EDINBURGH JOURNAL OF BOTANY 59 (3): 421–442 (2002)
DOI: 10.10M/S0960428602000252

VEGETATION CLASSIFICATION AND FLORISTICS OF THE SAVANNAS AND ASSOCIATED WETLANDS OF THE RIO BRAVO CONSERVATION AND MANAGEMENT AREA, BELIZE

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A floristic inventory and preliminary vegetation classification were made for the tracts of savanna and associated wetland vegetation in the Rio Bravo Conservation and Management Area (RBCMA) in Belize. A total of 258 species were recorded, representing c.7% of the Belizean flora. Of these, 148 species are characteristic of the drier savanna systems, while 47 show a preference for hydrologic savanna and wetland areas. Only 57 species (22% of RBCMA savanna flora) are woody, with the savanna tree flora comprising 15 species. The flora of the RBCMA was found to be fairly typical of the savannas of the Central American and Caribbean region. Savanna systems are generally poorly represented in conservation areas in Central America, and due to the diverse range of structural and ecological formations of this vegetation type found within the RBCMA, and its relatively diverse flora, this reserve constitutes an important protected area.

Keywords. Belize, floristics, phytogeography, savanna, wetlands.

Introduction

Neotropical savanna covers over 2 million km^2, and represents the second largest vegetation formation in the American tropics (Mistry, 2000). Several studies have assessed the phytogeographic affinities of this widely distributed vegetation type (e.g. Sarmiento, 1983; Lenthal *et al.*, 1999), although a lack of detailed floristic information for many savanna systems prevents the undertaking of rigorous, analytical studies. The savannas of Belize represent the most northerly distribution of the Central American savannas. They lie on the margin of lowland humid tropical formations and as such are of phytogeographic and ecological importance. At present there is only a poor account of the Belizean savanna flora, and there is a need for detailed floristic inventories to assist local and regional conservation planning.

In Central America and on the Caribbean islands, major savanna areas occur in southern Mexico, Belize, Honduras, Nicaragua, southwest Panama and central and eastern Cuba (Huber, 1987). These widespread savannas are ecologically varied; the lowland savannas tend to be hyperseasonal in nature (*sensu* Sarmiento, 1983), i.e.

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with flooding and drought conditions occurring during each annual cycle, while the upland savannas are usually better drained, with reduced ground water effects.

The study reported here focused on the hydrologic and well-drained savannas found in two areas in Belize, both lying within the Rio Bravo Conservation and Management Area (RBCMA) managed by the NGO (non-governmental organization) *Programme for Belize* (PfB) (Fig. 1). It seeks to refine the savanna and wetland vegetation classifications of Brokaw *et al.* (1990) for the RBCMA, and to provide comprehensive species lists for the savanna and related wetland flora for use in environmental planning.

The vegetation of Belize was first mapped in detail by the Land Use Survey Team (Wright *et al.*, 1959), and their classification of savanna and related vegetation (including pine forest) attributed c.262,467 hectares to these communities. This constitutes approximately 12% of the surface area of Belize, which covers a total of 22,963km^2. The report classified Belizean savannas and associated forest-type communities into seven broad categories. These include pine and oak forests, orchard and open grass communities, and areas of savanna with scattered pine. Wright attributes a further 62,157 hectares (2.8% of land area) to herbaceous marshes dominated by rush and sedge vegetation. A more recent study, by Rejmánková *et al.* (1996), characterized all Belizean wetland vegetation types into three basic types defined by species of *Eleocharis*, *Cladium* and *Typha.*

A later study, by King *et al.* (1992), groups all Belizean savannas and pine forests into one group – pine forest and orchard savanna. The stage at which 'pine savanna' ('savanna with scattered pines' or its denser form 'pine ridge'[1]) can be differentiated from 'pine forest' is a moot point, as the species composition of the two can be extremely similar and there is a continuous range of physiognomy uniting them. Most authors agree, therefore, that they should be classified together.

Brokaw *et al.* (1990) conducted the first detailed study of the vegetation of the RBCMA, distinguishing upland forest, cohune ridge and palm forest, swamp forest, marsh, pine ridge and savanna. This study estimated that 2.8% of the RBCMA area was covered by savanna. This includes pine ridge (pine woodland) which occurs mainly on the sandy soils in the northeast of the area. The vegetation descriptions resulting from this preliminary vegetation classification are valuable, but do not give any detailed floristic information on the savannas, nor do they make any floristic comparisons with other savanna areas. Owing to the reconnaissance nature of this initial study, the herbaceous component was also ignored. Iremonger & Brokaw (1995) devised a vegetation classification for Belize, and in this a number of savannas and wetland vegetation types were identified, with general pine savanna classified as 'lowland needle-leaf moist open forests over poor soils'. They also identify three

[1] In Belize, the local term 'ridge', when used to describe vegetation, e.g. pine ridge, cohune ridge, etc., can be confusing. It is used to describe a strip of vegetation and does not imply a change in topography. Where the term 'broken ridge' is used, this refers to an uneven canopy. In the case of pine ridge (often found scattered in open savanna) it implies a savanna-type vegetation with a reasonably dense occurrence of pine.

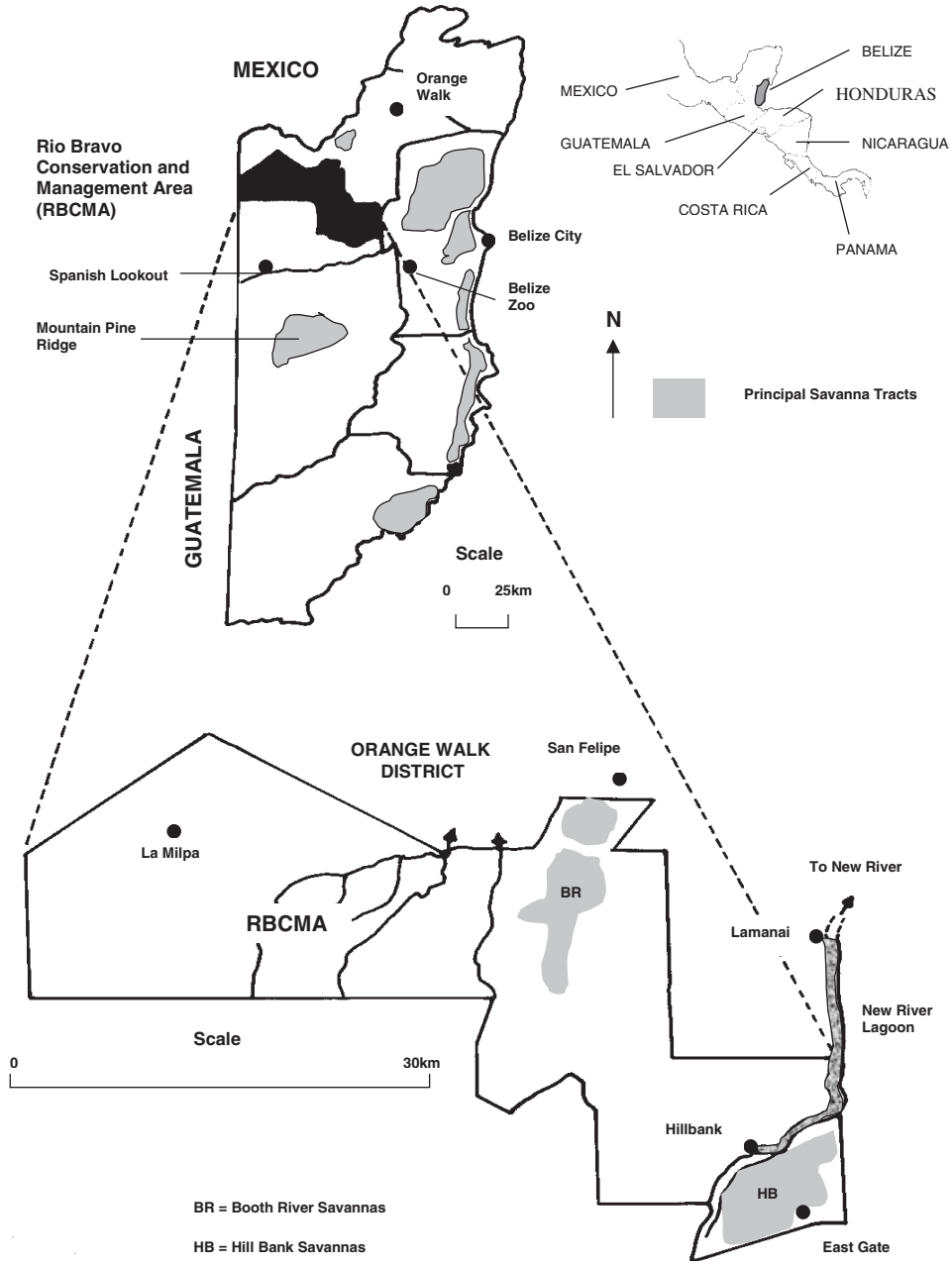

FIG. 1. Map of main savanna tracts within Belize, and savanna distribution within the RBCMA.

types of non-saline seasonally waterlogged scrubs, three types of non-saline scrub which are not influenced by high water tables, and four non-saline herbaceous communities, including freshwater wetlands.

Site Description and Methods

The RBCMA is situated in Orange Walk district, northwest Belize, and is considered geologically part of the Yucatán Peninsula. It covers an area of 82,000 hectares and is almost entirely covered with natural forest, savanna and marsh (Brokaw *et al.*, 1990). Figure 1 shows the distribution of savanna within the RBCMA, as well as the principal savanna and pine forest areas within Belize. The climate is subtropical, with only minor seasonal variations in temperature and a distinct dry season. Annual daytime temperatures vary between 26°C and 32°C, with the highest temperatures occurring in April and May, towards the end of the dry season. Total annual rainfall averages about 1500mm, with a marked dry season between February and May (Wright *et al.*, 1959). Following Koeppen's classification the climate is tropical wet-dry. The RBCMA occurs on a geological formation known as the Yucatán Platform. This consists of a limestone plain covering the northern half of Belize with geology and vegetation continuous with the southern half of the Yucatán of Mexico and the northern Petén of Guatemala (Standley & Record, 1936).

The savanna and wetland vegetation surveys were focused on the areas lying between East Gate and Hill Bank, and those around Booth River (Fig. 1). The study areas were initially identified through remotely sensed images using a 1993 Landsat TM image covering the full extent of the RBCMA, with additional information coming from aerial photography and a SPOT panchromatic image (Furley *et al.*, 2001). Areas identified as being savanna, wetland or savanna/forest transition communities were subsequently ground-truthed by wide-patrolling, general observation and collecting. The surveys loosely followed a series of transects cutting across the savanna area. Quantitative data were collected for 80 trees (20 points) for one area of dense savanna pine ridge close to East Gate using the point-centre quarter technique (Mueller-Dombois & Ellenberg, 1974). Field work was conducted in three phases: a two-month period from mid-July to mid-September 1996, a two-week period in March 2000, and a four-day period during March 2001.

Broad descriptions were made for all vegetation types encountered and an attempt was made to classify the vegetation subtypes following Brokaw & Mallory (1993). Where this was not possible new classifications were devised using terminology that complemented those already used locally. The dominant defining species and general physiognomy of all subtypes were noted. Duplicate collections were made of all higher plants found in the area and are currently held at the Royal Botanic Garden Edinburgh (E) and the Forestry Department, Ministry of Natural Resources, Belmopan, Belize (BRH).

Results

A total of 400 collections were made, representing 258 species. A full species list by family is given in Appendix 1, together with notes on growth forms. Appendix 2 provides species lists by habitat. Table 1 presents the phytosociological parameters for those tree species recorded in an area of broken pine ridge (pine woodland), and Table 2 lists the primary savanna and wetland vegetation subtypes found within the RBCMA. The text below gives general descriptions of the savanna and associated vegetation types encountered within the RBCMA.

Savanna and wetland vegetation classification

The vegetation encountered during the field surveys has been broadly grouped into three main categories: savanna, wetland and savanna/forest transition, according to overall physiognomy, water regime and species composition. Within each of the wetland and savanna categories a number of subtypes have been identified. The subtypes give an idea of the range and variety of savanna vegetation and provide a useful terminology, but most form part of an ecological succession, part of an ecotone or reflect anthropomorphic modifications. As such they should not necessarily be considered as stable communities.

Table 1. Phytosociological parameters for the RBCMA broken pine ridge: absolute density (AD), relative density (RD), absolute dominance (ADo), relative dominance (RDo), absolute frequency (AF), relative frequency (RF), and importance value index (IVI) = RD + RDo + RF

	No. of individuals	Density/ hectare		Dominance/ hectare		Frequency/ hectare		
		AD	RD	ADo	RDo	AF	RF	IVI
Pinus caribaea	66	76.7	82.5	7.49	92.06	100	66.67	241
Quercus oleoides	10	11.6	12.5	0.57	7.06	30	20.0	40
Curatella americana	4	4.6	5.0	0.07	0.88	20	13.33	19

No. of individuals per hectare = 93. Average height = 21m.

Table 2. Savanna and wetland vegetation classification for the RBCMA

1 Savanna	2 Wetland
1.1 Grassland and scrub grassland	2.1 Fringing riverine red mangrove
1.2 Pine–palmetto savanna	2.2 Cutting grass marsh
1.3 Palmetto thicket	2.3 Marl flat
1.4 Savanna orchard	2.4 Sedge marshland
1.5 Woodland and pine ridge	2.5 Eleocharis–calabash marsh
1.6 Oak thicket	

Although isolated forest patches occur on better soils within the savanna region and narrow fringes of gallery forest can be found crossing it in association with watercourses, these were not surveyed, and Brokaw & Mallory's forest classification (1993) should be consulted. The transition zone from savanna to forest is often marked by the presence of oak thickets. Ecological descriptions and species lists have been compiled for these.

1 Savanna

Following Wright *et al.* (1959), the term savanna is used here in the broadest sense, and includes grasslands, dense woody thickets, orchards, woodlands and broken pine ridge. Where there is a conspicuous woody component of the vegetation, the defining species are *Pinus caribaea* Morelet (pine), *Quercus oleoides* Schltdl. & Cham. (oak), *Acoelorraphe wrightii* H. Wendl. ex Becc. (palmetto) and in more hydrologic transition areas to wetlands, *Crescentia cujete* L. (calabash). These three species occur in varying proportions but their conspicuous presence usually indicates this broad vegetation type. Common associates (usually occurring as woody shrubs or small trees) are *Byrsonima crassifolia* (L.) Kunth, *Curatella americana* L., *Chrysobalanus icaco* L., *Bucida buceras* L., *Semialarium mexicanum* (Miers) A.M.W. Mennega, *Eugenia winzerlingii* Standl., *Morinda royoc* L., *Cameraria latifolia* L. and *Gliricidia sepium* Kunth. *Miconia albicans* (Swartz) Triana and *Clidemia sericea* D. Don. also form very conspicuous components of the vegetation, especially in denser thicket transition areas into forest. *Haematoxylon campechianum* L. and *Dalbergia glabra* (Mill.) Standl. are associates of wetter areas. The ground layer of more open areas is dominated by a more or less continuous cover of grasses, although there is a rich associated herbaceous flora, of which *Ageratum radicans* B.L. Rob., *Diodia teres* Walter, *Agalinis hispidula* (Mart.) D'Aray, *Xyris ambigua* Beyr. ex Kunth, *Sauvagesia erecta* L., *Turnera diffusa* Willd., *Polygala variabilis* Kunth and *Melochia spicata* (L.) Fryxell are among the most common species. The orange-coloured parasite *Cassytha filiformis* L. is frequently seen trailing over the lower vegetation. The small cycad *Zamia loddigesii* Miq., although not abundant, is a characteristic plant of the savanna.

Within the broad definition of savanna, a number of savanna vegetation subtypes can be identified. These occur as a mosaic across the area. Although each subtype varies in its exact structure and species composition, they can usually be easily recognized.

2 Wetland

Wetlands are defined here as permanently or seasonally inundated open areas, usually characterized by the dominance of *Cyperaceae* (sedges) in the herbaceous layer, rather than *Gramineae* (grasses). The water table is very close to the surface and standing water creating anaerobic waterlogged conditions is frequently present during the wet season. Trees and shrubs are generally absent, or if present are species

characteristic of wetter areas such as *Dalbergia glabra*, *Bucida buceras*, *Crescentia cujete*, *Mimosa asperata* L. and occasionally *Rhizophora mangle* L. with its distinctive stilt roots.

A number of wetland subtypes exist which support a diverse wetland flora. Some of the most distinctive plants include *Phyla nodiflora* Greene, *Phyla stoechadifolia* (L.) Kunth, *Sagittaria lancifolia* L., *Hymenocallis littoralis* (Jacq.) Salisb., *Ludwigia octovalvis* (Jacq.) Raven, *Centella asiatica* (L.) Urban, *Passiflora foetida* L. and *Nymphaea ampla* (Salisb.) DC., as well as many species of sedge.

Detailed Vegetation Descriptions including Subtypes

1 Savanna

1.1 Grassland and scrub grassland

This subtype is characterized by the complete absence of trees, the only woody vegetation being occasional dwarf shrubs of *Byrsonima crassifolia*, *Semialarium mexicanum*, *Crescentia cujete*, *Curatella americana*, *Calliandra houstoniana* (Mill.) Standl., *Coccoloba* cf. *reflexifolia* Standl., *Zamia loddigesii*, *Eugenia winzerlingii* and *Gliricidia sepium. Randia* spp. and *Myrica cerifera* L. occur in transitional wetter areas. There is an almost complete ground cover of grasses and sedges and a rich herbaceous flora, the most conspicuous species being *Ageratum radicans*, *Diodia teres*, *Agalinis hispidula*, *Sauvagesia erecta*, *Xyris ambigua* Beyr. ex Kunth, *Turnera diffusa*, *Polygala variabilis*, *Melochia spicata* (L.) Fryxell, *Oxalis frutescens* L., *Spermacoce verticillata* L., *Drosera capillaris* Poir, *Hyptis conferta* Pohl ex Benth. and *Lycopodiella caroliniana* (L.) Pic. Serm. The herbaceous vegetation is frequently covered by the dodder *Cassytha filiformis.* This vegetation type is probably transitional in nature, and is related to frequent occurrences of fire. The majority of the shrub species can attain sizeable tree stature and in the absence of fire could be expected to reach significant heights. However, edaphic determinants – the presence of infertile sandy soils and the seasonally high water table – may also be responsible for checking woody growth.

1.2 Pine–palmetto savanna

A very open vegetation, often on sandy soils, in which the ground layer is dominated by tussock-forming grasses, with occasional scattered pines to 20m (although the majority are smaller). With the exception of *Pinus caribaea*, few other woody species reach tree stature and are usually present as shrubs, although *Crescentia cujete*, *Byrsonima crassifolia*, *Curatella americana*, *Cameraria latifolia* L. and *Quercus oleoides* can reach 10m, with *Quercus oleoides* and *Byrsonima crassifolia* even reaching 15m at forest margins. *Eugenia winzerlingii*, *Semialarium mexicanum*, *Pithecellobium insigne* Micheli, *Roupala montana* Aubl. and *Clidemia sericea* are other common woody associates, usually found as shrubs or saplings. Many of the areas have the appearance of having been burnt regularly and there is evidence of logging. The

burning might explain the dwarf nature of many of the woody species which would usually form larger shrubs or trees. The ground layer is made up of an almost continuous cover of tussock-forming grasses to 40cm; species of *Paspalum* are especially abundant. Pine–palmetto savanna has a rich herbaceous flora similar in composition to the savanna grasslands (1.1).

1.3 Palmetto thicket

This is a dense subtype often forming discrete clumps or corridors within the other savanna vegetation types, and is dominated by the palm *Acoelorraphe wrightii* with other trees almost entirely absent, except for very occasional oaks and pines. Palmetto thickets are associated with wetter, poorly drained areas, and range in height from 2 to 6m. Common woody associates of this vegetation type are *Byrsonima crassifolia*, *Crescentia cujete*, *Curatella americana*, *Calliandra houstoniana*, *Parathesis cubana* (A. DC.) Molinet & Maza, *Clidemia sericea*, *Eugenia winzerlingii* and *Gliricidia sepium.* The density of the ground flora varies from open to closed, and it is usually composed of tussock-forming grasses and sedges. *Blechnum serrulatum* L., *Lycopodiella caroliniana*, *Eleocharis* spp. and *Calea peckii* B.L. Rob. are among the most characteristic ground layer species.

1.4 Savanna orchard

This vegetation has the appearance of an 'orchard' with the trees evenly spaced, the majority rarely exceeding 8m, although some mature individuals of *Bucida buceras* are emergent and can attain 15m. It has a greater density of woody shrubs and small trees than other savanna subtypes, but its relatively open canopy and small stature easily distinguish savanna orchard from forest and pine ridge (savanna woodland). This vegetation type has been seen only in hydrologic transitional areas from wetland to more typical savanna. Savanna orchard is frequently seasonally waterlogged. The species composition of the savanna orchards varies greatly, but they tend to be dominated by *Bucida buceras*, *Haematoxylon campechianum* L. and *Cameraria latifolia. Crescentia cujete* is a common associate in wetter areas, sometimes even to the extent of dominating the vegetation (e.g. close to Booth River), others being *Malpighia glabra* L., *Jacquinia macrocarpa* Cav., *Coccoloba* sp., *Semialarium mexicanum*, *Byrsonima crassifolia*, *Chrysobalanus icaco* L., *Myrica cerifera* and occasional clumps *of Acoelorraphe wrightii*. *Pinus caribaea* and *Quercus oleoides* are conspicuously absent. The ground layer is open, dominated by grasses and sedges, with abundant *Cassytha filiformis*, and the herbaceous flora is more depauperate than in other drier savanna areas. The strong influence of water is often reflected in the ground flora, which can be dominated by a single species of sedge (*Eleocharis interstincta* R. Br.), with *Nymphoides humboldtianum* Kunth and *Mimosa asperata* sometimes present. The trees and shrubs can support an abundant epiphytic flora of *Tillandsia* sp., other bromeliads, orchids and parasitic mistletoes' *Phthirusa* spp.

1.5 Woodland and pine ridge

These tend to be *Pinus caribaea*-dominated areas (although oak is sometimes a conspicuous component), with the larger trees attaining 15m (and c.50cm dbh), forming a broken canopy. The woodland is conspicuously denser and has a far greater abundance of pine than pine–palmetto savanna, but is still considered a savanna subtype because of its typically savanna floristic composition. These denser pine areas usually show signs of burning, and cut stumps are common, evidence that these areas were managed or exploited in the past. *Quercus oleoides*, *Curatella americana* and occasionally *Guazuma ulmifolia* are associates which, together with sparse shrubby *Byrsonima crassifolia*, *Semialarium mexicanum*, *Calliandra houstoniana*, *Clidemia sericea*, *Chomelia protracta* (Bart. ex DC.) Standl. and clumps of *Acoelorraphe wrightii*, form an open understorey. The dry and very sandy soils support an open herbaceous layer. Together with the savanna generalists such as *Ageratum radicans* and *Sauvagesia erecta*, *Polypremum procumbens* L. and *Hypericum pratense* Cham. & Schltdl. are present. Occasionally the woody component is partially or completely dominated by oak (oak woodland), with only a few scattered pines.

1.6 Oak thicket

This is dense, sometimes impenetrable, thicket, the characteristic feature being dominance of the canopy by *Quercus oleoides* reaching 15m, and the occasional emergent pine. This type of vegetation appears to form over deeper drier soils, and is frequently associated with forest margins. Typical forest species such as *Sabal mauritiiformis* Griseb. & H. Wendl., *Guettarda combsii* Urban, *Cupania rufescens* Triana & Planch, *Bucida buceras*, *Hampea trilobata* Standl., *Chrysophyllum mexicanum* T.S. Brandegee, *Calophyllum brasiliense* Camb., *Metopium brownei* (Jacq.) Urb. and *Bursera simarouba* (L.) Sarg. can be found. Other common associates, which form a dense understorey, are: *Byrsonima crassifolia*, *Myrica* sp., *Curatella americana*, *Calliandra houstoniana*, *Chomelia protracta*, *Parathesis cubana*, *Clidemia sericea*, *Erythroxylum rotundifolium* Lunan, *Miconia albicans*, *Turnera aromatica* Arbo, *Helicteres mexicana* Kunth, *Coccoloba* cf. *barbadensis* Jacq. and *Randia* sp. Some areas show an abundance of tall palmetto to 5m. There is a dense ground herbaceous layer dominated by the usual savanna herbaceous flora previously described. These oak thickets have the greatest diversity of woody species amongst the savanna subtypes, due to the presence of elements from both the pine–palmettto savanna and forest floras.

2 Wetland

2.1 Fringing riverine red mangrove

This consists of very dense stands of red mangrove (*Rhizophora mangle*) to 5m fringing the rivers, with *Cladium jamaicense* Crantz also abundant. Associate species include *Pachira aquatica* Aubl., *Mimosa asperata*, *Metopium brownei*, *Heteropteris laurifolia* (L.) A. Juss., *Boehmeria cylindrica* (L.) Sw., *Wedelia acapulcensis* Kunth, *Typha dominguensis* Pers., *Acrostichum aureum* L., *Thelypteris* aff. *ovata* R.P. St.

John, *Sagittaria lancifolia*, *Centella asiatica*, *Nymphaea ampla*, *Salvinia minima* Baker, *Utricularia foliosa* L., *Bletia purpurea* (Lam.) DC., *Philodendron* sp., *Polygonum punctatum* Elliot, *Phyla nodiflora*, *Struthanthus orbicularis* (Kunth) Blume ex Schult., *Phthirusa pyrifolia* (Kunth) Eichler, *Mikania micrantha* Kunth, *Ipomea indica* Merrill and *I. sagittata.*

2.2 Cutting grass marsh

This is an almost monodominant marsh of *Cladium jamaicense* (cutting grass) to 2.5m, with occasional small trees of *Dalbergia glabra*, *Crescentia cujete*, *Bucida buceras* and *Rhizophora mangle*, rarely exceeding 5m. Common smaller associates are *Mimosa pudica*, *Heteropteris laurifolia*, *Hymenocallis littoralis*, *Acrostichum aureum*, *Mimosa asperata*, *Sagittaria lancifolia*, *Wedelia acapulcensis*, *Mitreola petiolata*, *Phyla nodiflora*, *P. stoechadifolia* (L.) Kunth and *Eleocharis interstincta.* It occurs as riverine fringing vegetation.

2.3 Marl flat

This is an open vegetation type with *Cyperaceae* (to 50cm) giving a sparse vegetation cover on a seasonally inundated white marl substrate. Associate species are *Eleocharis* sp., *Phyla nodiflora*, *Mimosa asperata*, *Dalbergia glabra*, *Rhizophora mangle*, *Bucida buceras*, *Heteropteris laurifolia*, *Cladium jamaicense*, *Mitreola petiolata*, *Bletia purpurea* and *Passiflora foetida.* Some areas have abundant seedlings of *Heteropteris laurifolia*, with *Centella asiatica* also common in places.

2.4 Sedge marshland

This consists of waterlogged areas dominated by *Cyperus* spp. to 1m, with occasional *Mimosa asperata* and *Sagittaria lancifolia.*

2.5 Eleocharis–calabash marsh

This is marshland where the ground layer is completely dominated by *Eleocharis interstincta.* The area is probably inundated for most of the year. Occasionally scattered trees of *Crescentia cujete* form a conspicuous component of this formation. Associate ground species include *Centella asiatica*, *Pluchea foetida* L. and *Sagittaria lancifolia.*

Discussion

The 258 species found in the pine savanna and related vegetation of the RBCMA reserve represent c.7.5% of the total flora of Belize (3408 species as recorded by Balick *et al*., 2000). None of the 41 species recognized as endemic by Balick (1.2% of the flora) was recorded. Of those species observed during the present study, 148 have an apparent preference for drier savanna communities, with 44 preferentially found in the more humid wetland areas and 74 associated with forest margins. Brokaw *et al*. (1990) cite a total forest tree list of 167 species for the RBCMA. Of

the 'true' savanna species found during the present study, 57 (22%) are woody, of which 15 species (c.8% of the total savanna flora) can be classified as trees.

The characteristic savanna formations of RBCMA occur on soils of low fertility, mild acidity and coarse texture (Furley *et al*., 2001). The distinctive palmetto associations have a strong tendency to increase in areas where the water table rises to the surface, their root systems being adapted to seasonal changes in water availability (Milne, 1997). Iremonger & Brokaw (1995) identify one of their forest vegetation types as 'palmetto/coco plum variant' forest, and to some extent the RBCMA palmetto thickets equate to these, although those found in this study can be considered only thickets as they are of limited stature and extent. The wetland communities occur in areas of seasonal or permanent inundation on soils with an increased amount of clay and silt. Vegetation types typical of the transition zone between the savanna and wetland habitats (e.g. savanna orchard) are heavily influenced by the height of the water table during the wet and dry seasons, with the savannas on the boundary of the wetlands often being hydrologic in nature.

The woody flora of the study site, although depauperate when compared with the rich tree savannas of the Brazilian cerrado biome (Ratter *et al*., 1997), is fairly typical of the general savannas of the Central American and Caribbean region. In the Caribbean, the floristically most diverse savannas are found in Cuba, characterized by a high number of endemic palm species (Borhidi & Herrera, 1977). The dominant tree defining the RBCMA savannas is *Pinus caribaea* var. *hondurensis*, and this species occurs widely across the Central American region from Mexico to Honduras, in savanna, woodland and forest formations, up to an altitude of 600m. The other two classic widespread and abundant species found within RBCMA – *Byrsonima crassifolia* and *Curatella americana* – are the most widely distributed woody savanna species of the Neotropics. Both are identified as indicator species for Neotropical savannas and are considered to form a so-called 'basic floristic matrix' present in practically all Neotropical savanna lowlands (Huber, 1987). *Casearia sylvestris*, another species cited by Huber as belonging to this matrix, was not found in the RBCMA savannas, although it is present and common in Belize. Of the other woody savanna species recorded, most occur throughout Central America, and, as one might expect, the phytogeographic affinities of the RBCMA savannas lie very clearly with this region. A phytogeographic analysis of the floristic woody component of Neotropical savannas conducted by Lenthal *et al*. (1999) grouped together all the savannas of Central America and the Caribbean as a single phytogeographic province, with those from southern Mexico, the Petén and Belize not surprisingly most closely linked.

A comparison of the RBCMA savannas with other savanna areas within Belize reveals it to be floristically similar. The woody species list is nearly identical to those compiled by Furley & Ratter (1986) for savanna areas from Spanish Lookout and Belize Zoo (both to the south of the present study site in central Belize) and by Johnson & Chaffey (1973) for Mountain Pine Ridge (also in central Belize), the main exception being *Clethra occidentalis* which is recorded from the savannas and

pine forest of Mountain Pine Ridge, but is apparently absent from the RBCMA. *Clethra mexicana* and *Leucothoe mexicana* are also recorded as trees from the Mountain Pine Ridge savannas, with *C. mexicana* associated with savanna/gallery forest transition boundaries. Neither of these species was observed within the RBCMA. Another plant typical of the pine forests and savannas of Mountain Pine Ridge region and recognized as a Belizean endemic (Balick *et al.*, 2000) but noticeably absent from the RBCMA is *Schippia concolor.* The characteristic savanna orchard, dominated by *Crescentia cujete*, *Bucida buceras*, *Haematoxylon campechianum* and *Cameraria latifolia*, appears to be related to the 'jicaro savannas' described by Taylor (1963) from Nicaragua, which are characterized by *Crescentia alata* and *Haematoxylon brasiletto.* In Belize, *Haematoxylon campechianum* is noted by Balick *et al.* (2000) as being common in the Orange Walk and Corozal districts on periodically flooded limestone depressions. Savanna orchard appears to equate well with the 'bullet tree-logwood variant' forest of Iremonger & Brokaw (1995), although some of the species they identify as characteristic, such as *Calophyllum brasiliense* and *Manilkara zapota*, were not recorded in our studies.

The areas of broken 'pine ridge' are similar in structure to other larger tracts of pine forest areas within Belize. Johnson & Chaffey (1974) calculated a mean of 26 stems per hectare for pine forests at Sittee River and Deep River, for trees with a diameter greater than 15.2cm. A similar forest inventory of the Mountain Pine Ridge by the same authors (Johnson & Chaffey, 1973) recorded 61 stems per hectare for those over 15.2cm dbh. Although these surveys are not directly comparable to the phytosociological data of the present study, which recorded 93 stems per hectare for all trees with a dbh $\geqslant$10cm, the results suggest a fair degree of structural similarity. Fire is the predominant factor determining the density of pine stocking. It is clear that these savannas, as elsewhere in Central America, are a constantly changing mosaic of intergrading vegetation types representing stages on varying ecological continua, and as such none of the vegetation types can be considered as stable climaxes.

The factors maintaining pine savannas have been widely discussed (e.g. Standley & Record, 1936; Beard, 1953; Wright *et al.*, 1959; Taylor, 1963; Kellman & Meave, 1997; Negrón-Ortiz & Gorchov, 2000) and are beyond the scope of this study. Suffice it to say that current research suggests that in lowland tropical areas in the absence of fire, there may be a gradual replacement of pine savanna by broadleaf forest, even on nutrient-poor soils. This successional model has been proposed by Taylor (1963) for the pine savannas and broadleaf forests of Nicaragua where both are recorded as occurring on similarly nutrient-poor soils, with an observed invasion of broadleaf species into the savanna in the absence of fire. A similar invasion of pine forests by hardwood species has been noted in the Everglades National Park, where burning prescriptions were introduced to limit broadleaf invasion (Negrón-Ortiz & Gorchov, 2000). In a study on Mountain Pine Ridge, Kellman (1985) has shown that woody savanna plants can facilitate invasion by forest species through local addition of nutrients to the soil.

The present study shows that the savannas and wetlands of the RBCMA harbour a diverse flora, and are structurally varied, comprising both open and closed formations, with both well-drained and hydrologic formations represented. Considering the poor general conservation status of savanna systems, the RBCMA represents an important savanna conservation area.

Acknowledgements

We thank the following for their invaluable contributions to this work: the staff of PfB for assistance and friendship in the field; Caroline Whitefoord for help with determinations; Denis Adams for identifying ferns, grasses and sedges and for useful remarks on savanna ecology; Lourdes Rico for identifying the *Leguminosae*; and Steve Renvoize for determining the grasses and sedges. We also thank all the herbarium staff at the Natural History Museum for their assistance, Chris Minty, Station Manager at Las Cuevas, NHM, for invaluable logistical support, and Malcolm Murray and Neil Stewart of the Geography Department, University of Edinburgh. Finally we would like to thank Dominique Maingard for making available PCQ data from her MSc thesis (Geography Department, University of Edinburgh) and the British Ecological Society for partial funding of the work.

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Received 17 August 2001; accepted after minor revision 28 June 2002

Appendix 1

List of all species recorded, and growth form classification

Growth form: (t) tree; (s) shrub; (wh) woody herb; (h) herb; (c) climber; (p) parasite; (e) epiphyte.

SPERMATOPHYTA

Acanthaceae
Aphelandra scabra R. Br. s
Odontonema callistachyum (Schltdl. & Cham.) Kuntze s

Alismataceae
Sagittaria lancifolia L. h

Amaryllidaceae
Hymenocallis littoralis (Jacq.) Salisb. h

Annonaceae
Annona glabra L. s
Malmea depressa (Baill.) R.E. Fr. t

Apocynaceae
Aspidosperma megalocarpon Müll. Arg t
Cameraria latifolia L. t
Rauwolfia trichophylla Baker s
Tabernaemontana alba Mill. t
Thevetia ahuai (L.) Rafin. s

Aquifoliaceae
Ilex guianensis (Aubl.) Kuntze s

Araceae
Philodendron sp. h
Syngonium angustatum Schott h

Asclepiadaceae
Cynanchum stenomeres (Gray) Standl. & Steyerm. c

Asteraceae
Ageratum radicans B.L. Rob. wh
Calea peckii B.L. Rob. wh
Emilia fosbergii Nicolson h
Melanthera nivea O.E. Schulz h
Mikania micrantha Kunth c
Pluchea foetida L. h
Wedelia acapulcensis Kunth wh
W. aff. *hispida* Kunth s

Bignoniaceae
Crescentia cujete L. t

Bombacaceae
Pachira aquatica Aubl. t
Pseudobombax ellipticum (Kunth) Dugand t

Boraginaceae
Cordia spinescens L. s
Heliotropium ternatum Vahl h

Bromeliaceae
Tillandsia balbisiana Schult.f. e

Burseraceae
Bursera simarouba (L.) Sarg. t
Protium copal (Cham. & Schltdl.) Engl. t

Campanulaceae
Lobelia cardinalis L. h

Celastraceae
Crossopetalum puberulum (Lundell) Lundell s
Semialarium mexicanum (Miers) A.M.W. Mennega s
(Syn.: *Hemiangium excelsium*; *Hippocratea excelsea*)

Chrysobalanaceae
Chrysobalanus icaco L. s
Hirtella americana L. s
H. racemosa Lam. s

Cochlospermaceae
Cochlospermum vitifolium (Willd.) Spreng. s

Combretaceae
Bucida buceras L. t

Connaraceae
Connarus lambertii Britton s

Convolvulaceae
Evolvulus sericeus Benth. c
Ipomea indica Merrill c
I. sagittata Lam. c
I. tuxtlensis House c

Cyperaceae
Bulbostylis cf. *barbata* C.B. Clarke h
B. cf. *juncoides* (Vahl) Kük. h

Cladium jamaicense Crantz h
Cyperus aff. *aggregatus* Endl. h
Eleocharis cf. *interstincta* R. Br. h
Eleocharis sp. (S304) h
Fuirena cf. *umbellata* Rottb. h
Rhynchospora holoschoenoides Vahl h
Rhynchospora sp. (S256) h
Scleria bracteata Cav. h
S. distans Poir. h

Dilleniaceae
Curatella americana L. t
Tetracera mollis Standl. c

Droseraceae
Drosera capillaris Poir. h

Erythroxylaceae
Erythroxylum guatemalense Lundell s
E. rotundifolium Lunan s

Euphorbiaceae
Caperonia castaneaefolia (L.) A. St.-Hil. h
Croton hirtus L'Herit. wh
Croton sp. t
Dalechampia schippii Standl. c
Jatropha gaumeri Greenman s
Phyllanthus brasiliensis (Aubl.) Poir. s
Sebastiania adenophora Pax & K. Hoffm. t

Fagaceae
Quercus oleoides Schltdl. & Cham. t

Flacourtiaceae
Casearia corymbosa Kunth s/t
Laetia thamnia L. t
Xylosma anisophyllum Standl. s

Gentianaceae
Coutoubea spicata Aubl. h
Lisianthus axillaris Kuntze s
Schultesia guianensis (Aubl.) Malme h

Gramineae
Andropogon bicornis L. h
A. virginians L. h
Dichanthelium acuminatum (Swartz) F.W. Goul & C.A. Clark h
D. strigosum (Muhl.) Freekmann h
Digitaria cf. *cayoensis* Swallen h
Digitaria sp. (B94) h
Echinochloa colona (L.) Link h
Eragrostis elliotti S. Wats. h
Homolepis aturensis (Kunth) Chase h
Ischaemum latifolium (Spreng.) Kunth h
Mesosetum filifolium Hubb. h
Panicum cyanescens Nees h
P. virgatum L. h
Paspalum pulchellum Kunth h
P. serpentinum Hochst. ex Steud. h
P. setaceum Michx. h
Setaria parviflora (Poir.) Kerguélen h
Sorghastrum setosum Hitchc. h

Guttiferae
Calophyllum brasiliense Cambess. t
Hypericum pratense Cham. & Schltdl. wh
Vismia camparaguey Sprague & Riley t

Iridaceae
Cipura paludosa Aubl. h

Labiatae
Hyptis conferta Pohl ex Benth. wh
Marsypianthes chamaedrys (Vahl) Kuntze h

Lauraceae
Cassytha filiformis L. h
Nectandra cf. *salicifolia* (Kunth) Nees s

Leguminosae
Acacia collinsii Satford s
Andira inermis (W. Wr.) DC. t
Bauhinia divaricata L. s
B. ungulata L. s
Calliandra houstoniana (Mill.) Standl. s
C. tergemina (L.) Benth. s
Centrosema angustifolium (Kunth) Benth. wh
Chamaecrista flexuosa (L.) Greene wh
C. hispidula (Vahl) H.S. Irwin & R.C. Barneby wh
Clitoria guianensis (Aubl.) Benth. wh
Cojoba recordii Britton & Rose s
Crotalaria sagittalis L. h
Dalbergia glabra (Mill.) Standl. s
Desmodium barbatum (L.) Benth. & Oerst. s
D. canum Schinz & Thellung s
Enterolobium cyclocarpum (Jacq.) Griseb. t
Galactia striata (Jacq.) Urb. c
Gliricidia sepium Kunth s
Haematoxylum campechianum L. t
Havardia albicans (Kunth) Britton & Rose s
Lonchocarpus luteomaculatus Pittier t
L. rugosus Benth. s
Lysiloma latisiliquum (L.) Benth. t

Mimosa albida Humb. & Bonpl. s
M. asperata L. s
M. bahamensis Benth. s
M. pudica L. s
M. somnians Humb. & Bonpl. ex Willd. wh
Pithecellobium insigne Micheli s
P. lanceolatum (Humb. & Bonpl.) Benth. s
P. macrandium Donn. Sm. s
Rhynchosia americana (Mill.) Metz. c
Senna undulata (Benth.) H.S. Irwin & R.C. Barneby s
S. uniflora (Mill.) H.S. Irwin & R.C. Barneby s
Stylosanthes guianensis (Aubl.) Sw. h
S. viscosa Sw. wh
Swartzia cubensis (Britton & P. Wilson) Standley s/t
Zornia diphylla (L.) Pers. h

Lentibulariaceae
Utricularia foliosa L. (aquatic plant in lagoons and rivers) h

Loganiaceae
Mitreola petiolata (J.F. Gmel.) Torr. & Gray h
Polypremum procumbens L. h

Loranthaceae
Phthirusa pyrifolia (Kunth) Eichler p
Struthanthus orbicularis (Kunth) Blume ex Schult. p

Malpighiaceae
Byrsonima crassifolia (L.) Kunth t
Heteropteris laurifolia (L.) A. Juss. s
Malpighia glabra L. s
Stigmaphyllon ellipticum (Kunth) A. Juss. c

Malvaceae
Hampea trilobata Standl. t
Hibiscus costatus A. Rich. s/c
Sida linifolia Cov. wh

Marantaceae
Maranta arundinacea L. h

Melastomataceae
Clidemia novemnervia Triana s
C. sericea D. Don s
Henriettea succosa (Aubl.) DC. s
Miconia albicans (Swartz) Triana s
M. ciliata Benth. s
M. prasina (Sw.) DC. s
Pterolepis stenophylla Gleason h

Menispermaceae
Cissampelos pareira L. c
Hyperbaena winzerlingii Standl. s

Menyanthaceae
Nymphoides humboldtianum Kunth h

Moraceae
Brosimum alicastrum Sw. s
Cecropia peltata L. t
Ficus cf. *ovalis* Miq. t
F. maxima Miller t
Trophis racemosa (L.) Urban t

Myricaceae
Myrica cerifera L. s

Myrsinaceae
Parathesis cubana (A. DC.) Molinet & Maza s

Myrtaceae
Eugenia buxifolia Lam. t
E. cf. *axillaris* G. Don. s
E. origanoides O. Berg s
E. winzerlingii Standl. s

Nymphaceae
Nymphaea ampla (Salisb.) DC. h

Ochnaceae
Ouratea lucens (Kunth) Engl. s
O. nitida (Sw.) Engl. t
Sauvagesia erecta L. ssp. *brownei* (Planchon) Sastre h
S. erecta L. ssp. *erecta* h

Onagraceae
Ludwigia octovalvis (Jacq.) Raven h

Orchidaceae
Bletia purpurea (Lam.) DC. h
Spiranthes torta (Thunb.) Gray & H.R. Sweet h

Oxalidaceae
Oxalis frutescens L. h

Palmae
Acoelorraphe wrightii H. Wendl. ex Becc. s/t
Sabal mauritiiformis Griseb. & H. Wendl. t

Passifloraceae
Passiflora foetida L. c
P. urbaniana Killip c

Pinaceae
Pinus caribaea Morelet t

Polygalaceae
P. variabilis Kunth h
Polygala sp. h

Polygonaceae
Coccoloba cf. *barbadensis* Jacq. t
C. cf. *reflexifolia* Standl. s/t
C. cozumelensis Hensl. s
Polygonum punctatum Elliot h

Portulacaceae
Portulaca pilosa L. wh

Proteaceae
Roupala montana Aubl. s/t

Rhizophoraceae
Cassipourea guianensis Aubl. t
Rhizophora mangle L. t

Rubiaceae
Alibertia edulis (L. Rich.) A. Rich. s
Amaioua corymbosa (Willd.) Kunth t
Chiococca alba (L.) Hitchc. s
Chomelia protracta (Bart. ex DC.) Standl. s
Coccocypselum guianense (Aubl.) K. Schum. h
Diodia teres Walter wh
Guettarda combsii Urban t
G. gaumeri Standl. s
Machaonia acuminata Kunth s
M. lindeniana Baill. s
Morinda royoc L. s
Palicourea triphylla DC. s
Psychotria frucitetorum Standl. s/t
P. officinalis Kuntze s
Randia aculeata L. s/t
R. lundellii Standl. s
Randia sp. s
Spermacoce verticillata L. h

Sapindaceae
Allophylus cominia (L.) Sw. s
Cupania rufescens Triana & Planch. t
Matayba oppositifolia (A. Rich) Britton t
Paullinia pinnata L. c
Serjania adiantoides Radlk. c
Serjania sp. c

Sapotaceae
Chrysophyllum mexicanum T.S. Brandegee t
Manilkara zapota (L.) Van Royen t
Sideroxylon obtusifolium (Roem. & Schult.) Penn. s

Scrophulariaceae
Agalinis harperi Pennell h
A. hispidula (Mart.) D'Aray h
Angelonia ciliaris Robins h
Bacopa monnieri (L.) Pennell h
Buchnera pusilla Kunth h
Russelia sarmentosa Jacq. h

Simaroubaceae
Simarouba glauca DC. t

Smilacaceae
Smilax spinosa Miller c

Sterculiaceae
Guazuma ulmifolia Lam. t
Helicteres mexicana Kunth s
Melochia spicata (L.) Fryxell wh
Waltheria indica L. wh

Ternstroemiaceae
Ternstroemia tepezapote Schltdl. & Cham. s

Theophrastaceae
Jacquinia macrocarpa Cav. t

Turneraceae
Piriqueta cistoides (L.) Griseb. h
Turnera aromatica Arbo wh
T. diffusa Willd. wh
T. ulmifolia L. wh

Typhaceae
Typha dominguensis Pers. h

Umbelliferae
Centella asiatica (L.) Urban h

Urticaceae
Boehmeria cylindrica (L.) Sw. h

Verbenaceae
Cornutia pyramidata L. s
Lantana camara L. s
Phyla nodiflora Greene h
P. stoechadifolia (L.) Small h
Stachytarpheta jamaicensis (L.) Vahl h
Vitex gaumeri Green t

Violaceae
Hybanthus calceolaria Schulze wh

Xyridaceae	
Xyris jupicai L. Rich.	h
Zamiaceae	
Zamia loddigesii Miq.	s
PTERIDOPHYTA	
Blechnaceae	
Blechnum serrulatum L.	h
Pteridaceae	
Acrostichum aureum L.	h
Salviniaceae	
Salvinia minima Baker	h
Schizaeaceae	
Lygodium venustum Sw.	c
Thelypteridaceae	
Thelypteris aff. *ovata* R.P. St. John	h
LYCOPSIDA	
Lycopodiaceae	
Lycopodiella caroliniana (L.) Pic. Serm.	h

Appendix 2

Species list arranged by habitat type

Savanna

Acacia collinsii Satford
Acoelorraphe wrightii H. Wendl. ex Becc.
Agalinis harperi Pennell
A. hispidula (Mart.) D'Aray
Ageratum radicans B.L. Rob.
Allophylus cominia (L.) Sw.
Andropogon bicornis L.
A. virginians L.
Angelonia ciliaris Robins
Aphelandra scabra R. Br.
Bauhinia divaricata L.
B. ungulata L.
Blechnum serrulatum L.
Buchnera pusilla Kunth
Bulbostylis cf. *barbata* C.B. Clarke
B. cf. *juncoides* (Vahl) Kük.
Byrsonima crassifolia (L.) Kunth
Calea peckii B.L. Rob.
Calliandra houstoniana (Mill.) Standl.
Cameraria latifolia L.
Caperonia castaneaefolia (L.) A. St.-Hil.
Casearia corymbosa Kunth
Cassytha filiformis L.
Centrosema angustifolium (Kunth) Benth.
Chamaecrista flexuosa (L.) Greene
C. hispidula (Vahl.) H.S. Irwin & R.C. Barneby
Chrysobalanus icaco L.
Cipura paludosa Aubl.
Cissampelos pareira L.
Clidemia novemnervia Triana
C. sericea D. Don
Clitoria guianensis (Aubl.) Benth.
Coccoloba cf. *reflexifolia* Standl.
Cochlospermum vitifolium (Willd.) Spreng.
Cordia spinescens L.
Cornutia pyramidata L.
Coutoubea spicata Aubl.
Crescentia cujete L.
Crotalaria sagittalis L.
Croton hirtus L'Herit.
Curatella americana L.
Cynanchum stenomeres Standl. & Steyerm.
Dalechampia schippii Standl.
Desmodium barbatum (L.) Benth. & Oerst.
D. canum (J.F. Gmel.) Schinz & Thellung
Dichanthelium cf. *acuminatum* (Sw.) F.W. Goul & C.A. Clark
D. strigosum (Muhl.) Freckmann
Digitaria cayoensis Swallen
Digitaria sp. (B94)
Diodia teres Walter
Drosera capillaris Poir.
Echinochloa colona (L.) Link
Emilia fosbergii Nicolson
Eragrostis elliotti S. Wats.
Erythroxylum rotundifolium Lunan
Eugenia cf. *axillaris* G. Don
E. origanoides O. Berg
E. winzerlingii Standl.
Evolvulus sericeus Benth.
Gliricidia sepium Kunth

Guettarda combsii Urban
Havardia albicans (Kunth) Britton & Rose
Heliotropium ternatum Vahl
Henriettea succosa (Aubl.) DC.
Heteropteris laurifolia (L.) A. Juss.
Hibiscus costatus A. Rich.
Hirtella racemosa Lam.
Homolepis aturensis (Kunth) Chase
Hybanthus calceolaria Schulze
Hyperbaena winzerlingii Standl.
Hypericum pratense Cham. & Schltdl.
Hyptis conferta Pohl ex Benth.
Ilex guianensis (Aubl.) O. Kuntze
Ipomea sagittata Lam.
Ischaemum latifolium (Spreng.) Kunth
Jacquinia macrocarpa Cav.
Lantana camara L.
Lechea torreyi Leggett. var. *congesta* Hodgson
Lobelia cardinalis L.
Lycopodiella caroliniana (L.) Pic. Serm.
Lygodium venustum Sw.
Maranta arundinacea L.
Marsypianthes chamaedrys (Vahl) Kuntze
Melanthera nivea O.E. Schulz
Melochia spicata (L.) Fryxell
Mesosetum filifolium Hubb.
Miconia albicans (Swartz) Triana
Mimosa albida Humb. & Bonpl. ex Willd.
M. bahamensis Benth.
M. pudica L.
M. somnians Humb. & Bonpl. ex Willd.
Morinda royoc L.
Myrica cerifera L.
Nectandra cf. *salicifolia* (Kunth) Nees
Nymphaea ampla (Salisb.) DC.
Oxalis frutescens L.
Panicum virgatum L.
Parathesis cubana (A. DC.) Molinet & Maza
Paspalum pulchellum Kunth
P. setaceum Michx.
P. serpentinum Hochst. ex Steud.
Phthirusa pyrifolia (Kunth) Eichler
Pinus caribaea Morelet
Piriqueta cistoides (L.) Griseb.
Pithecellobium insigne Micheli
Pluchea foetida L.
Polygala paniculata L.
P. variabilis Kunth
Polypremum procumbens L.
Portulaca pilosa L.
Pterolepis stenophylla Gleason
Quercus oleoides Schltdl. & Cham.
Randia lundellii Standl.
Randia sp. (S267)
Rhynchosia americana (Mill.) M.C. Metz.
Roupala montana Aubl.
Sauvagesia erecta L. ssp. *brownei* (Planchon) Sastre
S. erecta L. ssp. *erecta*
Schultesia guianensis (Aubl.) Malme
Scleria bracteata Cav.
Semialarium mexicanum (Miers) A.M.W. Mennega
Senna undulata (Benth.) H.S. Irwin & R.C. Barneby
S. uniflora (Mill.) H.S. Irwin & R.C. Barneby
Setaria parviflora (Poir.) Kerguélen
Sida linifolia Cov.
Simarouba glauca DC.
Sorghastrum setosum Hitchc.
Spermacoce verticillata L.
Spiranthes torta (Thunb.) Gray & H.R. Sweet
Stachytarpheta jamaicensis (L.) Vahl
Stigmaphyllon ellipticum (Kunth) A. Juss.
Stylosanthes guianensis (Aubl.) Sw.
S. viscosa Sw.
Swartzia cubensis (Britton & P. Wils.) Standl.
Syngonium angustatum Schott
Ternstroemia tepezapote Schltdl. & Cham.
Tetracera mollis Standl.
Turnera aromatica Arbo
T. diffusa Willd.
T. ulmifolia L.
Vismia camparaguey Sprague & Riley
Vitex gaumeri Green
Waltheria indica L.
Wedelia acapulcensis Kunth
Xylosma anisophyllum Standl.
Xyris ambigua Beyr. ex Kunth
Zamia loddigesii Miq.
Zornia diphylla (L.) Pers.

Savanna/forest transition
Alibertia edulis (L. Rich.) A. Rich.
Amaioua corymbosa (Willd.) Kunth

Andira inermis (W. Wr.) DC.
Aspidosperma megalocarpon Müll. Arg
Brosimum alicastrum Sw.
Bucida buceras L.
Bursera simarouba Sarg.
Calliandra tergemina (L.) Benth.
Calophyllum brasiliense Camb.
Cassipourea guianensis Aubl.
Cecropia peltata L.
Chiococca alba (L.) Hitchc.
Chomelia protracta (Bart. ex DC.) Standl.
Chrysophyllum mexicanum T.S. Brandegee
Clusia massoniana Lundell
Coccocypselum guianense (Aubl.) K. Schum.
Coccoloba cf. *barbadensis* Jacq.
C. cozumelensis Hensl.
Cojoba recordii Britton & Rose
Connarus lambertii Britton
Crossopetalum cf. *puberulum* (Lundell) Lundell
Croton sp.
Cupania rufescens Triana & Planch.
Enterolobium cyclocarpum (Jacq.) Griseb.
Erythroxylum guatemalense Lundell
Eugenia buxifolia Lam.
Ficus maxima Miller
Guazuma ulmifolia Lam.
Guettarda gaumeri Standl.
Hampea trilobata Standl.
Helicteres mexicana Kunth
Hirtella americana L.
Ipomea tuxtlensis House
Jatropha gaumeri Greenman
Laetia thamnia L.
Lisianthius axillaris Kuntze
Lonchocarpus luteomaculatus Pittier
L. rugosus Benth.
Lysiloma latisiliquum (L.) Benth.
Machaonia acuminata Kunth
M. lindeniana Baill.
Malmea depressa (Baill.) R.E. Fr.
Manilkara zapota (L.) Van Royen
Matayba oppositifolia (A. Rich) Britton
Melochia spicata (L.) Fryxell
Miconia ciliata Benth.
M. prasina (Sw.) DC.
Odontomema callistachyum (Schltdl. & Cham.) Kuntze
Ouratea lucens (Kunth) Engl.
O. nitida (Sw.) Engl.
Palicourea triphylla DC.
Passiflora urbaniana Killip
Paullinia pinnata L.
Phyllanthus brasiliensis (Aubl.) Poir.
Pithecellobium lanceolatum (Humb. & Bonpl.) Benth.
P. macrandium Donn. Sm.
Protium copal (Cham. & Schltdl.) Engl.
Pseudobombax ellipticum (Kunth) Dugand
Psychotria frucitetorum Standl.
P. officinalis Kuntze
Randia aculeata L.
Rauwolfia trichophylla Baker
Russelia sarmentosa Jacq.
Sabal mauritiiformis Griseb. & H. Wendl.
Sebastiania adenophora Pax & K. Hoffm.
Serjania adiantoides Radlk.
Sideroxylon obtusifolium (Roem. & Schult.) Penn.
Simarouba glauca DC.
Smilax spinosa Miller
Tabernaemontana alba Mill.
Ternstroemia tepezapote Schltdl. & Cham.
Thevetia ahuai (L.) Rafin.
Trophis racemosa (L.) Urban
Waltheria indica L.
Wedelia aff. *hispida* Kunth

Wetland

Acrostichum aureum L.
Annona glabra L.
Bacopa monnieri (L.) Pennell
Bletia purpurea (Lam.) DC.
Boehmeria cylindrica (L.) Sw.
Buchnera pusilla Kunth
Caperonia sp.
Centella asiatica (L.) Urban
Cladium jamaicense Crantz
Cyperus aggregatus Endl.
Dalbergia glabra (Mill.) Standl.
Eleocharis cf. *interstincta* R. Br.
Eleocharis sp. (S304)
Ficus cf. *ovalis* Miq.
Fuirena cf. *umbellata* Rottb.
Galactia striata (Jacq.) Urb.
Haematoxylum campechianum L.
Heteropteris laurifolia (L.) A. Juss.
Hymenocallis littoralis (Jacq.) Salisb.
Ipomea indica Merrill
Ludwigia octovalvis (Jacq.) Raven

Malpighia glabra L.
Mikania micrantha Kunth
Mimosa asperata L.
Mitreola petiolata (J.F. Gmel.) Torr. & Gray
Nymphaea ampla (Salisb.) DC.
Nymphoides humboldtianum Kunth
Pachira aquatica Aubl.
Passiflora foetida L.
Philodendron sp.
Phthirusa pyrifolia (Kunth) Eichler
Phyla nodiflora Greene
Phyla stoechadifolia (L.) Kunth
Pluchea foetida L.
Polygonum punctatum Elliot
Rhizophora mangle L.
Rhynchospora holoschoenoides Vahl
Rhynchospora sp. (S256)
Sagittaria lancifolia L.
Salvinia minima Baker
Scleria distans Poir.
Struthanthus orbicularis (Kunth) Blume ex Schult.
Thelypteris aff. *ovata* R.P. St. John
Tillandsia balbisiana Schult.f.
Typha dominguensis Pers.
Utricularia foliosa L.
Wedelia acapulcensis Kunth