

# **REFORESTATION PLAN FOR THE TEXACO QUARRY AREA**

**WindMar Project  
Guayanilla, Puerto Rico**

**October 20, 2004**

## **A. Project Summary**

WindMar Renewable Energy (WindMar RE) proposes to construct Puerto Rico's first commercial wind energy project, rated at 41.3 MW (megawatts), on a 290-ha (725-acre) property it owns in Guayanilla. A renewable and emission-free energy project of this nature and size is important to Puerto Rico, which is largely dependent on expensive and polluting fossil fuels imported to power its aging electric grid. Unlike fossil-fuel and nuclear-energy plants, wind farms cannot be sited anywhere. They can only be located where there is an abundant wind resource. WindMar has measured the wind resource at its Guayanilla property and at three other Puerto Rican sites. Of these four sites, Guayanilla has the best wind, averaging 6.2 m/s (15 mph), an amount that makes the site commercially viable. WindMar's data have been confirmed by Garrad Hassan, a top international wind-energy consultancy.

Approximately 14.0 ha of dry forest habitat will be impacted by the siting of roads and construction areas for the WindMar wind farm. WindMar, however, proposes a generous mitigation plan that includes: 1) the reforestation of at least 2.6 ha of the abandoned Texaco quarry, a 3.1 ha area that has been devoid of vegetation for over 30 years; 2) the natural regeneration of dry forest habitat at construction sites and along road margins; and 3) a conservation easement that covers nearly 85% of the WindMar property (1750% of the impact).

The 290-hectare (725-acre) WindMar property is presently zoned R-0, which would permit construction of about 350 single-family dwellings on two-acre lots. WindMar is in the process of applying to the Puerto Rico Planning Board to permit on this property the construction of the wind turbines mills and the implementation of the conservation plan described in this HCP.

The land use surrounding the property includes heavy industrial, agricultural, and conservation uses. To the east, about 2 km across Guayanilla Bay – in plain view from the project site and distinctly audible, particularly at night – is a heavily industrialized area that includes two electric power plants (the gas-fired EcoEléctrica and the oil-fired Costa Sur), a liquid natural gas offloading terminal and storage facility, and a large defunct oil refinery. To the north of the WindMar property is Tropical Fruit, a 400-hectare (1,000-acre) commercial fruit plantation established on the site of an old sugar mill. Tropical Fruit grows mangoes and bananas for export. WindMar owns the access road through the fruit plantation to its project site. To the west is the Guánica State

Forest, a 4,400-hectare (11,000-acre) forest reserve owned and managed by the Department of Natural and Environmental Resources (DNER) of the Commonwealth of Puerto Rico. The nearest human settlement to the WindMar project site is Barrio Indio, a cluster of single-family residences about 1.5 km (one mile) distant, at the entrance to the fruit plantation. Like the WindMar property, Barrio Indio is located in the Boca Ward of the Municipality of Guayanilla.

The WindMar property is dominated by three upland areas – Punta Verraco, Cerro Toro, and Punta Ventana. These upland areas are a focus of the project because: 1) they are perfectly oriented to catch the abundant wind resource present at the site; 2) they are the only areas that will have wind turbines and supporting infrastructure; 3) they are covered almost entirely by dry forest, the principal habitat of the Puerto Rican Nightjar; and 4) the updrafts that occur along their seaward edges are frequently used by birds that soar along the coast, predominantly the Brown Pelican, Magnificent Frigatebird, and Turkey Vulture.

Punta Verraco and Cerro Toro are grouped together on the eastern side of the property (see Figure 1). They are separated from Punta Ventana by an ancient floodplain of the Yauco River. Punta Ventana abuts the Guánica State Forest and is part of the tableland that contains the State Forest. Adjacent to the WindMar property, to the north of Cerro Toro, is a 10-ha (25-acre) degraded mangrove swamp. Within the property, there are two disturbed level areas dominated by invasive plant species along the Caribbean shore. One is between Punta Verraco and Cerro Toro. The other is between Cerro Toro and Punta Ventana.

The principal soil of the site's dry forest areas is Ponce Limestone. Groundwater is generally much deeper than 30 feet. The upland areas of the site contain no permanent bodies of freshwater. Streams run only very briefly after heavy rains.

**B. Resolution from ARPE, Resolution from the Planning Board, and Consultation and Endorsement of DNER**

WindMar is in the process of applying for all necessary permits to conduct this project.

**C. Inventory of Trees**

Please see the attached plant list for the dry forest areas of the WindMar site.

Measuring 3.1 ha, the abandoned Texaco quarry area is virtually devoid of vegetation and has no trees.

**D. Map of Existing Trees**

Please see Figure 2.

## E. Reforestation Plan

WindMar has retained Dr. Alberto Areces to direct this reforestation project. One of the Caribbean region's top botanists, Dr. Areces is presently the Director of Parque Doña Inés, an arboretum for rare and endangered plants located at the Fundación Luis Muñoz Marín in Metropolitan San Juan. He also advises a remodeling project of the vegetation of the Ponce Campus of the University of Puerto Rico using native species. He will oversee a nursery operation on 0.1 hectare of the quarry area that will provide the required plants. The nursery and reforestation program will count on one or more drilled wells with a 100 gallon/minute capacity to provide water for irrigation (in many areas, drip irrigation), topsoil to be trucked in to improve the soil, compost to be prepared on site, and fertilizers to help the plants establish themselves.

Even though it was excavated thirty years ago, the 3.1 ha quarry is still a desolate area, virtually devoid of vegetation. WindMar will add 10-15 cm (3,000 to 4,500 m<sup>3</sup>) of topsoil and compost, transplant approximately 1,375 tree seedlings per hectare, and provide water via drip irrigation and other means at a rate of one gallon/tree every two days (approximately 1,800 gals/day) for the first three to five years as required.

The following pioneer tree and shrub species will be planted first in order to cover and stabilize the soil:

<i>Bourreria succulenta</i>	<i>Guettardia elliptica</i>
<i>Bourreria virgata</i>	<i>Guettardia krugii</i>
<i>Bursera simaruba</i>	<i>Gymnanthes lucida</i>
<i>Capparis cynophallophora</i>	<i>Jacquinia armillaris</i>
<i>Capparis flexuosa</i>	<i>Krameria ixine</i>
<i>Clerodendron aculeatum</i>	<i>Lantana involucrata</i>
<i>Coccoloba microstachya</i>	<i>Leucaena leucocephala</i>
<i>Colubrina arborescens</i>	<i>Melochia tomentosa</i>
<i>Comocladia dodonaea</i>	<i>Pictetia aculeata</i>
<i>Corchorus hirsutus</i>	<i>Pisonia albida</i>
<i>Croton discolor</i>	<i>Pithecellobium unguis-cati</i>
<i>Croton lucidus</i>	<i>Randia aculeata</i>
<i>Erythroxylum areolatum</i>	<i>Reynosia uncinata</i>
<i>Ficus citrifolia</i>	

In five years, these pioneer species will create a 3.0-3.5 m canopy with a shrubby understory. At this point, we will begin to add rare or uncommon trees and shrubs in order to enrich the forest. These will include:

<i>Amyris elemifera</i>	<i>Consolea rubescens</i>
<i>Canella winteriana</i>	<i>Crescentia linearifolia</i>
<i>Celtis trinervia</i>	<i>Crossopetalum rhacoma</i>
<i>Coccoloba krugii</i>	<i>Croton betulinus</i>
<i>Colubrina elliptica</i>	<i>Croton humilis</i>

*Erythroxylum rotundifolium*  
*Eugenia foetida*  
*Eugenia ligustrina*  
*Eugenia rhombea*  
*Guaiacum officinale*  
*Guaiacum sanctum*  
*Gyminda latifolia*  
*Helicteres jamaicensis*  
*Hypelate trifoliata*  
*Jacquinia berteroi*

*Krugiodendron ferreum*  
*Pilosocereus royenii*  
*Reynosia guama*  
*Rocheportia acanthophora*  
*Schaefferia frutescens*  
*Sideroxylon obovatum*  
*Tabebuia heterophylla*  
*Thouinia portoricensus*  
*Trichilia hirta*  
*Ziziphus reticulata*

During phase two of the restoration, a number of the pioneer species will begin to disappear because of shade. We will make sure that moth-loving shrubs are well represented in order to attract food for the nightjar.

At ten years, the canopy of this forest should top out at about 4.5-5.0 m. At this point, we will begin the third and final stage of the restoration, which will focus on adding the really rare species – *Ottoschultzia*, *Trichilia triacantha*, other *Pisonia* species (not *P. aculeata*), *Zanthoxylum flavum*, *Buxus vahlii*, etc. We will add these species at a rate of 15-25 individuals/ha. We hope to clone plants from tissue collected from individuals in the Guánica State Forest. Our goal is to establish safety-net populations for these species.

The end result will be a dry forest that provides optimal nightjar habitat, decreases existing habitat fragmentation in a key area, and increases protection of endangered plants through the establishment of safety-net populations.

#### **F. Map of Reforestation Plan**

Given the large scale of this project and the deforested nature of the site, a post-reforestation map is not provided.

#### **G. Maintenance Plan**

Maintenance is discussed in the reforestation plan above.

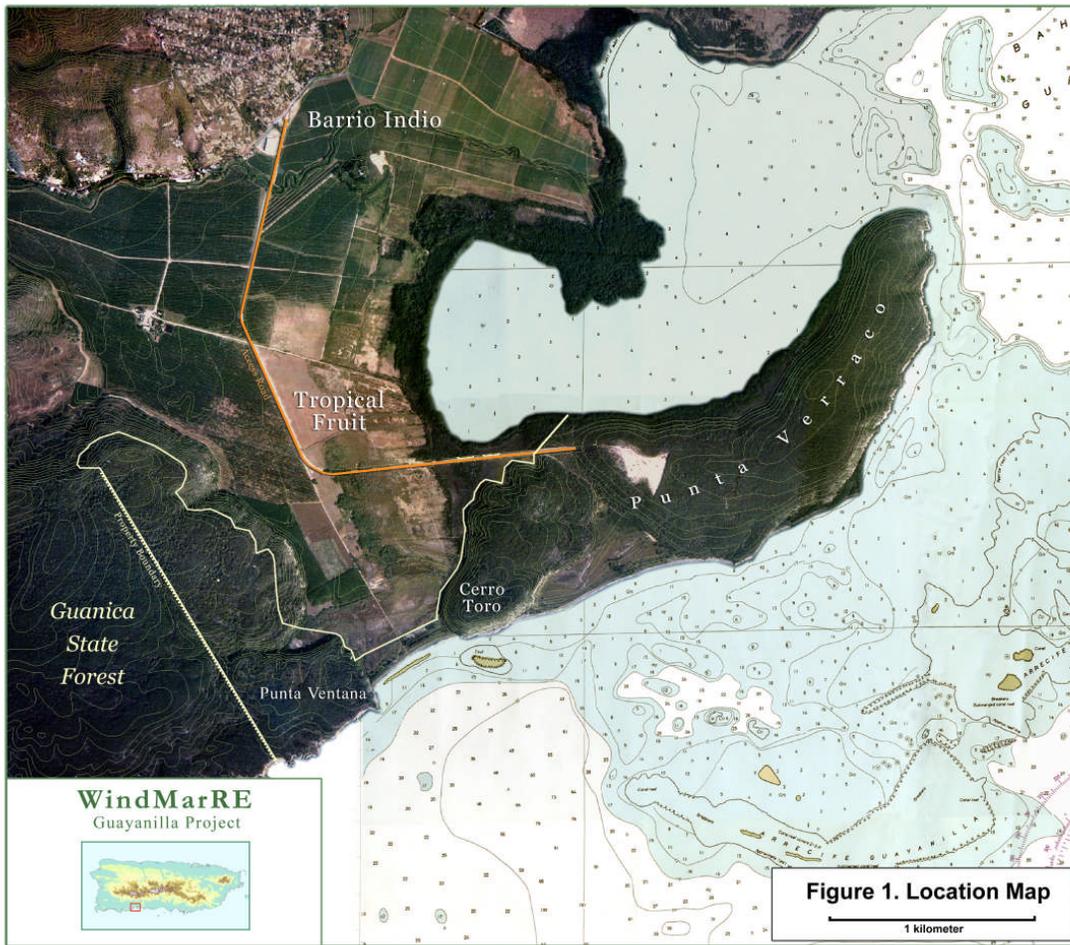
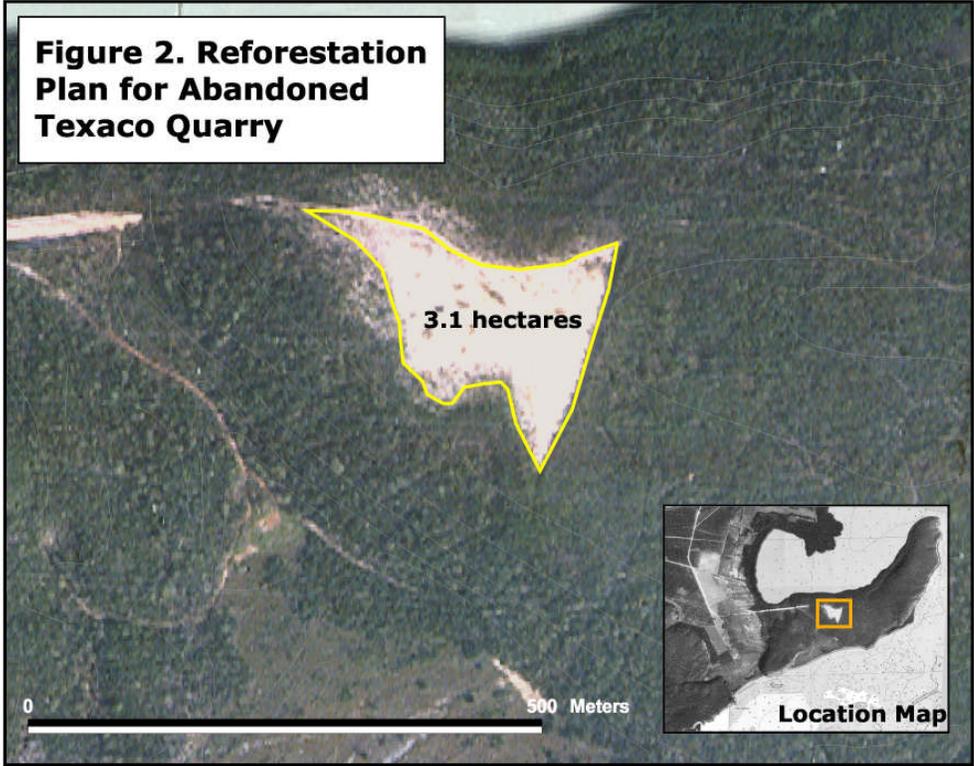


Figure 1. Location Map

1 kilometer

**Figure 2. Reforestation Plan for Abandoned Texaco Quarry**



## LIST OF VASCULAR PLANTS AT THE WINDMAR SITE

Growth Habits: H = herb; SA = sub-shrub; A = shrub; AR = tree; LI = vine; EP = epiphyte; SU = succulent; HP = hemiparasite.

#	SPECIES	H	SA	A	AR	LI	EP	SU	HP
1	<i>Abutilon umbellatum</i> (L.) Sweet		X						
2	<i>Adelia ricinella</i> L.			X	X				
3	<i>Amyris elemifera</i> L.			X	X				
4	<i>Annona glabra</i> L.			X	X				
5	<i>Antirhea acutata</i> (DC.) Urban			X	X				
6	<i>Antirhea lucida</i> (Sw.) Benth. & Hook. f.				X				
7	<i>Argythamnia candicans</i> Sw.		X	X					
8	<i>Aristolochia trilobata</i> L.					X			
9	<i>Ayenia insulicola</i> Cristóbal		X						
10	<i>Bernardia dichotoma</i> (Willd.) Muell. Arg.			X	X				
11	<i>Boerhavia coccinea</i> Mill.	X							
12	<i>Bourreria succulenta</i> Jacq.			X	X				
13	<i>Bourreria virgata</i> (Sw.) G. Don			X	X				
14	<i>Bouteloua repens</i> (HBK.) Scribn. & Merr.	X							
15	<i>Bucida buceras</i> L.				X				
16	<i>Bulbostylis curassavica</i> (Britton) Kük.	X							
17	<i>Bursera simaruba</i> (L.) Sarg.				X				
18	<i>Canella winteriana</i> (L.) Gaertn.			X	X				
19	<i>Capparis cynophallophora</i> L.			X	X				
20	<i>Capparis flexuosa</i> (L.) L.			X	X				
21	<i>Capraria biflora</i> L.	X	X						
22	<i>Castela erecta</i> Turp.			X					
23	<i>Celtis trinervia</i> Lam.				X				
24	<i>Cenchrus echinatus</i> L.	X							
25	<i>Cenchrus myosuroides</i> HBK.	X							
26	<i>Centrosema virginianum</i> (L.) Benth.					X			
27	<i>Chamaesyce turpinii</i> (Boiss.) Millsp.	X							
28	<i>Chloris ciliata</i> Sw.	X							
29	<i>Chloris radiata</i> (L.) Sw.	X							
30	<i>Cissus trifoliata</i> L.					X			
31	<i>Citharexylum fruticosum</i> L.			X	X				
32	<i>Clerodendron aculeatum</i> (L.) Schlecht.		X						
33	<i>Coccoloba diversifolia</i> Jacq.			X	X				
34	<i>Coccoloba krugii</i> Lindau in Engler			X	X				
35	<i>Coccoloba microstachya</i> Willd.			X	X				
36	<i>Colubrina arborescens</i> (Mill.) Sarg.			X	X				

37	<i>Colubrina elliptica</i> (Sw.) Briz. & Stern			X	X				
38	<i>Commelina diffusa</i> Burm. f.	X							
39	<i>Comocladia dodonaea</i> (L.) Urban								
40	<i>Conocarpus erecta</i> L.			X	X				
41	<i>Consolea rubescens</i> (Salm-Dyck ex DC.) Lem.				X			X	
42	<i>Corchorus hirsutus</i> L.			X					
43	<i>Cordia globosa</i> (Jacq.) HBK.			X					
44	<i>Cordia stenophylla</i> Alain			X					
45	<i>Crescentia linearifolia</i> Miers			X	X				
46	<i>Crossopetalum rhacoma</i> Crantz			X	X				
47	<i>Croton betulinus</i> Vahl		X						
48	<i>Croton discolor</i> Willd.			X					
49	<i>Croton humilis</i> L.			X					
50	<i>Croton lucidus</i> L.		X	X					
51	<i>Croton nummulariifolius</i> A. Rich.	X							
52	<i>Dalechampia scandens</i> L.					X			
53	<i>Distictis lactiflora</i> (Vahl.) DC.					X			
54	<i>Epidendrum bifidum</i> Aubl.						X		
55	<i>Ernodea littoralis</i> Sw.			X					
56	<i>Erithalis fruticosa</i> L.			X	X				
57	<i>Erythroxyllum areolatum</i> L.			X	X				
58	<i>Erythroxyllum rotundifolium</i> Lunan			X	X				
59	<i>Eugenia foetida</i> Pers.			X	X				
60	<i>Eugenia ligustrina</i> (Sw.) Willd.			X	X				
61	<i>Eugenia rhombea</i> (O. Berg) Krug & Urban.			X	X				
62	<i>Evolvulus convolvuloides</i> (Willd. ex Schultes) Stearn	X							
63	<i>Exostema caribaeum</i> (Jacq.) Roem & Schult.			X	X				
64	<i>Ficus citrifolia</i> P. Miller				X				
65	<i>Fimbristylis cymosa</i> R. Br. ssp. <i>spathacea</i> (Roth) Koy.	X							
66	<i>Fimbristylis spadicea</i> (L.) Vahl	X							
67	<i>Galactia dubia</i> DC.					X			
68	<i>Guaiacum officinale</i> L.				X				
69	<i>Guaiacum sanctum</i> L.				X				
70	<i>Guettarda elliptica</i> Sw.			X	X				
71	<i>Guettardia krugii</i> Urban			X	X				
72	<i>Gyminda latifolia</i> (Sw.) Urb.			X	X				
73	<i>Gymnanthes lucida</i> Sw.			X	X				
74	<i>Helicteres jamaicensis</i> Jacq.			X	X				
75	<i>Heliotropium indicum</i> L.	X							
76	<i>Herissantia crispa</i> (L.) Brizicki		X						
77	<i>Heteropteris purpurea</i> (L.) Kunth					X			
78	<i>Hibiscus phoeniceus</i> Jacq.	X	X						
79	<i>Hylocereus trigonus</i> (Haw.) Safford					X		X	

80	<i>Hypelate trifoliata</i> Sw.			X	X				
81	<i>Ipomoea cumanensis</i> (HBK.) O. Kuntze					X			
82	<i>Ipomoea</i> aff. <i>microdactyla</i> Griseb.					X			
83	<i>Ipomoea violacea</i> L.					X			
84	<i>Jacquemontia cumanensis</i> (HBK.) O. Ktze.					X			
85	<i>Jacquinia armillaris</i> Jacq.			X	X				
86	<i>Jaquinia berteroi</i> Spreng.			X	X				
87	<i>Jasminum fluminense</i> Vell.					X			
88	<i>Krameria ixine</i> L.			X					
89	<i>Krugiodendron ferreum</i> (Vahl) Urban					X			
90	<i>Laguncularia racemosa</i> (L.) Gaertn.			X	X				
91	<i>Lantana involucrata</i> L.			X					
92	<i>Lasiacis divaricata</i> (L.) Hitchc.	X							
93	<i>Leptocereus quadricostatus</i> (Bello) Britton & Rose			X					X
94	<i>Leucaena leucocephala</i> (Lam.) De Wit			X	X				
95	<i>Lithophila muscoides</i> Sw.	X							
96	<i>Malvastrum corchorifolium</i> (Desr.) Britton in Small			X					
97	<i>Matelea maritima</i> (Jacq.) Woodson					X			
98	<i>Mariscus planifolius</i> (L. C. Rich.) Urban	X							
99	<i>Melocactus intortus</i> (Mill.) Urb.								X
100	<i>Melochia tomentosa</i> L.		X	X					
101	<i>Mitracarpus polycladus</i> Urb.	X							
102	<i>Opuntia dillenii</i> (Ker-Gawl.) Haw.			X					X
103	<i>Panicum diffusum</i> Sw.	X							
104	<i>Panicum maximum</i> Jacq.	X							
105	<i>Paspalum caespitosum</i> Flügge	X							
106	<i>Paspalum vaginatum</i> Sw.	X							
107	<i>Passiflora anadenia</i> Urban					X			
108	<i>Passiflora suberosa</i> L.					X			
109	<i>Pentalinon luteum</i> (L.) Hansen & Wunderlin					X			
110	<i>Phoradendron trinervium</i> (Lam.) Griseb.								X
111	<i>Pictetia aculeata</i> (Vahl) Urban			X	X				
112	<i>Pilosocereus royenii</i> (L.) Byles & Rowley			X	X				X
113	<i>Pisonia aculeata</i> L.			X	X				
114	<i>Pisonia albida</i> (Heimerl) Britton					X			
115	<i>Pithecellobium unguis-cati</i> (L.) Mart.			X	X				
116	<i>Plumbago scandens</i> L.					X			
117	<i>Plumeria alba</i> L.			X	X				
118	<i>Portulaca oleracea</i> L.	X							X
119	<i>Portulaca rubricaulis</i> HBK.	X							X
120	<i>Prestonia agglutinata</i> (Jacq.) Woods.					X			
121	<i>Prosopis pallida</i> (H. & B. ex Willd.) HBK.			X	X				
122	<i>Randia aculeata</i> L.			X	X				

123	<i>Rauvolfia viridis</i> Willd. ex Roem. & Schultes			X	X				
124	<i>Reynosia guama</i> Urban			X	X				
125	<i>Reynosia uncinata</i> Urban			X	X				
126	<i>Rivina humilis</i> L.	X	X						
127	<i>Rochefortia acanthophora</i> (DC.) Griseb.			X	X				
128	<i>Ruellia brittoniana</i> León	X							
129	<i>Ruellia tuberosa</i> L.	X							
130	<i>Samyda dodecandra</i> Jacq.			X	X				
131	<i>Savia sessiliflora</i> (Sw.) Willd.			X	X				
132	<i>Schaefferia frutescens</i> Jacq.			X	X				
133	<i>Schoepfia obovata</i> C. Wright in Sauv.			X	X				
134	<i>Scolosanthus versicolor</i> Vahl			X					
135	<i>Securinega acidoton</i> (L.) Fawcett & Rendle			X	X				
136	<i>Senna polyphylla</i> (Jacq.) Irwin & Barneby			X	X				
137	<i>Serjania polyphylla</i> (L.) Radlk.						X		
138	<i>Sida abutilifolia</i> Mill.		X						
139	<i>Sida cordifolia</i> L.		X						
140	<i>Sideroxylon obovatum</i> Lam.				X				
141	<i>Sideroxylon salicifolium</i> (L.) Lam.				X				
142	<i>Solanum jamaicense</i> Mill.		X	X					
143	<i>Spartina patens</i> (Ait.) Muhl.	X							
144	<i>Sporobolus virginicus</i> (L.) Kunth	X							
145	<i>Stachytarpheta jamaicensis</i> (L.) Vahl	X							
146	<i>Stahlia monosperma</i> (Tul.) Urban				X				
147	<i>Stigmaphyllon emarginatum</i> (Cav.) A. Juss.					X			
148	<i>Stigmaphyllon bannisterioides</i> (L.) C. Anderson					X			
149	<i>Strumpfia maritima</i> Jacq.		X						
150	<i>Stylosanthes hamata</i> (L.) Taubert in Verh.		X						
151	<i>Suriana maritima</i> L.			X					
152	<i>Tabebuia heterophylla</i> (DC.) Britton				X				
153	<i>Tamonea boxiana</i> (Mold.) Howard		X						
154	<i>Tephrosia senna</i> HBK.	X							
155	<i>Thouinia portoricensis</i> Radlk			X	X				
156	<i>Tillandsia fasciculata</i> Sw.						X		
157	<i>Tillandsia recurvata</i> (L.) L.						X		
158	<i>Tolumnia variegata</i> (Sw.) Braem						X		
159	<i>Tournefortia microphylla</i> Bertero ex Spreng.					X			
160	<i>Tournefortia volubilis</i> L.					X			
161	<i>Tragia volubilis</i> L.					X			
162	<i>Tragus berteronianus</i> Schult.	X							
163	<i>Trichilia hirta</i> L.				X				
164	<i>Turnera diffusa</i> Willd. ex Schult.			X					
165	<i>Vanilla dilloniana</i> Corell					X			
166	<i>Wedelia lanceolata</i> DC.			X					
167	<i>Zanthoxylum flavum</i> Vahl.				X				

168	<i>Ziziphus reticulata</i> (Vahl) DC.			X	X				
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- \* Excluded are mangroves and halophitic, coastal, and subcoastal communities on rocky, sandy, or clay substrates.

#### LIFE FORM DISTRIBUTION

Herbs	14.4 %
Sub-shrubs	7.2 %
Shrubs	31.8 %
Trees	30.1 %
Vines	11.0 %
Epiphytes	1.7 %
Succulents	3.4 %
Hemiparasites	0.4 %

Shrubs and trees (61.9 %) dominate the plant communities studied.