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Contribution to the Knowledge of the Phytocenotic Diversity of the Lesser Antilles Revisiting Some Old and More Recent Floristic Data

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Abstract

The complex structure of the abiotic factors in the Lesser Antilles leads to singular vegetation ranging from the dry to the humid. Geomorphology by means of the wide variety of topographic facets is the determining parameter which leads to gradients of mesological factors. Among the latter, both on the windward and leeward facades, the precipitation is distinguished by bioclimatic staging associated with plant stagings which consist of a mosaic of phytocenoses of variable sizes, ages, floristic compositions and structures as well as of different architecture. Based on examples of old and recent floristic surveys by authors which indicate ecotones, types and inversions of vegetation, we have shown the great phytocenotic diversity of the plant cover in the Lesser Antilles which are all biosystemic responses to the effects of natural and anthropogenic hazards. Thanks to this significant ecosystemic plasticity, the Lesser Antilles represent veritable laboratories for autoecological and synecological studies as well as of floristic succession.

Subject Areas

Ecology, Ecosystem Science, Plant Science, Biodiversity, Biogeography

Keywords

Lesser Antilles, Bioclimates, Phytocenoses, Ecosystemic Potentialities, Types of Vegetation, Plant Dynamics, Anthropisation

1. Introduction

On a global scale, vegetations are mosaics of various specific units, ages, structures and compositions which belong to different stages of the plant succession and which show the structural variability of the mesological factors [1]-[12]. Anthropisation seems to be a factor in increasing biocenotic biodiversity [13] [14] [15] [16] [17]. The insular Caribbean is also affected by this global phenomenon of the humanisation of biotopes. Indeed, since the takeovers of the 17th century up to the present day, the groundcovers of the Lesser Antilles have been subject to the various effects in terms of intensity and frequency, of human activities [18] [19] [20]. The great diversity of the floristic formations constitutes one of the unique characteristics of the current flora of the Antilles [21] [22] [23] [24]. As a consequence, these islands represent a veritable laboratory for the synchronic study of the vegetation and therefore the landscapes [25] [26] [27] [28]; **Figure 1**). In what follows, we will show, using a few examples, the diversity of the physiognomic types which reflect a great specific and morphogenetic diversity. This summary is the result of studies based on qualitative indicators and constitutes a preliminary work ahead of more quantitative approaches.

2. Materials

With respect to their size and their geomorphology, the Lesser Antilles exhibit great variability [29] [30] [31] [32]. There are the low-lying islands, the low islands and the highland islands. These different groups consist of plural topographic facies which contribute to the great diversity of the biotopes. The peaks, the ridges, the valleys or dales, the flats, the plateaus, the plains and the rocky ledges are all topographic facets which modify, to a variable degree, the structure

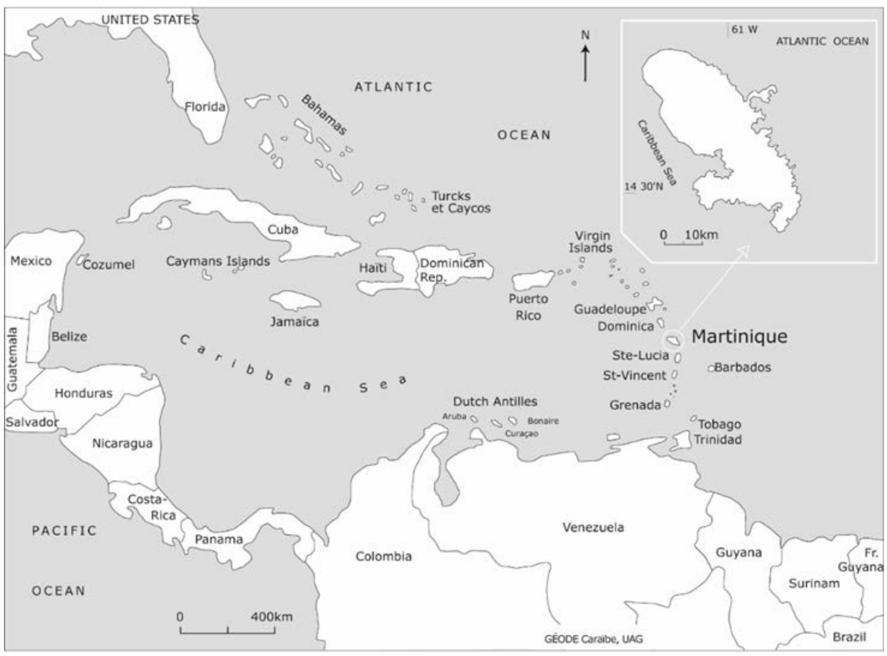


Figure 1. The Lesser Antilles in the Caribbean.

of the factors of the macroclimate [33] [34] [35]. Consequently, the latter are signified by differentiated altitudinal gradients. The result of all this is many microclimates and mesoclimates which lead to great specific and phytocenotic diversity. Precipitation is the key mesological factor, particularly concerning the mountainous Lesser Antilles. On these islands, the orographic rains delimit a bioclimatic staging which defines a plant staging which is therefore phytocenotic. From the coast to the summit, we can identify hyper-humid, humid, humid subhumid and dry subhumid bioclimates which typically give rise to the following forest vegetation: mountain ombrophilous, sub-mountain ombrophilous, seasonal evergreen types and seasonal evergreen in their xeric facies. This above-mentioned general outline makes it possible to identify the floristic potentialities of the low-lying islands.

3. Methods

To highlight the diversity of the phytocenoses and associated floristic corteges, we have taken certain data from our predecessors into account as well as our own [36] [37] [38] [39] [40]. These data come from inventories within minimum areas ranging from 400 m^2 (plant stages subject to the dry subhumid bioclimate) to more than 2000 m^2 (plant stages influenced by the humid bioclimate). When the eco-climatic conditions are homogeneous, these minimum areas correspond to the smallest surface areas providing the maximum of information on the structure and evolution of the phytocenoses and therefore on the ecological profiles of the taxa. Due to the differences in the surface area of inventories and the methods of the floristic surveys, the data generated by the above-mentioned authors were considered to be non-compliant. Consequently, for the purposes of the analysis and on the basis of these biodemographic data, we have constructed indicators of qualitative abundance [41]: (++++++: 500 individuals): very high abundance/(+++++: 100 individuals): high abundance/(++++: 50 individuals): medium abundance/(+++: 25): low abundance/very low abundance (++: 15): negligible (+: 6). The results are presented in two parts. In the first part, the ratios of abundance and by inference of dominance between taxa are indicated using tables summarising the data from different authors. However, the old data are presented in light of the conceptual framework of modern ecology. In the second part, in order to compare the stations with respect to the population structure of the species, we performed a CFA (Correspondence Factor Analysis) and an AHC (Ascending Hierarchical Classification) using the XLSTAT software based on a contingency table composed of the stational average floristic abundances. In the tables the strata correspond to different classes of heights.

4. Results

4.1. Examples of Pre-Sylvatic, Young Structured and Secondary Sylva Groupings Inventoried from 1938 to the Present Day

4.1.1. Saint-Kitt-Nevis (J. S. Beard, 1949)

The author does not specify the ratios of significance between the different species; however, the physiognomic description of this grouping seems to correspond to an organisation where the woody tree is ecologically predominant. Table 1 refers to a tropical seasonal evergreen plant formation of lower horizon, degraded and located at the pre-sylvatic or young sylvatic stage.

4.1.2. Montserrat (J. S. Beard, 1949)

In Table 2, the most abundant trees are *Lonchocarpus violaceus*, *Bursera simaruba*, *Tabebuia heterophylla*. Under this discontinuous structure, in unequal proportions, *Bourreria succulenta*, *Guaettarda scabra*, *Acacia sp*, *Croton flavens*, *Haemotoxylum campechianum*, *Citharexylum spinosum* form a matrix of non-stratified associations. The structural and architectural elements of Table 2 indicate that this grouping is in the presylvatic or young sylvatic evolutionary stage.

As regards Table 3, *Canella winterana*, *Coccoloba pubescens*, *Zanthoxylum monophyllum*, *Zanthoxylum punctatum* are structuring agents of an open tree phytocenosis with which dominate low xerophilous species, variously associated such as *Opuntia dillenii*, *Melocactus intortus*, *Croton sp*, *Agave sp*, *Pilosocereus roynei*, *Comocladia dodanea*, *Clerodendrum aculeatum*. In Table 3, this tropical seasonal evergreen floristic grouping of lower horizon in its most xeric facies corresponds to the preforest stage.

Table 1. Tropical seasonal evergreen unit of lower horizon.

Plant species	Abundance	Stratigraphic levels	Plant species	Abundance	Stratigraphic levels
Acacia ssp	+	*S3*	*Lonchocarpus pentaphyllus* (*)	+++	S2/S1
Bourreria succulenta	+	*S3*	*Pisonia suborbiculata*	+	*S3*
Capparis cynophallophoa	+	*S3*	*Pithecellobium unguis-cati*	+	*S3*
Chrysobalanus icaco	+	*S3*	*Plumeria alba*	+	*S3*
Coccoloba diversifolia	+++	*S2*/*S1*	*Prosopis juliflora*	+	S3
Coccoloba pubescens	+++	*S2*/*S1*	*Randia aculeata*	+	S3
Croton flavens	+	*S3*	*Sideroxylon salicifolia*	++	S2/S3
Ficus trigonata	+	*S3*	*Tabebuia heterophylla*	+++	S2/S1
Guettarda scabra	++	S3/S2			

(++++++): very high Abundance/(++++): high Abundance/(+++): Medium abundance/(++): low Abundance/(+): very low Abundance. (*): given the bioclimatic stage, it is highly plausible that it is *Lonchocarpus violaceus*, however stational conditions may allow for the installation of the species cited by the author. S1: Upper strata/S2: Middle strata/S3: Lower strata.

Table 2. Tropical seasonal evergreen formation of lower horizon.

Plant species	Abundance	Stratigraphic levels	Plant species	Abundance	Stratigraphic levels
Acacia sp.	++	S2/S3	*Inga laurina*	+	S2
Annona squamosa	+	S3	*Jacquinia armilaris*	+	S3
Bourreria succulenta	+++	S2/S3	*Leucaena leucocephla*	+++	S1/S2
Bursera simaruba	++++	S2/S1	*Lonchocarpus violaceus*	++++	S2/S1
Capparis flexuosa	+	S1	*Malpighia linearis*	+	S3
Citharexylum spinosum	+++	S1/S2	*Myrcia citrifolia*	++	S3
Coccoloba diversifolia	++	S1/S2	*Pilosocereus royeni*	+	S3
Croton astroides	+	S1	*Pisonia subcordata*	+++	S3
Croton flavens	+++	S1	*Plumeria alba*	+	S3/S2
Erytroxylon havanense	++	S1	*Randia aculeata*	+++	S3
Exostema caribaeum	++	S1/S2	*Tabebuia heterophylla*	++++	S1/S2
Guettarda scabra	++	S1/S2	*Tamarindus indica*	+	S2
Haemotoxylum campechianum	++	S1/S2	*Tecoma stans*	++	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

Table 3. Highly xeric littoral facies where xeromorphosis is pronounced.

Plant species	Abundance	Stratigraphic levels	Plant species	Abundance	Stratigraphic levels
Agave sp	+	*S3*	*Melocactus intortus*	+	S3
Canella winterana	+++	*S2/S3*	*Opuntia dillenii*	+	S3
Clerodendrum aculeatum	++	*S3*	*Pilosocereus roynei*	+	S3
Coccoloba pubescens	++++	*S2/S1*	*Prosopis juliflora*	+	S3
Comocladia dodanea	++	*S3*	*Zanthoxylum monophyllum*	++++	S2/S3
Croton sp	++	*S3*	*Zanthoxylum punctatum*	++++	S2/S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata / S3: Lower strata.

4.1.3. Dominique (J. S. Beard, 1949)

The species in **Table 4** form a low-stratified preforest eco-unit. However, *Tabebuia heterophylla*, *Byrsonima spicata*, *Lonchocarpus violaceus*, *Coccoloba*

Table 4. Highly degraded pre-forest facies.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Ardisia obovata	+	S3	*Haematoxylon campechianum*	+++	S3/S2
Byrsonima lucida	+	S2	*Lonchocarpus violaceus*	+++	S2/S1
Byrsonima spicata	++	S2/S1	*Myrcia citrifolia*	++	S3
Calliandra tergemina	+	S3	*Pimenta racemosa*	+	S2/S3
Capparis flexuosa	+	S3	*Pisonia fragrans*	++	S2/S3
Chamaecrista glandulosa var. swartzii	+	S3	*Randia aculeata*	+	S3
Coccoloba pubescens	+++	S2/S3	*Rhyticocos amara*	+	S2/S3
Croton ssp	++	S3	*Tabebuia heterophylla*	+++	S2/S3
Erithalis fruticosa	+	S3	*Tetrazygia angustifolia*	+	S3
Garcinia humilis	+	S2/S3	*Zanthoxylum punctatum*	++	S3
Guettarda scabra	++	S3/S2			

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

pubescens and *Pisonia fragrans*, although peaking at low heights, dominate the other taxa. The populations of the latter are characterised by a high density of individuals. The resulting structure is very heterogeneous from a synecological point of view: it equates to a dense mosaic of plant associations, most of whose representatives belong to the physiognomic class of nanophanerophytes.

4.1.4. Sainte-Lucie (J. S. Beard, 1949)

This plant cortege from Table 5 is in the preforest stage and is typical of the tropical seasonal evergreen flora of lower horizon and xeric facies within this example the most abundant trees being *Amyris elemifera*, *Guettrada scabra* and *Citharexylum spinosum*.

In Table 6 only the dominant taxa are presented and form a grouping at the secondary forest stage.

4.1.5. Saint-Vincent (J. S. Beard, J. P. Fiard, P. Joseph)

1) J. S. Beard (1949)

The species in Table 7 make up diverse pre-forest associations. Nevertheless, the observable physiognomies are identical. The predominant plant matrix is made up of bushes that have reached their optimal morphogenetic development and is dotted with trees in the expansion phase such as *Amyris elemifera*, *Citharexylum spinosum*, *Guettarda scabra*, *Piscidia carthagenensis*.

Table 5. Highly degraded pre-forest facies.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Acacia tamarindifolia	++	S3	*Croton sp*	+	S3
Aegiphila martinicensis	+	S3	*Erythroxylon havanense*	++	S3
Amyris elemifera	+++	S3	*Guettrada scabra*	+++	S2/S3
Bourreria succulenta	+++	S2/S3	*Plumeria alba*	+	S2/S3
Calliandra slaneae	+	S3	*Randia aculeata*	+	S3
Calliandra tergemina	++	S3	*Ternstroemia pedoncularis*	+	S3
Citharexylum spinosum	+++	S2/S3			

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

Table 6. Seasonal evergreen forest units (municipality of Praslin).

Plant species	Abundance	Stratigraphic level
Eugenia pseudopsidium	++++	S2/S1
Coccoloba pubescens	++++	S2/S1
Maytenus laevigata	+++	S2/S1
Tabebuia heterophylla.	+++	S2/S1

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

2) Joseph & J. P. Fiard (1996, King's Hill)

In view of the qualitative abundance indicators in Table 8, the dominant cortege of this late secondary or subclimactic sylva is, in order of significance, made up of *Inga laurina*, *Pouteria multiflora* and *Faramea occidentalis*. The species of the upper stratum are mainly *Hymenaea courbaril*, *Inga laurina* and *Pouteria multiflora*. This association is somewhat atypical since on the one hand *Inga Laurina* and on the other hand *Hymenaea courbaril* and *Pouteria multiflora* belong distinctly to the secondary and climactic forest stages. As for the middle and lower strata, they are made up of *Bursera simaruba*, *Pisonia fragrans*, *Chrysophyllum argenteum*, *Ocotea patens* and *Faramea occidentalis*.

4.1.6. The Grenadines (R. A. Howard, J. S. Beard & J. P. Fiard)

Very small islands, the Grenadines are exclusively under the influence of the dry bioclimate. The main potentiality is tropical seasonal evergreen vegetation of lower horizon and xeric facies. Since this small archipelago is characterised by a variable xericity, it is highly plausible that there once existed the typical semi-deciduous sylvatic climactic type in the tropical dry season. Today's biocenoses present a phenology close to that which characterises deciduous vegetation in the tropical dry season. Defoliation is total and is correlated with a long drought: sometimes more than five months.

Table 7. Seasonal evergreen forest grouping.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Acacia nilotica	++	S3/S2	*Guettarda odorata*	++	S3/S2
Acacia tamarindifolia	+	S3	*Guettarda scabra*	++	S3/S2
Aegiphila martinicensis	+	S3	*Lantana camara*	+	S3
Amyris elemifera	++	S3	*Lantana involucrata*	+	S3
Bourreria succlenta	+++	S2/S3	*Morisonia americana*	+	S3/S2
Capparis baducca	+	S3	*Piscidia carthagenensis*	++	S2/S3
Capparis cynophallophora	+	S3	*Pithecellobium unguis-cati*	++	S3/S2
Capparis hastata	++	S3	*Plumeria alba*	+	S3
Capparis odoratissima	+	S3S	*Randia aculeata*	+	S3
Citharexylum spinosum	++	S2/S3	*Rauvolfia viridis*	+	S3
Cordia globosa	++	S3/S2	*Schaefferia frutescens*	+	S3
Cordia obliqua	++	S2/S3	*Schoepfia schreberi*	+	S3
Erithalis fruticosa	+	S3	*Schoepfia schreberi*	+	S3
Erythroxylon hva-nense	++	S3	*Tecoma stans*	+	S3S
Eugenia monticola	+++	S3/S2	*Trichila hirta*	+	3/S2

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

Table 8. Seasonal evergreen forest grouping.

Plant species	Abundance	Stratigraphic level
Bursera simaruba	+++	S2/S1
Chrysophyllum argenteum	++	S3/S2
Faramea occidentalis	+++++++	S3/S2
Hymenaea courbaril	++	S2/S1
Inga laurina	+++++	S1/S2
Ocotea patens	++	S3/S2
Pisonia fragrans	++	S3/S2
Pouteria multiflora	++++	SS2/S1

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

1) R.A. Howard (1950): Isle of Ronde (examples of woody associations)

The tree associations of **Table 9** are dominated either by *Coccoloba venosa*, *Diospyros inconstans* and *Citharexylum spinosum* and are in the pre-forest

Table 9. Species of regressive seasonal evergreen formations.

Plant species	Abundance	Stratigraphic level
Bourreria succulent	++	S3/S2
Citharexylum spinosum	++++	S2
Coccoloba venosa	++++	S3
Diospyros inconstans	+++	S2
Jacquinia armillaris	+	S3
Malpighia emarginata	+	S3
Randia aculeata	+	S3
Croton flavens	++	S3
Cordia globosa	+	S3/S2
Capparis odoratissima	+	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata / S3: Lower strata.

stage. The different arrangements formed by the rest of the species show a notable variability of certain factors, including the methods of diaspore dispersal.

With respect to the differences in abundance of the species in Table 10, this plant unit at the pre-forest stage consists of *Pisonia fragrans* and *Leucaena leucocephala*. These two tree species emerge from a bush matrix composed of *Acacia nilotica* and *Pithecellobium unguis-cati*.

2) R. A. Howard (1950): Kick'Em Jenny

The species in Table 11(a) correspond to a preforest Phytocenosis mainly composed of *Pisonia fragrans* and *Bursera simaruba* which dominate bush units with *Capparis odoratissima* and *Acacia tamarindifolia*. Epiphytes typical of dry areas have dense populations: *Aechmea lingulata*, *Epidendrum ciliare*, *Passiflora suberosa*, *Cissus verticillata*, *Tillandsia utriculata* and *Tillandsia flexuosa*.

In this other example, Table 11(b) indicates a preforest grouping dominated by *Croton flavens*, *Cordia curassavica* and *Pilosocereus royeni* from which *Coccoloba venosa* emerges intermittently.

3) R. A. Howard (1950): Carriacou (the largest island in the Grenadines)

The plant association in Table 12 dominated by *Tabebuia heterophylla* and *Pisonia fragrans* respectively is in the preforest stage. *Jacquinia armillaris* forms a sparse lower stratum.

4) J. S. BEARD (1949): The Grenadines

In Table 13, *Lonchocarpus violaceus* and *Swietenia mahagoni* (native species to tropical America) are dominant. *Haematoxylon campechianum* (native to tropical America) often forms a dense, almost impenetrable, lower stratum.

In this phytocenosis of Table 14, two strata are observable. In reality, the vertical distribution of the crowns is heterogeneous and the average values make it possible to define two height classes corresponding to the upper and lower strata. Within this regressive cortege, some species of the advanced stages of

Table 10. Seasonal evergreen grouping.

Plant species	Abundance	Stratigraphic level
Acacia nilotica	+++++	S3/S2
Celtis iguanea	+	S3
Leucaena leucocephala	++	S3/S2
Pisonia fragrans	++++	S3/S2
Pithecellobium unguis-cati	++++++	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

Table 11. (a) Seasonal evergreen associations; (b) Seasonal evergreen associations.

(a)

Plant species	Abundance	Stratigraphic level
Acacia tamarindifolia	++++	S3
Bursera simaruba	+++	S2/S1
Capparis odoratissima	++++	S3
Ficus citrifolia	+	S3
Pisonia fragrans	++	S2/S1

(++++++): very strong Abundance/(++++): strong Abundance/(+++): Medium Abundance/(++): weak Abundance/(+): very weak Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

(b)

Plant species	Abundance	Stratigraphic level
Coccoloba venosa	++	S3
Cordia curassavica	+++	S3
Croton flavens	++++	S3
Pilosocereus royeni	+++	S3
Senna obtusifolia	+	S3
Solanum racemosum	+	S3

(++++++): very high Abundance/(++++): high/Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

Table 12. Tropical seasonal evergreen young forest of lower horizon.

Plant species	Abundance	Stratigraphic level
Jacquinia armillaris	++	S3
Pisonia fragrans	++++	S2/S1
Tabebuia heterophylla	++++++	S2/S1

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

plant succession persist or are installing themselves, such as *Brosimum alicastrum*, *Sideroxylon foetidissimum*, *Sideroxylon salicifolium*, *Cordia alliodora*, *Hymenaea courbaril*, *Swartzia simplex* and *Genipa americana*. Whether they

Table 13. Young forest formation.

Plant species	Abundance	Stratigraphic level
Haematoxylon campechianum	++++++	S3/S2
Lonchocarpus violaceus	++++	S2/S1
Swietenia mahagoni	+++	S2/S1

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

Table 14. Young forest grouping presenting a beginning of structuring.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Albizia caribaea	+	S2	*Ficus citrifolia*	+	S2
Brosimum alicastrum	+	S2/S3	*Genipa americana*	+	S2
Bursera simaruba	++++	S2/S1	*Hymenaea courbaril*	+	S2/S1
Capparis cynophallophora	++	S3/S2	*Lonchocarpus violaceus*	+++	S2/S1
Casearia guianensis	++	S2	*Sideroxylon foetidissimum*	+	S3/S2
Cordia alliodora	+	S2/S3	*Sideroxylon salicifolium*	+	S3
Daphnopsis americana	+	S2	*Swartzia simplex*	+	S3
Eugenia monticola	+++	S3	*Tabebuia heterophylla*	++++	S2/S1

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

come from an old mature or climactic forest or whether they are in the regeneration phase, these species were affected by very small populations and consequently had no ecological significance at this stage of evolution of the groundcover. Whatever their position in the primitive bipolar structure (matrix/gaps) was, the trees from the final chrono-sequences previously cited are common to the vast majority of the Lesser Antilles. Given the anthropogenic degradations of the time, this spatially very marginal and still structured organisation of the groundcover of Carriacou, the largest and highest islet of the small archipelago of the Grenadines, was a highly degraded example of the old or primary plant ecosystems.

These two examples of predominant old plant associations in the Grenadines reflect the extreme degradation of the original forest floor. The plant groupings belonged to the physiognomic types, bush, shrubland and herbaceous types. The plant communities were all heavily anthropised and derived from the tropical seasonal evergreen sylva of lower horizon in its most xeric facies. Human activities from the beginning and the low rainfall (on average 1000 mm/year) gave the landscapes of this archipelago a singularly dry appearance.

5) J. P Fiard, 1990: Union Island

Autochthonous and naturalised species participating in the various preforest and young forest communities (summary of a set of stations of various minimum areas from 400 m^2 to 800 m^2).

At the time the surveys were carried out, all units were in stages of decline. The phenology of a number of plants and the physiognomies described by the author at the end of the 20th century can be likened to those of semi-deciduous sylva in the tropical dry season, while the physical environment potentially leads to tropical seasonal evergreen groups of lower horizon. The eco-climatic factors of this island give rise to very long climatic droughts (average annual rainfall: 970 mm). Naturally, the opening of the forest roof due to land clearing led to an increasing phasing between the intra-vegetation microclimate and the macroclimate, with the appearance of secondary species more tolerant to light (heliophilous) with more general dynamic profiles. Via multiple combinations, the species in Table 15 give rise to young presylvatic and young secondary sylvatic phytocenoses (post-pioneer stages). The latter are dominated (density of individuals and population biomass) by *Pisonia fragrans* as well as in places with skeletal and rocky soils, *Bursera simaruba* and *Lonchocarpus violaceus*. The local eco-climatic conditions allow for the same successive phase, the emergence of mono- or multi-specific stands of *Pisonia fragrans* (Mount Parnassus), *Pisonia fragrans* and *Lonchocarpus violaceus* (Colin Cambelle Reserve).

Still today on this dry (high xericity) and heavily anthropised island, the taxa of Table 15 make up the most advanced forest units which are in the structured secondary dynamic stage. These forest units are characterised by species such as *Bursera simaruba*, *Pisonia fragrans*, *Lonchocarpus violaceus*, *Albizzia caribaea*, and *Spondias mombin* (Water Walk Reserve, peaks of Mount Taboï) which create the secondary forest. They form the upper strata and are more abundant than a set of heliophilous trees of lower strata dominated by *Bourreria succulenta*, *Casearia decandra*, *Guettarda scabra* and more rarely *Bunchosia glandulosa* and *Chionanthus compacta*. The species mentioned above constituting the lower strata can include all physiognomic types (shrub, bush, tree) and perpetuate themselves in late sylvan organisations as auxiliary species. Within these forest communities, species from the more advanced dynamic stages regenerate in a marginal fashion, e.g. *Maytenus laevigta*, *Genipa americana* and *Ocotea coriacea*, which were probably formerly part of climactic corteges of the primitive vegetation. Although they install from the barely structured preforest or young forest stage thanks to their dynamic profile, they once persisted in the final stages of the plant succession. Due to its mesological conditions, it is likely that Union Island was in the pre-colonial era the best place for the development of the tropical seasonal evergreen forest in its sub-type of lower horizon and in its most xeric facies. In the low islands and within the lower plant stage of the mountainous islands, the architecture and structure of what is known as the pre-Columbian forest depended on very specialised species like Courbaril

Table 15. Preforest and young forest communities.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Acacia macracantha	+	S3	*Exostema caribaeum*	+	S3/S2
Acacia nilotica	+	S3	*Ficus citrifolia*	+	S2
Acacia tamarindifolia	+	S3	*Forestiera rhamnifolia*	+	S2/S3
Albizzia caribaea	++	S2/S1	*Genipa americana*	+	S2
Albizzia lebbeck	+	S1/S2	*Guettarda scabra*	++++	S3/S2
Amyris elemifera	+	S3	*Hymenaea courbaril*	+	S2/S1
Anacardium occidendale	+	S3	*Hippomane mancinella*	+	S2/S1
Annona muricata	+	S3	*Jacquinia armillaris*	+	S3
Annona squamosa	+	S3	*Krugiodendron ferreum*	+	S2
Bourreria succulenta	++++++	S3	*Laetia thamnia*	+	S2/S3
Bunchosia glandulosa	++	S3	*Leucaena leucocephala*	+	S3
Bursera simaruba	++++	S1/S2	*Lonchocarpus pentaphyllus*	+	S2/S1
Caesalpinia coriaria	+	S2	*Lonchocarpus violaceus*	++++	S1/S2
Calotropis procera	+	S3	*Malpighia emarginata*	+	S3
Capparis flexuosa	+	S3	*Margaritaria nobilis*	+	S2/S1
Capparis hastata	+	S3	*Maytenus laevigata*	+	S2/S3
Capparis odoratissima	+	S3	*Ocotea coriacea*	+	S3/S2
Casearia decandra	++++	S2/S3	*Pisonia fragrans*	++++++	S2/S1
Catesbea melanocarpa	+	S3	*Pithecellobium unguis-cati*	+	S3
Ceiba pentandra	+	S1	*Plumeria alba*	+	S2/S3
Chionanthus compacta	++	S2/S3	*Psychotria microdon*	+	S3
Citharexylum spinosum	+	S2/S3	*Rauvolfia viridis*	+	S3
Coccoloba coronata	+	S2/S3	*Schaefferia frutescens*	+	S3
coccoloba uvifera	+	S2/S3	*Schoepfia schreberi*	+	S3
Comocladia dodonaea	+	S3	*Sideroxylon foedissimum*	+	S2/S3
Cordia collococca	+	S2/S3	*Spondias mombin*	+	S2/S1
Cordia obliqua	+	S2/S3	*Tabebuia heterophylla*	+	S2/S1
Erithalis odorifera	+	S3	*Tamarindus indica*	+	S2
Erythroxylon hananense	+	S3	*Tecoma stans*	+	S3
Eugenia cordata	+	S3	*Trichilia hirta*	+	S2/S3
Eugenia ligustrina	+	S3	*Eugenia rhombea*	+	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

(*Hymenaea courbaril*) and False Mastic (*Sideroxylon foetidissimum*). As far as sylvigenesis is concerned, the severe eco-climactic conditions prevailing on this island are limited. Human activities have resulted in the disappearance of the primitive vegetation. Even in sectors that have been exempt from anthropisation for decades, a return to the initial structuring is unlikely. As well as the marked xericity of the biotopes, there is also the erosion of the floristic diversity and the loss of efficiency in the dissemination of seeds.

4.1.7. J. S. Beard, 1949: Antigua

Species of tropical seasonal evergreen forest corteges, some of which colonise xeric environments on the lower stage (low islands and certain littoral areas on mountainous islands subject to eco-climatic conditions which lead to long climatic droughts).

1) Wallings Reservoir

In Table 16, the consistent species are, in order of dominance: *Inga laurina*, *Pisonia fragrans*, *Daphnopsis americana* and *Mangifera indica*. Some taxa of advanced dynamic or climactic phases such as the Courbaril (*Hymenaea courbaril*), the Spanish cedar (*Cedrela odorata*) and the Spanish elm (*Cordia alliodora*) regenerate tentatively. However, the latter two (*Cordia alliodora*, *Cedrela odorata*) are "scars" of gaps in mature forest formations. Because the species of climactic groupings are absent due to anthropisation, the forest matrix is mainly formed of less specialised secondary species and typical of the windthrow of advanced sylva. This symbolises the acute decline of the original vegetation.

2) Brecknocks Reservoir

As regards Table 17, *Haematoxylon campechianum*, *Guettarda scabra*, *Randia aculeata* and *Exostema caribaeum* constitute a dense floristic unit from which some *Tabebuia heterophylla* emerge whose overall phytomass is much more significant.

4.1.8. J. S. Beard (1949): Barbuda

The following species have a dynamic profile which enables them to participate in the successive processes from the start of the tree stages (Table 18). A small number of them persist in the most complex floristic combinations corresponding to the climax: *Sideroxylon obovatum*, *Sideroxylon salicifolium*, *Pimenta racemosa*, *Amyris elemifera*.

The species in Table 19 form a very dense bush physiological unit within which the first representatives of the young forest stage install and develop. *Coccoloba krugii*, *Byrsonima lucida*, *Gyminda latifolia* and *Guettarda scabra* are the predominant trees. Taxa, in marginal areas, belonging to a much more septentrional floristic region participate with very little demographic success in certain phytocenoses: *Eugenia bahamensis*, *Eugenia sintensii*, *Phyllantus angustifolius*.

Some examples of associations

Table 16. Tropical seasonal evergreen formation of lower horizon at structured secondary forest stage.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Acrocomia aculeata	+	S3	*Hymenaea courbaril*	+	S1
Albizzia lebbeck	+	S3/S2	*Inga laurina*	++++++	S1
Bucida buceras	++	S3	*Lonchocarpus pentaphyllus*	+	S1
Bursera simaruba	+	S3/S2	*Lonchocarpus violaceus*	+	S1
Byrsonima spicata	+	S3/S2/S1	*Mangifera indica*	+++	S1
Casearia guianensis	+	S3	*Melococcus bijugatus*	+	S2
Cedrela odorata	+	S1	*Ocotea patens*	+	S2
Ceiba pentandra (*)	+	S1	*Persea americana*	+	S2
Chionanthus compacta	+	S2	*Pisonia fragrans*	+++++	S1
Chrysophyllum argenteum	+	S2	*Pisonia subcordata*	+	S3
Coccoloba pubescens	+	S2	*Roystonea oleracea*	+	S1
Coccoloba venosa	+	S3	*Sapindus saponaria*	+	S2
Coccothrinax barbadensis	+	S3	*Sideroxylon foetidissimum*	+	S1
Cordia alliodora	+	S1	*Spondias mombin*	+	S1
Cordia sulcata	+	S2	*Swietenia mahagoni*	+	S1
Daphnopsis americana	++++	S2	*Tabebuia heterophylla*	+	S1
Ficus trigonata	+	S1	*Tabernaemontana citrifolia*	+	S2
Guazuma ulmifolia	+	S2	*Zanthoxylum martinicense*	+	S2

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

- Pure unit of *Bucida buceras* (++++++)
- Unit of *Bucida buceras* (+++++), *Coccothrinax Barbadensis* (++++) and *Cactus sp* (+++)
- Unit of *Bursera simaruba* (++++), *Pisonia fragrans* (+++), *Canella winterana* (++++), *Ficus laevigata* (+) and *Plumeria alba* (++)

These bush formations and presylvatics or young sylvatics are the various aspects of the regression of the primitive groundcover. However, the characteristics

Table 17. Extremely regressive form of the seasonal evergreen sylva of lower horizon.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Aegiphila martinicensis	+	S3	*Haematoxylon campechianum*	++++++	S3
Albizia lebbeck	+	S2	*Lantana involucrata*	+	S3
Amphitecna latifolia	+	S3	*Leucaena leucocephala*	+	S3
Bourreria succulenta	+	S3	*Melochia tomentosa*	+	?
Capparis cynophallophora	+	S3	*Myrcia citrifolia*	+	S3
Capparis indica	+	S3	*Piscidia carthagenensis*	+	S3
Casearia guianensis	+	S3	*Pisonia sp*	+	?
Chamaecrista gladulosa var.swartzii	+	S3	*Prosopis juliflora*	+	S2
Chrysophyllum argenteum	+	S2	*Psidium guajava*	+	S3
Citharexylum spinosum	+	S2	*Randia aculeata*	+++++	S3
Comocladia dodonaea	+	S3	*Solanum racemosum*	+	S3
Croton flavens	+	S3	*Swietenia mahagoni*	+	S1
Daphnopsis americana	+	S2	*Tabebuia heterophylla*	+	S1
Erythroxylon havanense	+	S3	*Tecoma stans*	+	S3
Exostea caribaeum	+++	S2	*Tetrazygia angustifolia*	+	S3
Guettarda scabra	++++++	S2	*Zanthoxylum monophyllum*	+	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

Table 18. Cortege of species from secondary tropical seasonal evergreen forest islets.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Amyris elemifera	+	S3	*Pimenta racemosa*	++	SI/S2
Bucida buceras	++	S3/S2	*Pisonia fragrans*	++	S1/S2/S3
Bursera simaruba	++++	S2/S1	*Pisonia subcordata*	+	S3
Canella winterana	++	S3/S2	*Sideroxylon obovatum*	+	S1/S2/S3
Coccoloba diversifolia	+++	S2/S3	*Sideroxylon salicifolium*	+	S1/S2
Ficus citrifolia	+	S2	*Tabebuia heterophylla*	++++	S1/S2/S3
Lonchocarpus pentaphyllus	+++	S2/S2/S1	*Zanthoxylum flavum*	++	S1/S2/S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

Table 19. Species of presylvatic regressive plant associations.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Bourreria succulenta	+++	S2/S3	*Eugenia cordata*	+	S3
Byrsonima lucida	++++	S2/S3	*Guettarda scabra*	++++	S2/S3
Capparis cynophallophora	+	S3	*Gyminda latifolia*	++++	S2/S1
Coccoloba krugii	++++	S2	*Jacquinia armillaris*	+	S3
Coccothrinax barbadensis	++	S2/S3	*Malpighia linearis*	+	S3
Comocladia dodonaea	+	S3	*Phyllanthus* (*angustifolius*)?	+	S3
Dodonaea viscosa	+	S3	*Pithecellobium unguis-cati*	++	S3
Eugenia axillaris	++	S3	*Plumeria alba*	+	S3/S2
Eugenia (*Bahamensis*)?	+	S3			

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper strata/S2: Middle strata/S3: Lower strata.

of the macroclimate are scarcely required for the installation of a forest cover. Secondary plant units are similar to hyper-xerophytic vegetation.

4.1.9. J. S. Beard (1949): Barbados

Table 20 presents a floristic grouping corresponding to the secondary tropical seasonal evergreen sylva in its sub-type of lower horizon, in which species of advanced dynamic stages find the potential for installation and probable expansion: *Sideroxylon salicifolium*, *Manilkara bidentata* for the most specialised.

4.1.10. H. Stehle (1937): Barbados

This survey by H. Stehle in Barbados (north centre) in 1937, summarised in Table 21, bears certain resemblances to the previous survey carried out on the same island, in 1945, by J.S. Beard (Table 20). In terms of ecosystemic analysis, we can formulate identical conclusions. Namely, that the inventoried floristic composition and the architectural organisation described refer to the following forest type: tropical seasonal evergreen sylva, in its sub-type of lower horizon and in an intra-sylvatic regressive dynamic facies (secondary structured). The post-pioneer sylvan species are dominant: in order of significance, *Lonchocarpus violaceus*, *Bursera simaruba* and *Coccoloba pubescens*.

4.1.11. The French Antilles

In Martinique and Guadeloupe, we offer, in illustration, some aspects of the groundcover, in the form of predominant floristic compositions.

1) Martinique (J. P. Fiard, 1992): Terre Rouge (peak, altitude 280 m, survey of 950 m^2)

Table 20. Secondary tropical seasonal evergreen sylva.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Aiphanes erosa	+	S2/S3/S1	*Hernendia sonora*	+	S2/S3
Bunchosia glandulosa	+	S3	*Hura crepitans*	+	S1/S2
Bursera simaruba	+++	S1/S2	*Hymenaea courbaril*	+	S1/S2
Byrsonima spicata	+++	S2/S1	*Inga laurina*	+	S1/S2
Casearia decandra	++	S3	*Maclura tinctoria*	+	S2/S3
Cedrela odorata	++	S1/S2	*Manilkara bidentata*	+	S1/S2
Ceiba pentandra	+	S1	*Ocotea patens*	+	S2/S3
Citharexylum spinosum	+	S3	*Pisonia fragrans*	++	S2/S3
Coccoloba diversifolia	++	S2/S1	*Roystonea oleacea*	++	S1/S2
Coccoloba pubescens	++	S2/S1	*Sapium Glandulosum*	++	S3
Coccoloba venosa	+	S3/S2	*Sideroxylon salicifolium*	+	S3
Cordia collococca	+	S3/S2	*Simaruba amara*	+	S1/S2
Cordia sulcata	+	S1/S2	*Tabebuia heterophylla*	+++	S1/S2
Crateva tapia	+	S2/S3	*Zanthoxylum martinicense*	+	S2/S3
Cupania americana	+	S2/S3	*Zanthoxylum punctatum*	+	S3
Faramea occidentalis	+	S3			

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

Table 22 shows that the most abundant species are heliophilous and are balanced in the chrono-sequence of succession considered, namely the structured secondary sylvatic stage: *Tabebuia heterophylla*, *Coccoloba swartzii* and *Eugenia confusa*. These three species can appear from the pre-sylvatic and sometimes mature bush stage.

2) Martinique (J. P. Fiard, 1992): Terre Rouge (northern slope, altitude 150 - 160 m, survey 1000 m^2)

The predominant species in Table 23 are mainly heliophilous and they can be primary (pioneers) or secondary (leading post-pioneers) and show that the "secondary forest" dynamic stage is expanding. In other words, the intra-forest ecological conditions allow the ecologically dominant species to find sites for installation and expansion. The floristic composition found indicates the dry bioclimate. However, the presence in this station of species of minor ecological significance belonging to the tropical seasonal evergreen sylva type and tropical

Table 21. Tropical seasonal evergreen sylva.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Aiphanes minima (*Aiphanes erosa*?)	+	S3	*Hura crepitans*	+	S1/S2
Bursera simaruba	+++	S1/S2	*Hymenaea courbaril*	+	S1./S2
Cecropia schreberiana	+	S1	*Lonchocarpus violaceus*	++++	S1/S2
Cedrela odorata	+	S1/S2	*Maclura tinctoria*	+	S2/S3
Ceiba pentandra	+	S1	*Roystenia regia* (*Roystenia olea-cea*?)	+	S1/S2
Citharexylum spi-nosum	++	S3	*Sapium Hippomane*	+	S1/S2/S3
Coccoloba pubescens	+++	S1/S2	*Sideroxylon salicifolium*	+	S2/S3
Cordia glabra?	+	S2/S3	*Zanthoxylum aribaea*	++	S2/S1
Hernandia sonora	+	S2/S3			

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

Table 22. Tropical seasonal evergreen forest in maturity phase, in its lower horizon subtype and in its structured secondary dynamic facies.

Plant species	Abundance	Stratigraphic levels	Plant species	Abundance	Stratigraphic levels
Bourreria succulenta	++	S2/S3	*Eugenia confusa*	++++++	S3
Busera simaruba	+++	S1/S2	*Eugenia lambertiana*	++	S3
Capparis flexuosa	+	S3	*Eugenia pseudopsidium*	++	S2/S3
Casearia decandra	++	S3	*Homalium racemosum*	+++	S1/S2
Cassipourea guianensis	+++	S3	*Inga laurina*	++	S1/S2
Chionanthus compacta	++	S3	*Ixora ferrea*	+	S3
Chrysophyllum argenteum	+	S3	*Lonchocarpus violaceus*	+++	S1/S2
Clusia major	+	S3	*Myrcia citrifolia var. imrayana*	+	S3
Coccoloba swartzii	++++++	S2/S3	*Myrciaria floribunba*	+++	S3
Cordia martinicensis	+	S3	*Pisonia fragrans*	+++	S1/S2/S3
Daphnopsis americana	++	S3	*Randia aculeata*	+	S3
Erythroxylon havanense	+	S3	*Tabebuia hétérophylla*	++++++	S1/S2

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

Table 23. Plant cover consisting of a tropical seasonal evergreen tree formation in its lower horizon subtype and in its secondary dynamic stage.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Bourreria succulenta	+	S3	*Eugenia ligustrina*	+	S3
Bunchosia glandulosa	+	S3	*Ficus citrifolia*	+	S2
Byrsonima spicata	+	S2/S3	*Inga laurina*	+	S2/S3
Calophyllum calaba	+	S2/S3	*Lonchocarpus v iolaceus*	++++++	S1/S2
Casearia decandra	+	S3	*Myrcia citrifolia var. imrayana*	+	S3
Cassipourea guianensis	+	S3	*Ocotea cernua*	+++	S2/S3
Chrysophyllum argenteum	+	S3	*Ocotea leucoxylon*	+	S1/S2
Cinnamomum elongatum	+	S3/S2	*Pisonia fragrans*	++++	S1/S2
Citharexylum spinosum	+	S2/S3	*Tabebuia heterophylla*	++	S1/S3
Coccoloba swartzii	+	S2/S3	*Tabernaemontana citrifolia*	+	S3
Conostegia calyptrata	+	S3	*Zanthoxylum caribaeum*	+	S2/S3
Eugenia gregii	+	S3	*Sapiumcaribaeum*	+	S1/S2
			Simaruba amara	+	S1/S2

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

seasonal umbro-evergreen sylva, attests to the less xeric nature of this biotope. This is compared to that which prevails in the region near the coast. These species are respectively, *Ocotea cernua*, *Eugenia pseudopsidium*, *Tabernaemontana citrifolia*, *Cinnamomum elongatum* for the secondary stage and *Cassipourea guianensis*, *Ocotea leucoxylon*, *Calophyllum calaba* for the final stage. It is logical to think that this formation will continue to expand. In the medium term, the resulting formation will be mature for this stage; however, the current predominant species will no longer be balanced and will only constitute its understructure. Concomitantly, the ecologically more specialised species already installed (*Ocotea leucoxylon*), as well as those originating from the advective potential, will find environmental conditions which are more favourable to their development.

3) Martinique (J. P. Fiard, 1992): Piton Pierreux sector (western ridge, southern slope, altitude 180 m, 850 m²)

This forest community represented in Table 24 is scarcely structured (insignificant stratification). Regenerations of more specialised species from the advanced secondary forest stage are non-existent[1]. For the entire plot, the

[1]The stage above the stage indicated by the population abundance in Table 24 and which is the young forest stage.

Table 24. Tropical seasonal evergreen sylvatic phytocenosis in its lower horizon subtype and in its structured young secondary dynamic facies.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Bourreria succulenta	+	S1	*Lonchocarpus violaceus*	++++++	S1/S2
Bursera simaruba	+++	S1/S2	*Myrcia citrifolia var.imrayana*	+	S3
Byrsonima spicata	+	S1/S2	*Picramnia pentandra*	+	S3
Casearia decandra	+	S3	*Pisonia fragrans*	+++	S1/S2
Chionanthus compacta	+	S3	*Psychotria microdon*	+	S3
Chrysophyllum argenteum	+	S3	*Randia aculeata*	+	S3
Coccoloba swartzii	++++	S 1/S2	*Tabebuia heterophylla*	+	SS2/S3/S1
Eugenia monticola	+	S3	*Tabernaemontana citrifolia*	+	S3
Eugenia pseudopsidium	+	S2/S3	*Zanthoxylum monophyllum*	+	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

considerable ecological dominance of edifying species, pioneer heliophilous species and post-pioneer species transitorily balanced from a population point of view[2], indicates a relatively open state of this forest vegetation. The ecological profile with a xeric tendency of the various auxiliary or regenerating species, definitively shows that here the ecosystemic potentiality is the tropical seasonal evergreen sylva of lower horizon. In the previous survey, Table 23, *Pisonia fragrans* and *Tabebuia heterophylla*, species from regressive forest environments, are associated with other edifying species from more humid areas (*Sapium caribaeum*, *Simaruba amara*) and sometimes more advanced dynamic stages (*Ocotea leucoxylon*). The presence of *Pisonia fragrans* in the dominant cortege, at two different altitudes (Piton Pierreux and Terre Rouge) distinctly corresponding to the medium (humid subhumid) and lower (dry subhumid) bioclimatic stages, in no way shows an analogy of sylvatic potential of the two floristic survey zones. It results from intra-vegetation changes to the ecoclimatic conditions of the phytocenosis of the middle stage. Indeed, the regression of the climactic sylvan groundcover on this stage resulted in the transition from a closed canopy with overlapping crowns to a sparse open canopy with non-contiguous sympodiums. The result is a greater phasing between the intra-vegetation microclimate and the macroclimate, which has given rise to installation and expansion sites specific to some species of the lower stage with broad ecological valency. This is

[2]In a balanced population of balanced plant species all age groups are represented.

an illustration of the phenomenon of floristic convergence between two distinct bioclimatic stages. Structural transformations linked to humans or to the effects of natural hazards in the middle plant stage influenced by the humid subhumid bioclimate can reveal floristic similarities with the lower plant stage subjected to the dry subhumid bioclimate.

4) Guadeloupe[3] (H. Stehle, 1939): The xeric littoral

The littoral areas, especially those which are leeward (in Basse-Terre), attest as in most of the other islands to a very marked xericity. In fact, difficult climatic conditions are characterised by low rainfall, very high evaporation, cloudiness much lower than in the other bioclimatic areas (especially in dry season, which can be very long) and intense sunshine.

These eco-climatic conditions lead to a pedogenesis which resulted in soils from vertisolisation[4] and a regressive xerophytic vegetation endowed with very specific morphological (xeromorphosis or ecomorphosis), anatomical and physiological adaptation mechanisms. These adaptations translate in practice into the establishment of water reserves in the tissues (transformation of support bodies) or the reduction to basal metabolism, of water losses by means of evapotranspiration (fluids in specialised cells, cuticles, hairs, etc.).

Despite the xeromorphoses, in its climactic phase the vegetation of the xeric littoral of Basse-Terre in Guadeloupe is sylvatic. What is indicated by data from digital surveys and observations is simply the result of the anthropogenic regression of the primitive forest units. The edifying species are probably very different from the autoecological point of view (temperament in relation to physical factors), than those of the interior spaces of this lower plant stage. In what follows, we will present some examples of sylvatic plant associations which convey floristic particularities among the plurality of potential arrangements influenced by strict mesological and anthropological factors.

5) Guadeloupe (H. Stehle, 1939): Inland regions

The particular conditions of the coastal regions, in this geographical area, are greatly attenuated and the plant type is dictated as much by eco-climatic as anthropogenic factors.

a) The calcareous plateaus and calcareous hills

The Grande-Terre of Guadeloupe, Désirade and Marie-Galante are mainly covered with a calcareous substratum dating from the Miocene (around 26 million years: a time when the angiosperms were expanding). The ecosystems of these relatively low regions, from which rise small massifs called *mornes*, have undergone an anthropisation not always similar in form, but extremely pronounced. Indeed, they were the site for the development of cultures of allochthonous plants of all kinds. This state of affairs has resulted in a regression of the original groundcover. By the time H. Stehle made his observations, the sylva had

[3]To demonstrate in a non-exhaustive fashion the diversity of the forest formations of Guadeloupe and its dependencies, we will use as a framework the reinterpreted descriptions and floristic surveys of H. Stehle (1936), as well as more recent data from our inventories in these dependencies.

[4]Vertisolisation is the process that leads to the formation of vertisols in climates with contrasting seasons, of the subtropical or tropical type.

decreased considerably in area. And the few forest examples that remained formed marginal islets inserted here and there in a matrix of bush species or in the agricultural flora.

The low altitude of these calcareous islands in relation to the significantly reduced rainfall, the minimal nebulosity and the high evaporation are all mesological factors which lead to a general climate which is highly xeric. The drought period is variable but nevertheless very long. As stated previously, the vegetation of 1936 in these calcareous environments, whatever its physiognomic type and its ecosystemic complexity, derived from that of pre-Columbian times which was essentially sylvan. The constituent units of the latter had reached a high degree of complexity and gave rise to an intra-forest environment with a certain autonomy with regard to the general climate. During the prehistory of the Guadeloupe archipelago, the flora which was predominant was composed of highly specialised species typical of final stages (climax stages). They showed no adaptation to drought (morphological or anatomical). By 1936, the original diversity had been greatly eroded. The different physiognomic units listed result from anthropogenic degradations. Stehle identifies several types of phytocenoses, however the presylvatics constitute a significant component of the landscape.

Grande-Terre (H. Stehle, 1936)

In Table 25, *Erythroxylon havanense*, *Zanthoxylum caribaeum*, *Zanthoxylum martinicense*, *Sideroxylon salicifolium*, *Tabebuia heterophylla* and *Pisonia fragrans* are well represented. These species, depending on the local eco-climatic conditions, can combine in variable ratios of dominance. They form plant units with mature bush or presylvatic physiognomy. The hills of Grande-Terre show an accentuated xericity, the association *Sideroxylon obovatum*-*Erythroxylon havanense* is frequently encountered. Indeed, a calciphilous tree species (*Sideroxylon obovatum*), arriving very early in the dynamic and participating in the advanced stages, is associated with a non-calciphilous pioneer bush species (*Erythroxylon havanense*) from xeric environments and belonging to the secondary regressive dynamic stages. This formation, composed of a low plant matrix from which the crowns of *Sideroxylon obovatum* emerge, is the result of an organisational peculiarity of the groundcover, reflecting both very dry bioclimatic conditions and the anthropisation of Grande-Terre. As well as these predominant plants, there are also other trees of lower ecological importance (Table 25).

Marie-Galante (H. Stehle, 1936)

The units that formed the vegetation all emerged in distinct proportions, from the predominant group of the following species, similar to that found on Grande-Terre in Guadeloupe: *Pisonia subcordata*, *Tabebuia heterophylla*, *Crossopetalum rhacoma*, *Byrsonima lucida*, *Sideroxylon salicifolium*, *Erythroxylon havanense*, *Eugenia axillaris* and *Gossipium barbadense*. The latter two species are predominant at the time. However, in certain places a vegetation was found which differed from that mentioned above, by way of a somewhat increased structuring (forest of Folle-Anse (1936)). The main formations mentioned were

Table 25. Tropical seasonal evergreen sylva.

Plant species	Abundance	Stratigraphic level
Bucida buceras	++	S3/S2
Byrsonima lucida	++	S3/S2
Coccothrinax barbadensis	+	S3/S2
Crossopetalum rhacoma	+	S3
Erythroxylon havanense	++++++	S3/S2
Morinda citrifolia (*)	+	S3
Pisonia subcordata	++	S3
Sideroxylon obovatum	+++++	S1/S2
Tabebuia heterophylla	++	S1/S2
Zanthoxylum caribaeum	+	S2/S3/S1
Zanthoxylum martinicense	+	S2/S3/S1

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

partly composed of more specialised species such as, *Zanthoxylum punctatum*, *Zanthoxylum flavum*, *Exostema sanctae-luciae* and *Xylosma buxifolium*.

La Désirade (H. Stehle, 1936)

According to Table 26, the plateau, the mornes and the west coast hosted a typical flora derived from pre-colonial sylvicultural ecosystems, which was dominated by the association *Canella winterana* and *Oplonia microphylla*. There were also: *Malpighia linearis* (very common), *Guaiacum officinale*[5], *Eupatorium sinuatum* and *Gyminda latifolia*. These species, which were among the most representative of the groundcover of the time, were associated with others already mentioned, specific to dry environments, some of which are calciphilous and common to insular areas with a calcareous substratum of the Guadeloupe archipelago (Marie-Galante, Grande-Terre, and the calcareous strip of Vieux-Fort (Basse-Terre)). Also indicated were associations of xerophytic open littoral environments with cacti (*Melocactus intortus*, *Opuntia rubescens*) and those which are mainly represented by crotons (*Croton flavens*: downwind region, *Croton astroites*: upwind region).

Vieux-Fort (Basse-Terre: H. Stehle, 1936)

As H. Stehle points out, the vegetation was located in a small area and constituted a relictual ecosystem of interest. Table 27 shows a group dominated by *Pimenta racemosa* and *Cornutia pyramidata*, with which other elective species were associated.

b) The area of the andesitic mornes of the lower region

In these territories, during the herborisation carried out by H. Stehle (mid-1930s), the vegetation assumed a very marked xero-heliophilous appearance, presenting some similarities with that of the leeward littoral areas directly

[5]Formerly very abundant, became rare in this period (1936) following excessive exploitation.

Table 26. Tropical seasonal evergreen vegetation.

Plant species	Abundance	Stratigraphic level
Canella winterana	++++++	S1/S2
Eupatorium sinuatum	+	S3
Guaiacum officinale	+	S1/S2
Gyminda latifolia	+	S1/S2
Malpighia linearis	++	S3
Oplonia microphylla	+++++	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Medium stratum/S3: Lower stratum.

Table 27. Tropical seasonal evergreen vegetation.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Pimenta racemosa	++++++	S1/S3	*Picramnia pentandra*	+	S3
Cornutia pyramidata	+++++	S2/S3	*Krugiodendron ferreum*	+	S2/S3
Malpighia glabra	++	S3	*Foresteria rhamnifolia*	+	S2/S3
Eugenia ligustrina	++	S3	*Erythroxylon havanense*	+	S3
Zanthoxylum punctatum	+	S3	*Brunfelsia americana*	+	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

exposed to the marine environment. Naturally, as for those which are currently developing under these eco-climatic conditions, the species outlined which are part of the various elementary groupings, present a fairly wide range of adaptive strategies, which relate to physiology (secretion of aromatic juices and essential oils, caducity), anatomy and morphology. According to the author, at this period the bush physiognomic type was the most frequent. By way of example and to demonstrate the ecosystemic diversity of these anthropised territories with andesitic substratum, we will cite a few corteges or species which were predominant in 1936 and which thus reflected a plurality of environments.

In Table 28, the predominant species in terms of their demography, distribution and biomass are, in order of significance: *Bursera simaruba*, *Protium attenuatum*, *Lonchocarpus violaceus*, *Amyris elemifera* and *Erythroxylon havanense*. The populations of these species are accompanied by those of *Coccoloba pubescens*, *Daphnopsis Americana*, *Eugenia confusa*, *Homalium racemosum*, *Lonchocarpus pantaphyllus* and *Ocotea coriacea*. The whole forms a canopy with non-overlapping crowns, and is therefore open.

Guadeloupe (Basse-Terre: H. Stehle, 1936):

Table 28. Tropical seasonal evergreen vegetation.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Amyris elemifera	+++++	S3	*Homalium racemosum*	++	S1/S2
Bursera simaruba	++++++	S1/S2	*Licania ternatensis*	+	S2/S3
Calliandra prupurea	+	S3	*Lonchocarpus pantaphyllus*	++	S2/S3
Cestrum sp	+	S3	*Lonchocarpus violaceus*	+++++	S2/S3
Coccoloba pubescens	+++	S2/S3	*Morisonia Americana*	+	S3
Coccoloba swartzii	++	S2/S3	*Ocotea coriacea*	++	S2/S3
Coccoloba venosa	+	S3	*Ocotea eggersiana*	+	S1/S2
Conostegia calyptrata	+	S3	*Ouratea guildingii*	++	S3
Cordia alliodora	++	S2/S1	*Pilocarpus racemosus*	++	S3
Croton corylifolius	+	S3	*Pouteria multifolia*	+	S1/S2
Daphnopsis americana	+++	S3	*Protium attenuatum*	++++++	S1/S2
Erythroxylon havanense	+++++	S3	*Rochefortia spinosa*	+	S2/S3
Eugenia confusa	+++	S3	*Tetrazygia angustifolia*	+	S3
Eugenia lambertiana	+	S3	*Vernonia albicaulis*	+	S3
Eugenia pseudopsidium	+	S3	*Vernonia arborescens*	+	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

Some examples of association

- Association of *Protium attenuatum* (+++++), *Bursera simaruba* (++++) and *Amyris elemifera* (+++).
- Association of *Lonchocarpus violaceus* (+++++) and *Bursera simaruba* (+++).
- Association of *Lonchocarpus pentaphyllus* (?, ++++) and *Bursera simaruba* (+++).
- Association of *Coccoloba swartzii* (+++++), *Coccoloba venosa* (++++), *Eugenia lambertiana* (+++), *Eugenia monticola* (+++) and *Ardisia obovata* (++).
- Formation dominated by *Ouratea guildinguii* (+++++).
- Formation dominated by *Cordia alliodora* (++++), with secondarily *Croton corylifolius* (+++).

- *Formation do*minated by *Calliandra purpurea* (+++++), with secondarily *Cordia alliodora* (++++), *Eugenia monticola* (+++), *Lonchocarpus violaceus* (++) and *Lonchocarpus pentaphyllus* (++).
- Formation dominated by *Homalium racemosum* (+++++).

Table 29 indicates another example of a floristic grouping where *Protium attenuatum*, *Bursera simaruba* and *Amyris elemifera* are dominant. In other words, they are more distributed spatially and have a higher aboveground population biomass.

Les Saintes (Terre-de-Bas: H. Stehle, 1936)

These very small islands are characterised by a long drought and most of the plant formations are in the young sylvatic stage. The predominant cortege mentioned in Table 30 is composed of *Rochefortia spinosa* and *Eugenia ligustrina*.

6) Guadeloupe (J.P. Fiard and B. Rollet, 1988): Les Saintes (Terre-de-bas)

Morne Abymes (altitude 296 m) and plateau (altitude 260 m) between Morne Abymes and Morne Sec (altitude 188 m).

Grouping of predominant species:

Hymenaea courbaril, *Pimenta racemosa*, *Inga laurina*, *Lonchocarpus violaceus*.

Dominant floristic set, upper stratum (17 m):

Hymenaea courbaril, *Pimenta racemosa*, *Inga laurina*, *Lonchocarpus violaceus*, *Pisonia fragrans*, *Zanthoxylum flavum*, *Cordia sulcata*, *Zanthoxylum caribaeum*, *Bursera simaruba*, *Tabebuia heterophylla*.

Dominated floristic set of greatest abundance, middle stratum (10 - 15 m):

Ocotea coriacea, *Zanthoxylum monophyllum*.

Dominated floristic set of second greatest abundance, lower stratum (3 - 10 m):

Zanthoxylum punctatum, *Eugenia ligustrina*.

The floristic composition mentioned in Table 31 is typical of a tropical seasonal evergreen formation in its lower horizon subtype and in its late secondary dynamic stage. With respect to current data on the sylvatic diversity of the Lesser Antilles islands, each of which has its own factorial identity, small volcanic islets like Les Saintes only allow the development of the lower horizon subtype of the tropical seasonal evergreen sylva. The observable successive stages result from anthropisation. The analysis of the composition of the species in terms of temperament and ecological dominance reveals a structural state which does not reflect the real dynamic state. Indeed the main plant framework of this station is produced by two electives of the final stage installing from the presylvatic phase: *Hymenaea courbaril* and *Pimenta racemosa*. Given the inventory data, it appears that the regenerative capacity is more significant for the regressive species[6] (bush or pre-forest). In reality, this formation derives from the mature sylva, while being edified by species which probably belonged to the original climax. The

[6]Temperament of primary or secondary pioneers.

Table 29. Formation dominated by three edifying species.

Plant species	Abundance	Stratigraphic level	Plant species	Abundance	Stratigraphic level
Amyris elemifera	+++++	S3	*Eugenia monticola*	++	S3
Bursera simaruba	+++++	S1/S2	*Exostema sanctae-luciae*	+	S2/S3
Cestrum sp	+	S3	*Faramea occidentalis*	+	S3
Cinnamomum elongatum	+	S2/S3	*Gyminda latifolia*	+	S2/S3
Coccoloba pubescens	+	S2/S1	*Ocotea coriacea*	++	S2/S3
Cordia alliodora	+++	S2/S1	*Protium attenuatum*	++++++	S2/S1
Croton corylifolius	+	S3	*Vernonia albicaulis*	+	S3
Croton sp	+	S3	*Vernonia arborescens*	+	S3
Daphnopsis americana	+	S2/S3			

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

Table 30. Typical of a tropical seasonal evergreen formation.

Plant species	Abundance	Stratigraphic levels	Plant species	Abundance	Stratigraphic levels
Acacia muricata	+	S3	*Plumieria alba*	+	S3
Argythamnia polygama	+	S3	*Rauvolfia viridis*	+	S3
Capparis cyno phallophora	+	S3	*Rochefortia spinosa*	++++++	S2/S3
Capparis flexuosa	+	S3	*Tabebuia heterophylla*	+	S2/S3/S1
Eugenia ligustrina	++++	S3	*Wedelia calycina*	+	S3
Malpighia emarginata	+	S3	*Zanyhoxylum martinicense*	+	S3/S2
Morisonia americana	+	S2/S3			

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

ecological changes due to the development of Les Saintes significantly reduced the regeneration capacity of these highly specialised and climactic species. Some authors clumsily call this ecosystemic state of the tropical seasonal evergreen sylva of lower horizon xerophytic secondary forest entity, when it quite simply corresponds to a transitional dynamic stage specific to the emergence of more general xerophilous plants.

Table 31. Typical of a tropical seasonal evergreen formation.

Plant species	Abundance	Stratigraphic levels	Plant species	Abundance	Stratigraphic levels
Acacia tamarinfolia	+	S3	*Eugenia monticola*	+	S3
Actinostemon caribaeus	+	S3	*Exothea caribaea*	+	S3/S3
Allophyllus racemosus	+	S2/S3	*Ficus citrifolia*	+	S2
Amyris elemifera	+	S3	*Guettarda scabra*	+	S2/S3
Anacardium occidentale	+	S3	*Haematoxylon campechianum*	+	S2/S3
Annona muricata	+	S3	*Hippomane manci-nella*	+	S2/S1
Annona squamosa	+	S3	*Hymenaea courbaril*	++++++	S1/S2
Bontia daphnoides	+	S3	*Inga laurina*	++++	S2/S1
Bourreria succulenta	+	S2/S3	*Jaquinia armillaris*	+	S3
Bromelia plumieri	+	S3	*Krugiodendron ferreum*	+	S2/S3
Bursera simaruba	++	S1/S2	*Lonchocarpus vi-olaceus*	++++	S1/S2
Byrsonima spicata	+	S1/S2	*Mangifera indica*	+	S1
Calliandra purpurea	+	S3	*Maytenus laevigata*	+	S2/S3
Capparis baducca	+	S3	*Melicoccus bijugatus*	+	S3
Capparis flexuosa	+	S3	*Morisonia americana*	+	S3
Capparis indica	+	S3	*Ocotea coriacea*	+	S2/S3
Casearia decandra	+	S2/S3	*Pimenta racemosa*	++++++	S1/S2
Cedrela odorata	+	S1/S2	*Piscidia carthagenensis*	+	S2/S3
Ceiba pentandra	+	S1	*Pisonia aculeata*	+	S3
Celtis iguanaea	+	S3	*Pisonia fragrans*	++	S2/S3
Chiococca alba	+	S3	*Plumieria alba*	+	S3
Citharexylum spinosum	+	S3/S2	*Psychotria microdon*	+	S3
Coccoloba pubescens	+	S2/S3/S1	*Randia aculeata*	+	S3
Coccoloba venosa	+	S3	*Rochefortia acanthophora*	+	S2/S3
Colubrina arborescens	+	S2/S3	*Schoepfia schreberi*	+	S3
Cordia collococca	+	S2/S3	*Spondias mombin*	+	S1/S2
Cordia martinicensis	+	S3	*Swietenia mahagoni*	+	S1/S2
Cordia sulcata	++	S2/S1	*Tabebuia heterophylla*	+	S1/S2

Continued

Croton corylifolius	+	S3	*Tabernaemontana citrifolia*	+	S3
Croton flavens	+	S3	*Triphasia trifolia*	+	S3
Erythroxylon havanense	+	S3	*Vangueria madagascariensis*	+	S3
Eugenia chrysobalanoides	+	S3	*Zanthoxylum caribaeum*	++	S2/S3
Eugenia cordata	+	S3	*Zanthoxylum lavum*	++	S2/S1
Eugenia hodgei	+	S3	*Zanthoxylum monophyllum*	+	S3
Eugenia ligustrina	+	S3	*Zanthoxylum punctatum*	+	S3
			Ziziphus mauritiana	+	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

7) P. Joseph and J.P. Fiard (1990): Les Saintes, Terre-de-Haut (Le Chameau, southern slope, survey at 600 m^2)

Grouping of structuring and predominant species: *Busera simaruba*, *Lonchocarpus violaceus*, *Hymenaea courbaril* and *Sideroxylon foetidissimum*.

A relictual forest unit, which once covered the whole of the Les Saintes archipelago. Although currently in a regressive state, it contains edifying species from the climactic final stage such as *Sideroxylon foetidissimum* (False Mastic of two metres in diameter). This sylva is highly significant, because it allows us to specify the potential sylvatic type of these regions subjected to the dry bioclimate. Admittedly, nowadays, the vegetation of Terre-de-Haut is completely ruined and the most frequent phytocenoses are of the shrubland or bush type. The relictual sylvan islets testify to the ecosystemic state of the primitive Les Saintes groundcover which should have corresponded to the tropical seasonal evergreen sylva in its lower horizon sub-type. The eco-units of the present are essentially engaged in dynamic processes belonging to the extra-sylvatic successional cycles. The resulting vegetation is low and open. In the exposed areas of the littoral, it presents a pronounced xeromorphic aspect which constitutes the extremity, almost irreversible, of the degradation of the original plant systems (**Table 32**).

8) P Joseph (1997, Martinique)

The following data are the result of surveys carried out in forest formations of the lower stage in Martinique. The diversity of the plant corteges corresponds to a phenological and physiognomic diversity. The floristic mosaic is dense. Each ecological unit is a regressive form and therefore transitional with respect to those which existed in the pre-Columbian period.

The forest in the lowlands of Martinique today occupies a small area and is highly heterogeneous. The numerous phytocenoses are mainly composed of regressive species as well as, depending on the stational eco-climatic conditions,

Table 32. Relictual forest unit.

Plant species	Abundance	Stratigraphic levels	Plant species	Abundance	Stratigraphic levels
Allophyllus racemosus	+	S3/S2	*Hymenaea courbaril*	+++	S1/S2
Amyris elemifera	+	S3	*Lonchocarpus violaceus*	+++++	S2/S1
Bourreria succulenta	+	S3	*Ocotea coroacea*	+	S2/S3/S1
Bursera simaruba	++++++	S1/S2	*Pimenta racemosa*	++	S1/S2
Citharexylum spinosum	+	S2/S3	*Pisonia fragrans*	++	S2/S3/S1
Erythroxylon havanense	+	S3	*Randia aculeata*	+	S3
Eugenia ligustrina	+	S3	*Sideroxylon foetidissimum*	+++	S2/S3/S1
Exostema caribaeum	+	S2/S3	*Zanthoxylum microcarpum* (?)	+	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

late and final secondary species such as *Maytenus laevigata*, *Sideroxylon foetidissimum*, *Manilkara bidentata*, *Guarea glabra*, *Licaria sericea*, *Buchenavia tetraphylla*, *Pouteria semecarpifolia* (Table 33).

4.2. Global Analysis of Table Data Using a CFA and an Ascending Hierarchical Classification (AHC)

The previous tables show different population data corresponding to minimum areas of floristic inventories. In other words, even if these are not equivalent, they provide information on the totality of each groundcover taken as a reference. The Correspondence Factor Analysis is based on a table of abundance (cross table) composed of 237 rows (species) and 34 columns (tables or inventories) [42] [43]. There is a link between the rows and the columns since the p-value (0.0001) calculated is lower than the alpha significance level (0.05). The F1 and F2 axes of Figure 2 show the TAB 26 and TAB 30 inventories which typically correspond with regard to the plant succession at the bush and sylvatic stage (Table 34) and which by their considerable floristic specificity focuses the other inventories (Table 34) practically at the start point of these factorial axes. This group of stations at the axes' start point presents differences.

By subtracting the TAB 26 and TAB 30 inventories from the data table, the new Correspondence Factor Analysis (CFA) highlights a group of presylvatic phytocenoses belonging to the extra-sylvatic dynamic phases and another affine of the sylvatic stages linked to the intra-sylvatic phases. On the F1 axis, the TAB 10 inventory distinction is to be related to its floristic specificities (Figure 3(a)).

Table 33. Structured secondary sylvatic.

Plant species	Abundance	Stratigraphic levels	Plant species	Abundance	Stratigraphic levels
Pimenta racemosa	++++++	S1/S2	*Ficus nymphaeifolia*	+	S1
Ocotea coriacea	++++++	S3/S2	*Eugenia axillaris*	+	S3
Maytenus laevigata	++++++	S2/S3	*Buchenavia tetraphylla*	+	S3
Sideroxylon foetidissimum	+++++	S2/S1	*Tabebuia heterophylla*	+	S2/S1
Myrcia fallax	+++	S2	*Daphnopsis americana*	+	S3/S2
Inga laurina	+++	S2/S1	*Exothea paniculata*	+	S2/S3
Pisonia fragrans	+++	S2/S1	*Pouteria semecarpifolia*	+	S2/S1
Bursera simaruba	++	S2/S1	*Eugenia oerstedeana*	+	S3
Chrysophyllum argenteum	++	S2/S3	*Simaruba amara*	+	S2/S3
Manilkara bidentata	++	S1/S2	*Capparis indica*	+	S2/S3
Eugenia pseudopsidium	++	S2	*Ocotea cernua*	+	S2/S3
Pilocarpus racemosus	++	S3	*Haematoxylon campechianum*	+	S2/S3
Coccoloba swartzii	+	S2/S3	*Ilex nitida*	+	
Mangifera indica	+	S1	*Antirhea coriacea*	n	S3/S2
Ocotea eggersiana	+	S1	*Ficus citrifolia*	+	S2/S1
Chionanthus compacta	+	S2/S3	*Brosimum alicastrum*	+	S2/S1
Guarea glabra	+	S2/S3	*Guazuma ulmifolia*	+	S2/S3
Ocotea patens	+	S2/S3	*Casearia decandra*	+	S3/S2
Faramea occidentalis	+	S3	*Sideroxylon obovatum*	+	S2/S3
Plinia pinnata	+	S3	*Exostema sanctae-luciae*	+	S2/S3
Spondias monbin	+	S1	*Sterculia caribaea*	+	S2/S1
Cassipourea guianensis	+	S2/S3	*Andira inermis*	+	S2/S3
Eugenia monticola	+	S3	*Zanthoxylum flavum*	+	S1/S2
Guarea macrophylla	+	S2/S3	*Hymenaea courbaril*	+	S2/S1
Eugenia ligustrina	+	S3	*Coccoloba pubescens*	+	S2/S1
Eugenia confusa	+	S3	*Eugenia t apacumensis*	+	S3/S2
Quararibea turbinata	+	S3/S2	*Lonchocarpus vioalaceus*	+	S2/S3

Continued

Rhyticocos amara	+	S2/S3	*Croton corylifolius*	+	S3
Guettarda scabra	+	S2/S3	*Capparis baducca*	+	S3
Tabernaemontana citrifolia	+	S2/S3	*Byrsonima spicata*	+	S3/S2
Licaria sericea	+	S2	*Ormosia monosperma*	+	S3/S2
Myrciaria floribunda	+	S3	*Bourreria succulenta*	+	S3

(++++++): very high Abundance/(++++): high Abundance/(+++): medium Abundance/(++): low Abundance/(+): very low Abundance. S1: Upper stratum/S2: Middle stratum/S3: Lower stratum.

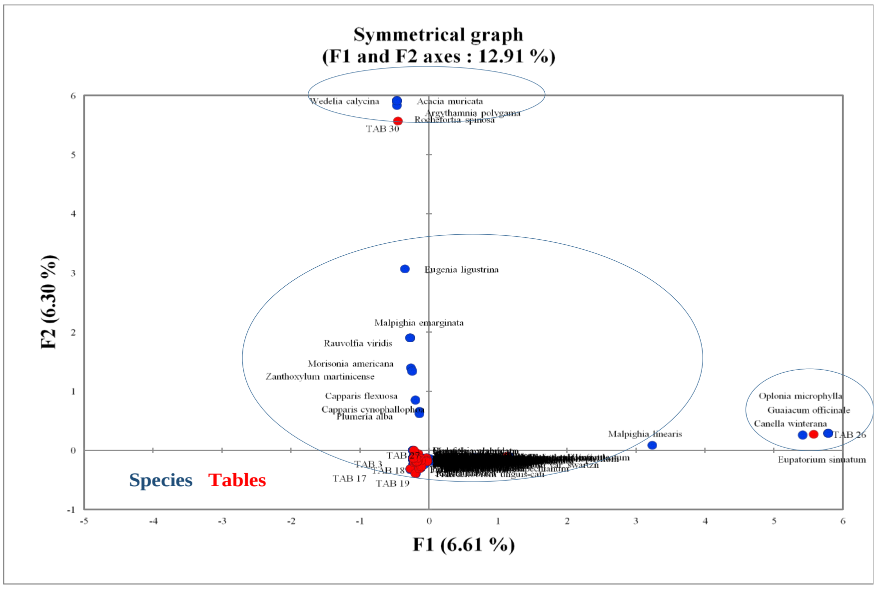


Figure 2. Comparison of the different surveys with regard to the population specificity of the species.

Whether these are pre-sylvatic or sylvatic groupings, the distances in the plane formed by the axes F1 and F2 of Figure 3(a) & Figure 3(b) between the points symbolising the surveys and the determining species associated with them indicate both qualitative (species) and quantitative differences (population abundances) and a diversity of ecological profiles related to the biotic and physical factors.

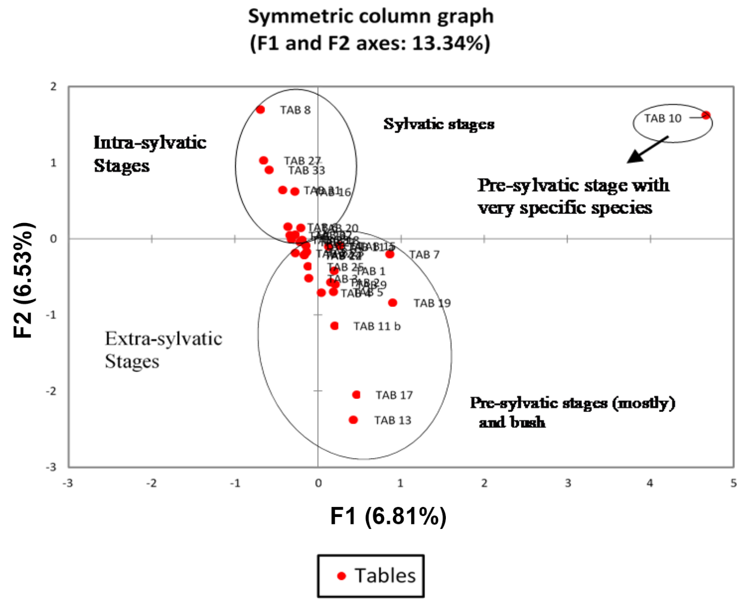
An Ascending Hierarchical Classification (AHC) carried out using a table of abundance of 237 species from 34 inventories (TAB) and based on the general similarity according to the "Complete Linkage" aggregation method shows a multitude of degrees of similarity (Figure 4) [44] [45]. Except for the TAB 33 surveys, the floristic inventories have a similarity of between 60% and 65% (Figure 4). These differences in similarity ranging from 62% to 92% on average result from the combination of several parameters involved in the installation of species such as the geomorphological specificities of the different Lesser Antilles considered in this study which engender a plurality of topographical facies,

Table 34. Bioclimates, ecosystemic potentialities and evolutionary stages.

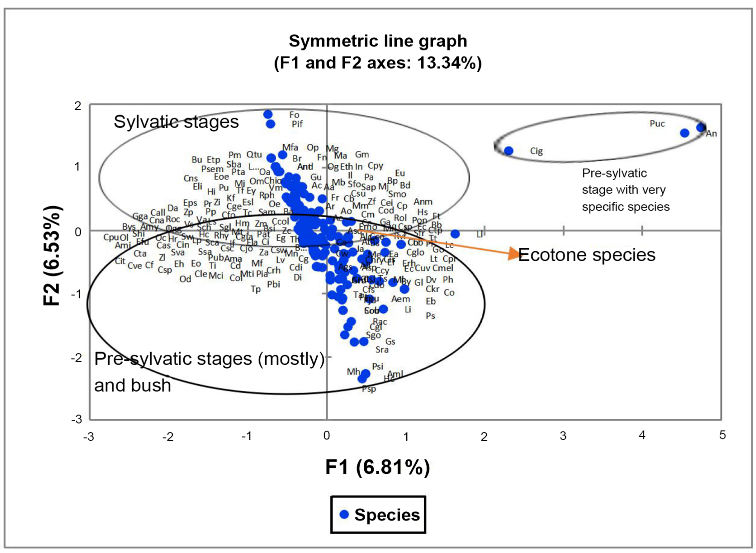
Tables (Stations)	Evolutionary stages	Bioclimates/Ecosystemic potentialities
1	Presylvatic or young sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
2	Presylvatic or young sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
3	Presylvatic	Dry subhumid (hyper-xeric facies)/Tropical seasonal evergreen of lower horizon
4	Presylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
5	Presylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
6	Secondary sylvatic	Humid subhumid/Tropical seasonal evergreen
7	Presylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
8	Subclimactic sylvatic	Humid/Seasonal evergreen forest ecotone/sub-montane ombrophilous
9	Presylvatic	Dry subhumid (hyper-xeric facies)/Tropical seasonal evergreen of lower horizon
10	Presylvatic	Dry subhumid (hyper-xeric facies)/Tropical seasonal evergreen of lower horizon
11	Presylvatic	Dry subhumid (hyper-xeric facies)/Tropical seasonal evergreen of lower horizon
12	Presylvatic	Dry subhumid (hyper-xeric facies)/Tropical seasonal evergreen of lower horizon
13	Presylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
14	Young sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
15	Presylvatic or young sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
16	Structured secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
17	Presylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
18	Secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
19	Presylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
20	Secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
21	Structured secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
22	Structured secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
23	Secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
24	Young sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
25	Presylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
26	Bush	Dry subhumid/Tropical seasonal evergreen of lower horizon
27	Secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
28	Secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon

Continued

29	Secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
30	Young sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
31	Structured secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
32	Secondary sylvatic	Dry subhumid/Tropical seasonal evergreen of lower horizon
33	Structured secondary sylvatic	Humid/Seasonal evergreen forest ecotone/sub-montane ombrophilous



(a)



(b)

Figure 3. (a) Relation of surveys with regard to the population structure of the species; (b) Relation of the species of the different surveys with regard to their population structure [see Annex 1 (List of species abbreviations)].

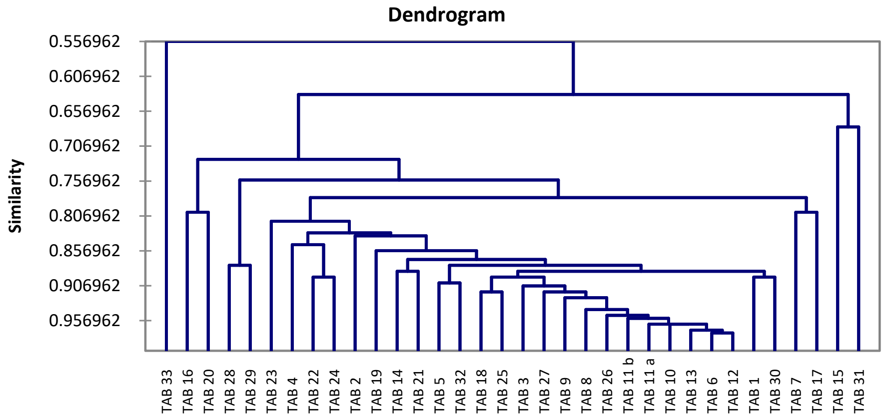


Figure 4. Degrees of similarity related to the types of species and their population structure.

bioclimatic affinities, edaphic characteristics, stages of ecosystemic evolution and spatiotemporal modalities of human activities (Figure 4). The topographic facets lead to mesoclimates subdivided into microclimates.

5. Discussion and Conclusion

The phytocenoses mentioned above, mainly through tables, are some examples of great diversity. The predominant species, both from a bio-demographic and ecological point of view, show the evolutionary stage of these phytocenoses. The above data highlight the considerable plasticity of the vegetation of the Lesser Antilles resulting from numerous floristic combinations. Indeed the contrasting geomorphology which leads to a multiplicity of topographical facets, the meso-climates ranging from dry to hyper-humid, the highly diverse edaphic systems resulting from these and the phases of the plant dynamics as well as the wind, in particular its impact at the littoral and high peaks, are the main factors behind the multiple habitats and therefore biodiversity, both specific and community [5] [46] [47] [48] [49]. Added to this are the phenomena of vegetation inversions which at the level of the peaks and ridges exposed to the wind as well as in valleys or dales increase the density of biotopes and therefore the potential for the colonisation of singular corteges of species. On the peaks and ridges of the humid bioclimate (middle and upper stages) exposed to wind and often shallow soils, evapotranspiration dries the environment and allows for the installation of affine species which thrive in conditions of the dry bioclimate (lower plant floor). Conversely, in the dales and valleys subject to the dry bioclimate (lower stage), the confinement which reduces the duration of sunshine and the colluviation due to the terrigenous erosion of the opposite slopes which considerably increases the depth of the soil leads to the installation of plant groups typical of moderately humid or even humid zones whose ecosystemic potentialities are characteristically the tropical seasonal evergreen sylva and the tropical submontane ombrophilous sylva. From one island to the next, anthropisation, which varies in terms of intensity and frequency, has led to and is still leading to a greater diversification of environments hosting a plurality of phytocenoses of variable areal significance. In general, it can be said that mesological factors with complex structures and anthropisation which varies as regards time and space are the drivers of the great diversity of biotopes and therefore phytocenoses. More than in pre-Columbian times, the anthropised Lesser Antilles of today can be considered as highly differentiated floristic assemblages. Each insular groundcover can give rise to a dense mosaic of phytocenoses of varying spatial significance, age, structure, architecture and floristic composition. A synchronic analysis makes it possible to reconstruct the evolutionary stages and to specify for the hyperhumid, humid, humid subhumid and dry subhumid bioclimates the ecosystemic potentialities and the various dominant plant combinations. Ultimately, in view of the above, the phytocenotic canvas typical of each Lesser Antilles, each unit of which is a biosystemic response, represents a veritable laboratory for the study of plant succession, a complex non-linear phenomenon of which the spatiotemporal characteristics remain to be deciphered.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Annex 1. List of Species Abbreviations

Acacia macracantha	Ama	*Chiococca alba*	*Chio*	*Exostema caribaeum*	*Eeu*
Acacia nilotica	*An*	*Chionanthus compacta*	*Cc*	*Exostema sanctae-luciae*	*Esl*
Acacia sp	*Asp*	*Chrysobalanus icaco*	*Chry*	*Exothea paniculata*	*Eth*
Acacia tamarindifolia	*At*	*Chrysophyllum argenteum*	*Cge*	*Faramea occidentalis*	*Fo*
Acrocomia aculeata	Aa	*Cinnamomum elongatum*	*Cin*	*Ficus citrifolia*	*Fc*
Actinostemon caribaeus	Ac	*Citharexylum spinosum*	*Cit*	*Ficus nymphaeifolia*	*Fn*
Aegiphila martinicensis	*Aem*	*Clerodendron aculeatum*	*Cle*	*Ficus trigonata*	*Ft*
Agave sp.	*Ags*	*Clusia major*	*Cjo*	*Forestiera rhamnifolia*	*Fr*
Aiphanes erosa	*Ae*	*Coccoloba coronata*	*Cta*	*Garcinia humilis*	*Gh*
Aiphanes minima	*Ami*	*Coccoloba diversifolia*	*Cdi*	*Genipa americana*	*Ga*
Albizia caribaea	*Alc*	*Coccoloba krugii*	*Ckr*	*Guarea macrophylla*	*Gm*
Albizzia lebbeck	*All*	*Coccoloba pubescens*	*Cpu*	*Guazuma ulmifolia*	*Gu*
Allophyllus racemosus	*Ar*	*Coccoloba swartzii*	*Csw*	*Guettarda odorata*	*Go*
Amphitecna latifolia	*Aml*	*Coccoloba uvifera*	*Cuv*	*Guettarda scabra*	*Gs*
Amyris elemifera	*Amy*	*Coccoloba venosa*	*Cve*	*Gyminda latifolia*	*Gl*
Anacardium occidentale	*Ao*	*Coccothrinax barbadensis*	*Cis*	*Haemathoxylon campechianum*	*Hc*
Andira inermis	*And*	*Colubrina arborescens*	*Cns*	*Hernendia sonora*	*Hs*
Annona muricata	*Anm*	*Comocladia dodeanea*	*Cdo*	*Hippomane mancinella*	*Hm*
Annona squamosa	*Asq*	*Conostegia calyptrata*	*Cgia*	*Homalium racemosum*	*Hr*
Antirhea coriacea	*Ant*	*Cordia alliodora*	*Call*	*Hura crepitans*	*Hc*
Ardisia obovata	*Ard*	*Cordia collococca*	*Ccol*	*Hymenea courbaril*	*Hi*
Bontia daphnoides	*Bd*	*Cordia curassavica*	*Ccu*	*Ilex nitida*	*In*
Bourreria succulenta	*Bs*	*Cordia glabra*	*Gga*	*Inga laurina*	*Il*
Bromelia plumieri	*Bp*	*Cordia globosa*	*Cglo*	*Ixora ferrea*	*If*
Brosimum alicastrum	*Ba*	*Cordia martinicensis*	*Cm*	*Jacquinia armilaris*	*Ja*
Brunfelsia americana	*Br*	*Cordia obliqua*	*Cob*	*Krugiodendron ferreum*	*Kf*
Buchenavia tetraphyl-la	*Bu*	*Cordia sulcata*	*Csu*	*Laetia thamnia*	*Lt*
Bucida buceras	*Bb*	*Cornutia pyramidata*	*Cpy*	*Lantana camara*	*Lc*
Bunchosia glandulosa	*Bg*	*Crateva tapia*	*Ctp*	*Lantana involucrata*	*Li*
Bursera simaruba	*Bsi*	*Crossopetalum rhacoma*	*Crh*	*Leucaena leucocephala*	*Ll*
Byrsonima lucida	*By*	*Croton astroides*	*Coi*	*Licania ternatensis*	*Ls*
Byrsonima spicata	*Bys*	*Croton corylifolius*	*Cfo*	*Licaria sericea*	*Le*
Caesalpinia coriaria	*Cco*	*Croton flavens*	*Cfs*	*Lonchocarpus pentaphyllus* (*)	*Lp*

Continued

Calliandra prupurea	*Cp*	*Croton sp.*	*Csp*	*Lonchocarpus violaceus*	*Lv*
Calliandra slaneae	*Csl*	*Cupania americana*	*Cna*	*Maclura tinctoria*	*Mt*
Calliandra tergemina	*Ct*	*Daphnopsis americana*	*Da*	*Malpighia emarginata*	*Me*
Calophyllum calaba	*Ca*	*Diospyros inconstans*	*Di*	*Malpighia glabra*	*Mg*
Calotropis procera	*Cpr*	*Dodonaea viscosa*	*Dv*	*Malpighia linearis*	*Ml*
Canella winterana	*Cw*	*Erithalis fruticosa*	*Ef*	*Mangifera indica*	*Mi*
Capparis baducca	*Cb*	*Erithalis odorifera*	*Eo*	*Manilkara bidentata*	*Mb*
Capparis cynophallophoa	*Ccy*	*Erythroxylon havanense*	*Eh*	*Margaritaria nobilis*	*Mn*
Capparis flexuosa	*Cf*	*Eugenia (Bahamensis)*	*Eb*	*Maytenus laevigata*	*Ma*
Capparis hastata	*Ch*	*Eugenia axillaris*	*Ea*	*Melocactus intortus*	*Mti*
Capparis indica	*Ci*	*Eugenia chrysobalanoides*	*Ey*	*Melochia tomentosa*	*Mh*
Capparis odoratissima	*Co*	*Eugenia confusa*	*Efu*	*Melococcus bijugatus*	*Mj*
Casearia decandra	*Cd*	*Eugenia cordata*	*Ec*	*Morinda citrifolia*	*Mf*
Casearia guianensis	*Cg*	*Eugenia gregii*	*Eg*	*Morisonia americana*	*Mm*
Cassipourea guianensis	*Cas*	*Eugenia hodgei*	*Eu*	*Myrcia citrifolia*	*Mci*
Catesbea melanocarpa	*Cmel*	*Eugenia lambertiana*	*Ela*	*Myrcia fallax*	*Mfa*
Cecropia schreberiana	*Csc*	*Eugenia ligustrina*	*Eli*	*Myrciaria floribunda*	*Mfl*
Cedrela odorata	*Cod*	*Eugenia monticola*	*Emo*	*Ocotea cernua*	*Oc*
Ceiba pentandra	*Cei*	*Eugenia oerstedeana*	*Eoe*	*Ocotea coriacea*	*Oa*
Celtis iguanea	*Cig*	*Eugenia pseudopsidium*	*Eps*	*Ocotea eggersiana*	*Oe*
Cestrum sp.	*Csp*	*Eugenia rhombea*	*Erh*	*Ocotea glabra*	*Og*
Chamaecrista glandulosa var. swartzii	*Cgl*	*Eugenia tapacumensis*	*Etp*	*Ocotea leucoxylon*	*Ol*
Ocotea patens	*Op*	*Tecoma stans*	*Ts*		
Opuntia dillenii	*Od*	*Ternstroenia peduncularis*	*Tp*		
Ormosia monosperma	*Om*	*Tetrazygia angustifolia*	*Ta*		
Ouratea guildingii	*Ogg*	*Trichilia hirta*	*Tt*		
Persea americana	*Pa*	*Triphasia trifolia*	*Tf*		
Phyllanthus (angustifolius)	*Ps*	*Vangueria madagascariensis*	*Vm*		
Picramnia pentandra	*Pp*	*Vernonia albicaulis*	*Va*		
Pilocarpus racemosus	*Pr*	*Vernonia arborescens*	*Vs*		
Pilosocereus royeni	*Pi*	*Zanthoxylum caribaeum*	*Zc*		
Pimenta racemosa	*Pm*	*Zanthoxylum flavum*	*Zf*		
Piscidia carthagenensis	*Ph*	*Zanthoxylum martinicense*	*Zm*		

Continued

Pisonia aculeata	*Pu*	*Zanthoxylum microcarpum*	*Zp*
Pisonia fragrans	*Pf*	*Zanthoxylum monophyllum*	*Zl*
Pisonia sp.	*Psp*	*Zanthoxylum punctatum*	*Za*
Pisonia subcordata	*Pub*	*Ziziphus mauritiana*	Zi
Pisonia suborbiculata	*Pbi*	*Sapium caribaeum*	*Sca*
Pithecellobium unguis-cati	*Puc*	*Sapium glandulosum*	*Sgl*
Plinia pinnata	*Pta*	*Sapium hippomane*	*Shi*
Plumeria alba	*Pia*	*Schaefferia frutescens*	*Sfr*
Pouteria multiflora	*Pif*	*Schoepfia schreberi*	*Sch*
Pouteria semecarpifolia	*Psem*	*Senna obtusifolia*	*Sob*
Prosopis juliflora	*Pju*	*Sideroxylon foetidissimum*	*Sfo*
Protium attenuatum	*Pat*	*Sideroxylon obovatum*	*Sva*
Psidium guajava	*Psi*	*Sideroxylon salicifolium*	*Ssa*
Psychotria microdon	*Pon*	*Simaruba amara*	*Sam*
Quararibea turbinata	*Qtu*	*Solanum racemosum*	*Sra*
Randia aculeata	*Rac*	*Spondias mombin*	*Smo*
Rauvolfia viridis	*Rvi*	*Sterculia caribaea*	*Sba*
Rhayticocos amara	*Rhy*	*Swartzia simplex*	*Sw*
Rochefortia acanthophora	*Rph*	*Swietenia mahagoni*	*Sgo*
Rochefortia spinosa	*Roc*	*Tabebuia heterophylla*	*Th*
Roystonea oleacea	*Rol*	*Tabernaemontana citrifolia*	*Tc*
Sapindus saponaria	*Sap*	*Tamarindus indica*	*Ti*