica and Trinidad. Vegetation sites at Dom 2 and Dom 3 were highly comparable. Sites at Dom 4 and Trin 3 were farthest apart and this was corroborated by the species composition at each site (Table 1)

Alpha diversity of all study sites on each island was low — 3.5 for Dominica, 4 for St. Lucia and 5.5 for Trinidad (Table 1). The greatest number of species at any site was recorded on Manzanilla, Trinidad, (T3), where eight species were present. In comparisons of the three islands, Trinidad, the largest island among the three, also registered the greatest gamma diversity — twelve for Trinidad, nine for Dominica, and four for St. Lucia. However, all sites supporting viable natural populations of halophytes on all three islands were characterized by low diversity, a pattern generally associated with natural stressful environments.

The floristic composition of these tropical communities was dominated by some of the larger plant families including Asteraceae, Fabaceae, Poaceae and Convolvulaceae (Table 1). Although species composition at various sites on the three islands differed floristically, there were similarities among species encountered at sites within and between islands. Overall, examinations of relative cover for the various species present on the different islands indicated a strong dominance by *Ipomoea pes-caprae* followed by *Sesuvium portulacastrum* and *Blutaparon vermiculare* (Table 1).

However, relative cover for the individual plant species differed among sites (Table 1). For example, *Ipomoea pes-caprae* had 100% cover at Lagon (Dominica), but dominance at Melville Hall (Dominica) was almost evenly divided between *I. pes-caprae* and *Wedelia trilobata*. A similar pattern was present at Icacos Point (Trinidad) where the distribution of *I. pes-caprae* and *Blutaparon vermiculare* was equally dominant. However, at all sites chosen for floristic studies on the islands, *I. pes-caprae* was either the dominant or co-dominant plant species. Native halophytic grasses commonly encountered were *Sporobolus virginicus* and *Paspalum vaginatum*.

Perennial herbaceous plants dominated growth forms in these sandy communities. Low-lying shrubs such as *Vigna luteola* and *Crotalaria pallida* were less frequently encountered. Two growth forms commonly encountered among the sandy plant communities were succulent perennials (*Ipomoea pes caprae*, *Sesuvium portulacastrum*) and sclerophylous grasses (*Sporobolus virginicus* and *Paspalum vaginatum*). Annual plants, *Heliotropium curassavicum* and *Crotalaria retusa*, encountered at sites examined were not as numerous, with the community dominated by perennial species (Table 1). Plant organs (leaves and stems) did not indicate damaged patches of any kind and had no desiccated spots common to plants growing in nutrient-poor or water stressed regions. Morphological and structural examination of plants indicated robust, thriving individuals in these undisturbed communities.

Table 2. Hierarchical cluster analysis indicating relationships among vegetation sites on the three islands, Dominica, St. Lucia, and Trinidad, based on species composition.

Cluster 1	Cluster 2	Distance
Dom 3	Dom 2	0.00
Dom 3	Dom 1	0.433
StLu 1	Dom 3	0.433
Trin 1	StL 1	0.433
Trin 2	Trin 1	0.433
Trin 2	Trin 4	0.433
Dom 4	Trin 2	0.559
Dom 4	Trin 3	0.559

Discussion

The floristic data for species composition collected in this study are supported by information presented in earlier published floras of the region (Hitchcock 1936, Beard 1946, 1949, Howard 1974, Nicolson 1991). Surprisingly absent from the Dominica flora, in this study, were *Sesuvium portulacastrum* and *Heliotropium curassavicum*, a fact corroborated by Nicolson's (1991) flora. Reports of their presence in Dominica had appeared in earlier flora compiled by Howard (1974) as well as Velez (1957). However, the results of these reports were later questioned by Nicolson (1991).

Results of the hierarchial cluster analysis based on species composition (Table 2) indicated similarity among the sites examined, in spite of the fact that the sites were located on different islands and several miles apart. Also noteworthy was the presence of the dominant species, *Ipomoea pes-caprae*, influencing all sites. The dissimilarity at sites Dom 4 and Trin 3 was, no doubt, a result of the presence of the genus, *Crotalaria*, on Dominica, which was not encountered on sites examined on Trinidad.

Although species diversity (alpha) at all sites on all the islands was low, the largest island, Trinidad, had the greatest number of halophytes, a finding consistent with basic ecological theory (Townsend *et al*. 2000). The low species diversity of these tropical, sandy, halophytic plant communities is not unusual for that type of environment but quite consistent with the low diversity of similar, highly stressed communities, though contrasting with generalizations of high species richness in tropical areas (Myers *et al*. 2000). These sandy herbaceous communities consist of halophytes structurally adapted for salt-stressed environments, with features such as salt glands and succulent tissues (*Blutaparon*, *Ipomoea* and *Sporobolus*). These halophytes are also rhizomatous creepers that are adapted to the dynamic state of continuously shifting sandy substrata, and it is not surprising that these same halophytes are widely distributed on several Caribbean coasts (Lewis 1982, Blits & Gallagher 1991).

Several ecological questions remain unanswered at these various sandy beach sites. Studies by Devall and Thien (1989) determined that similar communities, present in the Gulf of Mexico, were suitable habitats for selective animal species and were also sources of nutrients for the coastal environments. Interestingly, *Ipomoea*, the dominant plant present in these communities, is known to contain protective alkaloids which might explain the scarcity of tissue losses from herbivore activity in that community (Jirawongse *et al*. 1979).

However, the absence of native halophytic communities on many back beaches is as noteworthy as the positive locations of pristine native communities, since the pattern of destruction is likely to expand unless action is taken to prevent further loss. The marked absence of native halophytic communities on upper shores on St. Lucia is consistent with the fact that this island depends heavily on tourism for economic prosperity and, as a result, seashores are heavily lined with hotels supporting this industry.

Obtaining data for location and composition of these herbaceous sandy communities on these islands is only a beginning and, further, more in-depth studies are required if these halophytic species are to survive. As local governments seek sustainable development on these Caribbean islands where international tourism and human populations are both rapidly increasing, viable native, sandy beach-plant communities must be set aside for protection and conservation in order to slow the rate of their disappearance.

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References

Armantrout, N. & Wolotira, R. 1995: *Condition of the worlds aquatic habitat. Proceedings of the World Fisheries Congress*. — Sci. Publ. Inc., Lebanon, USA. 411 pp.

Beard, J. S. 1946: *The natural vegetation of Trinidad*. — Clarendon Press, London. 152 pp.

Beard, J. S. 1949: The natural vegetation of the Windward and Leeward Islands.— *Oxford Forestry Mem.* 21: 1–158.

Blits, K. & Gallagher, J. 1991: Morphological and physiological responses to increased salinity in marsh and dune ecotypes of *Sporobolus virginicus* (L.) Kunth.

— *Oecologia* 87: 330–335.

British West Indies Sheet Series 1958–1986. — Directorate of Overseas Surveys, Tolworth.

Cambers, G. 1991: *Coastlines of the Caribbean*. — Am. Soc. Civil Engineers, New York. 187 pp.

Condit, R. 1995: Research in large long term tropical lots. — *Trends Ecol. Evol.* 10: 18–22.

Devall, M. & Thien, L. 1989: Factors influencing the reproductive success of *Ipomoea pes-caprae* (Convolvulaceae) around the Gulf of Mexico. — *Amer. J. Bot.* 76: 1821–1831.

Hansen, M., Ruzzante, D., Nielsen, E. & Mensberg, K. 2001: Brown trout (*Salmo trutta*) stocking impact assessment using microsatellite DNA markers. — *Ecol. Appl.* 11: 148–160.

Hitchcock, A. S. 1936: *Manual of the grasses of the West Indies*. — U.S.D.A. Misc. Publ. 243. 312 pp.

Howard, R. A. 1974–1989: *Flora of the Lesser Antilles*. Vol. 1–6. — Arnold Arboretum, Jamaica Plain. 586 pp.

Hughes, T. P. 1994: Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef.— *Science* 265: 1547–1551.

Jefferies, R. L., Davy, A. & Rudmik, T. 1979: The growth strategies of coastal halophytes. — In: Jefferies, R. L. & Davy, A. J. (eds.), *Ecological processes in coastal environments*. — Blackwell Sci. Publ., London. 684 pp.

Jirawongse, V., Pharadai, T. & Tantivatana, P. 1979: The distribution of indole alkaloids in certain genera of Convolvulaceae growing in Thailand.— *J. Nat. Res. Council Thailand* 9: 17–24.

Kennish, M. 2001: Coastal salt marsh systems in the US: A review of anthropogenic impacts.— *J. Coast. Res.* 17: 731–748.

Laevastu, T., Alverson, D. & Marasco, R. 1996: *Exploitative marine ecosystems: Their behaviour and management*. — Fishing New Books, Oxford, London. 321 pp.

Lewis, R. 1982: *Creation and restoration of coastal plant communities*. — CRC Press, Boca Raton. 219 pp.

Livingston, R. T. 2000: *Eutrophication processes in coastal systems*. — CRC Press, New York. 352 pp.

Mulkey, S., Chazdon, R. & Smith, A. 1996: *Tropical forest plant ecophysiology*. — Chapman & Hall, New York. 675 pp.

Myers, N., Mittermeir, R., Mittermeir, G., Fonseca, G. & Kent, J. 2000: Biodiversity hot spots for conservation priorities.— *Nature* 403: 853–858.

Nicolson, D. H. 1991: *Flora of Dominica*. Part 2, Dicotyledoneae. — Smithsonian Inst. Press, Washington, D.C. 274 pp.

Preu, C. 1991. Human impact on the morphodynamics of coasts:— In: Erdelen, W., Ishwaran, N. & Muller, P. (eds.), *Tropical ecosystems*. Verlag Josef Margraf, Weikersheim, Germany. 202 pp.

Sheil, D. & May, R. 1996: Mortality and recruitment rate evaluation in heterogeneous tropical forests.— *J. Ecol.* 84: 91–100.

Shoulders, E. 1981: *Texture modifies water transport of nutrient ions in coastal plain soils*. Research paper SO-175. — U.S.D.A., Washington, DC. 6 pp.

Symstad, A. & Tilman, D. 2001: Diversity loss, recruitment limitation, and ecosystem functioning: lessons learned from a removal experiment.— *Oikos* 92: 424–435.

SYSTAT 2000: *SYSTAT® 10 Statistics*. — SPSS Inc, Chicago. 663 pp.

Townsend, C. R., Harper, J. & Begon, M. 2000: *Essentials of ecology*. — Blackwell Sci. Inc., Boston. 552 pp.

Velez, L. 1957: *Herbaceous angiosperms of the Lesser Antilles*. — San German, Puerto Rico. 121 pp.

Viles, H. & Spencer, T. 1995: *Coastal problems*. — Edward Arnold, London. 350 pp.