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Identification and characterization of floristic groups in dry forests relicts of a West Coast region of New Caledonia

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We describe the floristic composition of dry forest relicts on the west coast of New Caledonia. Using rnultivariate techniques, four floristic groups were defined frorn 71 flonstic sarnples. The large proportion of species with rain forest affinities in all floristic groups shows sirnilarities with the "dry" rainforest of Australia. The two more open and disturbed groups have the highest proportion of species associated with dry areas, the strongest level of endemism and more "most threatened" species. The two more closed groups have the highest proportion of rain forest species, but are slightly less original and have fewer threatened species. This raises the question of the exact relation of the dry forest still present in the study area to rnesic forest, which has not yet been studied separately frorn dense hurnid forest in New Caledonia. The influence of the local micro-climatic conditions on the distribution of floristic groups appears critical. A good knowledge of these conditions is necessary for a sound delimitation of new protected areas, and for the irnplementation of protective and restorative rneasures appropriate to each vegetation category.

Keys words: Dry forest, Sderophyll forest, "Dry" rainforest, Mesic forest, Floristic groups, Autochthonous flora, Endemisrn, Introduced species, Threatened specics, Conservation, IUCN status, New Caledonia.

INTRODUCTION

NEW Caledonian tropical forests have been divided into several main categories (Morat *et al.* 1981): *1)* evergreen humid forest from low and middle altitudes, which occurs on several substrates, with 1500 to 2000 mm rainfall per year; 2) evergreen humid forest from high altitude which grows above 1000 m and receives more than 2000 mm of rainfall per year; **3)** evergreen humid forest on calcareous substrates, mainly known at low altitude on the Loyalty Islands and on a few calcareous mountains of the main island ("Grande-Terre"), receiving between 1300 to 1800 mm of rainfall per year; 4) sclerophyll forest (or dry forest), called also tropical dry forest (TDF) (Aronson *et al.* 2005). Dry forest grows in the driest areas of the archipelago, receives generally no more than 1100 mm of rainfall per year (Jaffré *et al.* 1993) and has a dry period of more than 4 months some years (Fig. 1). Dry forest occurs typically on relatively fertile low altitude substrates (sometimes metamorphosed) of sedimentary origin, or more rarely on basalts. It has nearly disappeared in consequence, mainly, of pasture development.

New Caledonian dry forest is of relatively recent origin, containing largely late-tertiary and quaternaiy flora components. The dominant floristic affinities are with Australia (Jaffré *et al.* 1993; Morat *et al.* 1994). The main families present are: Euphorbiaceae, Myrtaceae, Sapindaceae, Rutaceae and Ebenaceae. Absent are taxa of archaic lineages such as Gymnosperms, tree ferns and certain flowering plant families (Palmae and Pandanaceae), although some of these are well represented in dense humid forest of low and medium elevation (Jaffré *et* al. 1994).

All low altitude forests (below ca. 300 m and not on ultramafic rocks) of the west coast of the "Grande-Terre" have been classified as sclerophyll forests, or dry forests, sensu Holdridge (1967). Characteristics of tropical and sub-tropical dry vegetation are: receiving between 250 and 2000 mm of rainfall per year, annual average temperature more than 17°C, and a ratio of evapo-transpiration potential / annual average rainfall in the range 1–2 (Holdridge 1967). Based on this definition, 40 to 45% of all tropical and sub-tropical forest areas belong to tropical dry forests (Bullock *et al.* 1995).

In the Pacific region, dry tropical forests occur in parts of eastern and northern Australia (Adam 1994; Baur 1957; Beadle 1981; Curran 2006, Fensham 1995, Gillison 1987) characterized, as in New Caledonia, by rainfall of 500–1100 mm/year with a marked seasonality. As a rule, such forests are lower and have fewer species than typical rainforest, but are still complex in structure with many understory trees and few or no herbs. Called "dry" rainforest, they have been incliided within the rainforest umbrella because of their structural and floristic affinities to wetter rainforests (Adam 1994; Bowman 2000; Fensham 1995; Gillison 1987).

New Caledonian dry forests have been mapped and botanically inventoried (Jaffré *et al.* 2004a; Jaffré and Veillon 1991; Veillon *et al.* 1999). Also completed are a global phyto-

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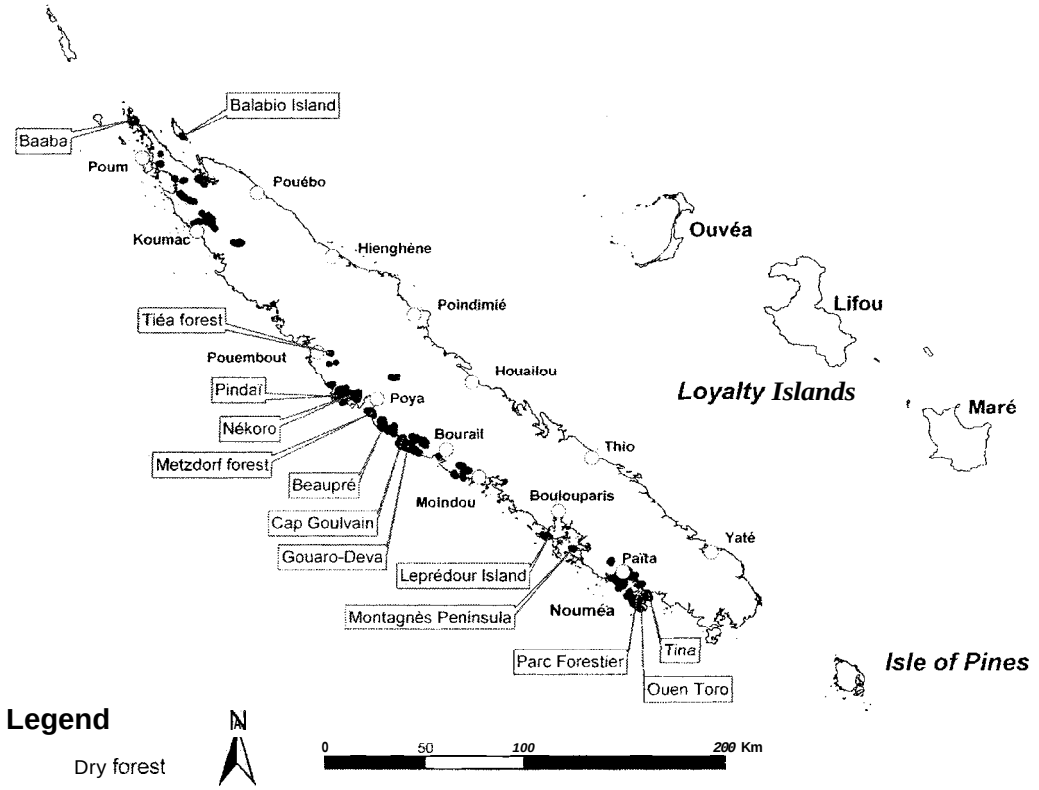

Fig. *1*. map of dry forest in New Caledonia, provided by Yann-Eric Boyeau (Dry Forest Program).

geographic and floristic analysis (Jaffré ***et*** *al.* 1993) and a structural and floristic comparison with several foreign dry forests (Gillespie and Jaffré 2003). The forest now occurs only as relictual isolated patches, always more or less degraded, and is considered one of the most endangered ecosystems of the territory (Bouchet *et al.* 1995; Jaffré ***et*** *al.* 1998). Lerdau ***et*** *al.* (1991), Janzen (1998) and Aronson ***et*** al. (2005) assert that the tropical dry forest is the most threatened tropical ecosystem in the world, and the most in need of protection and restoration.

These circumstances have justified the creation of a pluri-institutional and pluri-disciplinary programme for the conservation and the restoration of the New Caledonian dry forest (www.foretseche.nc). Two protected areas have already been established, one of 34 ha (Tiéa forest) in the Pouembout district and one of 14 ha (Metzdorf forest), in the Poya district. These two new sites are additional to the "Parc Forestier" (3 ha) and the Ouen Toro reserve (44 ha) in the Nouméa district. Some new protected areas are being considered, especially in the Poya district (Nékoro, 145 ha) (Fig. 1).

The aim of this study is to identify, describe, compare and characterize the floristic groups of seven dry forest relicts in a restricted dry forest area of New Caledonia.

METHODS

Study sites

The study focused on remnant dry forests near the coast and on the low hills between Païta and Boulouparis. These forests are scattered intermittently along a coastal strip ca. 50 km long and up to 6 km from the coast, from sea level to 350 m elevation (Fig. 2). This area is mainly covered by secondary vegetation, that is, savannas and various types of secondary thicket, which can be classified as derivative formations of dry forest resulting from repeated fires and pasture development. In each locality, only less disturbed forest fragments, mostly dominated by arborescent species, were retained for the analysis.

The study sites are scattered over three geographical and geomorphologic entities in areas protected from fire.

The first site, in Saint Vincent Bay, takes in the Montagnès peninsula (2 km long and ca. 800 m wide, highest point 116 m) and Leprédour Island (4 km long and 1.6 km wide, highest point 255 m in the south extremity), located 300 m off the coast. Forests are restricted mainly to the south part on steep slopes of Leprédour Island and to the south slopes of the Montagnès peninsula.

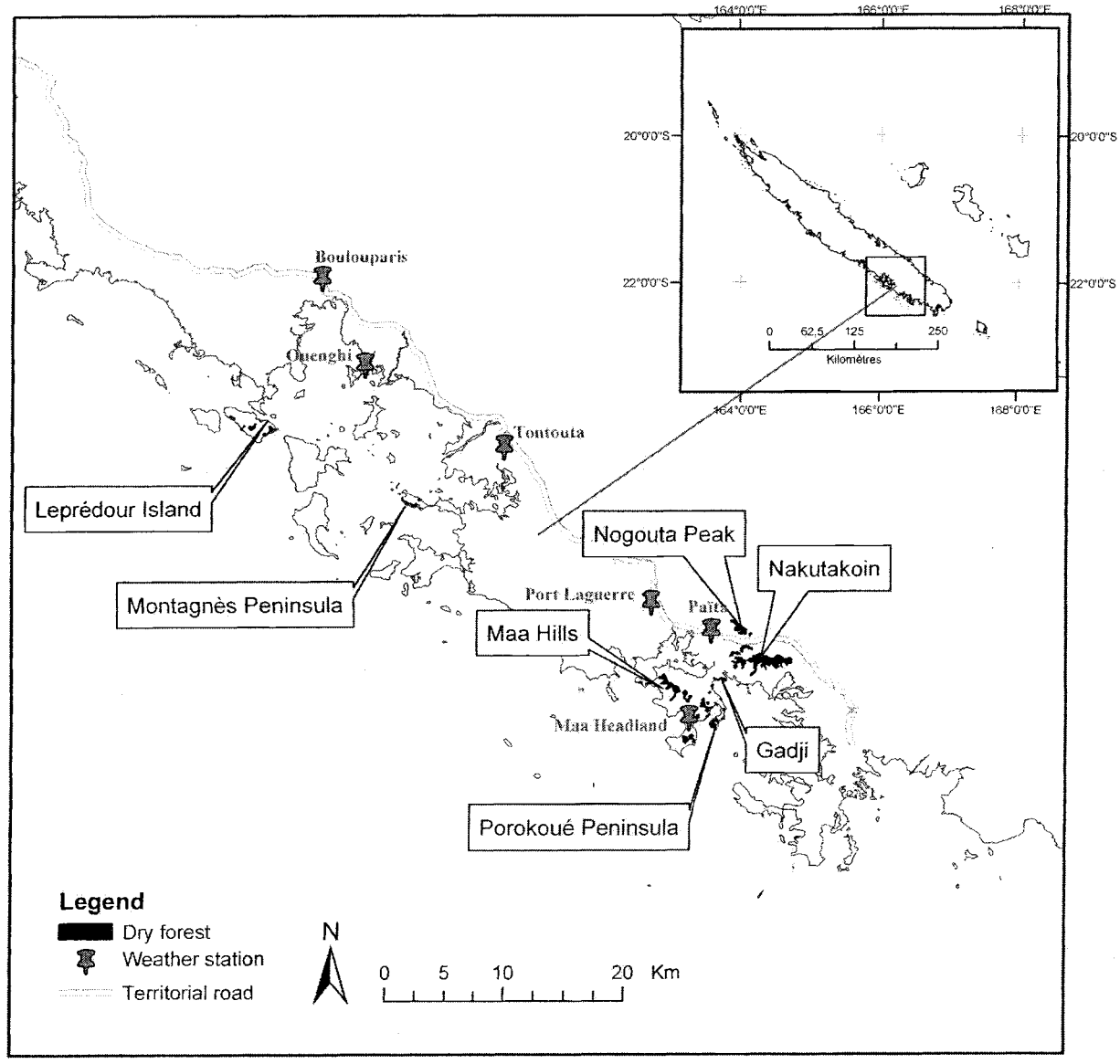

Fig. 2. map of the study area.

The second site includes the Maa Hills (highest points, the 375 m Gére Peak in the northeast, and the 245 m Nogutia summit in the south) and the more coastal southwest slopes of the Gadji headland and the Porokoué peninsula (112 m).

The third site includes a southern area 1 to 3 km from the sea and dominated by the 352 m Jacob Peak (the woody portion of this area is called "Nakutakoin forest"), and a northern range of hills, highest point the 366 m Nogouta Peak with forest on the southern and south-western slopes known as "Nogouta forest" or "Païta forest". Most of these forests are surrounded by well-maintained pastures, which are protection against fires, but which restrict any natural expansion.

All these forests were and sometimes still are visited by goats and/or deer, which strongly damage the plant cover (Bouchet *et al.* 1995; Gargominy *et al.* 1996; de Garine-Wichatitsky *et al.* 2003; de Garine-Wichatitsky *et al.* 2005). The damage has been particularly severe on Leprédour Island, a little less so in Montagnès peninsula, Mont Maa and Porokoué peninsula, while Païta, Gadji and Nakutakoin forests have moderate and less recent damage.

Floristic survey

Floristic samples were compiled following the phytosociological method on plots larger than the minimum area defined using the asymptote of the area-species curve (Guinochet 1973). The size of the minimum area was 400 m² in partially open and low forests, in Leprédour, Montagnès and Porokoué, and 625 m² in more closed and higher forests in Maa, Gadji, Nakutakoin and Païta. In each plot larger than the minimum area, each plant species was

scored on a scale using the Braun-Blancluet cover-abundance score system (Lemée 1967; Mueller-Dombois and Ellenberg 1974).

Floristic sample treatment and identification of floristic groups

Analysis used the Braun-Blanquet cover-abundance scores. estimated for each species within a plot. Similarity matrices were generated using the Bray-Curtis similarity index (Bray and Curtis 1957). This analysis provides a measure of compositional dissimilaritv between and similarity within plots. A cluster analysis (hierarchical agglomerative clustering with group average linkage) was used to check the grouping of plots. Floristic samples were also ordinated by non-metric multidimensional scaling (NMDS). The significance of the multivariate results was assessed using one way pairwise analysis of similarity (ANOSIM), with 999 permutations used. In this analysis, the values of R produced range from 0 (no separation between groups) to 1 (complete separation). The average contribution of individual species in floristic groups was identified using similarity percentage procedure (SIMPEK) (Clarke 1993).

All statistical treatrnents were performed using the computer software package PRIMER 6 (Plymouth Routines in Multivariate Ecological Research) 2nd Edition (Clarke and Warnick 2001).

Characteristics of the floristic groups

Comparison of the floristic groups is based on the relative importance of autochthonous, endemic and introduced species, on their ecological affinities, and on the number of rare or threatened species that they contain. For each species, appendix I gives status (autochthonous, endemic, introduced) and ecological affinities as expressed by its distribution in one or several vegetation categories: a) species known only from dry forest, b) in both dry and dense humid forest, c) in dry forest and in open vegetation disturbed by human activities and/or fire (savannas, secondary thickets, "maquis" or scrubland, areas landwards of mangrove swamps) (Jaffré *et al.* 2004b).

Rare or threatened species are listed and ordered following the IUCN criteria (Jaffré *et al.* 1998; IUCN 2001). The IUCN status of some species has been re-evaluated using recent data on their distribution from updated botanical inventories (Rigault and Dagostini 2003; Veillon *et al.* 1999), recent taxonomic work on Sapotaceae (Swenson *et al.* 2007) and Moraceae (Ungricht *et al.* 2005), our own field observations, and conimunications from taxonomists working on the "Flore de la Nouvelle-Calédonie". These data will be published in a submitted paper reviewing the IUCN status of all of the rare or threatened species of the dry forest of New Caledonia (Hequet 2007).

RESULTS

Environmental conditions

The geological substrate in New Caledonia is mixed calcareous and siliceous rocks of sedimentary and volcanic-sedimentary origin with extensive overlapping, resulting in very thin soils that have not been intensively investigated. Table 1 presents rain data from six meteorological locations included in, or near, the study areas (see Fig. 2), the Nouméa peninsula which supports relictual degraded dry forest, and Ouanaham on Lifou (Loyalty Islands), where a low-altitude humid rainforest on calcareous soils with floristic affinities to dry forest has been identified (Morat *et al.* 2001). Rain appears to increase with altitude and distance from the coast. The annual average evapo-transpiration calculated for Nouméa is 1440 mm (ORSTOM 1981). The evapo-transpiration of the study sites is similar and the ratio of the annual average of evapo-

Table 1. Rainfall and temperatures of the different meteomlogical locations of the study area, and also of Nouméa and Ouanaham

Locations (Number of years of observation)	Rainfall					Annual temperature °C	T/P x 100	ETP**/P
	Annual average (S D)	Annual Absolute Minimum	% of years < 600 mm	% of years < 800 mm	% of years < 1100 mm			
Boulouparis (46)	915 (311)	464	15.2	43.5	78.3	23*	2.51	1.57
Ouenghi (31)	821 (268)	414	25.5	48.4	80.6	23	2.8	1.75
Tontouta (54)	959 (236)	418	7.4	29.6	66.7	22.7	2.37	1.5
Port Laguerre (53)	1188 (282)	725	0	7.5	32	22.1	1.86	1.21
Païta (53)	1182 (283)	650	0	7.5	39.6	22.5*	1.9	1.22
Pointe Maa (53)	906 (223)	505	7.7	34.6	86.5	23*	2.54	1.59
Nouméa (54)	1063 (261)	577	1.9	16.7	57.4	23	2.16	1.35
Ouanaham (43)	1703 (478)	917	0	0	3.7	22.9	1.34	0.79

* Estimated values

** ETP calculated: 1440 for Nouméa, 1345 for Ouanaham and estimated to 1440 for the others locations

transpiration to annual rainfall is always >1, a criterion given by Holdridge (1967) for dry forest.

Close to the coast, the dry period can be severe in some years, with <800 mm of rainfall for 29-48% and <600 mm for 7.4–25.8 % of the years. In contrast, the two locations further from the coast (Païta and Port Laguerre) have no years with <600 mm, 7–8% of the years with <800 mm of rainfall, and annual average precipitation >1100 mm. Nouméa has similar rainfall to the study sites, while Ouanaham has more rain.

There are no meteorological locations on the sites studied, but some are close and provide reasonable estimates. Leprédour Island, Montagnès peninsula and Porokoué peninsula receive an average of 800 to 900 mm rainfall per year, the Nakutakoin and Nogouta forests receive 1100 mm, and the Maa Hills and Gadji forests receive 900 to 1000 mm. Annual average temperatures are ca. 23°C. Monthly average temperatures vary from 26°C during February to ca. 20°C in August. The daily minima during the cool season (June to August) are 12 to 15°C, while maxima during the hot season (December to March) are 31 to 34°C. The ratio of the annual average temperature to annual average rainfall, x 100, varies from 1.90 for Païta and 1.86 for Port Laguerre to 2.80 for Ouenghi. These numbers fall within the range of values (4.1 to 1.4) given by Murphy and Lugo (1986) for dry forests. For comparison, the Nouméa region (2.16) is in the same range whereas Ouanaham on the Loyalty Islands (1.34) is not.

Floristic groups

Using agglomerative hierarchical cluster analysis, the dendrogram divides fairly neatly into 4 clusters of plots (Fig. 3) with an overall similarity of about 28%. The first group consists of plots on Leprédour Island (Group 1), the second of plots from Montagnès and Porokoué peninsulas (Group II), the third of plots on Maa Hills and the Gadji Peninsula (Group III), and the last of plots from Noguta forest and from Nakutakoin forest (Group IV).

The NMDS ordination of plant species composition of the 71 plots (Fig. 4) has a stress value of 0.16. The plots separate into approximately the same four groups as in Fig. 3. However, there is limited overlap between Groups II and III, and Groups III and IV, indicating a gradua1 change of floristic composition between these groups. Nevertheless, the ANOSIN test showed significant differences in species composition among floristic groups (Global R=0.87, P=0.001), and pairwise tests found significant differences between all pairs of floristic groups. Pairings of Groups I-II (R= 0.74) and III-IV (R=0.75) were the least different, and 1-IV (R=1) and II-IV (R=0.98) were the most different.

Species contributing up to a cumulative 80% of the average Bray-Curtis similarity in each floristic group, determined by SIMPER analysis, are listed in Tables 2–5 for Groups I–IV respectively. The % contribution gives the average contribution of each species to the total similarity within the group. The constancy ratio (similarity/standard deviation) indicates the consistency with which each species contributes to the group across plots.

Frequency (number of quadrats on a scale from I to V) and extreme cover abundance score are given for each species across quadrats of each floristic group in Appendix I.

Occurrence of autochthonous, endemic and introduced species

The full floristic inventory includes 276 species, of which 35 (12.7%)are introduced and 241 (87.3%)are autochthonous.

Endemism values of autochthonous flora, are higher in Groups I (39 species, 57.4% of 68) and II (59, 50.4% of 117), than in Groups III (71 species, 44.4% of 160) and IV (71 species, 48 % of 148). Numbers of introduced species were: Group I, 7 (9.3%); Group II, 19 (14%); Group III 26 (14%); Group IV 10 (6.3%).

Description of plant groups

Group I

This group is a loose union of species on the south and southeast slopes of Leprédour Island. It is probably the driest and most disturbed sector of the studied area, damaged mainly by rabbits and deer. Excluding the ecotonal areas, the limited availability of this plant association allowed delimiting of only 10 × 400 m² plots.

Out of 75 inventoried species, eight species account for 50% and 17 species for 80% of the total contribution for this group (Table 2). The superior stratum, which is 3 to 10 m high, includes in decreasing order of contribution: *Drypetes deplanchei, Eugenia gacognei, Arytera collina, Alectryon carinatum, Premna serratifolia, Fontainea pancheri, Dysoxylum bijugum,* and *Diospyros pustulata* (cumulative 44% of the species contribution). The shrubby stratum comprises mainly heliophitic shrubby species which are rarely grazed by mammals: *Croton insularis, Wickstroemiu indica* and *Lantana camara* (which together provide 19% of the species con-

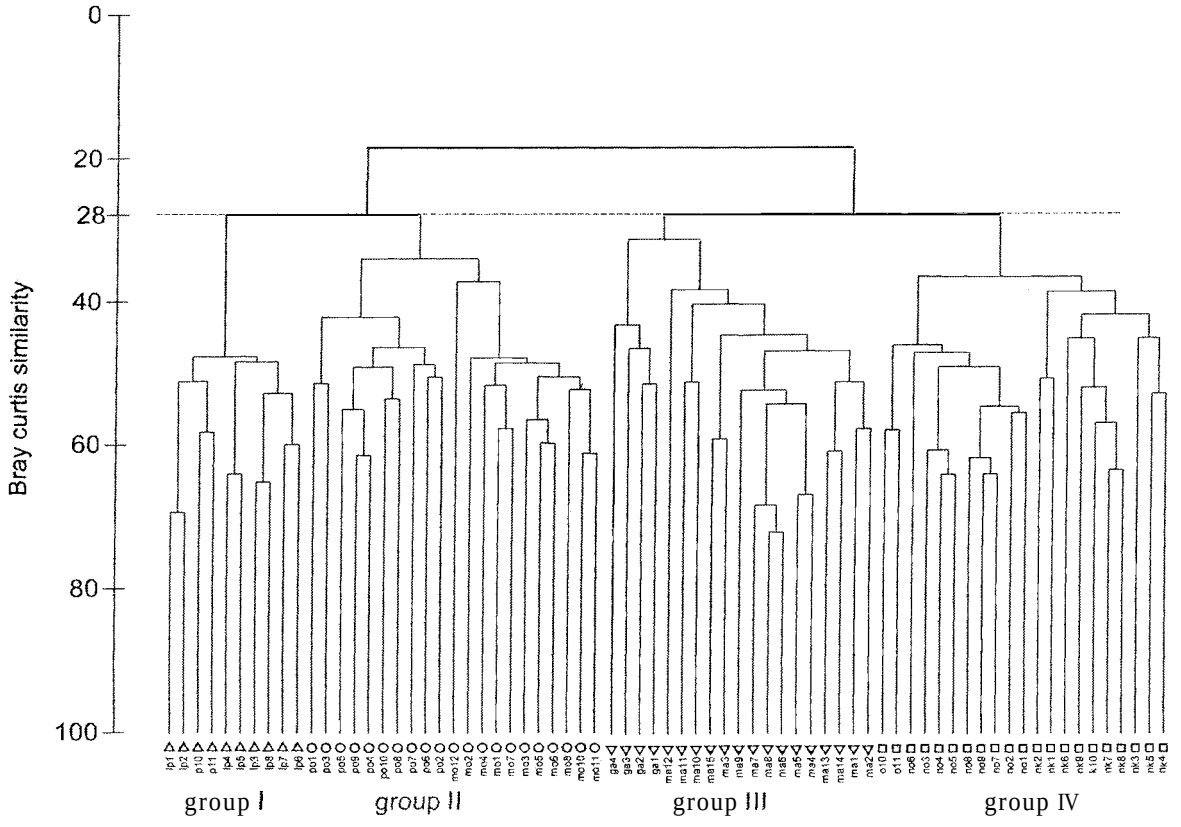

Fig. 3. Dendrogram of the 71 floristic samples, using group average clustering from Bray-Curtis similarities on species Braun Blanquet cover-abundance score.

Floristic samples: (ga: Gadji headland; lp: Leprédour Island; ma: Maa hills; mo: Montagnès peninsula; no: Nogutia or Païta forest; nk: Nakutakoin forest; po: Porokoué peninsula).

Table 2. SIMPER (Similarity Percentage) analysis — species contribution up 80% to the average Bray Curtis similarity in floristic group I.

Average similarity: 50,16

Species	Average similarity Si	Ratio Si/SD	Contribution % Si	Cumulative contribution %
Croton insularis	4.68	2.27	9.33	9.33
Drypetes deplanchei	4.64	3.36	9.24	18.57
Eugenia gacognei	4.11	1.83	8.19	26.77
Arytera collina	2.91	1.21	5.8	32.56
Alectryon carinatum	2.62	1.13	5.22	37.79
Premna serratifolia	2.52	1.52	5.01	42.8
Wikstroemia indica	2.51	3.31	5	47.8
Solanum seaforthianum	2.39	3.16	4.77	52.56
Fontuinea pancheri	2.33	1.47	4.65	57.22
Lantana camara	2.22	7.92	4.44	61.65
Trophis scandens	2.12	1.11	4.23	65.88
Casearia silvana	1.77	1.9	3.53	69.41
Dysoxylum bijugum	1.5	0.81	2.98	72.4
Oxalis corniculata	1.34	1.24	2.68	75.07
Diospyros pustulata	1.23	0.5	2.45	77.52
Melodinus celastroides	1.16	0.82	2.31	79.84
Alyxia tisserantii	1.07	0.87	2.14	81.98

tribution). The most abundant lianas are *Trophis scandens, Melodinus celastroides* and *Alyxia tisserantii* (cumulative 9%). The herbaceous stratum is mainly composed of two species: *Solanum seaforthianum* and *Oxalis corniculata* (cumulative 7%).

The constancy ratio is highest for *Lantana camara,* followed by *Drypetes deplanchei, Wickstroemia indica, Solanum seaforthianum* and *Croton insularis.* Except for *D. deplanchei,* these species are characteristic of vegetation disturbed by deer.

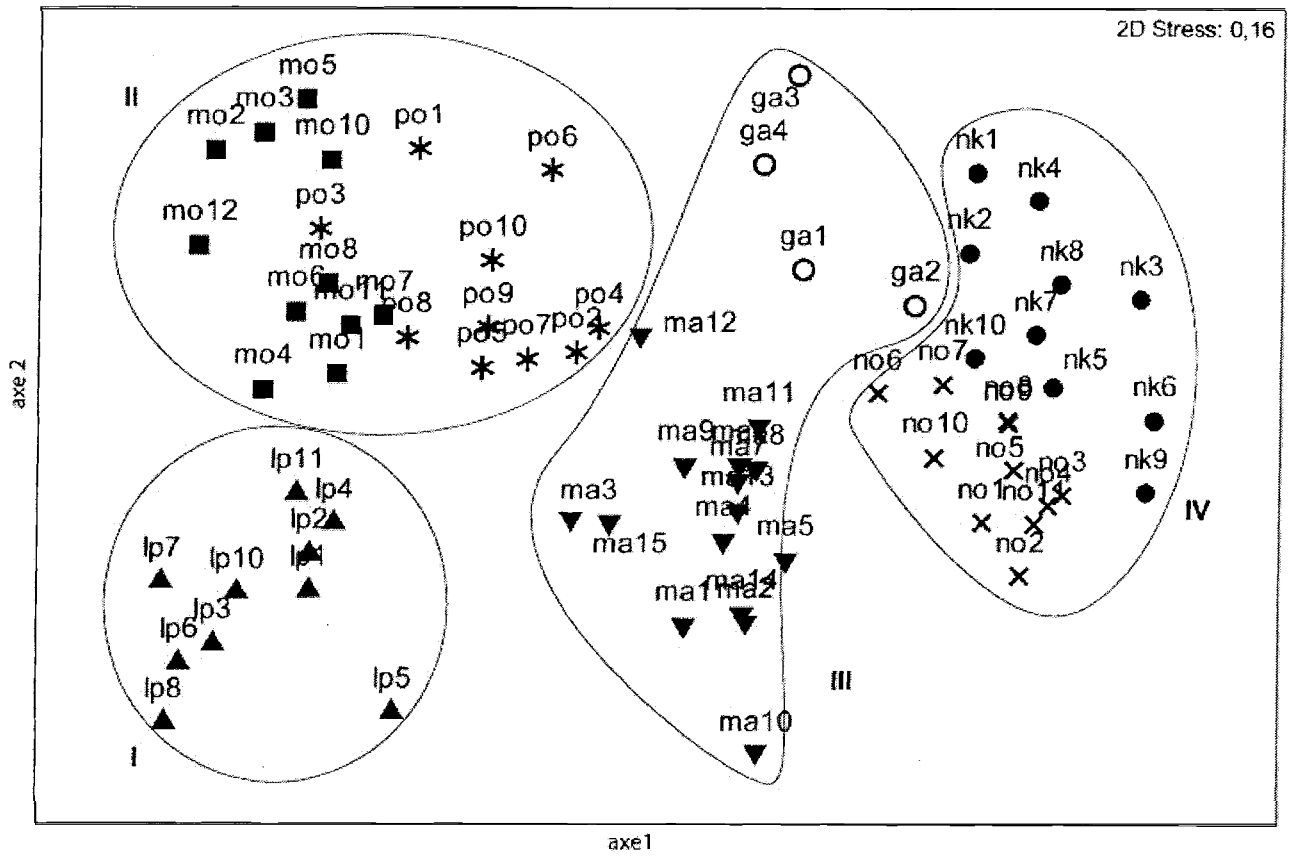

Fig. 4. Two dimensional non metric multidimentional scaling ordination (NMDS) of the 71 floristic samples. (ga: Gadji headland; Ip: Leprédour Island, ma: Maa hills; mo: Montagnès peninsula; no: Nogutia or Païta forest; nk: Nakutakoin forest; po: Porokoué peninsula).

Group I1

Group II includes 21 plots on the south side of the Montagnès Peninsula and on coastal Porokoué Peninsula. The plant cover is slightly less disturbed than for Group I. Respectively, 10 and 25 of the total of 136 species account for 50% and 80% of the total contribution (Table 3).

The arborescent layer reaches 6 to 12 (-15) m. Close to 25% of the cumulative contribution is constitute by species common to all four of the groups *(Premna serratifolia, Fontainea pancheri, Dysoxylum bijugum, Drypetes deplanchei, Cleistanthus stipitatus, Rhamnella vitienis, Celtis conferta).* Characteristic species that are also found in Group I include *Arytera collina, Planchonella cinerea, Eugenia gacognei* and *Homalium deplanchei* (cumulative contribution 12%). The shrubby discontinuous stratum, constituted mainly of heliophitic native species, comprises *Gardenia urvillei, Acacia spirorbis,* and *Cloezia artensis* (10% of the total contribution), three species that are rarely consumed by mammals. The most abundant climbers include in decreasing importance: *Alyxia tisserantii, Passiflora suberosa, Melodinus celastroides, Trophis scandens, Jasminum didymium* and *Capparis artensis* (cumulative 25%). The herbaceous stratum consists mainly of *Scleria brownii, Aristida novaecaledonica* and *Oplismenus compositus* (cumulative *7%).*

The highest constancy ratio was for *Passiflora suberosa* (an introduced and invasive species rarely consumed by deer), followed by *Alyxia tisserantii* (a climber), and two trees: *Premna serratifolia* and *Fontainea pancheri* (which is avoided by deer).

Group III

Group III includes 19 plots from the slopes of the Maa Hills with a S-SW exposure (100 to 300 m elevation), and the Gadji plots (40 to 60 m elevation). The sites are close to the coast. The heterogeneous substrate is mainly schist, but calcareous and siliceous rocks of jasper and conglomerate also occur. Only small patches of forest subsist on the plain, with most restricted to the thalwegs. Respectively 14 and 32 species accounted for 50% and 80% of the species contribution within the total flora of 186 species (Table 4).

The arborescent stratum is 10 to 15 m tall. In decreasing order of contribution, it is composed of species with high rainforest affinities, *Diospyros fasciculosa, Olea paniculata, Elattostachys apetala* (cumulative 15%) and more ubiquitous species:

Table 3. SIMPER (Similarity Percentage) analysis — species contribution up 80% to the average Bray Curtis similarity in floristic group II

Average similarity: 40,20

Species	Average similarity Si	Ratio Si/SD	Contribution % Si	Cumulative contribution %
Alyxia tisserantii	2.93	2.36	7.28	7.28
Premna serratifolia	2.85	2.36	7.1	14.38
Fontainea pancheri	2.46	2.14	6.12	20.5
Passiflora suberosa	2.46	2.37	6.11	26.61
Arytera collina	2.36	1.35	5.86	32.47
Gardenia urvillei	1.84	1.01	4.59	37.06
Melodinus celastroides	1.68	1.02	4.17	41.23
Dysoxylum bijugum	1.64	1.22	4.09	45.32
Acacia spirorbis	1.39	1.4	3.47	48.78
Planchonella cinerea	1.25	0.79	3.11	51.9
Trophis scandens	1.14	1.23	2.84	54.74
Scleria brownii	1.11	1.2	2.76	57.5
Aristida novaecaledoniae	1.06	0.73	2.64	60.14
Drypetes deplanchei	0.98	0.81	2.45	62.59
Cleistanthus stipitatus	0.88	0.47	2.2	64.79
Jasminum didymum	0.88	0.92	2.19	66.98
Cloezia artensis	0.86	0.43	2.14	69.12
Capparis artensis	0.81	0.94	2.03	71.14
Rhamnella vitiensis	0.67	0.63	1.66	72.8
Eugenia gacognei	0.57	0.56	1.43	74.23
Oplismenus compositus	0.55	0.54	1.37	75.6
Celtis conferta	0.9	0.55	1.26	76.87
Solanum tetrandrum	1	0.53	1.22	78.08
Wikstroemia indica	0.67	0.65	1.2	79.28
Homalium deplanchei	1	0.44	1.14	80.42

Table 4. SIMPER (Similarity Percentage) analysis — species contribution up 80% to the average Bray Curtis similarity in floristic group III

Average similarity: 40,55

Species	Average similarity Si	Ratio Si/SD	Contribution % Si	Cumulative contribution %
Diospyros fasciculosa	2.7	1.75	6.66	6.66
Adiantum diaphanum	1.72	1.83	4.23	10.89
Dysoxylum bijugum	1.66	1.36	4.1	14.99
Olea paniculata	1.62	0.95	3.99	18.98
Elattostachys apetala	1.61	0.92	3.97	22.96
Drypetes deplanchei	1.6	1.49	3.95	26.91
Fontainea pancheri	1.54	1.27	3.8	30.71
Oplismenus compositus	1.51	1.12	3.72	34.42
Trophis scandens	1.4	3.61	3.46	37.88
Passiflora suberosa	1.31	6.99	3.23	41.11
Premna serratifolia	1.24	1.58	3.06	44.17
Maclura cochinchinensis	1.08	1.09	2.65	46.82
Celtis conferta	0.94	1.42	2.33	49.15
Jasminum didymum	0.92	1.47	2.28	51.43
Desmodium adscendens	0.87	1.14	2.14	53.57
Alstonia balansae	0.85	0.77	2.11	55.68
Codiaeum peltatum	0.85	0.94	2.1	57.77
Wikstroemia indica	0.8	1.22	1.98	59.75
Arytera chartacea	0.79	0.82	1.94	61.69
Capparis artensis	0.78	1.25	1.93	63.63
Tetracera billardieri	0.75	0.81	1.86	65.49
Scleria brownii	0.73	0.97	1.8	67.29
Semecarpus atra	0.68	0.6	1.67	68.96
Glochidion billardieri	0.61	0.9	1.51	70.47
Maytenus fournieri	0.61	0.71	1.5	71.97
Eugenia gacognei	0.57	0.63	1.42	73.39
Asplenium vieillardii	0.55	0.52	1.36	74.75
Diospyros minimifolia	0.5	0.44	1.23	75.98
Schefflera veitchii	1	0.48	1.1	77.08
Lantana camara	0.58	0.68	1.04	78.12
Geitonoplesium cymosum	0.58	0.68	1.04	79.17
Peperomia sp v.6429	0.68	0.67	1.04	80.2

Dysoxylum bijugum, Drypetes deplanchei, Fontainea pancheri, Premna serratifolia, Celtis conferta, Aytera chartacea, Semecarpus atra and *Eugenia gacognei* (cumulative 22%). The shrubby stratum is composed, in decreasing order, of *Codiaeum peltatum* (a shade loving species), and the heliophitic species *Wickstroemia indica, Glochidion billardieri* and *Lantana camara*. Lianas comprise *Trophis scandens, Passiflora suberosa, Maclura cochinchinensis* and *Jusminum dzdymum* (cumulative *12%)*. The herbaceous stratum comprises two ferns *Adiantum diaphanum* and *Asplenium vieillardii*, a Gramineae *Oplismenus compositus* and a Cyperaceae *Scleria brownii* (cumulative 1*1%).*

The highest constancy ratios are for *Passiflora suberosa* and *Trophis scandens*, two invasive species characteristic of disturbed vegetation, followed by the fern *Adiantum diaphanum* and the trees *Diospyros fasciculosa* and *Premna serratifolia*.

Group IV

Group IV includes 21 plots from the "Païta region" (Noguta Peak and "Nakutakoin forest") below 300 m on the sides of the hills. These are mainly forests in thalwegs or at the base of slopes, occurring on masses of fallen rocks of rhyolite or phtanite. Out of a total of 158 species, respectively 14 and **33** contributed 50% and 80% of species to this plant association (Table *5)*.

The arborescent stratum is between 12 and 20 m in high, including a majority of species with high rain forest affinities. In decreasing order of contribution, it comprises *Diospyros fusciculosa, Olea paniculata, Schefflera gabriellae, Cupaniopsis glomeriflora, Oxera sulfurea, Polyalthia nitidissima, Diospyros olen, Aleurites mollucana, Elattostachys apetala* and *Me—ta denhnmii* (cumulative 28%).

The shrubby stratum includes a majority of shade-loving species, in decreasing frequency: *Codiaeum peltatum, Eugenia sp. V.* 7019, *Elaeodendron curtipendula, Psychotria collina, Micromelum minutum, Streblus pendulinus and Bocquillonia sessiliflora* (cumulative 24%).

The main lianas are: *Passiflora suberosa, Ventilago pseudocalyculata, Trophis scandens, Geitonoplesium cymosum,Jasminum didymum, Smilax* spp, *Maclura cochinchinensis* and *Capparis artensis* (cumulative 14%).

Table 5. SIMPER (Similarity Percentage) analysis — species contribution up 80% to the average Bray Curtis similarity in floristic group IV

Average similarity: 41,30

Species	Average similarity Si	Ratio Si/SD	Contribution % Si	Cumulative contribution %
Codiaeum peltatum	5.15	4.74	12.46	12.46
Diospyros fasciculosa	2.39	1.45	5.78	18.24
Olea paniculata	1.98	1.45	4.79	23.03
Eugenia sp v.7019	1.36	0.96	3.28	26.31
Schefflera gabriellae	1.32	1.03	3.2	29.51
Cupaniopsis glomeriflora	1.3	1.72	3.14	32.66
Tieghemopanax nothisii	1.28	1.05	3.09	35.75
Passiflora suberosa	1.03	1.57	2.49	38.24
Ventilago pseudocalyculata	1.02	1.17	2.47	40.71
Trophis scandens	1.01	1.17	2.45	43.16
Oxera sulfurea	0.97	0.87	2.35	45.51
Polyalthia nitidissima	0.88	1.06	2.13	47.65
Cassine curtipendula	0.87	0.77	2.12	49.76
Diospyros olen	0.84	0.77	2.04	51.8
Psychotria collina	0.79	1.12	1.92	53.72
Aleurites moluccana	0.78	0.6	1.89	55.61
Geitonoplesium cymosum	0.78	1.12	1.89	57.5
Fontainea. pancheri	0.77	0.78	1.86	59.35
Dysoxylum bijugum	0.73	0.71	1.77	61.13
Rivina humilis	0.71	0.69	1.72	62.85
Micromelum minutum	0.7	0.97	1.69	64.54
Streblus pendulinus	0.66	0.98	1.6	66.15
Lastreopsis vieillardii	0.63	0.6	1.53	67.68
Aglaia elaeagnoidea	0.61	0.61	1.48	69.16
Jasminum didymum	0.61	0.86	1.47	70.63
Bocquillonia sessiliflora	0.58	0.52	1.4	72.03
Drypetes deplanchei	0.57	0.75	1.37	73.4
Smilax spp	0.57	0.86	1.37	74.77
Elattostachys apetala	0.47	0.53	1.15	75.92
Meryta denhamii	0.76	0.65	1.13	77.05
Maclura cochinchinensis	0.81	0.65	**1.13**	78.18
Capparis artensis	0.57	0.67	**1.13**	79.31
Glochidion billardieri	0.86	0.65	1.03	80.34

The herbaceous stratum covers less than 10% and includes *Rivina humilis* and the fern *Lastreopsis vieillardii* (cumulative 3.5%)

The highest constancy ratios are for *Codiaeum peltatum*, the tree *Cupaniopsis glomerifera*, the introduced vine *Passiflora suberosa*, and for two common rain forest trees of low altitude, notably on the Loyalty Islands, *Diospyros fasciculosa* and *Olea paniculata*.

Ecological affinities of the flora of each Group

For each floristic group, we used ecological distribution information in the flora of New Caledonia (Jaffré *et al*. 2004b) to assess affiliations with floristic assemblages other than dry forest.

Numbers of species restricted to dry forest were: Group I, 16 (23.9%); Group II, 20 (17.2%);Group III, 12 (7.9%); Group IV, 9 (6%). Numbers of species in common with humid forest were: Group I, 27 (40.3%); Group II, 51 (44.0%); Group III, 94 (61.8%); Group IV, 116 (77.8%). Numbers of species in comnion with open vegetation (including savanna, brush, maquis, lowlands adjacent to mangrove swamps) were: Group I, 36 (53.7%); Group II, 72 (62.1%); Group III, 93 (61.2%); Group IV, 71 (47.7%). Adding introduced species to these counts raises the values to 43 (58.1%), 90 (67.2%), 119 (66.9%)and 84 (51.9%).

Distribution of rare or threatened species

The IUCN status of most of the rare and threatened species is available in Jaffré *et al.* (1998). Two species have larger distributions than originally thought, and should no longer be considered vulnerable (VU): *Ficus mutabilis* (Moraceae) (Ungricht *et al.* 2005), and *Eugenia noumeensis* (Myrtaceae).

One taxa, *Phyllanthus conjugatus* var. *maaensis* (Euphorbiaceae), has been raised to Critically endangered (CR) since 1998. *Pittosporum tanianum* (Pittosporaceae) was considered extinct, but was rediscovered on Leprédour Island (Group I). The population consists of two fruiting individuals and the species is the subject of propagation work under the "Dry Forest Program". Four rare species recently discovered or described have been added: *Eugenia lepredourii* Dawson ined. (Myrtaceae), *Leptostylis* sp. (V 6850); *Planchonella luteocostata* (Sapotaceae) (Swenson *et al.* 2007), and *Psychotria* sp. (V 7349) (Rubiaceae). Two rare species known only from the study areas were not found in the plots: *Callerya neocaledonica* (Nielsen and Veillon 2005) is known only as a herbarium specimen from Nakutakoin forest; *Ochrosia inventorum* (Apocynaceae) is found only in a secondary shrubby vegetation in the lower and drier area of Maa peninsula.

The threatened species constitute 7.5% of the native flora of the studied area. Group I has 9 threatened species (3 CR, 1 EN, 5 VU; 13.2% of natives), Group II, 13 threatened species (3 CR, 4 EN, 6 VU; 11.1%), Group III, 6 threatened species (1 CR, 1 EN, 4 VU; 3.8%), and Group IV, 5 threatened species (1 CR, 1 EN, 3 VU; 3.4%). Groups I and II together harbour 15 threatened species, 11.5% of their total flora, and groups III and IV together 8 threatened species, 5.4% of their total flora.

DISCUSSION

Even though situated within the climatic limits of the dry forest, the four floristic groups here defined (aniong the best conserved of the relict forests in the study region), show floristic affinities with humid dense forest.

Groups I and II, located in the portions of the study area with the least rainfall, correspond, as is often the case in Australia (Curran 2006), to residual forests situated in advantageous sites with respect to ridges and slopes exposed to the dominant winds. and therebv benefit from relatively moist microclimatic conditions. These Groups, which possess 4044 % of species also present in dense humid forest as defined by Morat et al (1981), seem to represent the leas't xerophilic elements of the original dry forest at the sites on Leprédour Island and on the Montagnès and Porokoué peninsulas. The neighbouring ridges and exposed zones, which originally supported a more xerophilic dry forest, are today entirely occupied by secondary vegetation (thickets, or else grassy or shrubby sparsely treed savanas). Groups III and IV, which have a high proportion of species widely represented in dense humid forest (64% and 79% respectively) and a low proportion of species considered most typical of dry vegetation (8% and 6% respectively), show strong floristic affinities with the dense humid forest of low altitude, notably with that on calcareous soil on the Loyalty Islands. This forest also possesses a level of endemism of 48% (Jaffré *et al.* 1997), similar to that of Group IV, but much lower than that of the overall dense humid forest (82%) (Jaffré *et al*. 2004b). The placing of Groups III and IV in the classification of the forests of New Caledonia may deserve to be re-examined, specifically with respect to a category mesic forests "forêts mésophiles", which in the classification of the vegetation formations of New Caledonia (Morat *et al*.1981) has not been separated frorn the dense humid forest, and which has not to date been the object of any detailed comparative study.

The problem of the regional or local distribution of dry forest is not restricted. to New Caledonia. Thus the delimitation, and

even the existence, of an original dry forest is a matter of debate for the island of Martinique (Fiard 1998), and even in the Pacific region the application of the term "dry forest" to certain forests of the Fijian archipelago is questioned by Muller-Dombois and Fosberg (1998). Another example is provided by Gillespie et al. (2000), who, in a comparative study of the dry forests in Central Arnerica, exclude from their analysis the gallery forests crossing the climatic domain of the dry forest.

The presence of numerous species of secondary vegetation in all groups reflects the opening and disturbance of the forest. The lowest rate is in Grour, IV, the arborescent stratum of which is the highest and most closed. Herbivores have an important impact on the flora through limiting the establishment of some introduced and many native species. Species that do well in the presence of herbivores are the introduced *Solanum seaforthianum* and *Lantana camara,* and the native *Croton insularis* and *Wzckstroemia indica*. In Groups I and II. where deer are the most numerous, there is no regeneration and clearings created by the fall of old trees are open areas invaded by heliophitic shrubby species and lianas. Consequently, the progressive disappearance of the original forest is inevitable. This situation is similar to that of the Hawaiian drv forest. where it was shown that control or even eradication of animal and plant pests was obligatory for restoration operations (Cabin et *al.* 2002; Cordell et *al.* 2002).

Groups I and II include 15 threatened species (11.5% of their native flora) as opposed to 8 species (5.4% of their native flora) for Groups III and IV. It thus appears that the driest Groups, which also have the highest level of endemism even though being the most degraded, possess the highest number of threatened species. This probably has to do with their closer floristic relationship, compared to that of Groups III and IV, with the most xerophilic dry forests that have now disappeared from the study region.

Focus on the dry forests (in the sense of Holdridge 1967) has brought to light the existence of rare and threatened species within an ecosystem that is often very degraded and has led to the establishment of a programme for their conservation. Nevertheless, the general defining parameters of the dry forest (rainfall, temperature, seasonality) are confirmed in the light of this study as insufficient to permit the inference of conservation and restoration measures that would be appropriate for a given experimental site. It appears, in fact, important to take into account variations in local microclimatic conditions, which make themselves evident by the presence of different vegetation groups within the initially defined "dry forest complex".

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REFERENCES

Adam, P., 1994. *Australian Rainforests*. Oxford, University Press, Oxford.

Aronson, J., Vallauri, D., Jaffré, T. and Lowry II, P, 2005. Restoring dry tropical forest. Pp. 285–90 *in* Beyond Planting Trees, Restoring Forests and their Functions in Landscapes ed by S. Mansourian. Springer, UK.

Baur, G. N., 1957. Nature and distribution of rain-forests in New South Wales. *Australian J. Bot. 5:* 190–233.

Beadle, N. C. W., 1981. The Vegetation of Australia. Ficher, Stuttgart.

Bouchet, P., Jaffré, T. and Veillon, J. M., 1995. Plant extinction in New Caledonia: Protection of sclerophyll forests urgently needed. *Biodiver. Conserv.* 4: 415–28.

Bowman, D. M. J. S., 2000. Australian Rainforests: Island of Green in a land of Fire. Cambridge University Press, Cambridge.

Bray, J. R. and Curtis, J. T., 1957. An ordination of the upland forest community of southern Wisconsin. *Ecol. Monogr.* 27: 325–49.

Bullock, S. H., Mooney, H. N. and Medina, E., 1995. Seasonally Dry Tropical Forests. Cambridge University Press, Cambridge UK.

Cabin, J., Weller, S. G., Lorence, D. H., Flynn, T. W., Sakay, A. K., Sandquist, D. and Hadway, L. J., 2002. Effects of long-term ungulate exclusion and recent alien species control on the preservation and restoration of Hawaïan tropical dry forest. *Conserv. Biol.* 14: 439–53.

Clarke, K. R., 1993. Non-parametric multivariate analyses of changes in community structure. *Aust. J. Ecology* **18:** 117–43.

Cordell, S., Cabin, R. J. and Hadway, L. J., 2002. Physiological ecology of native and alien dry forest shrubs in Hawaï. *Biological Invasion* 4: 387–96.

Curran, T. J., 2006. Rainforest, drought and soil type: phytogeography and functional and evolutionary ecology of dry rainforest on the western slopes of New South Wales. Unpublished PhD Thesis, the University of New England, Armidale, Australia.

de Garine-Wichatitsky, M., Duncan, P., Labbé, A., Suprin, B., Chardonnet, P. and Maillard, D., 2003. A review of the diet of rusa deer *Cervus timorensis russa* in New Caledonia: are the endemic plants defenceless against this introduced, eruptive ruminant? *Pac. Conserv. Biol. 9:* 136–43.

de Garine-Wichatitsky, M., Soubeyran, Y., Maillard, D. and Duncan, P., 2005. The diets of introduced rusa deer *(Cervus timorensis russa)* in a native sclerophyll forest and a native rainforest of New Caledonia. *N. Z. J. Zool.* 32: 117–26.

Fiard, J. P., 1990. La Forêt sèche climacique de la Martinique: aire d'extension, conditions d'installation, structure et composition floristique probable. Pp. 71–85 *in* Actes colloque de botanique "Pérennité et évolution de la flore des Caraïbes". Conservatoire des jardins et Paysages, Les Saintes-Guadeloupe.

Fensham, R. J., 1995. Floristic and environmental relations of inland dry rainforest in north Queensland, Australia. *J. Biogeogr.* 22: 1047–63.

Gargominy, O., Bouchet, Ph., Pascal, M., Jaffré, T. and Tourneur, J-C., 1996. Conséquences des introductions d'espèces animales et végétales sur la biodiversité en Nouvelle-Calédonie. *Rev. Ecol. (Erre vie)* 15: 375402.

Gillison, A.N., 1987. The "dry" rainforest of Terra Australis. Pp. 305–321 *in* The Rainforest Legacy. Australian National Rainforests study, vol. 1 ed. by Werren, G. and Kershaw, A. P. Australian Government Publishing Service, Canberra.

Gillespie, T. W., Grijalva, A. and Farris, C. N., 2000. Diversity, composition, and structure of tropical dry forest in Central America. *Plant Ecol.* 147: 37-47.

Gillespie, T. W. and Jaffré, T., 2003. Tropical dry forest in New Caledonia. *Biodivers. Conserv.* 12: 1687–1697.

Guinochet, M., 1973, Phytosociologie. Masson & Cie, Paris,

Hequet, V., 2007. Espèces végétales rares de forêt sèche calédonienne : révision de la liste et soumission de 68 taxons à la liste rouge UICN. Institut de Recherche pour le Développement — Rapport Programme Forêt Sèche No04/2007, Nouméa.

Holdridge, L. R., 1967. Life Zone Ecology. Tropical Science Center, San Jose, Costa Rica.

IUCN, 2001. Catégories et critères de l'UICN pour la liste rouge: version 3.1. Commission de la sauvegarde des espèces de l'IUCN. IUCN, Gland, Suisse et Cambridge, Royaume-Uni.

Jaffré, T., Bouchet, P. and Veillon, J. M., 1998. Threatened plants of New Caledonia: Is the system of protected areas adequate? *Biodivers. Conserv.* 7: 107–35.

Jaffré, T., Morat, P., Rigault, F., Veillon, J. M., and Dagostini, G., 2004b. Composition and characteristics of the native flora of New Caledonia. Documents Scientifiques et Technique II 4, IRD, Nouméa.

Jaffré, T., Morat, P. and Veillon, J. M., 1993. Etude floristique et phytogéographique de la forêt sclérophylle de Nouvelle-Calédonie. *Bull. Mus. Nat. Hist. Nat., B, Adansonia* 15: 107–47.

Jaffré, T., Morat, Ph. and Veillon, J. M., 1994. La flore, caractéristiques et composition floristique des principales formations végétales, dossier Nouvelle-Calédonie. *Bois et forêts des Tropiques* 242: 31–43.

Jaffré, T., Rigault, F., Dagostini, G., Fambart, J. and Manauté, J., 2004a. Le conservatoire botanique de forêt sclérophylle sèche de Tièa (Pouembout): typologie et analyse floristique des groupements végétaux. Pp. 257–270 *in* Les aires Protégées Insulaires et Littorales Tropicales ed by J. M. Lebigre and P. M. Decoudras. Université de Bordeaux 3, CRET, Coll. "Iles et archipels". Bordeaux.

Jaffré, T. and Veillon, J. M., 1991. La forêt sclérophylle de la Province Sud de la Nouvelle-Calédonie. Rapp. Sci. Tech. Sci. Vie. Bota. Convention n° 6 ORSTOM-Province Sud, Nouméa.

Jaffré, T., Veillon, J. M. and Pintaud, J. C., 1997. Comparaison de la diversité floristique des forêts denses humides sur roches ultramafiques et sur substrats différents en Nouvelle-Calédonie. Pp. 163–170 *in* Ecologie des Milieux sur Roches Ultramafiques et des Sols Métallifères ed by T. Jaffré, R.D. Reeves and Th. Becquer. ORSTOM, Nouméa.

Jansen, D. H., 1988. Tropical dry forest, the most endangered major tropical ecosystem. Pp. 130–37 *in* Biodiversity ed by E. D. Wilson. National Academic Press, Washington.

Kruskal, J. B. and Wish, M., 1978. Multidimentional scaling. Sage Publication, Beverley Hills, California.

Lerdau, M., Whitbeck, J. and Holbrook, N. M., 1991. Tropical deciduous forest: death of a biome. *TREE* **6:** 201–02.

Lemée, G., 1967. Précis de Biogéographie. Masson & Cie, Paris.

Morat, P., Jaffré, T., Veillon, J.M. and MacKee, H. S., 1981. Végétation. Atlas de la Nouvelle-Calédonie et Dépendances. ORSTOM, Paris: planche 15, carte et notice.

Morat, P., Jaffré, T. and Veillon, J.M., 1994. Richesse et affinités floristiques de la Nouvelle-Calédonie: conséquence directe de son histoire géologique. *Mem. Soc. Biogeographie (3éme série)* 4: 111–23.

Morat Ph., Jaffré T. and Veillon J. M., 2001, The flora of New Caledonia's calcareous substrates. *Adansonia, sel:* 3, 23: 109–27.

Mueller-Dombois, D. and Ellenberg, H., 1974. Aims and Methods of vegetation Ecology. Wiley Press, New York USA.

Mueller-Dombois, D. and Fosberg, F. R., 1998. Vegetation of the tropical Pacific Islands. Springer-Verlag, New York.

Murphy, P. G. and Lugo, A. E., 1986. Ecology of tropical dry forest. *Ann. Rev. Ecol. Syst.* 17: 67–88.

Nielsen, I. and Veillon, J. M., 2005. A new species of *Callerya* (Leguminosae, Papilionoideae, Millettieae) from New Caledonia. *Adansonia, sel: 3,* 27: 81–4.

ORSTOM, 1981. Eléments généraux du climat. Légende de la planche 12, Atlas de la Nouvelle-Calédonie. ORSOM Paris.

Rigault, F. and Dagostini, G., 2003. Caractéristiques floristiques et physionomiques de la forêt sèche de Nékoro. Pp. 12 + carte + annexes *in* Rapport de convention IRD/Programme Forêt sèche.

Swenson, U., Munzinger, J. and Bartish, I. 2007. Molecular phylogeny of *Planchonella* (Sapotaceae) and eight new species from New Caledonia. *Taxon* **56**(2): 329–354.

Ungricht, S., Rasplus, J-Y. and Kjellberg, F., 2005. Extinction threat evolution of endemic fig trees of New Caledonia: priority assessment for taxonomy and conservation with herbarium collections. *Biodiv. Conserv.* 14: 205–32.

Veillon, J. M., Dagostini, G. and Jaffré, T., 1999. Etude de la Forêt Sclérophylle de la Province Nord en Nouvelle-Calédonie. IRD, Nouméa.

Webb L. J. 1959. A physionomic classification of Australian Rain forests. *J. Ecol.* 47: 551–70.

APPENDIX

Species composition of the four floristic groups, giving for each species in each floristic group its status (E: Endemic, A. autochtonous, I: Introduced), its ecological distribution (F dense humid forest, L dry forest, O others*), its frequency on a scale from I to V, and its extreme cover abundance score from + to 5, across quadrats of each floristic group.

Species	Status	Ecol. D.	Floristic groups I	II	III	N
Ferms						
Aspleniaceae						
Asplenium vieillardii	E	FL			III (+,3)	II (+,1)
Davalliaceae						
Davallia solida	A	FLO		I (+,+)	I (+,+)	
Dryopteridaceae						
Lastreopsis tenera	A	F				I (+,+)
Lastreopsis vieillardii	E	FL				IV (+,2)
Lomariopsidaceae						
Nephrolepis cordifolia	A	LO				I (+,1)
Lygodiaceae						
Lygodium hians	E	FL				I (+,+)
Lygodium reticulatum	A	FLO			I (+,1)	I (+,+)
Polypodiaceae						
Microsorum punctatum	A	FLO				I (+,2)
Microsorum scolopendria	A	LO		I (+,+)		
Pyrrosia confluens	A	FL			I (+,+)	III (+,+)
Pteridaceae						
Adiantum aethiopicum	A	FL				I (+,1)
Adiantum diaphanum	A	FL		I (+,+)	V (+,3)	II (+,1)
Cheilanthes distans	A	FLO	II (+,+)			
Cheilanthes sieberi	A	FLO		I (+,+)	I (+,+)	
Doryopteris concolor	A	FL			I (+,+)	I (+,1)
Pteris ensiformis	A	FL			I (+,+)	II (+,1)
Pteris novaecaledoniae	E	FLO			II (+,+)	I (+,+)
Pteris vieillardii	E	FL			I (+,+)	II (+,1)
Vittaria elongata	A	FL			I (+,+)	
Selaginellaceae						
Selaginella firmuloides	A	FL			I (+,+)	I (+,+)
Monocot						
Amaryllidaceae						
Crinum asiaticum	A	LO		I (+,+)	II (+,1)	II (+,+)
Araceae						
Epipremnum pinnatum	A	FLO				I (+,+)
Cyperaceae						
Carex brunnea	A	FLO			I (+,+)	
Cyperus gracilis	A	LO	III (+,+)		I (+,2)	
Scleria brownii	A	LO	I (+,+)	IV (+,2)	IV (+,3)	II (+,2)
Dioscoreaceae						
Dioscorea bulbifera	A	FLO				III (+,+)
Graminae						
Ancistrachne numaeensis	E	L		I (2,2)		
Aristida novaecaledonine	E	LO	III (+,1)	IV (+,2)	II (+,4)	
Brachiaria reptans	A	LO	I (+,+)	I (2,2)		
Chrysopogon aciculatus	A	O			I (+,+)	
Leptochloa decipiens	A	LO		I (+,2)	I (+,2)	
Oplismenus compositus	A	FL		III (+,5)	V (+,4)	III (+,1)
Oplismenus hirtellus	A	FL			I (+,+)	III (+,+)
Panicum maximum	I	O		I (1,1)		
Setaria austrocaledonica	E	LO		I (+,1)	I (1,1)	
Setaria elegantula	E	LO		I (+,+)	I (+,+)	
Themeda gigantea	I	O		III (+,1)		
Tragus australianus	A	O	I (+,+)			
Hemerocallidaceae						
Dianella adenanthera	A	FLO		II (+,+)	III (+,1)	II (+,1)
Geitonoplesium cymosum	A	FL	I (+,+)	I (+,+)	IV (+,+)	IV (+,1)
Juncaceae						
Juncus pauciflorus	A	O			I (+,+)	
Laxmanniaceae						
Cordyline fruticosa	A	FLO			I (+,+)	II (+,+)
Orchidaceae						
Durabaculum sylvanum	A	FL	I (+,+)		I (+,+)	I (+,+)
Nervilia aragoana	A	FL				I (+,+)
Thelychiton comptonii	A	FL				I (+,+)

*open and more or less disturbed habitat (various type of thickets, savannas, scrub or "maquis" area landwards of mangrove swamps).

Appendix — continued

Species	Status	Ecol. D.	Floristic groups I	II	III	IV
Smilacaceae						
Smilax spp	A	FLO			II (+,+)	IV (+,1)
Dicot						
Acanthaceae						
Dicliptera caerulea	A	LO			I (+,+)	
Pseuderanthemum incisum	E	L	I (+,+)	III (+,2)	I (+,+)	I (+,1)
Arnaranthaceae						
Achyranthes aspera	A	LO		I (+,+)	I (+,+)	
Deeringia arborescens	A	FL	I (+,+)		I (+,+)	I (+,+)
Anacardiaceae						
Euroschinus obtusifolius	E	FL	III (+,2)		II (+,1)	III (+,3)
Semecarpus atra	E	FL	I (2,2)	I (2,2)	III (+,3)	III (+,4)
Annonaceae						
Polyalthia nitidissima	A	FL			III (+,2)	IV (+,2)
Apocynaceae						
Alstonia balansae	E	FLO			IV (+,4)	
Alyxia caletioides	E	LO				I (1,1)
Alyxia tisserantii	E	FLO	IV (+,1)	V (+,4)	I (+,+)	III (+,2)
Alyxia torqueata	E	FL			I (+,+)	I (+,+)
Carissa ouata	A	LO		I (1,1)		
Cerbera manghas	A	FLO		II (1,4)	I (+,+)	
Melodinus celastroides	E	LO	IV (+,1)	IV (+,4)	II (+,1)	I (+,+)
Melodinus phylliraeoides	E	LO			I (+,+)	I (+,+)
Melodinus scandens	E	LO		I (+,+)	I (+,1)	I (+,+)
Parsonsia pachycarpa	E	FL				I (+,+)
Parsonsia scabra	A	FL		I (+,+)		II (+,+)
Araliaceae						
Delarbrea paradoxa	A	FL		I (+,+)	II (+,2)	II (+,+)
Meryta denhamii	A	F			I (+,+)	IV (+,1)
Schefflera gabriellae	E	F				V (+,2)
Schefflera ueitchii	A	FL		II (+,2)	III (+,2)	II (+,1)
Tieghemopanax nothisii	E	L	I (+,+)	III (+,1)	II (+,1)	IV (+,2)
Asclepiadaceae						
Asclepias curassavica	I	O	I (+,+)			
Cryptostegia grandiflora	I	O	I (+,+)			
Gymnema tricholepis	A	LO			I (+,+)	I (+,+)
Hoya nicholsoniae	A	FL				II (+,1)
Sarcostemma viminale	A	LO	I (+,+)	I (1,1)	I (+,+)	I (+,+)
Secamone elliptica	A	FLO		II (+,1)	III (+,1)	II (+,+)
Balanophoraceae						
Balanophora fungosa	A	FL				II (+,2)
Bignoniaceae						
Tecoma stans	I	O		I (2,2)		
Boraginaceae						
Cordia dichotoma	A	LO		I (+,+)	I (1,1)	
Capparaceae						
Capparis artensis	E	LO	III (+,1)	IV (+,2)	IV (+,+)	IV (+,+)
Casuarinaceae						
Casuarina collina	E	LO	I (1,1)			
Celastraceae						
Celastrus paniculatus	A	LO		II (+,+)	II (+,1)	
Elaeodendron curtipendula	A	FL			I (+,1)	IV (+,3)
Maytenus fournieri	E	LO		I (+,+)	IV (+,3)	I (+,1)
Pleurostylia opposita	A	LO		III (1,1)		
Clusiaceae						
Garcinia neglecta	E	FLO				II (1,2)
Garcinia puat	E	FL				I (+,1)
Mammea neurophylla	E	FLO			I (+,1)	I (3,4)
Compositae						
Ageratum conyzoides	I	O			III (+,1)	
Bidens pilosa	I	O		I (+,+)	I (+,+)	
Elephantopus mollis	I	O				I (+,+)
Elephantopus scaber	I	O			II (+,1)	
Sigesbeckia orientalis	A	O			I (+,+)	
Sonchus oleraceus	I	O		I (+,+)	I (+,+)	
Synedrella nodiflora	A	O			I (+,+)	
Vittadinia simulans	E	O	I (+,+)			

Appendix — continued

Species	Status	Ecol. D.	Floristic groups I	II	III	IV
Connaraceae						
Rourea vieillardii	E	FL				I (+,+)
Convolvulaceae						
Dichondra repens	A	LO	III (+,1)	II (+,2)	I (+,+)	
Ipomoea cairica	I	LO		II (+,+)	II (+,+)	II (+,1)
Corynocarpaceae						
Corynocarpus dissimilis	E	FL			II (+,2)	III (+,3)
Cunoniaceae						
Codia microphylla	E	LO			I (+,+)	
Pancheria sp v.7108	E	LO			I (+,+)	
Dilleniaceae						
Tetracera billardieri	E	FLO			IV (+,1)	II (+,1)
Ebenaceae						
Diospyros fasciculosa	A	FL		I (+,3)	V (1,4)	V (+,4)
Diospyros minimifolia	E	L		II (+,1)	III (+,4)	I (+,1)
Diospyros olen	A	FL			III (+,1)	IV (+,3)
Diospyros pustulata	E	L	III (1,3)	II (1,3)		
Diospyros veillonii	E	L			I (2,3)	
Diospyros yaouhensis	E	FL				II (+,2)
Euphorbiaceae						
Aleurites moluccana	A	FLO			III (+,3)	III (+,2)
Bocquillonia sessiliflora	E	LO	II (+,1)	II (+,3)	I (+,1)	III (+,4)
Breynia disticha	A	O			II (+,+)	
Claoxylon insulanum	E	FLO				I (+,1)
Cleidion claoxyloides	E	FL				I (1,2)
Cleidion verticillatum	E	FL		I (1,1)	I (+,+)	
Cleistanthus stipitatus	E	FLO	I (1,1)	III (+,5)	I (+,2)	II (+,3)
Codiaeum peltatum	A	FLO		I (+,3)	IV (+,3)	V (2,5)
Croton insularis	A	LO	V (+,4)	I (+,2)		
Drypetes deplanchei	A	FL	V (+,2)	IV (+,3)	V (+,3)	IV (+,2)
Fontainea pancheri	A	FL	V (+,2)	V (+,2)	V (+,2)	IV (+,2)
Glochidion billardieri	E	FLO		II (+,+)	IV (+,1)	III (+,3)
Mallotus repandus	A	FLO			I (+,+)	I (+,1)
Omalanthus schlechteri	E	FLO			I (+,+)	
Phyllanthus conjugatus var. conjugatus	E	L		I (1,3)		
Phyllanthus deplanchei	E	L		III (+,1)	II (+,+)	
Phyllanthus faguetii	E	FLO			I (4,4)	I (+,+)
Phyllanthus virgatus	I	O	III (+,+)	II (+,+)	II (+,+)	
Flacourtiaceae						
Casearia silvana	E	FLO	V (+,+)	I (+,+)		
Homalium deplanchei	E	LO	II (1,2)	III (+,2)		
Xylosma pancheri	E	LO		I (+,+)		
Fabaceae						
Acacia farnesiana	I	O		I (1,1)	I (+,+)	
Acacia spirorbis	A	LO	I (+,+)	V (+,2)	II (+,1)	I (+,2)
Archidendropsis fournieri	E	FL			I (1,3)	
Archidendropsis granulosa	E	F				I (1,1)
Arthroclianthus microbotrys	E	FL			I (+,+)	II (+,3)
Caesalpinia bonduc	A	FLO				I (1,1)
Crotalaria pallida	I	O			I (+,+)	
Derris trifoliata	A	LO		I (1,4)		I (+,+)
Desmanthus virgatus	I	O		III (+,+)	II (+,+)	
Desmodium adscendens	I	O			V (+,2)	
Indigofera australis	A	LO				II (+,+)
Indigofera suffruticosa	I	O			I (+,+)	
Leucaena leucocephala	I	O		I (+,1)	II (+,1)	I (+,1)
Mimosa pudica	I	O			I (+,+)	
Sesbania cannabinn	I	O		I (+,+)	I (+,+)	
Storckiella pancheri	E	FO				I (+,2)
Labiatae						
Hyptis pectinata	I	O		I (+,+)		
Oxera pulchella	E	FL	I (+,+)			
Oxera sulfurea	E	FL			III (+,2)	IV (+,2)
Plectranthus forsteri	A	LO			I (+,+)	
Premna serratifolia	A	FLO	V (+,2)	V (1,3)	V (+,2)	II (+,1)
Vitex collina	A	FLO			II (1,3)	

Appendix — contznued

Species	Status	Ecol. D.	Floristic groups I	II	III	N
Lauraceae						
Cryptocarya chartacea	E	FL				II (+,4)
Cryptocarya schmidii	E	FL				I (+,2)
Malpighiaceae						
Rhyssopteris timoriensis	A	LO	I (+,+)	I (+,1)	I (+,1)	II (+,+)
Malvaceae						
Abutilon auritum	A	O			I (+,+)	
Melochia odorata	A	LO			I (+,1)	I (+,+)
Sida acuta	I	O			I (+,+)	
Sida cordifolia	I	O		II (+,1)	I (+,+)	
Meliaceae						
Aglaia elaeagnoidea	A	FL		I (+,+)	II (+,3)	III (+,4)
Dysoxylum bijugum	A	FLO	IV (+,1)	IV (+,3)	V (+,4)	IV (+,2)
Dysoxylum rufescens	E	FLO			I (1,1)	
Melia azedarach	I	O			I (+,+)	I (+,+)
Menispermaceae						
Hypserpa vieillardii	E	FO	I (+,1)	I (3,3)		I (+,+)
Pachygone loyaltiensis	E	FLO				I (+,+)
Moraceae						
Ficus fraseri	A	LO				I (+,+)
Ficus habrophylla	A	F			II (+,+)	II (+,2)
Ficus microcarpa	A	FL	II (+,2)		I (3,3)	I (2,2)
Ficus mutabilis	E	FLO			I (+,+)	
Ficus obliqua	A	FL	II (+,2)	II (+,2)	II (1,2)	I (1,1)
Ficus prolixa	A	FL	I (+,1)	I (+,1)	I (1,2)	I (+,1)
Ficus uirgata	A	FL	I (1,1)			
Maclura cochinchinensis	A	LO	II (+,1)	II (+,2)	V (+,2)	III (+,3)
Streblus pendulinus	A	FLO			II (+,1)	IV (+,1)
Trophis scandens	A	FLO	IV (+,1)	IV (+,2)	V (+,2)	V (+,2)
Myoporaceae						
Myoporum tenuifolium	E	LO	I (+,+)	II (+,1)		
Myrsinaceae						
Maesa novocaledonica	E	FLO				I (1,1)
Rapanea nouocaledonica	E	L	I (+,+)	I (+,+)	I (+,3)	
Myrtaceae						
Austromyrtus sp j.2535	E	L	I (2,3)	I (1,3)		
Austromyrtus sp v.6578	E	L	III (+,1)			I (1,1)
Cloezia artensis	E	LO	I (+,5)	III (+,5)		
Eugenia balansae	E	LO				I (+,1)
Eugenia brongnartiana	E	FLO			I (+,+)	I (1,2)
Eugenia daenikeri	E	L		I (+,1)		
Eugenia ericoides	E	LO	I (+,+)	I (+,1)		
Eugenia gacognei	E	FLO	V (1,3)	III (+,3)	III (+,2)	
Eugenia lepredourii (Dawson ined.)	E	L	II (+,1)	I (2,2)		
Eugenia noumeensis	E	L	III (+,1)	I (1,1)		
Eugenia sp v.6579	E	FL				I (1,1)
Eugenia sp v.7019	E	FL			I (+,+)	V (+,3)
Melaleuca quinqueneruia	A	O			I (1,3)	
Piliocalyx eugenioides	E	FLO				II (1,1)
Psidium guajava	I	O		I (+,+)	III (+,1)	I (+,+)
Syzygium cumini	I	O			I (+,+)	
Nyctaginaceae						
Pisonia aculeata	A	FL		I (1,1)		I (+,+)
Oleaceae						
Jasminum didymum	A	FLO		IV (+,2)	V (+,3)	IV (+,+)
Jasminum simplicifolium	E	FLO		I (+,+)	II (+,1)	
Olea paniculata	A	FLO			IV (1,4)	V (+,4)
Oxalidaceae						
Oxalis corniculata	A	LO	V (+,5)	II (+,1)	II (+,+)	
Oxalis debilis	I	O		I (+,+)		
Passifloraceae						
Passiflora foetida	I	O			I (+,+)	I (+,+)
Passiflora suberosa	I	O	III (+,+)	V (+,3)	V (+,1)	V (+,1)
Peperomiaceae						
Peperomia sp v.6429	E	FL		I (+,+)	III (+,1)	I (+,+)
Phytolaccaceae						
Rivina humilis	I	O	I (+,+)	II (+,1)	II (+,1)	IV (+,5)
Piperaceae						
Piper austrocaledonicum	A	FL			I (+,+)	I (+,+)

Appendix — continued

Species	Status	Ecol. D.	Floristic groups I	II	III	N
Pittosporaceae						
Pittosporum cherrieri	E	FL		I (+,+)	II (+,+)	II (+,+)
Pittosporum pancheri	E	FL		I (+,+)		
Pittosporum tanianum	E	L	I (+,+)			
Proteaceae						
Stenocarpus trinervis	E	FLO			I (1,2)	
Ranunculaceae						
Clematis pickeringii	A	LO		I (+,+)	II (+,+)	
Rhamnaceae						
Alphitonia neocaledonica	E	FLO			I (+,+)	I (1,3)
Colubrina asiatica	A	LO			I (+,+)	
Emmenosperma pancherianum	E	L	I (+,+)			
Gouania leratii	E	LO		II (+,1)	I (+,1)	
Rhamnella vitiensis	A	LO	I (+,+)	III (+,2)	III (+,2)	I (1,1)
Ventilago pseudocalyculata	E	FL	I (+,+)	I (+,+)	III (+,1)	V (+,2)
Rubiaceae						
Atractocarpus sp mk.41192	E	L		I (+,3)	I (1,1)	II (+,1)
Gardenia urvillei	E	L		IV (+,3)		
Ixora cauliflora	E	FL			I (+,4)	II (+,1)
Ixora collina	A	FLO			II (+,+)	I (+,+)
Ixora sp mk.42139	E	FL			I (+,+)	I (+,+)
Morinda citrifolia	A	FLO			I (1,1)	
Morinda mollis	A	LO		I (+,+)		
Morinda myrtifolia	A	FO	II (+,1)	II (+,2)	II (+,1)	II (+,+)
Pavetta opulina	A	FL		III (+,1)	I (+,+)	II (+,+)
Psychotria collina	A	FLO		II (+,2)	II (+,+)	V (+,1)
Psychotria deverdiana	E	LO		I (1,1)		
Psychotria semperflorens	E	FLO				I (+,+)
Psychotria sp v.7349	E	L				I (1,1)
Psychotria speciosa	E	FLO				III (+,+)
Psydrax odorata	A	LO	II (+,1)	II (+,2)	I (+,+)	I (+,1)
Spermacoce assurgens	A	LO			I (+,+)	
Rutaceae						
Acronychia laevis	A	LO		I (+,+)	II (+,1)	III (+,2)
Geijera balansae	E	FL			III (+,3)	
Geijera cauliflora	E	LO	I (+,+)	I (1,1)		
Halfordia kendac	A	LO		I (1,2)		
Micromelum minutum	A	FL		I (+,+)		IV (+,2)
Murraya crenulata	A	FL				I (+,+)
Murraya paniculata	A	FL		I (+,+)	I (+,+)	II (+,1)
Oxanthera sp 71.7005	E	L	II (+,1)	I (1,1)		
Picrella trifoliata va?: gracile	E	L		II (+,3)		
Picrella trifoliata va?: trifoliata	E	FLO	I (1,1)	I (+,+)	I (+,+)	II (+,+)
Sarcomelicope leiocarpa	E	FL		I (+,1)	II (+,1)	III (+,3)
Zanthoxylum pancheri	E	FLO	II (+,+)	II (+,1)	I (+,1)	I (+,+)
Santalaceae						
Santalum austrocaledonicum	E	FLO			I (2,2)	
Sapindaceae						
Alectryon carinatum	E	FL	IV (+,3)	I (+,1)	I (+,+)	I (+,+)
Arytera arcuata	E	FL				I (3,3)
Arytera chartacea	E	FL	II (+,1)	III (+,3)	IV (+,2)	II (+,2)
Arytera collina	E	L	IV (1,3)	V (+,5)	I (+,+)	
Cupaniopsis globosa	E	L		I (+,+)	II (+,3)	II (+,2)
Cupaniopsis glomeriflora	E	FLO		I (+,+)	III (+,1)	V (+,2)
Cupaniopsis trigonocarpa	E	FL			I (+,+)	III (+,2)
Dodonaea viscosa	A	LO		I (+,+)	I (+,1)	
Elattostachys apetala	A	FL		II (+,2)	IV (+,4)	III (+,2)
Guioa gracilis	E	FL			I (+,+)	
Harpullia austrocaledonica	E	FL			I (+,1)	I (1,2)
Podonephelium homei	E	FLO			I (1,1)	II (+,1)
Sapotaceae						
Leptostylis sp v.6850	E	L	I (+,1)	I (1,2)		
Planchonella cinerea	E	L	I (1,1)	IV (+,4)	II (+,3)	
Planchonella luteocostata	E	L	III (+,3)	I (3,3)	I (1,1)	
Simaroubaceae						
Soulamea tomentosa	E	FL		I (1,1)	II (+,5)	

Appendix — continued

Species	Status	Ecol. D.	Floristic groups 1	II	III	IV
Solanaceae						
Solanum pancheri	E	LO		I (1,2)		
Solanum sp	E	FL			I (+,+)	
Solanum seaforthianum	I	O	V (+,1)			I (+,+)
Solanum tetrandrum	A	LO		III (+,2)	I (+,+)	
Thymelaeaceae						
Lethedon tannenszs	E	FLO			III (+,2)	
Wikstroemia zndzca	A	FLO	V (+,2)	III (+,1)	IV (+,2)	
Tiliaceae						
Grewia crenata	A	FLO		I (+,+)	I (+,+)	I (+,+)
Triumfetta rhombozdea	I	O			I (+,+)	
Ulmaceae						
Celtzs balansae	E	FL				III (+,3)
Celtzs conferta	A	LO	III (+,1)	III (+,2)	V (+,1)	III (+,2)
Trema cannabina	A	LO			I (+,+)	
Verbenaceae						
Lantana camara	I	O	V (+,1)	III (+,+)	III (+,+)	
Lantana montevidensis	I	O			I (+,3)	
Stachytarpheta australis	I	O		I (+,+)	III (+,+)	I (+,+)
Violaceae						
Hybanthus caledonicus	E	FLO		II (+,1)	II (+,4)	I (2,2)
Vitaceae						
Cissus glaucoramea	A	FLO			I (+,+)	I (+,1)