EDINBURGH JOURNAL OF BOTANY 60 (1): 57–109 (2003) 57
DOI: 10.10M/S0960428603000064

ANALYSIS OF THE FLORISTIC COMPOSITION OF THE BRAZILIAN CERRADO VEGETATION III: COMPARISON OF THE WOODY VEGETATION OF 376 AREAS

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An analysis was made of the floristic composition of 376 areas of cerrado and Amazonian savanna, encompassing most of the area of such vegetation in Brazil. A total of 951 species of trees and large shrubs was recorded for these areas, of which 334 (35%) occurred at only a single locality (unicates). The core cerrado area and its outliers were studied in 315 areas, and 914 species were recorded. However, only 300 species occurred at more than eight of the sites (i.e. $\geq$2.5% of the total) and only 38 species at $\geq$50%, while the remaining 614 species, including 309 unicates, are very rare. About 300 species, therefore, dominate the core cerrado area; this number is expanded to 350 if the southern São Paulo cerrados are included. Alpha diversity, the number of tree species occurring in a single community, is often high, with more than 100 species of trees and shrubs growing together. We noted particular 'hotspots' in the drainage of the rivers Araguaia, Tocantins and Xingu, but high diversity figures occur in many other areas of the cerrado core, and also in São Paulo state. On the other hand, the disjunct Amazonian savannas, with the exception of Alter do Chão (Pará) and one site at Humaitá (Amazonas), represent a low diversity vegetation in which 117 species of trees and large shrubs were recorded in the 58 sites analysed. Of these, 77 are widespread species common in the core cerrados. The alpha diversity of disjunct Amazonian savannas seldom exceeds a dozen species of trees and large shrubs. The data were analysed using two techniques of multivariate analysis which we had found particularly appropriate in our previous work: (a) a divisive hierarchical classification by Two-Way Indicator Species Analysis (TWINSPAN), and (b) an agglomerative hierarchical classification by UPGMA (Unweighted Pair-Groups Method using Arithmetic Averages), using the Sørensen Coefficient of Community (cc) as a measure of similarity. The results of both methods showed great similarity, demonstrating a strong geographical pattern in the distribution of the cerrado biome similar to that outlined in the preliminary scheme of our previous work. The following geographic groups were recognized:

(i) A very distinctive group of southern sites in São Paulo, Paraná and southern Minas Gerais.

(ii) Central and southeastern sites from the Federal District, neighbouring Goiás, and southern and central Minas Gerais.

(iii) North and northeastern sites from Bahia, Ceará, the extreme north of Minas Gerais, Maranhão, Piauí, Tocantins, and one site in Pará very close to the Tocantins border.

(iv) Central-western sites made up of a huge swathe running across the states of Mato Grosso do Sul, Mato Grosso, Goiás, Tocantins, and into Pará.

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(v) Widely spread sites with a strong mesotrophic character; this group is particularly well represented in Mato Grosso do Sul.
(vi) Far western mesotrophic sites, forming a small group in Rondônia, Mato Grosso do Sul and Mato Grosso.
(vii) Disjunct Amazonian sites forming a very distinct group separated from the other sites at the first division of both TWINSPAN and UPGMA.

Keywords. Amazonian savanna, biodiversity, cerrado, multivariate analyses, phytogeography, woody vegetation.

Resumo

Efetuou-se a análise da composição florística de 376 áreas de cerrado e savana amazônica, abrangendo a maior parte da área ocupada por esta vegetação no Brasil. Registrou-se um total de 951 espécies de árvores e arbustos grandes, das quais 334 (35%) ocorreram em uma única localidade (unicatas). A flora do cerrado nuclear (excluindo as savanas amazônicas disjuntas) foi estudada em 315 áreas, com 914 espécies registradas. Dentre estas, apenas 300 espécies ocorreram em oito locais ou mais (ou seja, pelo menos em 2,5% do total) e somente 38 espécies estiveram presentes em 50% das áreas ou mais. As restantes 614 espécies, incluindo 309 unicatas, são muito raras. Cerca de 300 espécies, portanto, dominam a área nuclear do cerrado e esse número chega a 350 se forem considerados os cerrados de São Paulo. A diversidade alfa (número de espécies ocorrendo em uma única comunidade) é freqüentemente alta, com mais de 100 espécies de árvores ou arbustos compartilhando o espaço. Foram observados alguns 'hotspots' na bacia dos rios Araguaia, Tocantins e Xingu, mas muitas outras áreas de alta diversidade encontram-se na região nuclear do cerrado e também no Estado de São Paulo. Por outro lado, as isoladas savanas amazônicas, com exceção de Alter do Chão (Pará) e um sítio em Humaitá (Amazonas), contêm baixa diversidade florística, tendo sido registradas apenas 177 espécies em 58 áreas estudadas. Dentre estas, 77 são espécies de distribuição ampla, comuns na região nuclear do cerrado. A diversidade alfa das savanas amazônicas raramente vai além de uma dúzia de espécies de árvores ou arbustos grandes. Os dados foram submetidos a duas técnicas de análise multivariada que se mostraram particularmente apropriadas em nossos estudos anteriores: (a) uma classificação hierárquica divisiva por 'Two-Way Indicator Species Analysis' (TWINSPAN) e (b) uma classificação hierárquica aglomerativa por 'Unweighted Pair-Groups Method using Arithmetic Averages' (UPGMA), utilizando o Coeficiente de Comunidade de Sørensen (cc) como índice de similaridade. Os dois métodos apresentaram resultados semelhantes, demonstrando um forte padrão fitogeográfico na distribuição do bioma cerrado, conforme verificado nos esquemas preliminares gerados por nossos trabalhos anteriores. Os seguintes grupos fitogeográficos foram reconhecidos:
(i) Meridional, um grupo bastante distinto composto por áreas de São Paulo, Paraná e sul de Minas Gerais.
(ii) Centro-sudeste, com áreas do Distrito Federal, áreas vizinhas de Goiás, sul e centro de Minas Gerais.
(iii) Norte-nordeste, com áreas do extremo norte de Minas Gerais, Bahia, Ceará, Maranhão, Piauí e Tocantins e uma área do Pará próxima à divisa com Tocantins.
(iv) Centro-oeste, com áreas distribuídas em uma extensa faixa através dos estados de Mato Grosso do Sul, Mato Grosso, Goiás, Tocantins e Pará.
(v) Áreas amplamente dispersas com um forte caráter mesotrófico – este grupo particularmente bem representado em Mato Grosso do Sul.

(vi) Áreas mesotróficas do extremo oeste, formando um pequeno grupo em Rondônia, Mato Grosso do Sul e Mato Grosso.
(vii) Áreas isoladas da Amazônia, formando um grupo muito distinto, separado dos outros na primeira divisão por TWINSPAN e UPGMA.

Palavras-chaves. Análises multivariadas, biodiversidade, cerrado, fitogeografia, savanas amazônicas, vegetação lenhosa.

Introduction

This is the third communication in a series reporting floristic diversity and patterns of geographic composition of woody cerrado vegetation. The first (Ratter & Dargie, 1992) reported a comparison of 26 areas of cerrado, representing all the survey records available to us in 1986–87, while the second (Ratter *et al*., 1996) compared 98 areas for which information existed in 1994. The present communication is based on surveys of 376 areas, demonstrating the enormous increase in scientific work carried out in the cerrado biome during the last few years. When one of us (J.A.R.) started work in the cerrado in 1967 the literature on the biome was tiny, but it has now increased to a very large corpus of, often disparate, information. Much of the present interest in the cerrado has been stimulated by the realization that the biome is a world centre of biodiversity (Dias, 1992; Fonseca *et al*., 2000; Myers *et al*., 2000) and that it is highly endangered by the expansion of modern agriculture, already having lost nearly 50% of its original 2 million km^2 area (Alho & Martins, 1995; Ratter *et al*., 1997).

Several recent projects have provided large quantities of information. The *Conservação e Manejo da Biodiversidade do Bioma Cerrado* (CMBBC) project based on collaboration of Embrapa Cerrados, University of Brasília, and the Royal Botanic Garden Edinburgh, with funding from the UK Department for International Development (DFID), has carried out 170 surveys in the northern and central-western parts of the cerrado biome (Ratter *et al*. 2000a, 2001). Miranda (1997) has made a comprehensive survey of the Amazonian savannas of Roraima including the inventory of 45 sites. The *Biogeografia dos Cerrados* project team based in Brasília has made many surveys in the extensive Chapadas Pratinha and dos Veadeiros in Central Brazil (see for example Felfili & Silva Junior (1993) and Felfili *et al*. (1997)), while the group of Brandão and associates has worked over a great area of southern and central Minas Gerais. In addition, Durigan (2001) and Durigan *et al*. (in press) have studied 86 areas as part of the project *Conservation Feasibility of the Cerrado Remnants in São Paulo State*, financed by the Biota Programme. Since they are so recent, data from the last project are not included in the multivariate analyses of the 376 areas in the present paper, but are considered at various points in the text. As discussed in our previous works, studies similar to ours have been carried out by Dr Alberto Jorge F. de Castro of the Federal University of Piauí (Castro, 1994a,b; Castro *et al*., 1998, 1999; Castro & Martins, 1999) and provide essential data for comparison.

Materials and Methods

Floristic and soil data

As in our previous work (Ratter *et al.*, 1996) the existing database was expanded by searching literature for floristic lists and by the addition of our own new surveys, almost entirely produced as part of the CMBBC project. As previously discussed in Ratter & Dargie (1992) and Ratter *et al.* (1996), the survey sites vary greatly in area, and different workers have used different plant-size criteria for species inclusion; nevertheless we feel the floristic lists provide a reasonable basis for comparison. The sites range in richness of woody species from some of those of the cerrado core area and its southern outliers with considerably more than 100 species to Amazonian savannas containing only a single woody species. In total, data were assembled for 376 sites, giving representative cover for about 75% of the cerrado domain and also including a large number of Amazonian savanna sites. The localities are listed in Table 1 and shown on the map in Fig. 1 (p. 72).

Only those species forming trees or large shrubs and belonging to the savannic element of the cerrado biome (i.e. cerrado *sensu lato*, consisting of campo sujo, cerrado ralo (campo cerrado), cerrado *sensu stricto*, and cerradão) were entered in the comparisons. The other woody communities of the biome such as gallery and mesophytic forests were not included. 'Large shrubs' were defined as having the capability to attain 1.5m in height and 3cm basal diameter, so that small and slender shrubs with shoots of short duration produced from a long-lived rootstock (geoxyles or hemixyles), an important growth-form in the cerrado biome, were excluded. In some cases it is difficult to decide whether a species should qualify for inclusion or not, and readers may disagree over some of the choices; a number of such examples are discussed in Ratter *et al.* (2000a, p. 9). The occurrence of a species in our surveys is registered if it has the potential of reaching the qualifying size, even if the only plant present is a small, young individual. However, this is not the case in the work of many other authors, particularly those specializing in physiognomic studies, who record only individuals reaching a qualifying size.

As yet data are insufficient to allow extensive phytogeographic comparisons including species of the 'ground layer' ('vegetação rasteira'). In the rare instances where detailed floristic lists including the ground layer are available (e.g. Ratter, 1986; Pereira *et al.*, 1993) they record four to six times the number of small species as for trees and large shrubs, and thus collection of data is a much greater task.

A list of taxa used in the study is given in Appendices 1 and 2; all are identified to specific or morphospecific level (occasionally without a formal epithet, for example to genus or family with collector's number) since taxa with less complete determinations (vernacular names, etc.) do not provide a reliable basis for comparison. In our surveys some sterile specimens, usually belonging to taxonomically notoriously difficult groups, could not be identified with sufficient accuracy to have any value in comparisons and have therefore been excluded from the list. The quantity of such material was small: perusal of our data for a representative sample consisting of

TABLE 1. Areas of cerrado (and Amazonian savannas) compared in the study. The sites are arranged by state from south to north, and alphabetically within each state. NS, no. of species; MS, no. of mesotrophic species; MI, mesotrophic index (see p. 71); R. *et al.*, Ratter *et al.*

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
1	PR01	Jaguariaíva	24°09′S, 50°18′W	78	0	0	Uhlmann (1995), Uhlmann *et al.* (1998)
2	SP01	Analândia	22°08′S, 47°40′W	60	0	0	Pagano *et al.* (1989)
3	SP02	Angatuba	23°28′S, 48°28′W	70	1	0.01	R. *et al.* (1988a)
4	SP03	Botucatu	22°45′S, 48°25′W	53	1	0.02	Silberbauer-Gottsberger & Eiten (1983)
5	SP04	Brotas-Itirapina	22°15′S, 47°49′W	38	0	0	Souza (1977)
6	SP05	Corumbataí	22°13′S, 47°37′W	86	2	0.02	Pagano *et al.* (1989)
7	SP06	Corumbataí	22°15′S, 47°00′W	92	3	0.03	Cesar *et al.* (1988)
8	SP07	E. Ecológica de Assis	22°36′S, 50°23′W	193	10	0.05	Durigan *et al.* (1999)
9	SP08	Emas	22°02′S, 47°30′W	106	3	0.03	Batalha *et al.* (1997)
10	SP09	Fazenda Campininha	22°15′S, 47°10′W	103	3	0.03	Gibbs *et al.* (1983), Eiten (1963)
11	SP10	Itirapina	22°19′S, 47°44′W	68	1	0.01	Pagano *et al.* (1989)
12	SP11	Itirapina	22°08′S, 47°47′W	42	0	0	Durigan *et al.* (1994)
13	SP12	Itirapina	22°15′S, 47°49′W	117	4	0.03	Gianotti & Leitão Filho (1992)
14	SP13	Luis Antônio Expt. Stn.	21°40′S, 47°49′W	62	1	0.02	Toledo-Filho (1984)
15	SP14	Moji Guaçu	22°15′S, 47°08′W	118	5	0.04	Mantovani & Martins (1993)
16	SP15	Mojí-Mirim	22°26′S, 46°57′W	90	3	0.03	Toledo-Filho *et al.* (1989)
17	SP16	Pé de Gigante	21°38′S, 47°36′W	87	0	0	Castro (1994a)
18	SP17	Sta. Maria da Serra	22°38′S, 48°07′W	61	1	0.02	Pagano *et al.* (1989)
19	SP18	Vaçununga	21°41′S, 47°37′W	70	0	0	Castro (1987)
20	MG01	Alpinópolis	20°55′S, 46°15′W	46	0	0	Carvalho (1987)
21	MG02	Araxá	19°46′S, 46°55′W	39	0	0	Brandão & Gavilanes (1992)
22	MG03	Arinos	15°28′S, 45°47′W	71	1	0.01	R. *et al.* (2001)
23	MG04	Arinos	15°55′S, 46°09′W	58	5	0.08	R. *et al.* (2001)
24	MG05	Bocaiuva	16°45′S, 43°52′W	35	6	0.17	Camargo (1997)
25	MG06	Campo do Meio	21°06′S, 45°50′W	56	1	0.02	Carvalho (1987)
26	MG07	Corinto	18°22′S, 44°27′W	54	5	0.09	Brandão & Gavilanes (1992)
27	MG08	Coromandel	18°20′S, 47°12′W	43	1	0.02	Brandão & Gavilanes (1992)
28	MG09	Curvelo	18°45′S, 44°27′W	59	6	0.1	Brandão & Gavilanes (1992), Rizzini (1975)
29	MG10	Fazenda Trijunção (Formoso)	14°53′S, 46°02′W	65	0	0	R. *et al.* (2001)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
30	MG11	Fazenda Trijunção (Formoso)	14°52′S, 46°02′W	45	0	0	R. *et al.* (2001)
31	MG12	Fazenda Trijunção (Formoso)	14°52′S, 46°02′W	64	0	0	R. *et al.* (2001)
32	MG13	Fazenda Brejão, Brasilândia	17°02′S, 45°50′W	97	11	0.11	Almeida Lima (1997)
33	MG14	Felixlândia	18°45′S, 44°52′W	55	5	0.09	Brandão & Gavilanes (1992)
34	MG15	Galheiro-Perdizes	18°55′S, 48°55′W	47	0	0	Cardoso *et al.* (2002)
35	MG16	Itumirim	21°18′S, 44°48′W	47	2	0.04	Brandão & Gavilanes (1992)
36	MG17	Januária	15°20′S, 44°23′W	38	8	0.21	R. *et al.* (1977)
37	MG18	Januária	15°32′S, 44°36′W	48	7	0.15	R. *et al.* (2001)
38	MG19	Lagoa Santa	19°39′S, 43°44′W	57	6	0.1	Brandão & Gavilanes (1992)
39	MG20	Lagoa Santa	19°39′S, 43°44′W	135	11	0.08	Warming (1892)
40	MG21	Lavras	21°14′S, 44°59′W	69	5	0.07	Brandão & Gavilanes (1992)
41	MG22	Montes Claros	16°45′S, 43°52′W	74	4	0.06	Araújo (1994)
42	MG23	Montes Claros	16°45′S, 43°52′W	105	9	0.09	Brandão *et al.* (1993b)
43	MG24	Montes Claros	16°45′S, 43°52′W	76	9	0.12	Brandão & Gavilanes (1992)
44	MG25	Pandeiros	15°29′S, 44°40′W	44	1	0.02	R. *et al.* (2001)
45	MG26	Pandeiros	15°31′S, 44°45′W	50	2	0.04	R. *et al.* (2001)
46	MG27	Paracatú	17°00′S, 46°45′W	53	1	0.02	Felfili & Silva Junior (1993)
47	MG28	Paraopeba	19°20′S, 44°20′W	111	13	0.12	Thibau *et al.* (1975)
48	MG29	Paraopeba	19°20′S, 44°20′W	60	7	0.11	Silva Junior (1984)
49	MG30	Paraopeba	19°18′S, 44°25′W	60	5	0.08	Brandão & Gavilanes (1992)
50	MG31	Patos de Minas	18°34′S, 46°31′W	33	1	0.03	Brandão & Gavilanes (1992)
51	MG32	Patrocínio	18°47′S, 46°25′W	57	1	0.02	Felfili & Silva Junior (1993)
52	MG33	Pedro Leopoldo	19°38′S, 44°03′W	90	9	0.1	Brandão & Gavilanes (1997)
53	MG34	Pedro Leopoldo	19°39′S, 44°03′W	28	2	0.07	Rizzini (1975)
54	MG35	Pimenta	20°30′S, 45°50′W	73	4	0.05	Carvalho (1987)
55	MG36	Prudente de Morais	19°28′S, 44°15′W	128	8	0.06	Brandão *et al.* (1996)
56	MG37	Prudente de Morais	19°36′S, 44°04′W	58	4	0.07	Brandão & Gavilanes (1992)
57	MG38	Sagarana	16°00′S, 46°30′W	48	14	0.29	R. *et al.* (1996)
58	MG39	São Joaquim	15°29′S, 45°10′W	63	2	0.03	R. *et al.* (2001)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
59	MG40	São Roque de Minas	20°22′S, 46°11′W	33	0	0	R. *et al.* (2001)
60	MG41	São Roque de Minas	20°16′S, 46°21′W	55	0	0	R. *et al.* (2001)
61	MG42	Sete Lagoas	19°27′S, 44°14′W	113	10	0.09	Brandão *et al.* (1993a)
62	MG43	Sete Lagoas	19°32′S, 44°06′W	69	4	0.06	Brandão & Gavilanes (1992)
63	MG44	Três Marias	18°12′S, 45°10′W	55	6	0.11	Brandão & Gavilanes (1992)
64	MG45	Triângulo Mineiro	19°29′S, 48°50′W	116	9	0.08	Goodland (1970)
65	MG46	Uberaba	19°47′S, 47°57′W	35	0	0	Brandão & Gavilanes (1992)
66	MG47	Mun. de Uberaba	19°47′S, 47°57′W	106	10	0.09	Brandão *et al.* (1995)
67	MG48	Mun. de Uberlândia	18°55′S, 48°55′W	68	0	0	Apolinário (1995)
68	MG49	Mun. de Uberlândia	18°55′S, 48°55′W	39	1	0.03	Araújo *et al.* (1997)
69	MG50	Mun. de Uberlândia	18°55′S, 48°55′W	46	0	0	Araújo *et al.* (1997)
70	MG51	Mun. de Uberlândia	18°55′S, 48°55′W	33	0	0	Araújo *et al.* (1997)
71	MG52	Mun. de Uberlândia	18°55′S, 48°55′W	40	0	0	Araújo *et al.* (1997)
72	MG53	Mun. de Uberlândia	18°55′S, 48°55′W	33	0	0	Araújo *et al.* (1997)
73	MG54	Mun. de Uberlândia	18°55′S, 48°55′W	41	0	0	Araújo *et al.* (1997)
74	MG55	Mun. de Uberlândia	18°55′S, 48°55′W	41	0	0	Araújo *et al.* (1997)
75	MG56	Mun. de Uberlândia	18°55′S, 48°55′W	40	0	0	Araújo *et al.* (1997)
76	MG57	Mun. de Uberlândia	18°55′S, 48°55′W	38	1	0.03	Araújo *et al.* (1997)
77	MG58	Mun. de Uberlândia	18°55′S, 48°55′W	38	0	0	Araújo *et al.* (1997)
78	MG59	Mun. de Uberlândia	18°55′S, 48°55′W	22	0	0	Araújo *et al.* (1997)
79	MG60	Mun. de Uberlândia	18°55′S, 48°55′W	36	0	0	Araújo *et al.* (1997)
80	MG61	Mun. de Uberlândia	18°55′S, 48°55′W	37	0	0	Araújo *et al.* (1997)
81	MG62	Mun. de Uberlândia	18°55′S, 48°55′W	40	0	0	Araújo *et al.* (1997)
82	MG63	Mun. de Uberlândia	18°55′S, 48°55′W	35	0	0	Araújo *et al.* (1997)
83	MG64	Mun. de Uberlândia	18°55′S, 48°55′W	40	0	0	Araújo *et al.* (1997)
84	MG65	Mun. de Uberlândia	18°55′S, 48°55′W	43	0	0	Araújo *et al.* (1997)
85	MG66	Mun. de Uberlândia	18°55′S, 48°55′W	33	0	0	Araújo *et al.* (1997)
86	MG67	Mun. de Uberlândia	18°55′S, 48°55′W	45	0	0	Araújo *et al.* (1997)
87	MG68	Mun. de Uberlândia	18°55′S, 48°55′W	27	0	0	Araújo *et al.* (1997)
88	MS01	Água Clara	20°27′S, 52°52′W	54	1	0.02	R. *et al.* (2001)
89	MS02	Água Clara	20°26′S, 53°03′W	60	0	0	R. *et al.* (2001)
90	MS03	Água Clara	20°25′S, 53°21′W	65	1	0.01	R. *et al.* (2001)
91	MS04	Anhanduí	20°49′S, 54°29′W	74	7	0.09	R. *et al.* (2001)
92	MS05	Aquidauana (Serra de Maracaju)	20°30′S, 55°37′W	43	5	0.11	R. *et al.* (2001)
93	MS06	Aquidauana	20°23′S, 56°04′W	51	20	0.39	R. *et al.* (2001)
94	MS07	Aquidauana	20°32′S, 55°24′W	68	18	0.26	R. *et al.* (2001)
95	MS08	Autopôsto de Piqui	21°16′S, 55°03′W	52	14	0.27	R. *et al.* (2001)
96	MS09	Autopôsto de Piquí (2)	21°05′S, 54°57′W	40	5	0.12	R. *et al.* (2001)
97	MS10	Bodoquena	20°23′S, 56°31′W	28	13	0.46	R. *et al.* (2001)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
98	MS11	Bonito	20°50′S, 56°37′W	57	19	0.33	R. *et al.* (2001)
99	MS12	Bonito	20°58′S, 56°32′W	50	22	0.44	R. *et al.* (2001)
100	MS13	Camapuã	19°30′S, 53°58′W	64	10	0.16	R. *et al.* (2001)
101	MS14	Camapuã	19°23′S, 53°36′W	76	6	0.08	R. *et al.* (2001)
102	MS15	Campo Grande	20°26′S, 55°06′W	63	5	0.08	R. *et al.* (2001)
103	MS16	Cipolândia	20°00′S, 55°20′W	65	9	0.14	R. *et al.* (2001)
104	MS17	Coxim	18°30′S, 54°42′W	72	5	0.07	R. *et al.* (2001)
105	MS18	Fazenda Acurizal	17°45′S, 57°37′W	57	18	0.32	Prance & Schaller (1982)
106	MS19	Fazenda Água Amarela	21°46′S, 56°14′W	59	20	0.34	R. *et al.* (2001)
107	MS20	Fazenda Nhumirim	18°59′S, 56°39′W	88	17	0.19	Pott *et al.* (1986)
108	MS21	Fazenda Renascença	20°25′S, 52°46′W	70	3	0.04	R. *et al.* (2001)
109	MS22	Guia Lopes da Laguna	21°24′S, 56°01′W	59	15	0.25	R. *et al.* (2001)
110	MS23	Maracajú	21°27′S, 55°09′W	29	16	0.55	R. *et al.* (2001)
111	MS24	Paraíso	19°04′S, 52°27′W	75	3	0.04	R. *et al.* (2001)
112	MS25	Paranaíba	19°20′S, 51°20′W	68	5	0.07	R. *et al.* (2001)
113	MS26	Porto d'Areia	20°53′S, 51°40′W	56	9	0.16	R. *et al.* (2001)
114	MS27	Ribas do Rio Pardo	20°27′S, 53°46′W	72	4	0.05	R. *et al.* (2001)
115	MS28	Rio Caracol	21°41′S, 56°48′W	63	22	0.35	R. *et al.* (2001)
116	MS29	São Gabriel do Oeste	19°31′S, 54°27′W	69	1	0.01	R. *et al.* (2001)
117	MS30	Serrinha	20°37′S, 52°15′W	52	14	0.27	R. *et al.* (2001)
118	MS31	Sidrolândia	20°16′S, 55°03′W	35	12	0.34	R. *et al.* (2001)
119	MS32	Três Lagoas	20°40′S, 52°08′W	63	14	0.22	R. *et al.* (2001)
120	MS33	Inocência	20°00′S, 51°52′W	75	5	0.07	R. *et al.* (2001)
121	DF01	Águas Emendadas	15°31′S, 47°32′W	65	1	0.01	Felfili & Silva Junior (1993)
122	DF02	Águas Emendadas	15°31′S, 47°32′W	133	6	0.04	Silva Junior & Felfili (1996)
123	DF03	APA Gama da Cab. Vead.	15°52′S, 47°50′W	59	1	0.02	Felfili & Silva Junior (1993)
124	DF04	Brasília National Park	15°37′S, 47°54′W	140	13	0.09	Ramos (1995)
125	DF05	Brasília National Park	15°37′S, 47°54′W	52	0	0	Felfili & Silva Junior (1993)
126	DF06	Fazenda Água Limpa	15°45′S, 47°57′W	130	4	0.03	Ratter (1986)
127	DF07	Campus, UnB	15°43′S, 47°54′W	67	0	0	Heringer (1971)
128	DF08	Jardim Botânico, Brasília	15°48′S, 47°50′W	83	6	0.07	Azevedo *et al.* (1990)
129	DF09	Parque Ecológica Norte, Brasília	15°45′S, 47°55′W	52	0	0	Rossi *et al.* (1998)
130	DF10	Planaltina	15°39′S, 47°38′W	111	1	0.01	Ribeiro *et al.* (1985)
131	DF11	Res. Ecol. do IBGE	15°55′S, 47°53′W	114	6	0.05	Pereira *et al.* (1993)
132	DF12	São Bartolomeu	15°50′S, 47°30′W	137	6	0.04	Pereira *et al.* (1985)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
133	DF13	nr. Brasília	15°55′S, 47°57′W	90	0	0	Eiten & Sambuichi (1996)
134	GO01	Porangatu	12°51′S, 49°06′W	90	13	0.14	R. *et al.* (2001)
135	GO02	Porangatu	13°50′S, 49°03′W	85	15	0.17	R. *et al.* (2001)
136	GO03	Aparecida do Rio Claro	15°52′S, 51°04′W	68	21	0.31	R. *et al.* (2001)
137	GO04	Baliza	16°30′S, 52°23′W	74	1	0.01	CMBBC (unpubl.)
138	GO05	Bandeirantes	13°41′S, 50°43′W	92	11	0.12	R. *et al.* (2001)
139	GO06	Caiapônia & Mineiros	17°22′S, 52°10′W	58	15	0.26	R. *et al.* (1996)
140	GO07	Caiapônia	16°57′S, 51°49′W	125	22	0.18	R. *et al.* (1996)
141	GO08	Campos Belos	13°16′S, 46°57′W	71	18	0.25	R. *et al.* (2001)
142	GO09	Chapada dos Veadeiros	14°07′S, 47°16′W	89	27	0.3	R. *et al.* (1996)
143	GO10	Chapada dos Veadeiros	14°07′S, 47°31′W	54	1	0.02	R. *et al.* (1996)
144	GO11	Chapada dos Veadeiros	14°07′S, 47°13′W	59	15	0.25	R. *et al.* (1996)
145	GO12	Chapada dos Veadeiros	13°55′S, 47°23′W	62	0	0	R. *et al.* (1996)
146	GO13	Chapada dos Veadeiros	14°02′S, 47°26′W	51	0	0	R. *et al.* (1996)
147	GO14	Colinas do Sul	14°26′S, 48°08′W	74	4	0.05	R. *et al.* (2001)
148	GO15	Doverlândia	16°52′S, 52°20′W	100	17	0.17	CMBBC (unpubl.)
149	GO16	Doverlândia	16°44′S, 52°37′W	72	21	0.29	CMBBC (unpubl.)
150	GO17	Jussara	16°05′S, 50°48′W	83	10	0.12	R. *et al.* (2001)
151	GO18	Iporá	16°23′S, 51°02′W	70	10	0.14	R. *et al.* (2001)
152	GO19	Israelândia	16°14′S, 50°47′W	79	16	0.2	R. *et al.* (2001)
153	GO20	Israelândia	16°19′S, 50°59′W	74	16	0.22	R. *et al.* (2001)
154	GO21	Itarumã	18°55′S, 51°27′W	75	6	0.08	R. *et al.* (2001)
155	GO22	Jataí	17°58′S, 51°45′W	61	6	0.1	R. *et al.* (1996)
156	GO23	Niquelândia	14°27′S, 48°18′W	87	11	0.13	R. *et al.* (2001)
157	GO24	Nova Crixás	14°16′S, 50°15′W	80	8	0.1	R. *et al.* (2001)
158	GO25	Crixás	14°24′S, 50° 08′W	90	14	0.15	R. *et al.* (2001)
159	GO26	Padre Bernardo	15°15′S, 48°30′W	83	15	0.18	R. *et al.* (1977)
160	GO27	Parque Nacional das Emas	17°49′S, 52°39′W	55	1	0.02	Álvares da Silva (1996)
161	GO28	São Miguel do Araguaia	13°16′S, 49°58′W	86	14	0.16	R. *et al.* (2001)
162	GO29	Serra Dourada	16°22′S, 50°20′W	40	0	0	Rizzo (1970)
163	GO30	Silvânia	16°30′S, 48°30′W	64	2	0.03	Felfili & Silva Junior (1993)
164	GO31	Sta. Terezinha de Goiás	14°22′S, 49°31′W	84	13	0.15	R. *et al.* (2001)
165	GO32	Teresina do Goiás	13°40′S, 47°14′W	88	13	0.15	R. *et al.* (2001)
166	GO33	Uruaçú	14°29′S, 49°09′W	91	12	0.13	R. *et al.* (2001)
167	GO34	Uruaçú	14°33′S, 49°09′W	90	6	0.07	R. *et al.* (2001)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
168	MT01	Alto Araguaia	17°15′S, 53°21′W	54	1	0.02	R. *et al.* (2001)
169	MT02	Baixada Cuiabana	15°30′S, 56°02′W	111	21	0.19	Oliveira-Filho & Martins (1991)
170	MT03	Base Camp, Rib. Cascalheira	12°49′S, 51°46′W	129	19	0.15	R. *et al.* (1973)
171	MT04	Cáceres	16°15′S, 57°40′W	64	21	0.33	R. *et al.* (2001)
172	MT05	Campinápolis	14°16′S, 52°43′W	51	0	0	R. *et al.* (2001)
173	MT06	Campinápolis	14°15′S, 52°42′W	59	15	0.25	R. *et al.* (2001)
174	MT07	Campinápolis	14°20′S, 52°47′W	41	17	0.41	R. *et al.* (2001)
175	MT08	Campo de Murundus	12°00′S, 50°47′W	54	5	0.09	Marimon & Lima (1998, 2001)
176	MT09	Canarana	13°31′S, 52°28′W	106	11	0.1	R. *et al.* (2001)
177	MT10	Canarana	13°32′S, 52°39′W	78	1	0.01	R. *et al.* (2001)
178	MT11	Canarana	13°41′S, 52°04′W	85	4	0.05	R. *et al.* (2001)
179	MT12	Chapada dos Guimarães	15°21′S, 55°49′W	188	19	0.1	Oliveira-Filho (1984)
180	MT13	Cocalinho	12°42′S, 50°55′W	95	5	0.05	Marimon & Lima (1998, 2001)
181	MT14	Comodoro	13°50′S, 59°45′W	59	0	0	R. *et al.* (2001)
182	MT15	Comodoro	13°30′S, 59°50′W	59	0	0	R. *et al.* (2001)
183	MT16	Cuiabá	15°50′S, 56°50′W	56	3	0.05	R. *et al.* (2001)
184	MT17	Cuiabá	15°36′S, 56°06′W	37	3	0.08	Nascimento & Saddi (1992)
185	MT18	Cuiabá	15°32′S, 56°05′W	88	14	0.16	Macedo (1993)
186	MT19	Fazenda Porto do Sol	11°59′S, 50°47′W	77	4	0.05	Marimon & Lima (1998, 2001)
187	MT20	Fazenda Porto do Sol	11°54′S, 50°48′W	33	0	0	Marimon & Lima (1998, 2001)
188	MT21	Fazenda Porto do Sol	11°53′S, 50°47′W	47	4	0.08	Marimon & Lima (1998, 2001)
189	MT22	Primavera do Oeste	15°28′S, 55°00′W	64	0	0	R. *et al.* (2001)
190	MT23	General Carneiro	15°46′S, 52°31′W	60	0	0	R. *et al.* (2001)
191	MT24	General Carneiro	15°41′S, 52°41′W	70	6	0.08	R. *et al.* (2001)
192	MT25	Cocalinho (Fazenda Pequi)	14°40′S, 51°20′W	55	3	0.05	R. *et al.* (2001)
193	MT26	Cuiabá	15°32′S, 56°05′W	23	4	0.17	Guarim Neto *et al.* (1994)
194	MT27	Mario Viana, Nova Xavantina	14°41′S, 52°20′W	95	6	0.06	Marimon *et al.* (1998)
195	MT28	Nova Xavantina	14°45′S, 52°20′W	121	14	0.11	R. *et al.* (1973)
196	MT29	Nova Xavantina	14°44′S, 52°40′W	72	1	0.01	R. *et al.* (2001)
197	MT30	Nova Xavantina	14°45′S, 52°20′W	79	7	0.09	R. *et al.* (2001)
198	MT31	Poconé	16°16′S, 56°37′W	34	18	0.53	R. *et al.* (1988b)
199	MT32	Poconé	16°16′S, 56°37′W	33	16	0.48	Guarim *et al.* (2000)
200	MT33	Primavera do Oeste	15°37′S, 54°00′W	69	0	0	R. *et al.* (2001)
201	MT34	Riberão Cascalheira	13°55′S, 52°10′W	62	3	0.05	R. *et al.* (2001)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
202	MT35	Riberão Cascalheira	12°49′S, 51°46′W	92	4	0.04	R. *et al.* (2001)
203	MT36	Riberão Cascalheira	13°05′S, 52°00′W	67	8	0.12	R. *et al.* (2001)
204	MT37	Rondonôpolis	16°29′S, 54°37′W	94	15	0.16	R. *et al.* (1996)
205	MT38	Serra Azul (Barra do Garças)	15°51′S, 52°12′W	62	1	0.02	R. *et al.* (2001)
206	MT39	Serra da Petrovina	16°47′S, 54°06′W	94	20	0.21	R. *et al.* (1996)
207	MT40	Tatuapé	16°59′S, 54°03′W	77	0	0	R. *et al.* (2001)
208	MT41	Torixoreu	15°53′S, 52°23′W	53	18	0.34	Furley *et al.* (1988)
209	MT42	Vale de Sonhos	15°00′S, 52°13′W	72	12	0.17	Ratter *et al.* (1977)
210	RO1	Cacoal	11°24′S, 61°38′W	32	2	0.06	R. *et al.* (2001)
211	RO2	Colorado do Oeste	12°54′S, 60°22′W	48	0	0	R. *et al.* (2001)
212	RO3	Espigão do Oeste	11°41′S, 60°37′W	55	17	0.31	R. *et al.* (2001)
213	RO4	Fazenda Cachoeira	12°31′S, 60°25′W	49	0	0	R. *et al.* (2001)
214	RO5	Alta Floresta do Oeste	12°14′S, 62°02′W	60	13	0.22	R. *et al.* (2001)
215	RO6	Pimenta Bueno	11°43′S, 61°09′W	36	8	0.22	R. *et al.* (2001)
216	RO7	Pimenta Bueno	11°44′S, 61°06′W	29	5	0.17	R. *et al.* (2001)
217	RO8	Pimenta Bueno	11°36′S, 61°13′W	27	6	0.22	R. *et al.* (2001)
218	RO9	Querência, Parecis	12°10′S, 61°20′W	42	7	0.17	R. *et al.* (2001)
219	RO10	Vilhena	12°41′S, 60°07′W	63	0	0	R. *et al.* (2001)
220	BA01	Barreiras	12°09′S, 44°37′W	43	0	0	R. *et al.* (2001)
221	BA02	Barreiras	12°09′S, 44°58′W	55	1	0.02	R. *et al.* (2001)
222	BA03	Cocos	14°01′S, 44°27′W	54	1	0.02	R. *et al.* (2001)
223	BA04	Cocos	14°05′S, 44°30′W	55	2	0.04	R. *et al.* (2001)
224	BA05	Coribe	13°52′S, 44°27′W	54	2	0.04	R. *et al.* (2001)
225	BA06	Correntina	13°23′S, 44°41′W	55	0	0	R. *et al.* (2001)
226	BA07	Correntina	13°23′S, 44°35′W	55	3	0.05	R. *et al.* (2001)
227	BA08	Fazenda Trijunção (Mun. Cocos)	14°49′S, 45°58′W	54	0	0	R. *et al.* (2001)
228	BA09	Fazenda Trijunção (Mun. Jaborandi)	14°48′S, 45°57′W	50	0	0	R. *et al.* (2001)
229	BA10	Fazenda Jatobá	13°23′S, 44°41′W	108	3	0.03	Andrade & Machado (1991–93)
230	BA11	Formoso do Rio Preto	11°27′S, 46°00′W	74	1	0.01	Walter & Ribeiro (1996)
231	BA12	Lençóis	12°29′S, 41°20′W	39	0	0	R. *et al.* (2001)
232	BA13	Lençóis	12°26′S, 41°30′W	42	1	0.02	R. *et al.* (2001)
233	BA14	Riachão das Neves	11°46′S, 44°54′W	49	5	0.1	R. *et al.* (2001)
234	BA15	Santa Maria da Vitória	13°24′S, 44°13′W	29	3	0.1	R. *et al.* (2001)
235	BA16	São Desidério	12°19′S, 44°59′W	51	1	0.02	R. *et al.* (2001)
236	TO01	Alvorada	12°31′S, 49°10′W	92	11	0.12	R. *et al.* (2001)
237	TO02	Arraias	12°47′S, 47°03′W	67	13	0.19	R. *et al.* (2001)
238	TO03	Arraias	12°39′S, 47°06′W	80	13	0.16	R. *et al.* (2001)
239	TO04	Arraias	12°53′S, 47°00′W	91	18	0.2	R. *et al.* (2001)
240	TO05	Barrolândia	09°47′S, 48°43′W	70	6	0.09	R. *et al.* (2001)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
241	TO06	Bom Jesus do Tocantins	08°43′S, 47°44′W	81	10	0.12	R. *et al.* (2001)
242	TO07	Bom Jesus do Tocantins	08°50′S, 47°52′W	98	14	0.14	R. *et al.* (2001)
243	TO08	Bom Jesus do Tocantins	08°34′S, 47°45′W	56	2	0.04	R. *et al.* (2001)
244	TO09	Caseara	09°53′S, 49°53′W	60	3	0.05	R. *et al.* (2001)
245	TO10	Cristalândia	10°35′S, 49°10′W	54	0	0	R. *et al.* (2001)
246	TO11	Divinópolis	09°48′S, 49°36′W	35	0	0	R. *et al.* (2001)
247	TO12	Fazenda Belo Horizonte	10°05′S, 48°55′W	60	9	0.15	R. *et al.* (1996)
248	TO13	Fazenda Bragança	06°53′S, 47°48′W	34	2	0.06	R. *et al.* (1996)
249	TO14	Fazenda Odara do Tocantins	11°26′S, 48°53′W	79	11	0.14	R. *et al.* (2001)
250	TO15	Fazenda Odara do Tocantins (2)	11°28′S, 48°53′W	82	14	0.17	R. *et al.* (2001)
251	TO16	Figueirópolis	12°04′S, 49°10′W	76	13	0.17	R. *et al.* (1996)
252	TO17	Figueirópolis	12°14′S, 49°15′W	75	6	0.08	R. *et al.* (2001)
253	TO18	Gurupí	11°43′S, 49°07′W	83	5	0.06	R. *et al.* (2001)
254	TO19	Gurupí	11°54′S, 49°10′W	73	11	0.15	R. *et al.* (2001)
255	TO20	Gurupí	11°52′S, 49°25′W	90	12	0.13	R. *et al.* (2001)
256	TO21	Ilha do Bananal	10°26′S, 50°25′W	106	13	0.12	Ratter (1987)
257	TO22	Lagoa de Confusão	10°44′S, 49°34′W	86	18	0.21	R. *et al.* (2001)
258	TO23	Lajeado	09°45′S, 48°21′W	79	12	0.15	R. *et al.* (2001)
259	TO24	Lajeado	09°38′S, 48°23′W	63	0	0	R. *et al.* (2001)
260	TO25	Parque Estadual de Lajeado	10°16′S, 48°22′W	79	0	0	Santos (2000)
261	TO26	Monte do Carmo	10°48′S, 48°05′W	86	12	0.14	R. *et al.* (2001)
262	TO27	Monte Santo	09°53′S, 49°08′W	74	8	0.11	R. *et al.* (2001)
263	TO28	Natividade	11°49′S, 47°29′W	90	14	0.15	R. *et al.* (2001)
264	TO29	Natividade	11°40′S, 47°43′W	80	10	0.12	R. *et al.* (2001)
265	TO30	Natividade	11°53′S, 48°07′W	83	10	0.12	R. *et al.* (2001)
266	TO31	Natividade	11°41′S, 47°29′W	78	13	0.17	R. *et al.* (2001)
267	TO32	Palmas	10°01′S, 48°18′W	53	9	0.17	R. *et al.* (2001)
268	TO33	Paraíso de Tocantins	10°05′S, 48°56′W	74	7	0.09	R. *et al.* (2001)
269	TO34	Peixe	11°58′S, 48°37′W	90	12	0.13	R. *et al.* (2001)
270	TO35	Ponte Alta	10°24′S, 47°05′W	45	0	0	R. *et al.* (2001)
271	TO36	Ponte Alta	10°30′S, 47°11′W	24	0	0	R. *et al.* (2001)
272	TO37	Ponte Alta	10°27′S, 47°10′W	30	0	0	R. *et al.* (2001)
273	TO38	Ponte Alta	11°02′S, 47°28′W	81	3	0.04	R. *et al.* (2001)
274	TO39	Ponte Alta	10°39′S, 47°55′W	82	9	0.11	R. *et al.* (2001)
275	TO40	Ponte Alta	10°24′S, 47°06′W	54	1	0.02	R. *et al.* (2001)
276	TO41	Porto Nacional	10°45′S, 47°58′W	79	1	0.01	R. *et al.* (2001)
277	TO42	Porto Nacional	10°31′S, 48°22′W	77	5	0.06	R. *et al.* (2001)
278	TO43	Porto Nacional	10°26′S, 48°18′W	50	0	0	R. *et al.* (2001)
279	TO44	Pugmil	10°27′S, 48°53′W	84	18	0.21	R. *et al.* (2001)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
280	TO45	Rio Sono	09°24′S, 47°49′W	73	2	0.03	R. *et al*. (2001)
281	TO46	Rio Sono	09°25′S, 47°37′W	95	11	0.12	R. *et al*. (2001)
282	TO47	Rio Sono	09°32′S, 47°40′W	73	0	0	R. *et al*. (2001)
283	TO48	Taquaras	10°19′S, 48°13′W	68	14	0.2	R. *et al*. (2001)
284	MA01	Alto Parnaíba	09°12′S, 46°03′W	65	1	0.01	R. *et al*. (2001)
285	MA02	Alto Parnaíba	09°03′S, 45°52′W	52	0	0	R. *et al*. (2001)
286	MA03	Alto Parnaíba	09°09′S, 45°55′W	56	0	0	R. *et al*. (2001)
287	MA04	Barão de Grajaú	06°32′S, 43°31′W	38	2	0.05	R. *et al*. (2001)
288	MA05	Carolina	07°07′S, 47°25′W	63	2	0.03	R. *et al*. (1996)
289	MA06	Carolina	07°07′S, 47°25′W	21	9	0.43	R. *et al*. (1996)
290	MA07	Fazenda Parnaíba	07°30′S, 46°05′W	60	11	0.18	R. *et al*. (1996)
291	MA08	Fortaleza dos Nogueiras	06°50′S, 46°10′W	79	5	0.06	R. *et al*. (2001)
292	MA09	Fortaleza dos Nogueiras	06°53′S, 46°10′W	60	1	0.02	R. *et al*. (2001)
293	MA10	Gerais de Balsas	08°38′S, 46°43′W	63	0	0	Walter *et al*. (2000)
294	MA11	Loreto	07°21′S, 45°05′W	66	13	0.2	Eiten (1998)
295	MA12	Loreto	07°22′S, 45°06′W	54	6	0.11	R. *et al*. (2001)
296	MA13	Loreto	07°20′S, 45°09′W	50	1	0.02	R. *et al*. (2001)
297	MA14	Loreto (Fazenda Morro)	07°23′S, 45°01′W	45	2	0.04	R. *et al*. (2001)
298	MA15	Loreto (Fazenda Morro)	07°20′S, 45°04′W	20	6	0.3	R. *et al*. (2001)
299	MA16	Loreto	07°21′S, 45°05′W	40	7	0.17	R. *et al*. (2001)
300	MA17	Pé de Galinha	07°45′S, 45°50′W	62	10	0.16	R. *et al*. (1996)
301	MA18	Pedra Caída	06°57′S, 47°28′W	62	1	0.02	R. *et al*. (1996)
302	MA19	Rio Balsinha	07°30′S, 46°05′W	43	1	0.02	R. *et al*. (1996)
303	MA20	São João dos Patos	06°32′S, 43°31′W	38	2	0.05	R. *et al*. (2001)
304	MA21	Tasso Fragoso	08°26′S, 45°48′W	60	3	0.05	R. *et al*. (2001)
305	CE01	Chapada do Araripe	07°17′S, 39°29′W	44	0	0	R. *et al*. (2001)
306	CE02	Sertão de Salgado	06°38′S, 39°30′W	20	2	0.1	Figueiredo (1987)
307	PI01	Corrente	10°28′S, 45°10′W	30	10	0.33	R. *et al*. (2001)
308	PI02	Corrente	10°05′S, 45°15′W	36	0	0	R. *et al*. (2001)
309	PI03	Fazenda Piloto	06°36′S, 42°16′W	69	4	0.06	Castro (1994a)
310	PI04	Gilbués	09°44′S, 45°23′W	55	3	0.05	R. *et al*. (2001)
311	PI05	Gilbués	09°17′S, 45°35′W	41	0	0	R. *et al*. (2001)
312	PI06	Santo Filomena	09°14′S, 45°43′W	44	12	0.27	R. *et al*. (2001)
313	PI07	Uruçuí-Una	08°50′S, 44°10′W	37	2	0.05	Castro (1986)
314	PA01	Alter do Chão	02°36′S, 54°56′W	49	2	0.04	Sanaiotti (1991), Branch & Silva (1983), Miranda (1993)
315	PA02	Ariramba	01°10′S, 55°35′W	24	0	0	Egler (1960)
316	PA03	Campo de Joanes, Marajó	00°58′S, 48°34′W	15	0	0	Bastos (1984)
317	PA04	Fazenda Chocolate	08°21′S, 50°00′W	64	9	0.14	R. *et al*. (1996)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
318	PA05	Fazenda de Prof. Getulinho	08°21′S, 50°06′W	66	8	0.12	R. *et al.* (1996)
319	PA06	Marajó	00°45′S, 48°30′W	20	0	0	Bastos (1984)
320	AM01	Humaitá	07°31′S, 63°00′W	17	0	0	Gottsberger & Morawetz (1986)
321	AM02	Humaitá	07°40′S, 63°00′W	46	1	0.02	Janssen (1986)
322	AP01	114km N of Macapá	00°46′N, 51°18′W	11	0	0	Sanaiotti *et al.* (1997)
323	AP02	36km N of Macapá	00°20′N, 51°05′W	15	0	0	Sanaiotti *et al.* (1997)
324	AP03	5km S of Calçoene	02°27′N, 50°33′W	6	0	0	Sanaiotti *et al.* (1997)
325	AP04	APA de Curiaú	00°20′N, 51°03′W	17	0	0	Sanaiotti *et al.* (1997)
326	AP05	EMBRAPA Stn., Macapá	00°37′N, 51°05′W	19	1	0.05	Sanaiotti *et al.* (1997)
327	AP06	Gleba de Pedreira	00°40′N, 51°45′W	19	0	0	Sanaiotti *et al.* (1997)
328	AP07	Tartarugalzinho	01°40′N, 50°50′W	7	0	0	Sanaiotti *et al.* (1997)
329	RR01	Alto Alegre	02°51′N, 60°57′W	2	0	0	Miranda (1997)
330	RR02	Alto Alegre	03°09′N, 61°08′W	5	0	0	Miranda (1997)
331	RR03	Boa Vista	03°20′N, 61°26′W	11	1	0.09	Takeuchi (1960)
332	RR04	Bonfim	03°16′N, 60°00′W	2	0	0	Miranda (1997)
333	RR05	Cantá	02°46′N, 60°36′W	8	0	0	Miranda (1997)
334	RR06	Cantá	02°39′N, 60°42′W	5	0	0	Miranda (1997)
335	RR07	Igarapé do Rébenque	04°26′N, 59°50′W	9	0	0	Miranda (1997)
336	RR08	Ilha do Maracá	03°22′N, 61°26′W	8	0	0	Milliken & Ratter (1989)
337	RR09	Lago Caracaranã	03°50′N, 59°46′W	10	0	0	Miranda (1997)
338	RR10	Lago Redondo	02°54′N, 60°28′W	8	0	0	Miranda (1997)
339	RR11	Maloca da Cachoeirinha	04°01′N, 59°54′W	6	0	0	Miranda (1997)
340	RR12	Maloca do Cajueiro	03°56′N, 59°37′W	7	0	0	Miranda (1997)
341	RR13	Maloca do Maracanã	04°21′N, 60°01′W	10	0	0	Miranda (1997)
342	RR14	Maloca do Napoleão	03°52′N, 60°01′W	5	0	0	Miranda (1997)
343	RR15	Mucajaí	02°40′N, 60°46′W	11	0	0	Miranda (1997)
344	RR16	Mucajaí	02°41′N, 60°47′W	7	0	0	Miranda (1997)
345	RR17	Mucajaí	02°40′N, 60°46′W	3	0	0	Miranda (1997)
346	RR18	Normândia	03°56′N, 59°51′W	5	0	0	Miranda (1997)
347	RR19	Normândia	04°03′N, 60°06′W	9	0	0	Miranda (1997)
348	RR20	Normândia	03°59′N, 59°36′W	8	0	0	Miranda (1997)
349	RR21	Normândia	03°54′N, 59°37′W	6	0	0	Miranda (1997)
350	RR22	Pedra Pintada	03°52′N, 60°54′W	7	0	0	Miranda (1997)
351	RR23	Roraima	03°48′N, 59°46′W	6	0	0	Dantas & Rodrigues (1982)

TABLE 1. (*Cont'd*)

No.	Code	Locality	Co-ordinates	NS	MS	MI	Reference
352	RR24	Serra da Lua	02°41′N, 60°23′W	6	0	0	Miranda (1997)
353	RR25	Serra da Lua	02°25′N, 60°06′W	7	0	0	Miranda (1997)
354	RR26	Serra da Lua	02°44′N, 60°33′W	8	0	0	Miranda (1997)
355	RR27	Serra da Lua	02°39′N, 60°18′W	8	0	0	Miranda (1997)
356	RR28	Vila Brasil	03°31′N, 61°24′W	14	1	0.07	Miranda (1997)
357	RR29	Vila Brasil	03°37′N, 61°30′W	7	0	0	Miranda (1997)
358	RR30	Vila da Água Fria	04°29′N, 60°18′W	7	0	0	Miranda (1997)
359	RR31	Vila do Contão	04°15′N, 60°30′W	4	0	0	Miranda (1997)
360	RR32	Vila do Contão	04°19′N, 60°29′W	10	0	0	Miranda (1997)
361	RR33	Vila do Socó	04°29′N, 60°12′W	5	0	0	Miranda (1997)
362	RR34	Vila do Surumu	04°10′N, 60°40′W	11	0	0	Miranda (1997)
363	RR35	Vila do Surumu	04°08′N, 60°45′W	12	0	0	Miranda (1997)
364	RR36	Vila do Surumu	03°55′N, 60°58′W	3	0	0	Miranda (1997)
365	RR37	Vila do Surumu	04°12′N, 60°49′W	8	1	0.12	Miranda (1997)
366	RR38	Vila do Surumu	04°05′N, 60°27′W	10	0	0	Miranda (1997)
367	RR39	Vila do Surumu	03°57′N, 60°26′W	4	0	0	Miranda (1997)
368	RR40	Vila do Surumu	04°09′N, 60°32′W	10	0	0	Miranda (1997)
369	RR41	Vila do Taiano	03°16′N, 61°16′W	5	0	0	Miranda (1997)
370	RR42	Vila do Taiano	03°22′N, 60°09′W	9	0	0	Miranda (1997)
371	RR43	Vila do Taiano	03°29′N, 61°16′W	4	0	0	Miranda (1997)
372	RR44	Vila do Taiano	03°20′N, 61°05′W	1	0	0	Miranda (1997)
373	RR45	Vila do Taiano	03°15′N, 61°15′W	3	0	0	Miranda (1997)
374	RR46	Vila do Uiramutã	04°35′N, 60°09′W	7	0	0	Miranda (1997)
375	RR47	Vila São Silvestre	02°50′N, 61°13′W	1	0	0	Miranda (1997)
376	RR48	Vila São Silvestre	02°50′N, 61°06′W	2	0	0	Miranda (1997)

47 surveys with an average of 61 species each shows that only 60 out of a total of 2860 species records fell into this category. In processing the results of other workers, some vaguely identified taxa which could not be related to species were also excluded from the matrix.

Soil samples were made for all surveys of the CMBBC project and a detailed analysis of the relationship of plant community with soil type will appear in a future publication. Such analyses have already been carried out for the surveys made in Goiás, Tocantins, Minas Gerais and Bahia, and they conform exactly with our previous observations on the occurrence of distinctive cerrado communities on dystrophic and mesotrophic soils (Ratter *et al*., 1977; Furley & Ratter, 1988). In addition, detailed soil data are available for the great majority of our previous studies but there is no information for many sites surveyed by other workers. However, as in Ratter *et al*. (1996), presence of mesotrophic soils in areas where no soil analyses are available was inferred by the occurrence of indicator species (see Ratter *et al*., 1973, 1977), marked in bold in Appendices 1 and 2. A 'mesotrophic index' (no. of mesotrophic soil indicator species/total no. of species) was calculated for all sites as a basis for comparison (see Table 1). While such an index is of some use, a

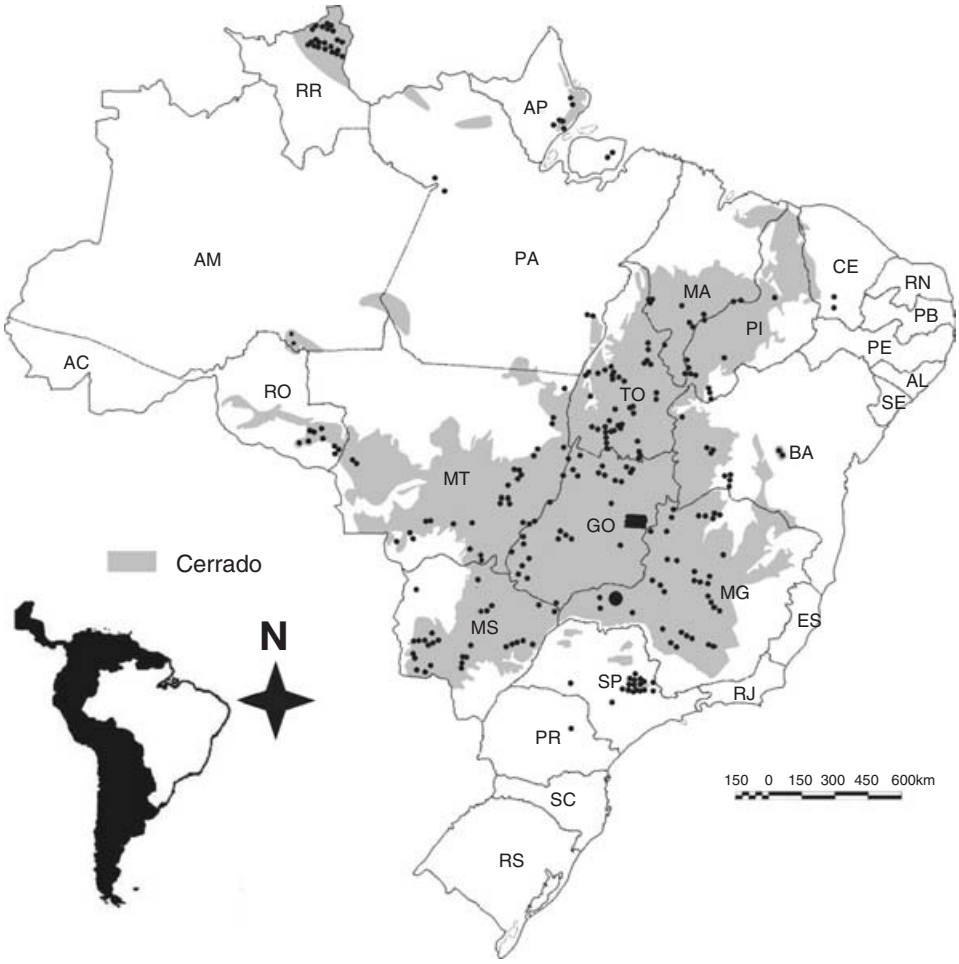

FIG. 1. Map of Brazil showing sites compared in the study. See Table 1 for full locality details. The number of sites appears fewer than the 376 localities in the table due to overlap of adjoining dots; the rectangular block is the Distrito Federal (DF) and represents 13 sites; the large dot in the Triângulo Mineiro represents 21 sites in the Municipality of Uberlândia. The shaded area shows the extent of the cerrado biome in Brazil. Letters are state abbreviations; those referred to in the text are: AM, Amazonas; AP, Amapá; BA, Bahia; CE, Ceará; GO, Goiás; MA, Maranhão; MG, Minas Gerais; MS, Mato Grosso do Sul; MT, Mato Grosso; PA, Pará; PI, Piauí; PR, Paraná; RO, Rondônia; RR, Roraima; SP, São Paulo; TO, Tocantins.

'Mesotrophic Importance Index' based on Importance Value Index, Cover Value Index or Basal Area would be much better, since in many mesotrophic communities the indicator species have high values for these parameters, while many other species present are relatively unimportant as constituents of the total vegetation. Unfortunately, however, data are not available to calculate a Mesotrophic Importance Index for most of the sites considered.

Floristic survey of the Conservação e Manejo da Biodiversidade do Bioma Cerrado (CMBBC) project

Since the results of this project form a vital part of this paper, it is appropriate to give a brief account of its aims and the techniques used. The object of the floristic survey of the project was to provide within a period of four years the maximum amount of data on woody cerrado vegetation for largely unsampled northern and central-western parts of the cerrado biome. Areas were targeted on the basis of previous lack of information or sometimes on indications of exceptional floristic diversity. The grid of 1° latitude × 1°30′ longitude used by the national RADAMBRASIL project (see Fig. 2) with, where possible, at least three sites in each rectangle, was used to obtain a spatial representation of the surveys. The first two areas targeted were the states of Mato Grosso do Sul (MS) and Tocantins (TO), where there was an extreme lack of existing data. Other areas were later included and in total 170 sites were surveyed (Ratter *et al*., 2001), made up by state as follows (the figures in parentheses are those known to us as existing prior to the CMBBC surveys): Bahia 14 (2), Ceará 1 (1), Goiás 19 (15), Maranhão 13 (8), Mato Grosso 23 (19), Mato Grosso do Sul 31 (3), Minas Gerais 11 (57), Piauí 5 (13), Tocantins 43 (5), Rondônia 10 (1). Wherever possible, local experts worked with us in the surveys and their knowledge of regional geography and flora was invaluable.

A rapid survey technique was used to allow us to carry out so many surveys within a limited period. This was developed as a refinement of 'wide-patrolling' and bears some resemblance to 'caminhamento' (Filgueiras *et al*., 1994). The adoption of this technique was based on our experience working as a large team in the states of Maranhão, Mato Grosso, Pará and Goiás in 1993. During this period groups of up to eight people worked on numerous transects and plots, while usually a single person carried out wide-patrolling of the same area. To our surprise, the teams of the transects/plot group never recorded a single species unnoticed by the wide-patroller, but on the other hand the latter frequently noted 50% more species than them. Thus wide-patrolling represents a particularly effective method for producing comprehensive floristic data rapidly, providing, of course, that patrollers have a very good knowledge of the flora.

The method used was refined by introducing a timing element so that a species number/time curve could be produced, giving a quantitative measurement for judging the correct time to end a survey. The survey was carried out usually by a team of three or four, one of whom acted as recorder and also registered 15-minute intervals, while the others shouted out the species observed. Typically species recording occupied four to eight 15-minute intervals, according to the floristic diversity, size and topography of the area. As previously discussed, all species which can attain a height of at least 1.5m and basal diameter of 3cm were recorded (even if the only individuals present were smaller than this). Our survey technique is not tied to a specific area (often the finding of suitable patches of cerrado in targeted areas was fortuitous and we had to be pragmatic about our choice); however, areas too small to provide communities representative of a good range of species diversity were avoided.

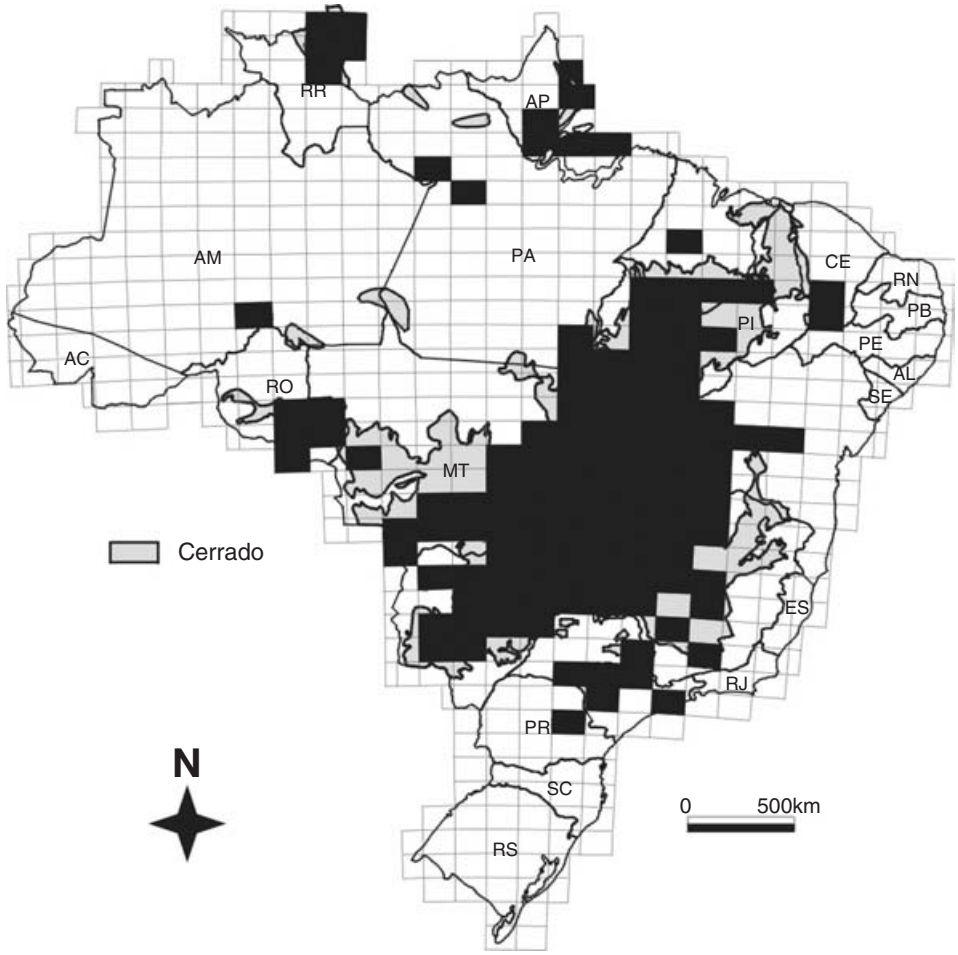

FIG. 2. Survey grid of 1° latitude × 1°30′ longitude, as used by the national RADAMBRASIL survey. Areas of cerrado and Amazonian savanna covered by the CMBBC and other surveys are in black; cerrado biome is in grey. Outlying sites are in disjunct cerrado islands or in Amazonian savanna. State abbreviations as in Fig. 1.

At the suggestion of Dr C. Proença, we carried out a trial of the method to judge its efficiency before applying it in the CMBBC fieldwork. This consisted of re-surveying an area of cerrado *sensu stricto* at Fazenda Água Limpa (ecological reserve of the University of Brasília) which had been studied using plots, wide-patrolling (and general collecting) in 1976–77 (Ratter, 1986). A team of five took $1\frac{3}{4}$ hours to find 68 of the 69 species previously recorded (one species, *Ferdinandusa elliptica*, originally represented by only two specimens was not refound), while three additional species were found. The latter were adventives which must have entered the area in the 20 years since the first survey, and one of these, *Aegiphila lhotskiana*, was quite frequent.

Data analysis

The floristic matrix was compiled using EXCEL, with the data entered in simple binary form, i.e. presence/absence. Two multivariate techniques were used to analyse these data in an attempt to identify floristic patterns within the matrix, the methodology following closely that of Oliveira-Filho & Ratter (1995) and Ratter *et al.* (1996). The two techniques were (a) a divisive hierarchical classification by Two-Way Indicator Species Analysis (TWINSPAN) (Hill, 1979), and (b) an agglomerative hierarchical classification by UPGMA (Unweighted Pair-Groups Method using Arithmetic Averages) using the Sørensen Coefficient of Community (cc) as a measure of similarity (Kent & Coker, 1992). The versions of these analytical programs used were contained in the statistical package for Windows PC-ORD (Version 4.17) (McCune & Mefford, 1999).

In total the floristic matrix comprised 951 species recorded at 376 sites. This was analysed four times using both multivariate techniques. The first approach included all species present in the matrix, and in the second the data set was modified by the removal of the 334 unicate species (occurring at only one area), following the methodology described in Ratter *et al.* (1996). The results of these first two approaches were essentially the same, although the analyses presented here are those with the unicates excluded as these illustrate clearer patterns within the data set. The reasons for this are outlined on p. 82.

In addition, two further analyses were run to investigate the effect of the presence of mesotrophic indicator species on the floristic patterns indicated by the study. All sites were first classified as either mesotrophic or dystrophic based on the presence or absence of mesotrophic indicator species (Ratter *et al.*, 1977; Ratter & Dargie, 1992), and the data subsequently analysed a further twice. The first ran both TWINSPAN and UPGMA analyses of a data set of only those sites classified by the authors as strongly mesotrophic, and the second of sites regarded as dystrophic. The patterns illustrated did not vary significantly from those revealed by the full data set and so are not presented here.

Results and Discussion

Species diversity

A total of 951 species was recorded in the 376 areas, of which 334 (35%) are unicates, i.e. occur at only a single locality. Appendix 1 gives a list of species occurring at more than one site and the number of sites at which they occurred, while Appendix 2 lists the unicates. Space does not allow the table of species occurrence at all sites to be reproduced here but copies are available from the authors and those for the 170 surveys of the CMBBC project are given in Ratter *et al.* (2001).

The first division of both the TWINSPAN and UPGMA analyses (Figs 4 and 7) separated the 376 areas into Amazonian savanna sites (more or less those north of

the river Amazon) and the core cerrado area with its related outlier sites. These two groups will be considered separately in the following account.

Disjunct Amazonian sites

The disjunct Amazonian sites, with the exception of Alter do Chão (Pará) and one site at Humaitá (Amazonas), represent a low diversity savanna with a total species list of 117 spp. (marked A in Appendices 1 and 2). Of these, 77 (marked W and C in Appendices 1 and 2) are widespread species common in the core cerrado area. No less than 59 species (50%) are unicates occurring at only a single site, while 81 (69%) have three or fewer occurrences. By far the commonest species are *Byrsonima crassifolia*, occurring at 47 sites (80%), and *Curatella americana* at 48 (81%). The commonest species in the 58 sites are *Anacardium occidentale*, *Bowdichia virgilioides*, *Byrsonima coccolobifolia*, *B. crassifolia*, *B. verbascifolia*, *Casearia sylvestris*, *Curatella americana*, *Erythroxylum suberosum*, *Genipa americana*, *Himatanthus articulatus*, *Hirtella ciliata*, *Ouratea hexasperma*, *Palicourea rigida*, *Psidium guineense*, *Roupala montana*, *Salvertia convallariodora*, *Tocoyena formosa* and *Xylopia aromatica*. Some of these species, e.g. *Byrsonima crassifolia* and *Curatella americana*, are very resistant to high water-tables for part of the year so are characteristic of hydrologic savannas and/or have weedy tendencies, e.g. *Genipa americana* and *Xylopia aromatica*. Species indicating mesotrophic soils are almost completely absent from the disjunct Amazonian sites (see number of mesotrophic species and the mesotrophic indices in Table 1).

Core area and outliers

In total 914 species were recorded for the 315 areas comprising the core cerrado and its outliers (the latter excluding Alter do Chão, Pará and one site at Humaitá, Amazonas, which, however, have strong affinities with the core area). Of these, only 300 species occur at eight or more sites (i.e. $\geq 2.5\%$ of the total), while the remaining 614 species, including 309 unicates, are very rare. The appendices give figures for site occurrence of all species and Fig. 3 gives numbers in percentage bands. As in our previous studies (Ratter & Dargie, 1992; Ratter *et al.*, 1996), no species occurs at all sites, and once again the most widespread is *Qualea grandiflora* with 274 occurrences (85% of the total). Only the 38 species listed in Table 2 were recorded for 50% (158) or more of the sites; figures for the same species obtained in our previous works are also given. The agreement of the frequencies of the commonest species in the present work and in Ratter *et al.* (1996) is surprisingly high, despite a more than threefold increase in areas sampled, and seems to indicate a consistent suite of important species. The only species recorded for $\geq 50\%$ of surveys in Ratter *et al.* (1996) and not reaching this level in the present study is *Copaifera langsdorfii* with 45% occurrence. There is also a very high correspondence with the commonest

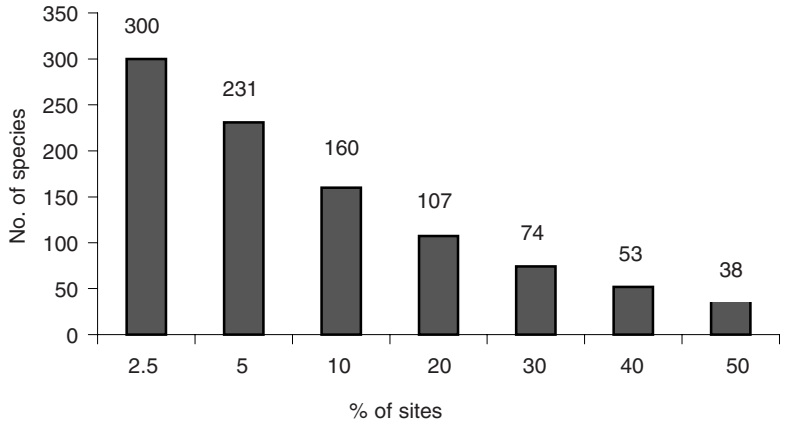

FIG. 3. Species occurrence vs. percentage of sites in cerrado core area (e.g. 38 species occur at $\geq$50% of sites, while 300 species occur at $\geq$2.5%).

TABLE 2. Species occurring at 158 (50%) or more sites of core area and outliers. The figures indicate the percentage of sites where the species occur, with equivalent values for Ratter & Dargie (1992) and Ratter *et al.* (1996), respectively, in parentheses. Figures from these previous studies were recalculated to eliminate records from disjunct Amazonian savannas

Species	%	Species	%
Qualea grandiflora	85 (96, 96)	*Byrsonima crassa*	60 (41, 47)
Q. parviflora	78 (75, 71)	*Himatanthus obovatus*	59 (41, 45)
Bowdichia virgilioides	77 (79, 76)	*Vatairea macrocarpa*	59 (58, 48)
Dimorphandra mollis	74 (71, 77)	*Davilla elliptica*	58 (66, 47)
Lafoensia pacari	74 (71, 62)	*Machaerium acutifolium*	58 (62, 65)
Connarus suberosus	73 (75, 71)	*Tocoyena formosa*	58 (75, 58)
Hymenaea stigonocarpa	73 (62, 78)	*Diospyros hispida*	57 (50, 45)
Kielmeyera coriacea	70 (62, 77)	*Salvertia convallariodora*	56 (54, 53)
Tabebuia aurea	67 (75, 56)	*Astronium fraxinifolium*	55 (58, 52)
T. ochracea	66 (37, 57)	*Sclerolobium aureum*	55 (58, 47)
Byrsonima coccolobifolia	65 (83, 71)	*Xylopia aromatica*	55 (58, 57)
Pouteria ramiflora	65 (62, 60)	*Annona coriacea*	54 (42, 48)
Casearia sylvestris	64 (71, 71)	*Hancornia speciosa*	53 (42, 51)
Roupala montana	62 (54, 62)	*Ouratea hexasperma*	53 (42, 41)
Acosmium dasycarpum	62 (58, 60)	*Plathymenia reticulata*	53 (58, 47)
Curatella americana	62 (75, 71)	*Aspidosperma tomentosum*	51 (65, 49)
Erythroxylum suberosum	62 (71, 54)	*Qualea multiflora*	51 (61, 63)
Caryocar brasiliense	61 (75, 78)	*Byrsonima verbascifolia*	50 (61, 55)
Brosimum gaudichaudii	60 (54, 62)	*Eriotheca gracilipes*	50 (50, 37)

species recorded in Ratter & Dargie (1992), despite the fact that the data in that work came from less than 10% of the number of surveys reported here.

The 300 species occurring in $\geq$2.5% of the surveys represent the most common

and widespread woody species of at least 75% of the cerrado region. There should be added to them a further approximately 50 species relatively common in the São Paulo cerrados but apparently rare or absent elsewhere (Durigan, pers. comm.), 40 of which are registered as rare in our species matrix (Appendices 1 and 2) while the others are unrecorded. This therefore indicates a group of about 350 species which overwhelmingly dominates the woody vegetation of cerrado *sensu lato* throughout the cerrado biome. However, the total woody flora of cerrado *sensu lato* is much greater than this (as demonstrated by the 951 species recorded in this paper) as it includes many rare 'characteristic' species, together with accessory and ecotonal elements. We are reserving detailed consideration of our results on cerrado species diversity for a future publication.

It is interesting to compare our conclusion that the woody vegetation of cerrado *sensu lato* is dominated by some 350 species with recent results from the Amazonian forest. Pitman *et al*. (2001) have studied dominance and distribution of tree species in great areas of *terra firme* forests in Ecuador and Peru. They found oligarchies of 150 species dominating thousands of square kilometres of forest in each country, although the total species diversity was much greater because of the huge numbers of rare species present. This bears a strong resemblance to the situation in the cerrado, although the dominance of our 350 species-group is much stronger than that of the oligarchies encountered in Amazonian forest.

Alpha diversity

Although a total of 914 species was recorded in the 315 areas (i.e. all those analysed but excluding the disjunct Amazonian sites) and we regard about 350 as relatively common characteristic species of cerrado *sensu lato*, the number of species occurring in the communities at any given site (alpha diversity) is very much lower. In fact, it is very rare to find over 100 species in any community, other than in sites of very large area and/or where intensive studies have been conducted over a long period, thus allowing extreme rarities to be encountered. The species richness of communities varies considerably throughout the cerrado region, but since methods of collecting data have differed considerably, particularly in size of areas studied, it is possible to give only some very general observations. Comparing our CMBBC project results of species per community for 170 rapid survey sites shows 28–55 (average 47) spp. for Bahia (14 sites), 65–91 (av. 79) for Goiás (19 sites), 33–70 (av. 54) for northern Minas Gerais (11 sites), 19–79 (av. 49) for Maranhão (13 sites), 41–106 (av. 65) for Mato Grosso (23 sites), 28–76 (av. 58) for Mato Grosso do Sul (31 sites), 30–55 (av. 41) for southern Piauí (5 sites), 23–97 (av. 72) for Tocantins (43 sites), 21–63 (av. 42) for Rondônia (10 sites), and 20–44 (av. 32) for Ceará (2 sites). We have noticed particularly high species richness in the Araguaia and Tocantins drainage regions of Goiás, Tocantins and Mato Grosso, and in the Xingu drainage of Mato Grosso. There are also many records of high alpha diversity in the São Paulo cerrados.

Differences in species richness are not always obvious to the observer simply looking at the overall appearance of areas of cerrado. Thus magnificent cerrado landscapes in Maranhão and Piauí often contain about 50 species, a much lower figure than is general in parts of Goiás and Tocantins. However, this does not indicate by any means that the former are any less worthy of conservation, since they have an extremely interesting flora and provide a unique representation of regional biodiversity. As stressed by Bates & Demos (2001), when determining conservation value it is a gross oversimplification to pit areas against one another on comparative biodiversity values.

As we have already discussed (e.g. Ratter *et al.*, 2000a), diversity is often lower in areas with richer soils, where dominance of characteristic 'indicator' species such as *Callisthene fasciculata*, *Magonia pubescens*, *Terminalia argentea*, *Luehea paniculata*, etc., occurs. Examples of such sites occur throughout a great part of the cerrado region, for example at Poconé (Mato Grosso, MT31) 34 spp., Carolina (Maranhão, MA06) 21 spp., Corrente (Piauí, PI01) 30 spp., and 27–36 spp. at a number of the Rondônia sites on *solo chocolate* – see below.

Mesotrophic indices

As shown in Table 1, there are great differences in mesotrophic indices between sites and regions. Thus in São Paulo state the figures are consistently low, indicating the prevalence of dystrophic soils, while in most other areas of the core cerrado region there is considerable variation, often reflecting the occurrence of ancient, leached dystrophic soils on the chapadas, in contrast to regions where erosion has cut valleys into lower, more mineral-rich strata. Mato Grosso do Sul is the state where we found mesotrophic soils most common in cerrado: 20 of the 33 sites analysed had mesotrophic indices greater than 0.10.

An interesting situation occurs in Rondônia where mesotrophic cerrados occur on the widespread *solo chocolate*. This soil is named for a mineral-rich, shallow, chocolate-brown pan which impedes drainage and is found at varying depths in the soil horizon. The staff of EMATER-RO (the state agricultural extension service) informed us that this type of soil extends from Pimenta Bueno to Guaporé and right into Bolivia. On the other hand, the well-drained, sandy soils of the state carry a dystrophic cerrado. The mesotrophic index of cerrados on the *solo chocolate* is 0.17 to 0.22, while on the sandy, well-drained soils it is 0.0.

We plan to give further details of both mesotrophic indices and Rondônian cerrados in future publications.

Multivariate Analyses

The multivariate analyses of the floristic data show a great deal of coincidence in the patterns derived from both techniques used. A detailed description and discussion of the results obtained are given below.

1. Divisive hierarchical classification (TWINSPAN) site hierarchy

Figure 4 shows eight groups which we regard as meaningful. Of these, Group 8 (the Amazonian savanna sites) was split off at the first division, Group 1 (the most southern sites) at the third division, while the other six groups result from four levels of division. Details of the divisions and the indicator species on which they are partly based are too lengthy to reproduce here, but are available from the authors. The groupings produced by the analysis are mapped in Fig. 5.

Interpretation of grouping. The main features of groups and group sets are as follows:

Group 1: This is a geographically very natural group consisting of 18 São Paulo sites (all of those included in the analysis, apart from one of the Itirapina surveys (Gianotti & Leitão Filho, 1992)), three sites from the Rio Grande region of southern Minas Gerais, close to the São Paulo border (Carvalho, 1987), and the single Paraná site. All of the sites show low occurrence of mesotrophic indicator species. This is a very distinct southern group corresponding to Group 2 of Ratter *et al.* (1996).

Group 2: Like the previous, this is also a clearly natural group. It consists of 24 sites from Minas Gerais, mostly situated in the southern or central part of the state. The number of mesotrophic indicator species occurring in most of the sites is relatively low. The group corresponds to Group 3 recognized by Ratter *et al.* (1996).

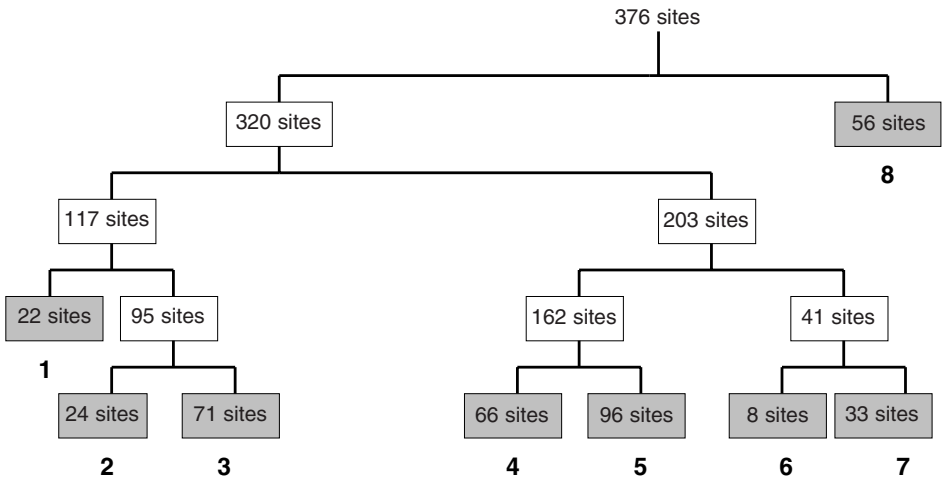

FIG. 4. Site hierarchy derived from the TWINSPAN analysis. 1, Southern dystrophic sites (SP, MG, PR); 2, Southeastern, mainly dystrophic sites (MG); 3, Broad geographical grouping with strong dystrophic tendencies (MG, DF, GO, MT, MS, BA, PA, RR, SP, TO); 4, Predominantly northeastern group, with some outliers (MA, TO, BA, PI, CE, GO, MG, PA, MT, RO); 5, Central-western mesotrophic group (TO, MT, GO, MS, (MG)); 6, Mesotrophic far western sites (RO); 7, Widely spread sites with strong mesotrophic tendencies (MS, GO, MT, MA, CE, PI, TO); 8, Disjunct Amazonian sites. State abbreviations as in Fig. 1.

Group 3: This constitutes a large group of 71 mainly dystrophic sites, many aspects of which are difficult to interpret. It includes all 13 Federal District sites, 33 from Minas Gerais, and some with a far western distribution from Rondônia, Mato Grosso de Sul and even Humaitá, Amazonas (Janssen, 1986). Other sites are from Goiás, Tocantins, the far west of Bahia, Itirapina (São Paulo), and two grossly misclassified sites from Roraima which both contain only a single woody species!

Clearly, this group is partly based on natural affinities, of which the grouping of all Federal District sites and large number of those from Minas Gerais is an example. Some others, particularly those from Roraima, are certainly misclassified (and no attempt has been made to map them).

Group 4: This is a large group of 66 sites with a strongly northeastern distribution and few mesotrophic indicator species. It contains 13 (out of a total of 17) Bahia sites, a Ceará site from the Chapada do Araripe, five from the extreme north of Minas Gerais, 20 (out of 21) from Maranhão, five (out of seven) from Piauí, 16 from Tocantins, and three in Pará (one of which is certainly misclassified). There are also two sites in Mato Grosso (MT17 and MT20 of Table 1) and one in Rondônia which do not seem to fit well into the group.

Group 5: This represents a huge group of 96 sites, all with mesotrophic indicator species, which stretch as a central-western band running across the states of Mato Grosso do Sul, Mato Grosso, Goiás and Tocantins, with two outliers in NW Minas Gerais and a single in Pará, very close to the Tocantins border. It seems to represent a natural grouping, associated with a central-western distribution and widespread occurrence of mesotrophic soils.

Group 6: A small very natural group of eight mesotrophic sites in Rondônia, characterized by presence of indicators such as *Callisthene fasciculata*, etc., and mostly associated with strongly mesotrophic *solo chocolate* characteristic of a large area of the state (see p. 79).

Group 7: A group of 33 strongly mesotrophic sites, including the two with the highest mesotrophic indices in the whole study: MT31 (Poconé) and MS23 (Maracaju), the latter really more properly classified as mesophytic forest than mesotrophic cerradão. These sites are mainly of mesotrophic facies cerradão, and Mato Grosso do Sul, where this community is very widespread, is particularly well represented.

Group 8: This consists of the 56 Amazonian savanna sites which were separated from all the others at the first level of division. It contains all Roraima sites apart from two misclassified in Group 3, all Amapá sites, two from Pará, and one from Humaitá, Amazonas. This is clearly a natural group of species-poor Amazonian sites, with woody species varying in number from 19 to one, and diversity characteristics which have already been discussed on p. 76. However, two disjunct Amazonian sites have much higher species diversity and are classified as having affinities to the core area: Alter do Chão (PA01) falls into northeastern Group 4 and Humaitá (AM02) into Group 2.

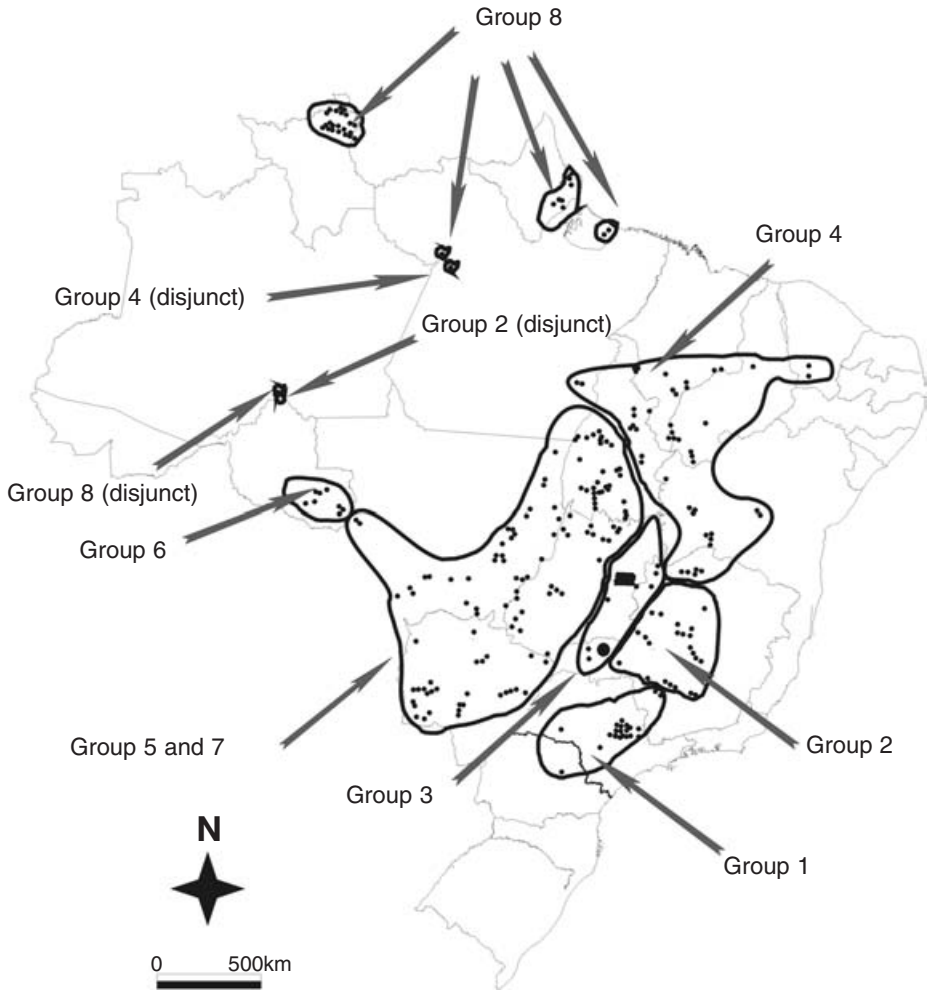

FIG. 5. Map of Brazil showing the groups defined by TWINSPAN.

2. Agglomerative hierarchical classification (UPGMA)

Analyses were made using the same data matrix as for TWINSPAN. Thus we used a slightly modified Sørensen Coefficient of Community since unicate species (occurring at only a single site) were excluded. We decided on this as in our previous studies the matrix minus unicates was undoubtedly superior in geographical fit and other factors to the complete matrix. The explanation of this is perhaps that the inclusion of unicates produces irrelevant 'noise', since many of them are undoubtedly 'rogues', including, for instance, non-cerrado species from adjacent vegetation types (gallery forests, etc.), misidentifications, unrecognized synonyms, etc.

Figure 7 shows a dendrogram derived from the UPGMA analysis and Fig. 6 is a

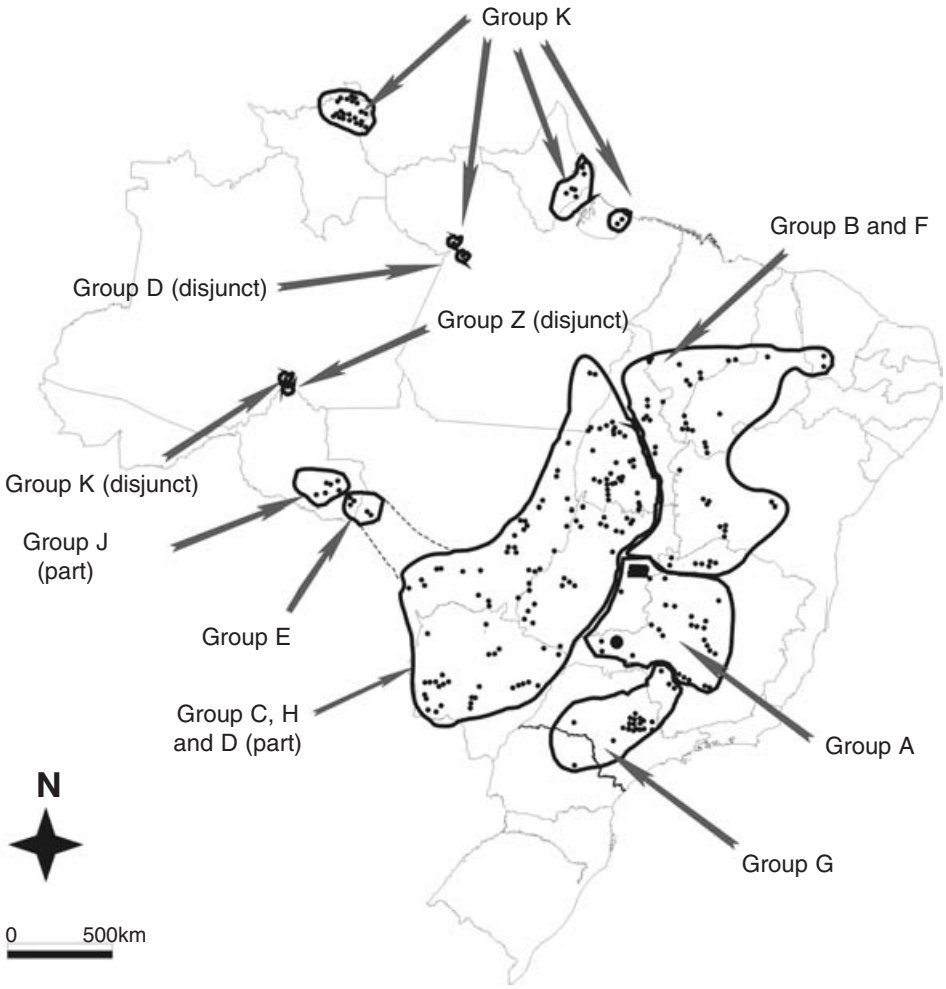

FIG. 6. Map of Brazil showing the groups defined by UPGMA.

map based on it. As the following account demonstrates, there is considerable correspondence of the results of the UPGMA and TWINSPAN analyses, as shown by the similarity of the two maps (Figs 5 and 6). Similar agreement of the results from these two methods of analysis occurred in Ratter *et al.* (1996), although in that work the data set was smaller and less complicated and the correspondence closer.

Group G consists of the southern sites and corresponds to Group 1 of the TWINSPAN classification almost exactly. The group contains all São Paulo sites, the three southern Minas Gerais sites from the Rio Grande region close to the São Paulo border (Carvalho, 1987) and the single record from Paraná. However, two further south Minas Gerais sites from São Roque de Minas are also included in the

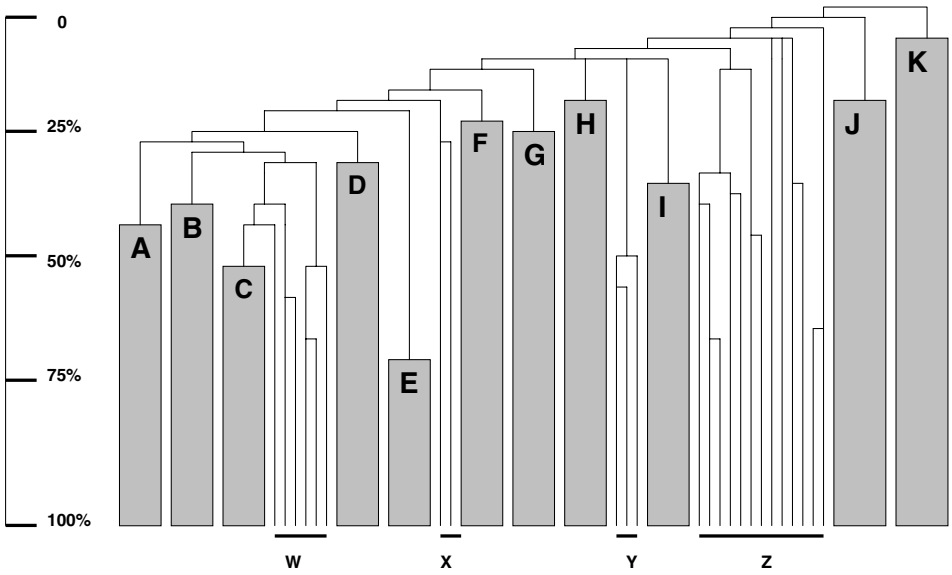

FIG. 7. Similarity dendrogram yielded by UPGMA Sørensen Coefficients of Community. A, Southeastern and Federal District sites (MG, DF, GO); B, Northeastern sites (TO, MA, BA, MG, PI); C, Central-western sites with strong mesotrophic tendencies (MS, MT, GO, TO, PA, MG); D, Mixed geographical group (PA, MT, TO); E, Far western dystrophic sites (RO, MT); F, Mainly northeastern mesotrophic grouping (MA, PI, BA, MG, MT); G, Southern sites (SP, MG, PR); H, Western mesotrophic sites (RO, MS); I, Southeastern sites (MG); J, Far western mesotrophic sites (RO); K, Disjunct Amazonian savanna sites; W, X, Y, Z, Small mixed groupings. State abbreviations as in Fig. 1.

UPGMA classification. These sites fell into the large TWINSPAN Group 3, but the indication of their affinity by UPGMA seems more appropriate. As was concluded by Ratter *et al.* (1996), the southern group is clearly a very natural one, stretching from Paraná, across São Paulo, to the south of Minas Gerais (see Fig. 6).

Group A consists of all 13 Federal District sites, one from Goiás close to the Federal District, and 31 from Minas Gerais, particularly from the central and southern parts of the state. It should also be related to the rather anomalous Group I consisting of 20 sites in the municipality of Uberlândia, Minas Gerais, reported by Araújo *et al.* (1997). These sites all showed low diversity, ranging from 20 to 37 species, almost undoubtedly because of the employment of a very small representative sample (30 Point-Centered Quarter points, i.e. 120 individuals), and gave the impression of a very natural, almost endemic group for the Triângulo Mineiro. However, when the floristic lists of all these sites were added together they provided a total list of 99 species which we noticed bore a strong resemblance to that of the typical cerrado flora of the Federal District. Comparison of this composite list with that of Fazenda Água Limpa, Federal District (Ratter, 1986) gave a Sørensen Coefficient of Community of 0.84, thus demonstrating a very high floristic affinity between the

Federal District and Uberlândia. Group A, with Group I combined, corresponds more or less to the core Federal District and Minas Gerais component of Group 3 of the TWINSPAN classification, but without the outliers and obviously misclassified sites of the TWINSPAN group.

Group B consists of 46 sites with a northeastern affinity, 13 from Bahia, 17 from Maranhão, six from the extreme north of Minas Gerais, three from Piauí, and seven from Tocantins. In addition, there is a probably misclassified site from southern Minas Gerais (MG37, Prudente de Moraes). Thirty-two of these sites are in the large TWINSPAN Group 4, but the UPGMA group, unlike the TWINSPAN, does not include outliers from, for instance, Mato Grosso, Pará and Goiás.

Group C consists of 116 sites concentrated in Goiás, Mato Grosso do Sul, Mato Grosso and Tocantins, with two sites in northwestern Minas Gerais and two in Pará very close to the border with Tocantins. It has 92 sites in common with the 96 sites of TWINSPAN Group 5 with which it clearly equates. As already stated, this group is generally characterized by the presence of mesotrophic indicator species and seems to represent a natural grouping, probably associated with the widespread occurrence of mesotrophic soils. It can be described as a central-western group with strong mesotrophic tendencies.

Group J forms another natural group and consists of nine far western mesotrophic sites, six of them from Rondônia associated with mesotrophic *solo chocolate* (forming Group 6 of the TWINSPAN classification) and three sites (MS23, MT31 and MT32 of Table 1) with the highest mesotrophic species indices found in the study, all of which were placed in Group 7 of TWINSPAN.

Group H is yet another natural group, of 18 western mesotrophic sites (15 from Mato Grosso do Sul, two from Mato Grosso, and one from Rondônia). It forms approximately half of the TWINSPAN Group 7, while the other half of the sites of this TWINSPAN group fall into UPGMA Group C (nine western sites with strong mesotrophic tendency), Group J (three far western mesotrophic sites), and Group F (nine northeastern sites, again with strong mesotrophic character). Clearly this group is linked to the presence of strongly mesotrophic soils.

Group F consists of nine northeastern sites with strong mesotrophic character (two from Bahia, two from Maranhão, three from the extreme north of Minas Gerais, and two from Piauí). As already mentioned, it equates with part of the mesotrophic TWINSPAN Group 7.

Group E consists of five far western dystrophic sites (three in Rondônia and the other two in Mato Grosso close to the border between the two states). These sites fall into the western part of the large TWINSPAN Group 3.

Group D is also small and western, consisting of nine sites. Six of these lie along the eastern Mato Grosso frontier, in the area of the Pantanal do Rio das Mortes, and are classified by TWINSPAN in the large widespread central-western Group 5. The

remaining three sites are in Alter do Chão (Pará), Divinópolis (Tocantins) and Cuiabá (MT) and were placed in the northern and northeastern Group 4 by TWINSPAN.

Group K consists of 58 Amazonian savanna sites and corresponds almost exactly with TWINSPAN Group 8. One difference is in the Pará sites, where TWINSPAN includes PA02 (Ariramba) but excludes PA06 (Marajó), while UPGMA does the converse. As in the TWINSPAN classification, the two disjunct Amazonian sites with higher species diversity are associated with the core cerrado areas: Alter do Chão (PA01) in Group D and Humaitá (AM02) in Group Z (both notably heterogeneous groups).

Other groups: In addition, there is a small number of groups (W, X, Y and Z) comprising only 5% of the surveys which are very difficult to classify.

Analysis of separated dystrophic and mesotrophic sites

Division based on presence or absence of mesotrophic indicator species gave groups of 'mesotrophic' and 'dystrophic' sites, both of which were analysed separately using TWINSPAN and UPGMA. These analyses produced classifications rather similar to those provided by analysing the undivided database and there is therefore no point in describing them here. We were surprised that the division did not lead to a significantly different classification; the reason for this probably lies in the fact that it is based entirely on floristic lists and the geographical floristic similarities must far outweigh the differences in occurrence of comparatively few trophic indicator species.

Overall classification evaluation

The TWINSPAN and UPGMA analyses reveal patterns which to a large extent are concordant and demonstrate natural geographic groups within the vast area of the cerrado biome. The basic pattern can be related to that suggested by Ratter *et al.* (1996) from the analysis of 98 areas, but the great increase in sampling of the present work has actually complicated the concept of some of the central and western 'provinces'. This is not surprising as inadequate sampling often tends to produce oversimplified and clear-cut results which become less distinct in the light of further data.

The main core area of cerrado *sensu lato* is clearly a floristic continuum with much geographic variation based on soil, climatic and spatial factors. The consensus map (Fig. 8) is almost a repeat of that produced from the UPGMA analysis, since we feel that in general it provides a more accurate pattern than that produced by TWINSPAN, although as discussed there is a high degree of agreement between the results of the two methods. An exception to this is the treatment of the dystrophic Rondônian and extreme western Mato Grosso sites which have been united with the central-western group as in TWINSPAN rather than maintained as an isolated group

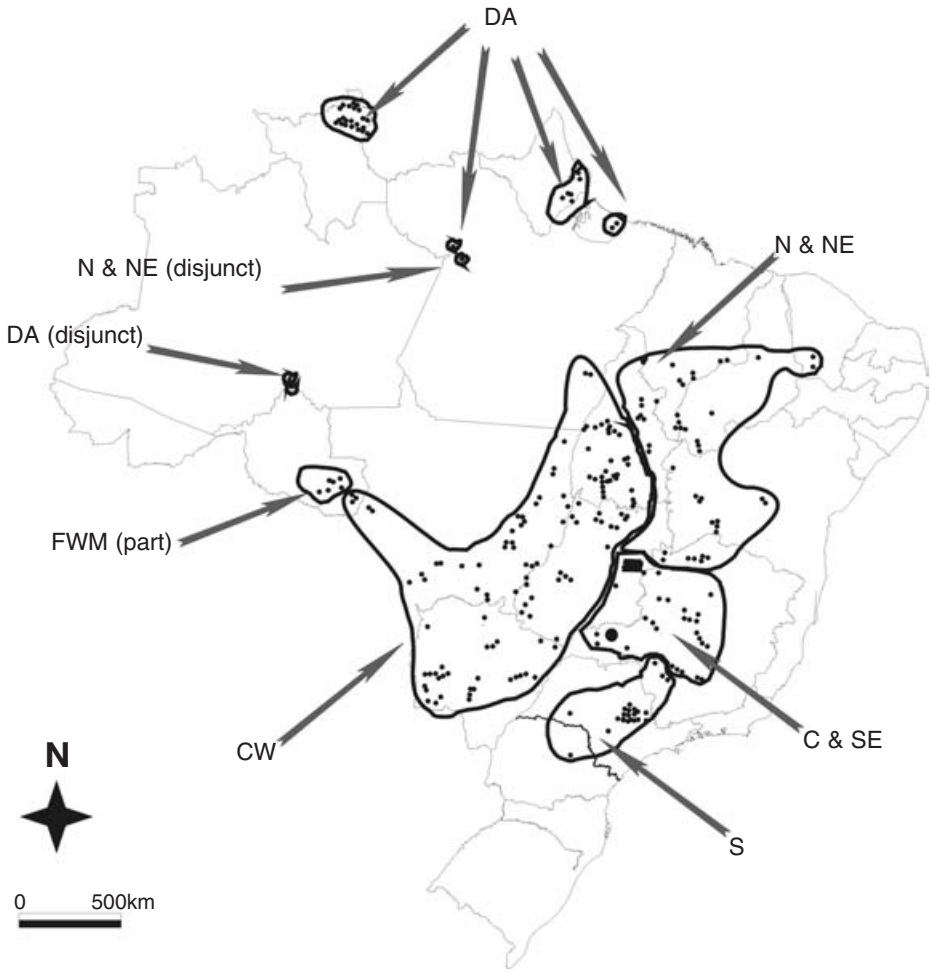

FIG. 8. Consensus map showing floristic regions within the cerrado biome of Brazil. C & SE, Central & southeastern; CW, Central-western; DA, Disjunct Amazonian savannas; FWM, Far western mesotrophic sites; N & NE, North and northeastern; S, Southern.

following UPGMA. A summary of the characteristics of the geographical groups recognized is given below.

Southern sites. These form one of the most distinctive groups recognized and consist of the São Paulo sites, the single site recorded for Paraná, and a small number in the south of Minas Gerais (TWINSPAN Group 1, UPGMA Group G). These areas have been well studied and contain a large number of characteristic species.

Central and southeastern sites. These are made up of UPGMA Groups A and I, comprising all the Federal District sites, one in neighbouring Goiás, and 51 from Minas Gerais, mostly in the south and central parts of the state. The grouping more

or less unites TWINSPAN Groups 2 and a part of 3; we feel that the merger of these groups gives a more workable classification.

North and northeastern sites. These correspond approximately to TWINSPAN Group 4 and UPGMA Groups B and F and include sites from Bahia, Ceará, the extreme north of Minas Gerais, Maranhão, Piauí, Tocantins, and one site in Pará very close to the Tocantins border. They equate, at least in part, to the northern sites of Ratter *et al.* (1996), although there has been a huge increase in information available since that publication.

Central-western sites. This is made up of a huge swathe of sites running across the states of Mato Grosso do Sul, Mato Grosso, Goiás, Tocantins, and into Pará close to the Tocantins border. It is the group which is classified as Group 5 by TWINSPAN (96 sites) and Group C by UPGMA (116 sites). As previously mentioned, this group contains sites with many mesotrophic indicator species and thus is frequently characteristic of richer cerrado soils.

Widely spread sites of strong mesotrophic character. This group occurs in Ceará, Goiás, Mato Grosso, Piauí and Tocantins, but is particularly well represented in Mato Grosso do Sul where the original dominant vegetation of large areas was mesotrophic facies cerradão with *Terminalia argentea* as perhaps the most characteristic tree. It corresponds to TWINSPAN Group 7 and much of UPGMA Group H (see discussion under TWINSPAN, p. 81, and UPGMA, p. 85). The group is probably largely linked to soil factors and much of its range falls within that of the large central-western group.

Far western mesotrophic sites. This is a small set of 10 sites occurring on mesotrophic soils in Rondônia, Mato Grosso do Sul (Maracaju) and on capões (small isolated forest patches) in the Mato Grosso Pantanal at Poconé. It forms Group 6 of TWINSPAN and Group J of UPGMA (see discussion on pp. 81 and 85), and is closely related to the previous group above. Clearly the dominant factor in determining the characteristics of this floristic group is the presence of mesotrophic soils.

Disjunct Amazonian sites. As already discussed, these form a very distinct group in both TWINSPAN and UPGMA classifications.

Thus we recognize six geographical subsets within the immense cerrado region, albeit that several show considerable overlap (so much so that it was not practical to place the 'widely spread sites of strong mesotrophic character' on the map), and, in addition, a very distinct Amazonian savanna group. Essentially we are describing regional variation within a vegetation continuum, although the floristic heterogeneity of different parts of this continuum can be very great. To some extent these regions can be recognized in the field by the few people familiar with the whole of the cerrado region. On a few occasions our team has noticed differences during journeys and remarked on 'the flora becoming like that of the Federal District here', or 'this reminds me of Xavantina', or 'quite a strong southern element here'. It would be

interesting to give experienced people unlabelled representative herbarium collections and ask them to identify the geographic source, or to transport them in a windowless aircraft to identify their destination on the basis of cerrado floristics! The clues lie in characteristic marker species, for example *Hirtella ciliata*, *Caryocar cuneatum* and *Parkia platycephala* in north and northeastern sites, *Vochysia gardneri*, *Platonia insignis* and *Martiodendron mediterraneum* in the northeast (the latter pair rather improbable-looking cerrado trees), *Mezilaurus crassiramea*, *Aspidosperma multiflorum* and *Eschweilera nana* in central-western sites, and *Acosmium subelegans*, *Campomanesia adamantium*, *Erythroxylum cuneifolium*, *Gochnatia* spp. and many *Lauraceae* in southern sites, to name but a few. Detailed consideration of regional floristic variation is being reserved for a future publication.

General Discussion and Conclusions

The analysis of the greatly increased data set now available strengthens the knowledge of the distribution patterns of the flora of the cerrado biome shown by our previous work (Ratter & Dargie, 1992; Ratter *et al*., 1996) and by other workers (Castro, 1994a,b; Castro & Martins, 1999). As in Ratter *et al*. (1996), there is a close correspondence between the results of TWINSPAN and UPGMA analyses, and this has allowed us to construct a fairly congruent phytogeographic scheme (pp. 87–88, Fig. 8).

The most striking feature of the analyses is the separation at first division of the species-poor Roraima and the majority of the other isolated Amazonian savannas from the central continuous cerrado core and its more southern outliers. Our observations of the latter agree quite well with those of Castro (1994a,b) and Castro & Martins (1999) who recognize three supercentres of biodiversity within the cerrado biome on the basis of the analysis of 145 surveys. These are:

(a) São Paulo state (where two subdivisions, SP1 and SP2, were recognized, with cerradão and campo cerrado respectively as the dominant components).
(b) Planalto central with four subdivisions (PC1, PC2, PC3 and the Pantanal).
(c) A northeastern group.

These more or less correspond in our classification on pp. 87–88 to:

(a) The southern sites.
(b) The central and southeastern and the central-western sites and, to some extent, the widely spread mesotrophic sites.
(c) Our north and northeastern sites.

The southern sites form a very distinct group in our analyses and those of Castro (1994a,b) and Castro & Martins (1999). Further information is available from very recent work of Durigan (2001) who in a comprehensive study surveyed and compared by multivariate analyses no less than 86 areas in the state of São Paulo. Durigan *et al*. (in press) have also compared their floristic data with species lists from surveys of 137 areas made by other workers in the states of Paraná, Minas Gerais, Mato

Grosso do Sul, Goiás and Mato Grosso. As in the work of Castro (1994a,b) and Castro & Martins (1999), their results demonstrate that two physiognomically correlated groups occur in the São Paulo cerrado flora: one, predominantly of cerrado ralo (campo cerrado) from the centre to the north and northeast of the state, shows affinity with areas in the south of Minas Gerais and Mato Grosso do Sul, but is very distinct from those of Goiás, while the other, of cerradões from the northwest, shows stronger separation from all cerrados external to the state.

Castro (1994a,b) and Castro & Martins (1999) correlate their groups and 'supercentres of biodiversity' with climatic factors of the environment. They point out that across the cerrado region soil hydric deficiency increases in a southeast–northeast direction, as does mean temperature, and suggest that species distributions can be correlated with this trend. They state that two climatic barriers cut across the region of the cerrados: occurrence of frosts to the south of 20°S, and of severe droughts to the north and east of 15°S, 45°W. In addition, altitude reinforces the separation of these supercentres. These conclusions are undoubtedly valid and support, with enormously more data and detail, the very preliminary observations of Ratter & Dargie (1992) of major gradients correlated with latitude and to some extent longitude. The third, and strongest, determining factor observed by Ratter & Dargie (1992) was soil type (mesotrophic vs. dystrophic); however, the floristic differentiation associated with this involves a suite of relatively few calcicolous species (Ratter *et al.*, 1977; Furley & Ratter, 1988) which can occur sporadically wherever erosion cuts down into base-rich rocks, and thus the distribution of this floristic subtype (mesotrophic facies cerradão) can be very scattered, although it sometimes covers large tracts, as in Mato Grosso do Sul. In addition to modern environmental factors, the present vegetation pattern of the cerrado biome must reflect major dynamic changes during the Tertiary and Quaternary periods, and much further research is necessary to correlate our observations with new data emerging on this subject.

Consideration of the total woody biodiversity of the cerrado biome is being reserved for a future publication but it is worth stressing one point here. Previous researchers (Rizzini, 1963, 1979; Castro & Martins, 1999) have considered that core areas of the cerrado are richest in species while the periphery shows a poorer flora containing accessory species characteristic of neighbouring biomes. However, our observations show that although much of the core (e.g. Federal District, etc.) is very rich in species, peripheral areas in the Rio Xingu, Araguaia and Tocantins drainage, and even in São Paulo state, show equally high, or sometimes higher, diversity. Furthermore, the diversity of their flora is of typical endemic, 'savannic', elements, not accessories shared with neighbouring biomes as has been suggested by some workers.

In conclusion, the data presented in this communication greatly amplify those of Ratter *et al.* (1996) and provide an enhanced picture of biogeographic patterns in the cerrado biome. They have already been used in identifying priority areas for conservation by the Global Environment Facility and Brazilian Government-financed project *Ações Prioritárias para a Conservação da Biodiversidade do Cerrado*

e Pantanal (see Cavalcanti, 1999). Many other results of the CMBBC project are to be published in the near future and it is hoped that they will influence the conservation of the cerrado biome as an important World Centre of Biodiversity.

Acknowledgements

We are very grateful to a large number of people whose contribution to our work was of fundamental importance. The fieldwork of the *Conservation and Management of the Biodiversity of the Cerrado Biome* (CMBBC) project comprised 170 surveys over a vast area of the cerrado biome, and involved the participation of various teams over the years. We wish, in particular, to thank Joaquim Fonsêca Filho (driver/collector of Embrapa Cerrados) who took part in almost all the surveys, and helped us enormously as a result of his superb field knowledge of the flora; in addition, he drove about 50,000km with his usual skill, much of it over dirt roads. We were fortunate to have expert help and guidance from the following local experts: Dr Arnildo Pott (Embrapa CPAP) and Professora Eliana de Lima Jacques (UFMS, Três Lagoas) in Mato Grosso do Sul; the team of the Department of Biology, State University of Mato Grosso, Nova Xavantina campus, and particularly Prof. Edson de Souza Lima, in eastern Mato Grosso; Profs Fernando F. Leão, Alessandra Kozovits and Eder S. Pinto and their team from the Agronomy Department, State University of Tocantins, Gurupí campus, in southern Tocantins; and the technician João Ferreira (EMATER-RO, Pimenta Bueno) in Rondônia. Others who played major roles in the fieldwork were Prof. Sueli Maria Gomes (Catholic University of Brasília) in Mato Grosso do Sul, Terezinha A. B. Dias (Embrapa, Recursos Genéticos) in Rondônia, João Batista dos Santos (Técnico, Embrapa Cerrados) in Bahia and Minas Gerais, Edson Cardoso (driver/técnico, Department of Forestry, University of Brasília) in eastern Mato Grosso, and José de Carmo Lima (Técnico, University of Brasília herbarium) in Tocantins. Dr Carolyn Proença (Curator of the University of Brasília herbarium) participated in fieldwork, made valuable suggestions to improve the rapid survey technique, and provided excellent herbarium support, while the postgraduate students Rosana Farias, Fabiana Aquino, Joice Ferreira, Marcelo Simon, Gilmar dos Santos and Carlos Cardoso made a valuable contribution in the field. Particular thanks are due to Dr Giselda Durigan, Forestry Institute of São Paulo state, for giving us access to her extensive data on the cerrado vegetation of the state of São Paulo, for useful discussions, and for critical reading of the manuscript of this paper. We received a kind invitation to work on Fazenda Trijunção from its environmentally conscious proprietors, Srs Theodoro Hungria Machado, Neuber Joaquim dos Santos and José Roberto Marinho, and were provided during the work with friendship, generous logistic support, and hospitality.

Our recent research has been financed by the Baring Foundation, the European Community (financial contribution B92/4-3040/9304) and the DFID-funded *Conservation and Management of the Biodiversity of the Cerrado Biome* project

(contract no. CNTR 95 5574), while Embrapa Cerrados has provided a great amount of logistic support (including transport) and staff time.

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Received 13 May 2002; accepted after minor revision 14 November 2002

Appendix 1

The 617 species present at two or more sites and thus used in the analyses. The figures give the number of sites at which species occur. Species indicating richer (mesotrophic) soils are in bold. A, species occurring in the disjunct Amazonian savanna sites; W, widespread species recorded in cerrado area and disjunct Amazonian savanna sites; C, species found in core area but in this study recorded only in disjunct Amazonian sites; SP, recorded as a common species in São Paulo state surveys (Durigan, pers. comm. – see p. 78). When given, collectors' numbers are in parentheses.

Abuta grandifolia (Mart.) Sandw. 7
A. selloana (Benth.) Eichler 5
Acacia polyphylla DC. 5
A. paniculata Willd. 10
A. plumosa Lowe 2
Acosmium dasycarpum (Vogel) Yakovlev 200
A. nitens (Vogel) Yakovlev 4 **A**, **C**
A. subelegans (Mohl.) Yakovlev 64
***Acrocomia aculeata* (Jacq.) Lodd. ex Mart.** 53
Aegiphila integrifolia (Jacq.) Jacks. 2 **A**
A. lhotskiana Cham. 90
A. paraguariensis Briq. 5
A. sellowiana Cham. 3
A. tomentosa Cham. 2
A. verticillata Vell. 2
Agonandra brasiliensis Miers 129 **A**, **W**
Aiouea trinervis Meissn. 2
***Albizzia niopoides* (Spruce ex Benth.) Burk.** 3
Alchornea schomburgkii Klotzsch (incl. *A. discolor* Poepp. & Endl.) 12
A. triplinervia Müll. Arg. 4 **SP**

Alibertia concolor (Cham.) K. Schum. 8
A. edulis (L. Rich) A. Rich (incl. *A. lanceolata*) 115 **A**, **W**
A. elliptica (Cham.) K. Schum. 19
A. macrophylla K. Schum. 8
A. obtusa K. Schum. 64
A. sessilis (Vell.) K. Schum. 40
A. verrucosa S. Moore 8
Allophylus edulis Radlk. ex Warm. 5
***Aloysia virgata* Juss.** 2
Amaioua guianensis Aubl. 5 **SP**
Amburana cearensis (Fr. Allem.) A.C. Sm. 2
Anacardium occidentale L. 118 **A**, **W**
***Anadenanthera colubrina* (Vell.) Brenan var. *cebil* (Griseb.) Altschul** 39
A. peregrina (L.) Speg. 49 **A**, **W**
Andira cordata Arroyo ex R.T. Pennington 18
A. cuiabensis Benth. 90
A. inermis Kunth 5
A. vermifuga Mart. 148
Annona cacans Warm. 2
A. coriacea Mart. 173
A. crassiflora Mart. 148
A. dioica A. St.-Hil. 6
A. paludosa Aubl. 5 **A**
A. tomentosa R.E. Fr. 25
Annona sp. (R8012) 5
Annonaceae (R8202) 2
Antonia ovata Pohl 46 **A**, **W**
Apeiba tibourbou Aubl. 18 **A**, **W**
Apuleia leiocarpa (Vogel) J. Macbr. 9
Aspidosperma cylindrocarpum Müll. Arg. 5 **SP**
A. macrocarpon Mart. 123
A. multiflorum A. DC. 14
A. nobile Müll. Arg. 77
A. olivaceum Müll. Arg. 2
A. parvifolium A. DC. 9
***A. subincanum* Mart.** 70
A. tomentosum Mart. 165
Astrocaryum aculeatum G. Mey. 3
A. vulgare Mart. 3 **A**, **W**
***Astronium fraxinifolium* Schott** 178 **A**, **W**
***A. urundeuva* Fr. Allem.** 77
***Attalea phalerata* Mart.** 2
***A. speciosa* Mart. ex Spreng.** 4 **A**, **W**
Austroplenckia populnea (Reissek) Lundell 80
Baccharis dracunculifolia DC. 8
Banisteriopsis latifolia (A. Juss.) Cuatrec. 21
B. pubipetala (A. Juss.) Cuatrec. 5
Bauhinia brevipes Vogel (syn. *B. bongardii* Steud.) 14
***B. cupulata* Benth.** 7
B. forficata Link. 10
B. holophylla Steud. 6
B. mollis Walp. 2
B. pulchella Benth. 11
B. rufa (Bong.) Steud. 75
B. tenella Benth. 2
B. ungulata L. 12
Blepharocalyx salicifolius (Kunth) O. Berg (syn. *B. suaveolens* (Cambess.) Bur. & *B. acuminatus* O. Berg) 25
Bowdichia virgilioides Kunth 278 **A**, **W**
Bredemeyera altissima Klotzsch ex A.W. Benn. 4
B. floribunda Willd. 16
Brosimum gaudichaudii Trécul 195
Buchenavia tomentosa Eichler 81
Butia archeri (Glassman) Glassman (=*B. leiospatha* (Mart.) Becc.) 17
B. paraguayensis (Barb.-Rodr.) L.H. Bailey 4
Byrsonima basiloba A. Juss. 43
B. clausenniana A. Juss. 3
B. coccolobifolia Kunth 230 **A**, **W**
B. coriacea DC. 5 **SP**
B. correifolia A. Juss. 7
B. crassa Nied. (syn. *B. pachyphylla* A. Juss.) 195
B. crassifolia (L.) Kunth (syn. *B. fagifolia* Nied.) 84 **A**, **W**
B. cydoniifolia A. Juss. (syn. *B. orbignyana* A. Juss.) 11
B. dealbata Griseb. 2
B. guilleminiana A. Juss. 2
B. inodorum S. Moore 4
B. intermedia A. Juss. 62
B. lancifolia A. Juss. 3
B. cf. *oblongifolia* A. Juss. 2
B. psilandra Griseb. 2
B. schomburgkiana Benth. 4 **A**
B. sericea DC. 15
B. sessilifolia Benth. 3
B. stipulacea A. Juss. 7
B. variabilis A. Juss. 2

B. verbascifolia Rich. ex A. Juss. 176 **A**, **W**
Byrsonima sp. (R7756V) 4

Cabralea canjerana (Vell.) Mart. 7
***Callisthene fasciculata* (Spreng.) Mart.** 74
C. major Mart. 33
C. minor Mart. 3
Callisthene sp. nov.? (R7228) 19
Calophyllum brasiliense Cambess. 6
Calycolpus goetheanus Berg 2 **A**
***Calycophyllum multiflorum* Griseb.** 5
Campomanesia adamantium (Cambess.) O. Berg (= *C. cambessediana* O. Berg) 5 **SP**
C. coerulescens O. Berg 4
C. cf. *xanthocarpa* O. Berg 2
C. pubescens O. Berg (syn. *C. corymbosa* Blume) 34
C. salviaefolia O. Berg 2
Caraipa densifolia Mart. 2
Cardiopetalum calophyllum Schltdl. 24
Cariniana domestica (Mart.) Miers (incl. *C. rubra* Gardner ex Miers) 7
Caryocar brasiliense Cambess. 198
C. cuneatum Wittm. 54
Casearia arborea Urb. 11
C. decandra Jacq. 4
C. gossypiosperma Briq. 3
C. grandiflora Cambess. 40 **A**, **W**
C. javitensis Kunth 4
***C. rupestris* Eichler** 10
C. sylvestris Sw. 218 **A**, **W**
Cecropia pachystachya Trécul 46 **A**, **W**
***Cedrella fissilis* Vell.** 2
***Ceiba speciosa* (A. St.-Hil.) Gibbs & Semir** 2
Celtis pubescens (Kunth) Spreng. 8
Cenostigma macrophyllum Tul. 19
***Cereus jamacaru* DC.** 3
Chaetocarpus echinocarpus (Baill.) Ducke 4
C. multijuga Rich. 2 **A**
Chamaecrista orbiculata (Benth.) Irwin & Barneby 8
Cheiloclinium cognatum (Miers) A.C. Sm. 3
Chiococca alba Hitchc. 4
Chomelia obtusa Cham. & Schltdl. 11
C. pohliana Müll. Arg. 8
C. ribesioides Benth. 20
Chrysophyllum arenarium Fr. Allem. 3
C. marginatum Radlk. 11
Clusia sellowii Schltdl. 3
***Cnidoscolus vitifolia* (L.) Pohl** 16
Coccoloba brasiliensis Nees & Mart. 3
C. mollis Casar. 30
Cochlospermum orinocense Steud. 2
C. vitifolium (Willd.) Spreng. 26
***Combretum duarteanum* Cambess.** 6
***C. leprosum* Mart.** 8
C. mellifluum Eichler
Connarus suberosus Planch. 237
Copaifera langsdorfii Desf. 147
C. malmei Harms 51
C. martii Hayne 57
C. oblongifolia Mart. ex Hayne 3
Cordia alliodora (Ruiz & Pav.) Oken 5
***C. glabrata* (Mart.) A. DC.** 28
C. insignis Cham. 7
C. sellowiana Cham. 8
C. superba Cham. 7
***C. trichotoma* (Vell.) Arrab.** 13
Couepia grandiflora (Mart.) Benth. 131
Couepia sp. (S1082) 2
Coussarea hydrangeaefolia (Benth.) Müll. Arg. 46
Coutarea hexandra (Jacq.) K. Schum. 2
Croton floribundus Spreng. 3 **SP**
Cupania vernalis Cambess. 11
Curatella americana L. 247 **A**, **W**
Cybianthus densiflorus Mart. 2
C. detergens Mart. 18
Cybistax antisyphilitica Mart. 96

Dalbergia cuiabensis Benth. 5
D. glandulosa Benth. 2
D. miscolobium Benth. (= *D. violacea* (Vogel) Malme) 142
Daphnopsis fasciculata (Meissn.) Nevling 7
Davilla elliptica A. St.-Hil. 186
D. grandiflora A. St.-Hil. & Tul. 2
Dictyoloma incanescens DC. 2
Didymopanax distractiflorum Harms 20 **A**, **W**
D. macrocarpum (Cham. & Schltdl.) Seem. 66
D. morototoni Decne & Planch. 6
D. vinosum (Cham. & Schltdl.) March. 37
Didymopanax sp. (R8142) 2
Didymopanax sp. (S1004) 2
Didymopanax sp. (S1092) 2

***Dilodendron bipinnatum* Radlk.** 67
Dimorphandra mollis Benth. (incl. *D. gardnerianum* Tul.) 238
Diospyros hispida DC. 184
D. sericea DC. 38
***Dipteryx alata* Vogel** 101
Diptychandra aurantiaca (Mart.) Tul. (syn. *D. glabra* Benth.) 31
Doliocarpus dentatus (Aubl.) Standl. 3
Duguetia furfuracea (A. St.-Hil.) Benth. & Hook. 90
D. lanceolata A. St.-Hil. 5
D. magraviana Mart. 3

Emmotum nitens (Benth.) Miers 141
***Enterolobium contortisiliquum* (Vell.) Morong** 13
E. gummiferum (Mart.) J. Macbr. 119
Eremanthus glomerulatus Less. 28
E. goyazensis (Gardn.) Sch. Bip. 11
E. graciellae MacLeish & Shumach. 3
E. incanus (Less.) Less. 2
E. mattogrossensis O. Kuntze 6
Eriotheca gracilipes (Schum.) A. Robyns 159
Eriotheca parvifolia (Mart. & Zucc.) A. Robyns 26
E. pubescens (Mart. & Zucc.) Schott. & Endl. 61
E. rondoniensis 3
Eriotheca sp. (R7863V) 2
***Erythrina mulungu* Mart.** 3
Erythroxylum ambiguum Peyr. 9
E. anguifugum Mart. 3
E. betulaceum Mart. 6
E. citrifolium A. St.-Hil. 2
E. cuneifolium Poepp. ex O.E. Schulz 10
E. daphnites Mart. 31
E. deciduum A. St.-Hil. 85
E. engleri O.E. Schulz 5
E. cf. *foetidum* T. Plowman 3 **A**
E. gonocladum (Mart.) Schulz 4
E. pelleterianum A. St.-Hil. 2 **SP**
E. pruinosum O.E. Schulz 5
E. suberosum A. St.-Hil. 215 **A**, **W**
E. subracemosum Turcz. 6 **A**, **W**
E. tortuosum Mart. 99
E. vacciniifolium Mart. 2
Erythroxylum sp. (R7870) 3
Eschweilera nana (O. Berg) Miers 31
Eugenia aurata O. Berg 33
E. biflora DC. 6
E. bimarginata DC. 19
E. chrysantha O. Berg 7
E. coarensis Greves 2 **A**
***E. dysenterica* DC.** 121
E. florida DC. 7
E. hyemalis Cambess. 5
E. klotzschiana O. Berg 3
E. livida O. Berg 6 **SP**
E. pluriflora Mart. 3 **SP**
E. punicifolia (Kunth) DC. (syn. *E. polyphylla* O. Berg) 15 **A**, **W**
E. uniflora L. 2
Euplassa inaequalis (Pohl) Engl. 25

Ferdinandusa elliptica Pohl 56
Ficus citrifolia P. Mill. 3
F. gomelleira Kunth & Bouché 2

Genipa americana L. 18 **A**, **W**
Gochnatia barrosii Cabrera 10
G. polymorpha DC. 4 **SP**
G. pulchra Cabrera 7
Gomidesia lindeniana O. Berg 5
Guadua sp. 2
Guapira graciliflora (Mart. ex J.A. Schmidt) Lundell 48
G. noxia (Netto) Lundell var. *noxia* 63
G. noxia (Netto) Lundell var. *psammophila* (Mart. ex J.A. Schmidt) ined. 39
G. opposita (Vell.) Reitz 7 **SP**
G. tomentosa (Casar.) Lundell 5
Guatteria sellowiana Schltdl. 5
***Guazuma ulmifolia* Lam.** 85
***Guettarda viburnoides* Cham. & Schltdl.** 82

Hancornia speciosa Gomez (incl. *H. pubescens* Nees & Mart.) 173 **A**, **W**
Heisteria citrifolia Engl. 3
H. ovata Benth. 31
***Helicteres brevispira* A. Juss. in A. St.-Hil.** 18
H. corylifolia Nees & Mart. 2
H. sacarolha A. St.-Hil. 5
Heteropterys byrsonimifolia A. Juss. 84
Hibiscus peruvianus R.E. Fr. 2 **A**
Himatanthus articulatus (Vahl) Woodson 26 **A**, **W**

H. bracteatus (A. DC.) Woodson 2
H. obovatus (Müll. Arg.) Woodson 193 **A**, **W**
H. tarapotensis (Schumann) Plumel ex Spreng. 2
Hirtella ciliata Mart. ex Zucc. 54 **A**, **W**
H. glandulosa Spreng. 62 **A**, **W**
H. gracilipes (Hook.f.) Prance 8
H. racemosa Lam. 2
Humiria balsamifera (Aubl.) A. St.-Hil. 5 **A**, **C**
Hymenaea courbaril L. var. *stilbocarpa* (Hayne) Lee & Lagn. 36
H. eriogyne Benth. 6
H. stigonocarpa Mart. ex Hayne 236
Hyptidendron canum (Pohl ex Benth.) Harley (=*Hyptis cana* Pohl ex Benth.) 28

Ilex affinis DC. 4
I. cerasifolia Reissek 5
I. concocarpa Reissek 6
Inga vera Willd. ssp. *affinis* (DC.) T.D. Pennington 2

Jacaranda brasiliana Pers. 46
J. caroba (Vell.) DC. 18 **A**, **W**
***J. cuspidifolia* Mart.** 35

Kielmeyera coriacea (Spreng.) Mart. 227
K. corymbosa Mart. 6
K. grandiflora (Wawra) N. Saddi 3
K. lathrophyton Saddi 40
K. rosea Mart. 6
K. rubriflora Cambess. 56
K. speciosa A. St.-Hil. 34
Kielmeyera sp. nov.? (R7954) 19

Lacistema aggregatum (Berg) Rusby 7 **A**, **W**
L. floribundum Miq. 2
L. hasslerianum Chodat 5 **SP**
Lafoensia pacari A. St.-Hil. (incl. *L. densiflora* Pohl) 238 **A**, **W**
L. replicata Pohl 2
Lamanonia ternata Vell. 3
Leandra involucrata Raddi 3
L. lacunosa Cogn. 6
Licania gardneri (Hook.f.) Fritsch 15
L. humilis Cham. & Schltdl. 50
L. octandra (Hoffm. ex Roem. & Schult.) O. Kuntze 2
L. sclerophylla Mart. ex Hook.f. 12
Lippia corymbosa Cham. 2
L. microphylla Cham. 7 **A**
Lithraea molleoides (Vell.) Engl. (syn. *L. aroerinha* March. ex Warm.) 23
***Luehea candicans* Mart.** 11
L. divaricata Mart. 15
***L. grandiflora* Mart.** (syn. *L. rufescens* A. St.-Hil., *L. speciosa* sensu K. Schum. non Willd.) 23
***L. paniculata* Mart.** 101
Luetzelburgia auriculata (Fr. Allem.) Ducke 3
L. praecox Harms 8
Lychnophora ericoides Mart. 3

Mabea fistulifera Mart. 17 **A**, **W**
Macairea radula DC. 8
Machaerium aculeatum Raddi 3
M. acutifolium Vogel 189
M. angustifolium Mart. ex Benth. 12
M. hirtum (Vell.) Stellfeld 3 **SP**
M. opacum Vogel 99
***M. scleroxylon* Tul.** 8
M. stipitatum Vogel 2
M. tortum 2
M. villosum Vogel 10
***Maclura tinctoria* (L.) Don ex Steud.** 4
***Magonia pubescens* A. St.-Hil.** 146
Manihot grandiflora Müll. Arg. 2
M. tripartita (Spreng.) Müll. Arg. 9
Maprounea guianensis Aubl. 66 **A**, **W**
Martiodendron mediterraneum (Mart. ex Benth.) Koeppen 3
Matayba elaeagnoides Radlk. 2 **SP**
M. guianensis Aubl. 101 **A**, **W**
Maytenus ilicifolia Mart. ex Reissek 3
M. robusta Reissek 2 **SP**
Mezilaurus crassiramea (Meissn.) Taub. 27
M. matogrossensis nom. inedit. 2
Miconia albicans (Sw.) Triana 151 **A**, **W**
M. alborufescens Naud. 2
M. argyrophylla DC. 2 **A**
M. burchellii Triana 9
M. fallax DC. 17
M. ferruginata DC. 34
M. holosericea Triana 3 **A**, **W**
M. langsdorffii Cogn. 4 **SP**
M. ligustroides (DC.) Naud. 16
M. macrothyrsa Benth. 9

M. nervosa (Sm.) Triana 2 **A**, **W**
M. pepericarpa DC. 2
M. pohliana Cogn. 20
M. rubiginosa (Bonpl.) DC. 28 **A**, **W**
M. sellowiana Naud. 10
M. stenostachya DC. 26
M. theaezans Cogn. 4
Miconia sp. (R8199) 2
Mimosa acutistipula (Mart.) Benth. 2
M. claussenii Benth. 16
M. laticifera Rizzini & Mattos f. 18
M. manidea Barneby 2
M. microcephala Humb. & Bonpl. ex Willd. 4 **A**
M. pteridifolia Benth. 5
M. sericantha Benth. 2
M. verrucosa Benth. 2
Mollia burchellii Sprague 5
Monnina martiana Klotzcsh ex A.W. Benn. 2
Mouriri elliptica Mart. 95
M. pusa Gardner 63
Myrcia albotomentosa Cambess. 26
M. bella Cambess. 2 **SP**
M. camapuanensis N.J.E. Silveira 5
M. canescens O. Berg 10
M. castrensis (O. Berg) Legr. 4
M. fallax (Rich.) DC. 3 **SP**
M. formosiana Cambess. 2
M. gardneriana O. Berg. 3
M. guajavifolia O. Berg 2
M. intermedia Kiaersk. 3
M. lanuginosa O. Berg 12
M. lasiantha DC. 9
M. lingua (O. Berg) Mattos & Legr. 22
M. multiflora DC. 8
M. mutabilis O. Berg 2
M. ochroides O. Berg 4
M. pallens DC. 12
M. pubipetala Miq. 3
M. cf. *regnelliana* O. Berg 3
M. rorida (O. Berg) Kiaersk. 21
M. rostrata DC. 26
M. rufipes DC. 3
M. schottiana O. Berg 7
M. sellowiana O. Berg 31
M. sphaerocarpa DC. 2
M. splendens (Sw.) DC. 21
M. superba O. Berg 2
M. tomentosa (Aubl.) DC. 49
M. uberavensis O. Berg 9
M. variabilis DC. 18
M. venulosa DC. 2 **SP**
M. sp. (R8159) 2
M. sp. (R8160) 2
M. sp. (S1070) 6
M. sp. (S2243) 2
M. sp. (Sueli 275) 3
M. sp. (R7874V) 2
M. sp. (R7890) 3
M. sp. (R7927V) 3
M. sp. (R7944) 2
Myrciaria floribunda (West ex Willd.) O. Berg 2
Myrtaceae sp. (R8107) 2
Myrtaceae sp. (S1126V) 3
Myrtaceae sp. (Sueli 276) 4

Nectandra cuspidata Nees & Mart. 2 **SP**
Neea spruceana Heimerl. 2
N. theifera Oerst. 116
Norantea adamantinum Cambess. 2
N. goyazensis Cambess. 2

Ocotea acutifolia (Nees) Mez 4
O. corymbosa (Meissn.) Mez 5 **SP**
O. minarum Mart. ex Nees 15
O. pomaderroides (Meissn.) Mez 3
O. pulchella Mart. 19
O. spixiana (Nees) Mez 6
O. suaveolens (Meissn.) Hassler 3
Ouratea castaneaefolia Engl. 51 **A**, **W**
O. cuspidata (A. St.-Hil.) Engl. 2
O. hexasperma (A. St.-Hil.) Benth. 176 **A**, **W**
O. spectabilis (Mart.) Engl. 81
Oxandra sessiliflora R.E. Fr. 2

Palicourea rigida Kunth 140 **A**, **W**
Parkia platycephala Benth. 34
Peltogyne confertiflora (Hayne) Benth. 22
Peltophorum dubium (Spreng.) Taub. 2
Pera glabrata (Schott.) Baill. 22
P. obovata Baill. 4 **SP**
Persea pyrifolia Nees & Mart. ex Nees 3 **SP**
Phoebe erythropus (Nees, Mart. & Spix) Mez 5
***Physocallyma scaberimmum* Pohl** 49 **A**, **W**

Piptadenia gonoacantha (Mart.) J. Macbr. 5
P. moniliformis Benth. 3
Piptocarpha rotundifolia (Less.) Baker 125
Plathymenia reticulata Benth. 173 **A**, **W**
Platonia insignis Mart. 9 **A**, **W**
***Platymiscium floribundum* Vogel** 3
***Platypodium elegans* Vogel** (syn. *P. grandiflorum* Benth.) 44
Pouteria ramiflora (Mart.) Radlk. 210
P. torta (Mart.) Radlk. 91
***Priogymnanthus hasslerianus* (Chodat) P.S. Green** (syn. *Linociera hassleriana* (Chod.) Hassler) 14
Protium brasiliense (Spreng.) Benth. 4
P. heptaphyllum (Aubl.) Marchal 100 **A**, **W**
P. ovatum Engl. 18
Prunus brasiliensis (Cham. & Schltdl.) Schott. ex Spreng. 2
P. myrtifolia (L.) Urb. 3
P. sellowii Koehne 3
Pseudobombax grandiflorum (Cav.) A. Robyns 2
P. longiflorum (Mart. & Zucc.) A. Robyns 149
P. marginatum (A. St.-Hil., A. Juss. & Cambess.) A. Robyns 19
***P. tomentosum* (Mart. & Zucc.) A. Robyns** 74
Psidium aerugineum O. Berg 3
P. araça Raddi 3 **A**, **W**
P. australe Cambess. 4
P. cinereum Mart. ex DC. 3
P. guineense Sw. 28 **A**, **W**
P. myrsinoides O. Berg 76
P. pohlianum O. Berg 13
P. warmingianum Kiaersk. 21
Psychotria sessilis (Vell.) Müll. Arg. 3
Pterodon polygalaeflorus Benth. 68
P. pubescens Benth. 92
Pterogyne nitens Tul. 2

Qualea cordata Spreng. 10
Q. densiflora Warm. 2
Q. dichotoma (Mart.) Warm. 26
Q. glauca Mart. 2
Q. grandiflora Mart. 274
Q. multiflora Mart. 164
Q. parviflora Mart. 251

Randia armata (Sw.) DC. 3 **A**, **W**
R. formosa (Jacq.) K. Schum. 4 **A**, **C**
Rapanea ferruginea (Ruiz & Pav.) Mez 13
R. guianensis Kuntze 65
R. lancifolia (Mart.) Mez 6
R. leuconeura (Mart.) Mez 2
R. umbellata (Mart. ex DC.) Mez 20
Remijia amazonica K. Schum. 2 **A**, **W**
***Rhamnidium elaeocarpum* Reissek** 58
Richeria grandis Vahl 2
Rollinia emarginata Schltdl. 3
Roupala montana Aubl. 216 **A**, **W**
Rourea induta Planch. 126
Rudgea amazonica Müll. Arg. 3
R. viburnoides (Cham.) Benth. 68

Sacoglottis guianensis Benth. 2
Salacia crassifolia (Mart.) Peyr. 108
S. elliptica (Mart.) G. Don 22
Salvertia convallariodora A. St.-Hil. 189 **A**, **W**
Sapium longifolium (Müll. Arg.) Huber 10
S. marginatum Müll. Arg. 7
Sapium sp. (S1090) 2
***Schinopsis brasiliensis* Engl.** 2
Schinus terebinthifolius Raddi 19
Sclerolobium aureum (Tul.) Benth. 178
S. paniculatum Vogel 159 **A**, **W**
Sebastiana brasiliensis Spreng. 3
Senna bicapularis (Benth.) Irwin & Barneby 4
S. macranthera (DC. ex Colladon) Irwin & Barneby 3
S. obtusifolia (L.) Irwin & Barneby 4
S. rugosa (G. Don) Irwin & Barneby 18
S. silvestris (Vell.) Irwin & Barneby 14
S. uniflora (P. Mill.) Irwin & Barneby 2
S. velutina (Vogel) Irwin & Barneby 2
Simaba blanchettii Turcz. 3
Simarouba amara Aubl. 5 **A**, **W**
S. versicolor A. St.-Hil. 154 **A**, **W**
Siparuna guianensis Aubl. 73 **A**, **W**
Siphoneugena densiflora O. Berg 9
Solanum crinitum Lam. 7
S. lycocarpum A. St.-Hil. 47
Sorocea guilleminiana Gaud. 3
***Spondias mombin* L.** 4
***Sterculia striata* A. St.-Hil. & Naud.** 21
Strychnos pseudoquina A. St.-Hil. 137

Stryphnodendron adstringens (Mart.) Cov. 96
S. cf. *rotundifolium* Mart. ex Benth. 4
S. coriaceum Benth. 24
S. obovatum Benth. 110
S. polyphyllum Mart. 28
Styrax ambiguus Seub. 2
S. camporum Pohl 43
S. ferrugineus Nees & Mart. 94
S. nervosum A. DC. 2
Swartzia apetala Raddi 2
S. laurifolia Benth. 3 **A**
Syagrus comosa (Mart.) Mart. 82
S. flexuosa (Mart.) Becc. 68
S. oleracea (Mart.) Becc. 5
S. romanzoffiana (Cham.) Glassman 2 **SP**
Symplocos guianensis (Aubl.) Gurke 2 **A**
S. lanceolata (Mart.) A. DC. 4
S. nitens (Pohl) Benth. 5
S. pubescens Klotzsch ex Benth. 4 **SP**
S. rhamnifolia A. DC. 12
S. tenuifolia Brand. 3
S. uniflora (Pohl) Benth. 2

Tabebuia alba (Cham.) Sandw. 2
T. aurea (Manso) Benth. & Hook.f. ex S. Moore 218 **A**, **W**
***T. impetiginosa* (Mart. ex A. DC.) Standl.** 19
T. ochracea (Cham.) Standl. 214 **A**, **W**
T. roseoalba (Ridley) Sandw. 30
T. serratifolia (Vahl) Nich. 37
Tapirira guianensis Aubl. 107 **A**, **W**
Tapura amazonica Poepp. & Endl. 13
***Terminalia argentea* Mart. & Zucc.** 136
T. fagifolia Mart. & Zucc. 72
T. glabrescens Mart. 33
T. phaeocarpa Eichler 3
Ternstroemia brasiliensis Cambess. 3
Tetragastris balsamifera (Sw.) Oken 4
T. unifoliolata (Engl.) Cuatrec. 5 **A**, **W**
Tibouchina aspera Aubl. 7 **A**
T. candolleana Cogn. 5
T. sellowiana (Cham.) Cogn. 2
T. stenocarpa (DC.) Cogn. 2
Tocoyena brasiliensis Mart. 6 **SP**
T. bullata (Vell.) Mart. 3
T. formosa (Cham. & Schltdl.) K. Schum. 196 **A**, **W**
T. neglecta Brown 4 **A**
***Trema micrantha* Blume** 8
Trembleya parviflora (D. Don) Cogn. 4
Trichilia elegans A. Juss. 3
T. pallida Sw. 2
Triplaris americana L. 3

Unonopsis lindmannii R.E. Fr. 3
Unonopsis sp. (S2250) 3

Vanillosmopsis erythropappa (DC.) Sch.-Bip. 4
V. pohlii Baker 3
V. polycephala (DC.) Sch.-Bip. 7
Vatairea macrocarpa (Benth.) Ducke 190
Vellozia squamata Pohl 30
Vernonia diffusa Less. 2 **SP**
V. ferruginea Less. 90
V. rubiramea Mart. ex DC. 2
V. ruficoma Schltdl. ex Mart. 6
Virola sebifera Aubl. 57 **A**, **W**
Virola subsessilis Warb. 12
Vismia cayennensis (Jacq.) Pers. 5 **A**, **W**
V. glaziovii Ruhl. 14
V. guianensis (Aubl.) Choisy 4 **A**, **W**
***Vitex cymosa* Bert. ex Spreng.** 9
***V. polygama* Cham.** 17 **A**, **W**
V. regnelliana Mold. 2
V. schomburgkiana Schauer 5 **A**
Vochysia cinnamomea Pohl 39
V. elliptica Mart. 43
V. gardneri Warm. 31
V. haenkeana Mart. 22 **A**, **W**
V. pruinosa Pohl 2
V. rufa (C.K. Spreng.) Mart. 124
V. thyrsoidea Pohl 36
V. tucanorum (C.K. Spreng.) Mart. 41

***Ximenia americana* L.** 11
Xylopia amazonica R.E. Fr. 2 **A**, **W**
X. aromatica Lam. 185
X. brasiliensis Spreng. 6
X. nitida Dunal 2
X. sericea A. St.-Hil. 28
Xylosma benthamii Triana & Planch. 2

Zanthoxylum hasslerianum Chodat 2
Z. rhoifolium Lam. 49
***Z. riedelianum* Engl.** 32
Zeyheria montana Mart. 103

Appendix 2

The 334 species recorded at only one site. Those indicating richer (mesotrophic) soils are in bold. A, species occurring in the disjunct Amazonian savanna sites; C, species found in core area but in this study recorded only in disjunct Amazonian sites; SP, recorded as a common species in São Paulo state surveys (Durigan, pers. comm. – see p. 78).

Abarema cochliacarpos Gomes, Barneby & Grimes
Acacia glomerosa Benth.
Acacia lorentensis J. Macbr.
Acosmium lentiscifolium Schott.
Actinostemon conceptionis (Chodat & Hassler) Pax & K. Hoffm. **SP**
Aegiphila amazonica Mold. **A**
A. cf. *intermedia* Mold. **A**
Alibertia myrciifolia K. Schum.
Allophylus quercifolius (Mart.) Radlk.
Annona aurantiaca Barb. Rodr.
A. jahnii Saff. **A**
A. sp. (R7988)
Annonaceae sp. (R8222)
Aspidosperma camporum Müll. Arg.
A. polyneuron Müll. Arg.
A. populifolium A. DC.
A. pyricollum Müll. Arg.
A. warmingii Müll. Arg.
Attalea eichleri (Drude) Henderson
A. exigua Drude
A. maripa (Aubl.) Mart. **A**
Auxemma oncocalyx Taub.

Baccharis concinna G.M. Barroso
B. pseudotenuifolia Teodoro
Banisteriopsis malifolia (Nees & Mart.) B. Gates
B. variabilis B. Gates
Banisteriopsis sp. (S755)
Barbacenia ignea Mart.
Bauhinia burchellii Benth.
B. dubia G. Don var. *nitida* Benth.
B. longifolia (Bong.) Steud.
B. obtusata Vogel
Bocageopsis mattogrossensis (R.E. Fr.) R.E. Fr.
B. multiflora (Mart.) R.E. Fr.
Bocoa mollis (Benth.) Cowan
Bredemeyera brevifolia (Benth.) Kl. ex Benn.
Buchenavia tetraphylla (Aubl.) Howard (syn. *B. capitata* (Vahl) Eichler)
Byrsonima affinis W. Anderson
B. campestris L.
B. gardneriana A. Juss.
B. laxiflora Griseb.
B. leucophlebia Griseb.
B. ligustrina A. Juss.
B. ligustroides A. Juss.
B. linguifera Nied. **A**
B. vacciniaefolia A. Juss.

Caesalpinia bracteosa Tul.
Callisthene hassleri Briq.
C. microphylla Warm.
***Calotropis procera* Dryand**
Calyptranthes clusiaefolia (Miq.) O. Berg
C. concina DC. **SP**
C. lucida Mart. ex DC.
Campomanesia guazumaefolia (Cambess.) O. Berg
Cariniana estrellensis (Raddi) O. Kuntze
Casearia commersoniana Cambess.
C. lasiophylla Eichler **SP**
C. ulmifolia Vahl ex Vent. **A**
Cassia catingae Harms
Cecropia concolor Willd. **A**
C. cyrtostachya Miq.
Celtis sp. (R7548)
Centrolobium tomentosum Guill. ex Benth.
Cereus peruvianus (L.) Mill.
Chamaecrista eitenorum (Irwin & Barneby) Irwin & Barneby
C. cf. *peruana* Irwin & Barneby
C. speciosa Kunth
Chaunochiton kappleri Ducke
Chomelia parviflora Müll. Arg.
C. tenuiflora Benth. **A**
Chrysophyllum gonocarpum (Mart. & Eichler) Engler
Chrysophyllum sp. (S554)
Cinnamomum sellowianum (Nees & Mart.) Kosterm.
Clethra brasiliensis Cham. & Schltdl.
C. scabra Pers.

***Cnidoscolus urens* (L.) Arthur A, C**
Coccoloba cf. *uvifera* L.
C. paniculata Meissn.
***Commiphora leptophloeos* (Mart.) Gillet**
Connarus perottetii (DC.) Planch. var. *angustifolium* Radlk. **A**, **C**
Copaifera coriacea Mart.
C. marginata Benth.
Cordia bicolor DC. **A**
C. multispicata Cham. **A**
C. piauhiensis Fresen.
Croton urucurana Baill.
Cupania polyodonta
C. rubiginosa (Poir.) Radlk. **A**
***Cyclolobium brasiliense* Benth.**

Davilla kunthii A. St.-Hil.
Desmoncus orthacanthos Mart.
Diatenopteryx sorbifolia Radlk.
Diospyros coccolobaefolia Mart. ex Miq.
D. matogrossensis Hoehne
Duguetia cauliflora R.E. Fr.
D. glabriuscula R.E. Fr.

Ephedranthus parviflorus S. Moore
Eremanthus argenteus Mcleish & Schumach.
Erythrochiton brasiliense Nees & Mart.
Erythroxylum mucronatum Benth.
E. rufum Cav.
E. squamatum Sw.
Esenbeckia febrifuga A. Juss.
Eugenia albotomentosa Cambess.
E. brasiliana Legr.
E. cerasiflora Kurz
E. geminiflora O. Berg
E. inundata DC.
E. mugiensis O. Berg
E. myrcianthes Nied.
E. pitanga (O. Berg) Kiaersk.
E. pyriformis Cambess. **SP**
E. uruguayensis Cambess.
Eupatorium vautherianum DC.
Exellodendron gardneri (Hook.f.) Prance

Ficus doliaria Mart.
F. guaranitica Chodat
F. guianensis Desv.

Genipa caruto Kunth
Guapira obtusata (Jacq.) Lundell
G. paniculata
Guatteria australis A. St.-Hil.
G. coriacea R.E. Fr.
G. nigrescens Mart.
G. silvatica R.E. Fr.
G. subsessilis Mart.
G. villosa A. St.-Hil.
Guatteria sp. (R8086V)
Guettarda spruceana Müll. Arg.

Helicteres guazumifolia Kunth
***H. lhotskyana* (Schott. & Endl.) K. Schum.**
Helietta apiculata Benth. **SP**
Heteropterys acutifolia A. Juss.
H. anoptera A. Juss.
H. cf. *escaloniifolia* A. Juss.
H. cf. *procoriacea* Nied.
Himatanthus sucuuba (Spruce) Woodson
Hirtella angustifolia Schott.
Hymenaea maranhensis Lee & Langenheim
H. parvifolia Huber

Ilex paraguariensis A. St.-Hil.
I. theezans Mart. ex Reissek
Inga alba Willd.
I. fagifolia (L.) Willd.
I. marginata Willd.
I. striata Benth.

Jacaranda jasminoides (Thunb.) Sandw.
J. micrantha Cham.

Kielmeyera petiolaris Mart.
K. rugosa Choisy

Lacistema serrulatum Mart.
Lafoensia punicaefolia DC.
L. vandelliana Cham. & Schltdl.
Laplacea fruticosa (Schrader) Kobuski
Leandra solenifera Cogn.
Licania apetala (E. Mey.) Fritsch **A**, **C**
L. blackii Prance
L. dealbata Hook.f.
L. minutiflora (Sagot) Fritsch
L. rigida Benth.
Licania sp. (R7601V)
Lonchocarpus araripensis Benth.

Lonchocarpus sp. (R7759)
Ludwigia nervosa (Poir.) Hara

Maba inconstans (Jacq.) Griseb.
Mabea nitida Benth.
M. pohliana Müll. Arg.
M. riedelii Müll. Arg.
Machaerium brasiliense Vogel **SP**
M. lanatum Tul.
Manihot coerulescens Pohl
Matayba inelegans (Spruce) Radlk.
Maytenus alaternoides Reissek
M. communis Reissek
M. evonymoides Reissek
Maytenus sp. (R7833)
Melochia hirsuta Cav. **A**
Miconia argentea DC.
M. chamissois Naud.
M. chartacea Triana
M. cuspidata Naud.
M. flavescens Cogn. ex Britton
M. ibaguensis (Bonpl.) Triana
M. irwinii Wurdack
M. minutiflora (Bonpl.) DC.
M. paniculata Naud.
M. pyrifolia Naud.
M. thyrsoidea Benth.
M. tiliaefolia Naud. **A**
Micropholis gardneriana (A. DC.) Pierre
Mimosa adenocarpa Benth.
M. adenophylla Taub.
M. exalbenses Barneby
M. hebecarpa Benth.
M. imbricata Benth.
Moutabea excoriata Mart. ex Benn.
M. guianensis Aubl.
Myrcia amethystina (O. Berg) Kiaersk.
M. arborescens O. Berg
M. breviramis (O. Berg) Legr.
M. cuprea (O. Berg) Kiaersk. **A**
M. deflexa (Poir.) DC.
M. guianensis (Aubl.) DC.
M. cf. *lasiopus* DC.
M. longipes (O. Berg) Kiaersk.
M. nigropunctata (O. Berg) N. Silveira
M. obtecta (O. Berg) Kiaersk.
M. prunifola DC.
M. rhodosepala Kiaersk.
M. vestita DC.
Myrciaria ciliolata Cambess. **SP**

Nectandra lanceolata Nees
Neea macrophylla Poepp. & Endl.
N. mollis Spruce ex K. Schum.
Neea sp. (R7580)

Ocotea pretiosa Benth. & Hook.f.
O. velloziana (Meissn.) Mez **SP**
O. velutina Mart. **SP**
Ormosia arborea (Vell.) Harms.
O. smithiana O.C. Schmidt **A**
Ouratea ferruginea Engl.
O. floribunda Engl.
O. pygmaea (Tiegh.) K. Yam.
O. schomburgkii (Planch.) Engl. **A**

Pallasia stanleyana Klotzsch **A**
Parkia pendula (Willd.) Benth. ex Walp.
Peltogyne campestris L. **A**
Persea alba Nees
P. venosa Nees & Mart. ex Nees
Phyllocarpus riedelii Tul.
Piper aduncum L.
Piptocarpha axillaris (Less.) Baker
P. macropoda (DC.) Baker
P. regnellii (Schultz) Cabrera
P. tomentosa Baker
Pisonia ambigua Heimerl.
Pithecellobium moniliforme Ducke
P. parvifolium (Willd.) Benth.
Platycyamus regnellii Benth.
Plumeria velutina Müll. Arg.
Prockia crucis L.
Protium grandifolium Engl.
P. paniculatum Engl.
Pseudolmedia laevigata Trécul
Psidium acutangulum DC.
P. incanescens Mart. ex DC.
P. sartorianum (O. Berg) Nied.
P. widgrenianum O. Berg
Psidium sp. (S1074)
Psychotria involucrata Sw.

Randia densiflora Benth. **A**
R. hebecarpa Benth. **A**
Rapanea brasiliensis
R. intermedia Mez
R. oblonga Pohl ex Miq.
R. paniculata Naud.
Remijia ferruginea (A. St.-Hil.) DC.

Rhamnus sphaerosperma Sw. var. *pubescens* (Reissek) M.C. Johnston
Rollinia cf. *mucosa* (Jacq.) Baill.
R. silvatica (A. St-Hil.) Mart.
Rudgea burchelliana Müll. Arg.
R. crassiloba (Benth.) B.L. Robinson
R. jacobinensis Müll. Arg.
R. krukovii Standl.
R. obtusa Standl.
R. villosa Benth.
Rynchanthera grandiflora (Aubl.) DC. **A**

Sapium glandulatum (Vell.) Pax
***S. glandulosum* (L.) Morong**
S. obovatum Klotzsch ex Müll. Arg.
Schinus longifolius (Lindl.) Speg. var. *paraguariensis* (Hassler) Barkl.
Schoepfia lucida Pulle
Senna alata (L.) Roxb.
S. cana (Nees & Mart.) Irwin & Barneby
S. chrysocarpa (Desv.) Irwin & Barneby
S. latifolia (G. Mey.) Irwin & Barneby
S. obovata Link
S. ovalifolia Batka
S. pendula (Willd.) Irwin & Barneby
S. quinquangulata (L.C. Rich) Irwin & Barneby
S. spectabilis (DC.) Irwin & Barneby var. *excelsa* (Schroder) Irwin & Barneby
S. splendida (Vogel) Irwin & Barneby
Simaba ferruginea A. St.-Hil.
S. glabra Engl.
S. trichilioides A. St.-Hil.
Simira hexandra (S. Moore) Steyerm.
S. rubescens (Benth.) Bremek. ex Steyerm.
Siphoneugena widgreniana O. Berg
Sloanea monosperma Vell.
Solanum cordifolium Dun.
S. grandiflorum Ruiz & Pav.
S. jamaicense Mill. **A**
S. subinerme Jacq. **A**
Stryphnodendron microstachyum Endl.
Stylogyne warmingii Mez
Styrax martii Seub.
S. pallidus A. DC.
Swartzia grandifolia Bong. ex Benth. **A**
S. racemosa Benth. **A**
Swartzia sp. nov. (R7762)
Syagrus coronata (Mart.) Becc.
Symplocos celastrinea Mart. ex Miq.
S. frondosa Brand.
S. mosenii Brand.

Tabebuia heptaphylla (Vell.) Toledo
T. insignis (Miq.) Sandw.
Tabernaemontana hystrix Steud.
Talisia subalbens Radlk.
Tapirira marchandii Engl.
Thiloa glaucocarpa (Mart.) Eichler
Tibouchina clidemioides (Berg ex Triana) Cogn.
T. fothergillae Cogn.
Tococa formicaria Mart.
Tontelea micrantha (Mart.) A.C. Sm.
Trattinickia rhoifolia Willd.
***Trichilia catigua* A. Juss.**
Trigonia villosa Aubl. **A**

Vanillosmopsis arborea (Gardn.) Baker
Vatairea sericea Ducke
Vernonia brasiliana (L.) Druce **A**
V. cinerea Less.
V. cognata Less.
V. polyanthes Less.
V. venosissima Sch.-Bip. ex Baker
Vitex montevidensis Cham.
***V. panshiniana* Mold.**

Wunderlichia crulsiana Taub.
W. mirabilis Riedel ex Baker

Zanthoxylum caribaeum Lam.
Z. gardneri Engl.
Z. hiemale A. St.-Hil.
Zeyheria tuberculosa (Vell.) Bureau ex Verlot **SP**
Zollernia ilicifolia Vogel
Z. paraensis Huber