Are *Mauritia flexuosa* L. f. palm swamps in the Brazilian *Pantanal* true *veredas*? A floristic appraisal

Os buritizais (*Mauritia flexuosa* L. f.) no Pantanal brasileiro são verdadeiras veredas? Uma avaliação florística

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Abstract: In this first report on the flora of *Mauritia flexuosa* L. f. palm swamps in the *Pantanal* wetland of Brazil, we surveyed and compared the angiosperm flora of eight areas of palm swamps in the *Pantanal* plain to determine if they correspond to *veredas*. Studied areas were four sites near the upland in Rio Verde and Coxim, and four in the *Parque Estadual do Pantanal do Rio Negro*, Aquidauana, state of Mato Grosso do Sul, Brazil. To determine species similarity, we compared our results with inventories of aquatic plants of the *Pantanal* and of species of *veredas* in the state. Using the wandering method, we recorded a total of 385 species of phanerogams. Species richness was higher in Rio Verde/Coxim (273 species) than in Rio Negro (243 species), with a similarity of 33.7%. We found a rare and endemic plant, *Polygala grazielae* Marques, first record in the *Pantanal*. We found that both sites correspond to two types of palm swamps but with different floras. The species associated with *M. flexuosa* in the park are much the same as those of seasonally flooding grasslands of the *Pantanal*, while on the edge of the plain many species are common to the upland true *veredas*, particularly on organic soil. Thus, we conclude that the Rio Verde/Coxim areas are true *veredas*. These palm swamps and *veredas* in the *Pantanal* should receive the same legal protection as the *veredas* in *Cerrado*.

Keywords: Moriche palm. Flora. Grassland. *Polygala*. Savanna. Wetland.

Resumo: Este é o primeiro levantamento da flora dos buritizais (*Mauritia flexuosa* L. f.) no Pantanal. Pouco se sabe sobre a flora das veredas no Pantanal. Pesquisamos e comparamos a flora de angiospermas em oito formações com buriti na planície pantaneira, sendo quatro áreas próximas à área de planalto em rio Verde e Coxim, e quatro áreas no Parque Estadual do Pantanal do Rio Negro, em Aquidauana, estado de Mato Grosso do Sul, Brasil, através do método de caminhamento. Para determinar a similaridade de espécies, comparamos nossos resultados com os inventários das plantas aquáticas do Pantanal e das espécies das veredas do estado. Registramos um total de 385 espécies de fanerógamas. A riqueza de espécies foi maior no rio Verde/Coxim (273 espécies) do que em rio Negro (243), com uma similaridade de 33,7%. Encontramos uma planta rara e endêmica, *Polygala grazielae* Marques, primeiro registro no Pantanal. Verificamos que os dois locais correspondem a dois tipos de buritizais, com diferentes floras. As espécies associadas a *Mauritia flexuosa* no rio Negro são praticamente as mesmas das áreas sazonalmente inundadas do Pantanal, enquanto na borda da planície (rio Verde/Coxim) são mais similares às veredas verdadeiras do planalto, particularmente em solo orgânico. Assim, concluímos que as áreas de rio Verde/Coxim são verdadeiras veredas. Acreditamos que estas áreas com buritis e as veredas no Pantanal devem receber a mesma proteção que as veredas no Cerrado.

Palavras-chave: Buriti. Flora. Campo úmido. *Polygala*. Savana. Áreas úmidas.

MOREIRA, S. N., V. J. POTT, E. B. SOUZA & A. POTT, 2017. Are *Mauritia flexuosa* L.f. palm swamps in the Brazilian *Pantanal* true *veredas*? A floristic appraisal. **Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais** 12(2): 221-238.
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Recebido em 22/04/2017
Aprovado em 21/09/2017
Responsabilidade editorial: Fernando da Silva Carvalho Filho

INTRODUCTION

Veredas correspond to one of the grassland elements in the *Cerrado* domain (Carvalho, 1991). They are environments with water table outcrop between gallery forests and the *Cerrado* proper, and they play an important link between the physiognomies (Oliveira-Filho & Martins, 1986; Carvalho, 1991). *Veredas* are legally protected and considered Permanent Preservation Areas (Brasil, 2002). Nevertheless, these wetlands suffer anthropic impacts that can become irreversible (Oliveira *et al*., 2009), for being highly sensitive to disturbances and poorly resilient (Carvalho, 1991).

According to *Conselho Nacional do Meio Ambiente* (CONAMA) (Brasil, 2002), *veredas* are defined as swampy or waterlogged spaces, which contain springs or the headwaters of creeks, on hydromorphic soils, usually characterized by rows of moriche palms (*Mauritia flexuosa*) and other forms of typical vegetation. In an amendment to that definition, Moreira *et al*. (2015) carried out a wide sampling of the vegetation of wetlands with and without *M. flexuosa* and concluded that the moriche palm is only an additional species that permits the identification of a *vereda*, however, it is not an exclusive species to these environments.

The *M. flexuosa* palmland (*buritizal*) has been mapped in the *Pantanal* and is restricted to the eastern edge of the plain and corresponds to only 0.2% of the vegetation (Silva *et al*., 2000). There is an information gap on the floristics of the these palmlands or *veredas* in the *Pantanal*, except for brief reports on their flora, *e.g.*, Pott *et al*. (2011), insufficient to provide a floristic inventory and to compare them with *veredas* and the aquatic macrophytes of *Pantanal*.

Therefore, we sought to inventory the flora of representative areas in order to compare the flora of two types of *M. flexuosa* swamps at eight sites in the *Pantanal* wetland in relation to the upland *veredas* and to the aquatic macrophytes of the *Pantanal*, to determine if the areas with moriche palms in the *Pantanal* can be considered *veredas*.

MATERIAL AND METHODS

We inventoried the angiosperm flora of eight selected areas of *Mauritia flexuosa* palm swamps in two sites in the *Pantanal* wetland. One sampled site was located in the *Parque Estadual do Pantanal do Rio Negro*, in the municipality of Aquidauana, and the other near the eastern border of the plain, in the municipalities of Rio Verde and Coxim, in Mato Grosso do Sul, Brazil (Figure 1), with four sample points per site. We used the wandering method (Filgueiras *et al*., 1994), whereby the area is inspected up and down a few times until no additional species are found. Sampling effort was similar between areas, with three botanists observing during *c.* 6 h per area of *c.* 100 x 200 m. Fertile specimens were collected for the CGMS and BHCB herbaria.

For a more accurate comparison between the targeted vegetation types, we compared three floristic lists. The first is the flora of *veredas* of Mato Grosso do Sul (see Moreira, 2015), the second one represents the object of the present work, and the third one shows the species of aquatic macrophytes of the *Pantanal* (see Pott *et al*., 2012). Based on the species occurrence, we calculated the Bray-Curtis similarity.

The eight sampling areas were the following:

- Site 1: *Parque Estadual do Pantanal do Rio Negro*, municipality of Aquidauana: riparian forest with *M. flexuosa* 19° 44' 17.1" S, 56° 41' 51" W, 100 m altitude; 19° 29' 26" S, 56° 33' 22" W, 104 m altitude; swampy forest with *M. flexuosa* 19° 44' 25" S, 56° 41' 47.5" W, 99 m altitude; floodable grassland with many dead and few young *M. flexuosa* 19° 28' 58.7" S, 56° 41' 23.8" W, 98 m altitude; seasonal stream with *M. flexuosa* 19° 29' 44.8" S, 56° 40' 27.8" W, 98 m altitude; 19° 35' 33" S, 56° 48' 25" W, 96 m altitude;

- Site 2: municipality of Rio Verde: Ranch Fazenda Buritizal, stream Córrego Feioso 18° 40' 06.8" S, 55° 10' 59.1" W, 165 m altitude; stream Córrego Pindaivão, 18° 49' 46.5" S, 55° 07' 55.6" W, 187 m altitude; stream Córrego Pindaivão, 18° 47' 17.7" S, 55° 04' 17.1" W, 176 m altitude; municipality of Coxim: ranch Fazenda Nova Esperança, 18° 11' 05" S, 54° 53' 23" W, 190 m altitude.

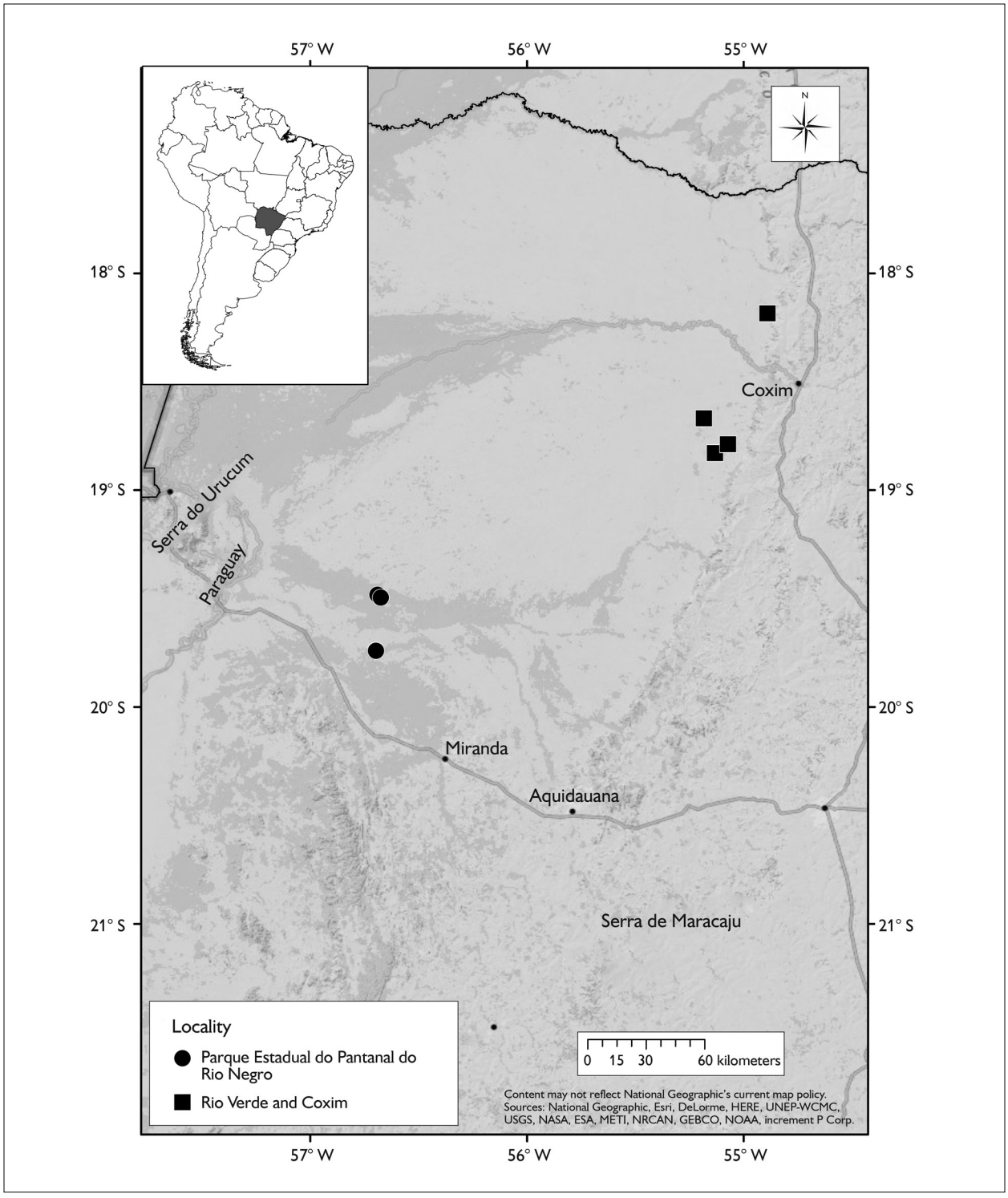

Figure 1. Map of the sampling areas in two sites, *Parque Estadual do Pantanal do Rio Negro* and *Rio Verde/Coxim*, in the *Pantanal* wetland, Mato Grosso do Sul, Brazil.

The soils are sandy in the Rio Verde areas, but organic in Coxim, and sandy-loamy in the park. Flooding is short and shallow in the first, from local seasonal rain and water table rise forming streams, compared with the second site that is under influence of seasonal flooding by the Aquidauana River. The organic soil in the Coxim swamp is waterlogged nearly year round.

RESULTS AND DISCUSSION

We found 385 phanerogams in *Mauritia flexuosa* palm swamps in the *Pantanal* wetland, recording 243 species in the Rio Negro Park and 273 in Rio Verde/Coxim, both sites having 130 species in common (Appendix). Most species were collected elsewhere on the floodplain (Pott & Pott, 2000). Comparing these results with the work reported by Moreira *et al*. (2015) in true *veredas* on the uplands, we can see that species sharing is on the order of only 30%, showing more similarity with riparian and flooding grassland vegetation of the *Pantanal* wetland (Figure 2). Although the similarity dendrogram suggests the greatest sharing of species between the vegetation of the areas of *M. flexuosa* palmlands in the *Pantanal* and the aquatic vegetation of the *Pantanal*, we perceived that the similarity is low, approximately 40% (Figure 2).

The studied *M. flexuosa* swamps on the lowland have a much lower species richness than the upland *veredas*, where over 1,000 species of phanerogams have been inventoried (Moreira, 2015). Obviously the sampling effort on the vegetation of *veredas* was much higher than on the vegetation composing the moriche palmlands in the *Pantanal*. Nevertheless, our preliminary results provide important information on these vegetation types and their peculiarities. The palm swamps in the park have many more aquatic plants and more riparian species typical of the *Pantanal* (Pott *et al*., 2011) than those in the area of Rio Verde/Coxim. Worth mentioning is that the park had just being created, so there was no time yet for vegetation changes due to cattle exclusion. The seasonal regime of flood and dry, characteristic of the *Pantanal*, is probably why these palmlands in Aquidauana differ from permanently wet, true *veredas*.

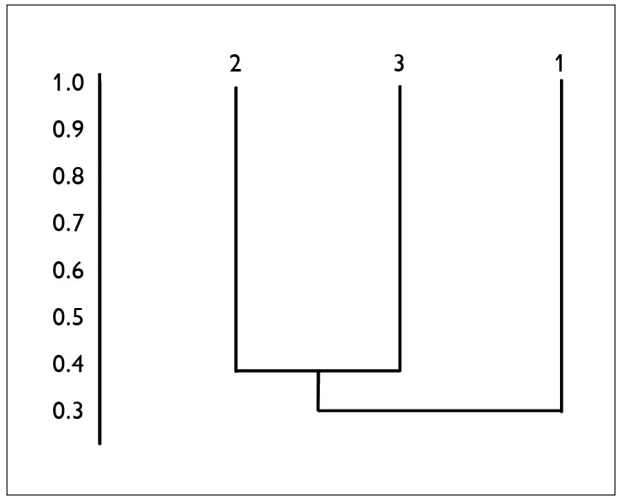

Figure 2. Bray-Curtis similarity based on plant species occurrences in *veredas* (1), *Mauritia flexuosa* palmlands of the *Pantanal* (2), and aquatic macrophytes of the *Pantanal* (3).

Near the Aquidauana River there is moriche palm grove in its upper stretch inside the plain. Downstream from the junction with the Miranda River the moriche palm is no longer seen, replaced by another palm, *Copernicia alba* Morong ex Morong & Britton, probably because of soil differences, due to sediments with higher pH from the Bodoquena plateau that is rich in limestone.

The probable reason for occurrence of palm swamps further north, near the pediment of the Maracaju highland, is surface water from small seasonal streams and the possibly rise of underground water from the upland. Such outflow is common in foothill *veredas* in the *Cerrado* region (Queiroz, 2009). Some palm swamps close to the outer border of the plain lack a defined stream, always present in true *veredas*, instead there is a flow of shallow seasonal flooding and prolonged waterlogging. That is the hydrological reason why they can be considered true *veredas*. In addition, the soil of the palmland on the plain is not as organic and waterlogged as in upland *veredas*, except the organic soil swamp in the Coxim area.

In the Rio Negro Park some *M. flexuosa* groves occur by the river, in pure stands or mixed with riparian forest, and other areas were sampled away from the riverside, as monodominant savanna. Near the river, the palms looked healthy, with various ages, since there is open drainage, with subsurface water flow. However, farther from the river, we observed many dead moriche palms, particularly in the wettest areas, where young palms were scarce. Although *M. flexuosa* is considered flood tolerant, due to its pneumatophores (Pott & Pott, 2004), it tends to have some mortality in years with excessive flooding. That seems paradoxal, but standing water in backwater-swamps may be unfavorable. We observed a similar population decline of the palm in the sub-region of Barão de Melgaço, attributed to the dam effect of a road. Furthermore, in spite of being fire tolerant, those aerial respiratory roots can be damaged under burned tall grasses in very dry years, as deduced from stems blackened by fire, and then the palm can die. Such deleterious effect of fire had already been observed in drained *M. flexuosa* swamps in the Ivinhema watershed (Pott *et al*., 2014). The interaction of flood with fire has been shown to occur in riparian forests of the *Pantanal* (Arruda *et al*., 2016). In spots with fallen palms there is succession to vines, known gap colonizers, *e.g.*, *Ipomoea rubens* Choisy and *Merremia umbellata* (L.) Hallier f. We did not see signs of wildfire on the riverside palms, probably because of little flammable grass in the dense shrubby understorey.

The palmlands near the plain edge in the Rio Verde/Coxim site show similarity with upland *veredas*, *e.g.*, nine species of *Utricularia*, many Poaceae, Cyperaceae, and Melastomataceae, whereas the areas in the park have a flora composed of aquatic and seasonally flooded grassland plants and riparian scrub from the *Pantanal*, as had already been suggested by Pott *et al*. (2011). Thus, the eastern areas share only 1/3 of the flora with the Rio Negro Park and are a transition to upland *veredas*.

We found a rare and endemic plant as a first record in the *Pantanal*, *Polygala grazielae*, only known from three previous collections by Gert Hatschbach, who discovered it along streams in the Rio Verde upland (CRIA, 2017).

The eastern border is the most cleared part of the *Pantanal* (Pott & Silva, 2015), leaving the *M. flexuosa* stripes and patches isolated, as the surrounding woodland (*cerradão*) has been converted into *Urochloa* spp. pastures. The lowland palm swamps are also used for cattle ranching, though grazing has recently stopped inside the park. The organic soil *vereda* in Coxim is too boggy for cattle, so it is still conserved. The Rio Verde areas are for most part invaded by *Urochloa humidicola* (Rendle) Morrone & Zuloaga, and in one area the exotic grass was even planted, at least leaving the palms alive, but we did not observe seedlings. This point (Córrego Pindaivão) has seasonal ponds that were reported as *veredas* by Moreira (2015). Nonetheless, both the palm swamps and *veredas* should be preserved for their spatial diversity and uniqueness in the unique *Pantanal*.

CONCLUSIONS

We conclude that *Mauritia flexuosa* swamps of the Rio Negro Park are not true *veredas*, because most plant species are associated with the flooding grasslands of the *Pantanal* wetland, whereas the Rio Verde/Coxim areas can be considered true *veredas*, for sharing species with the flora of *veredas* of the upper basin and exhibiting some exclusive species do not occur elsewhere on the plain. Palm swamps and *veredas* in the *Pantanal* should receive the same legal protection as the *veredas* in the upland *Cerrado*.

ACKNOWLEDGEMENTS

The authors thank the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) (Project n. 477675/2011-5, and scholarship to SNM); the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES) (Visiting Professorship grant to AP); the *Programa de Pós-Graduação em Biologia Vegetal* and the CGMS UFMS Herbarium; the *Programa de Pós-Graduação em Biologia Vegetal* UFMG, UEMS Campus Coxim; the *Instituto de Meio Ambiente de Mato Grosso do Sul*; biologist João Fabri, for help in the field; and Filipe Soares de Souza, M.Sc. in Botany, for the map.

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Appendix. Phanerogamic flora of *Mauritia flexuosa* palm swamps in the *Pantanal* wetland. Site 1 = Aquidauna and Site 2 = Rio Verde/ Coxim. Moreira *et al*. (2015) shows the common species between areas with and without *M. flexuosa*. Voucher collectors: SNM = Suzana Neves Moreira; VJP = Vali Joana Pott; AP = Arnildo Pott; P = present; * = exotic species.

(Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Acanthaceae	*Hygrophila costata* Nees	VJP 8894	-	-	-
	Justicia laevilinguis (Nees) Lindau	VJP 8889	SNM 1563	-	-
	Staurogyne diantheroides Lindau	P	SNM 1543	-	-
	Stenandrium diphyllum Nees	-	SNM 869	-	-
Alismataceae	*Echinodorus glaucus* Rataj	VJP 8887	P	-	-
	E. longipetalus Michele	-	SNM 1565	-	X
	E. paniculatus Michele	VJP 8225	-	-	-
	E. scaber Rataj	VJP 8226	-	-	-
	Helanthium tenellum (Mart.) Britton	VJP 8224	SNM 818	-	-
	Limnocharis laforestii Duchass.	-	SNM 831	-	-
	Sagittaria guayanensis Kunth	P	AP 4475	-	X
	S. rhombifolia Cham.	VJP 8223	VJP 17371	-	-
Anacardiaceae	*Tapirira guianensis* Aubl.	-	P	-	X
Amaranthaceae	*Gomphrena elegans* Mart.	VJP 8222	-	-	-
	Iresine macrophylla R.E. Fr.	AP 13435	-	-	-
Annonaceae	*Annona dioica* Mart.	-	P	-	-
	Unonopsis guatterioides (A. DC.) R.E. Fr.	AP 13460	-	-	-
	Xylopia aromatica (Lam.) Mart.		AP 2584		
	X. emarginata (Lam.) Mart.	-	P	X	X
Apocynaceae	*Funastrum clausum* (Jacq.) Schltr.	P	-	-	-
	Mandevilla rugosa (Benth.) Woodson	-	SNM 836	X	X
	Rhabdadenia madida (Vell.) Miers	VJP 8901	-	-	-
	Tabernaemontana siphilitica (L.f.) Leeuwenb.	AP 13447	-	-	-
	Tassadia berteroana (Spreng.) W.D. Stevens	P	P	-	-
Aquifoliaceae	*Ilex affinis* Gardner	-	SNM 1563	X	X
Araceae	*Dieffenbachia aglaonaematifolia* Engl.	P	-	-	-
	Pistia stratiotes L.	VJP 8276	-	-	-
	Urospatha sagittifolia (Rudge) Schott	-	P	-	X
	Xanthosoma striatipes (Kunth & Bouché) Madison	P	P	-	X
	Wolffiella lingulata (Hegelm.) Hegelm.	VJP 8888	-	-	-
Araliaceae	*Hydrocotyle pusilla* A. Rich.	-	SNM 1562	X	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Arecaceae	*Attalea phalerata* Mart. ex Spreng.	P	-	-	-
	Bactris glaucescens Druce	P	-	-	-
	Mauritia flexuosa L. f.	VJP 8904	SNM 952	-	X
Asteraceae	*Acilepidopsis echitifolia* (Mart. ex DC.) H. Rob.	-	VJP 2077	X	X
	Aspilia latissima Malme	P	-	-	-
	Baccharis glutinosa Pers.	AP 2146	P	-	X
	Barrosoa candolleana (Hook. & Arn.)	VJP 8263	-	-	X
	Chromolaena lilacina (Hieron.) R.M. King & H. Rob.	-	SNM 848	X	-
	Elephantopus palustris Gardner	-	SNM 832	X	X
	Erechtites hieracifolius (L.) Rafin	-	SNM 1566	-	-
	Erigeron tweediei Hook. & Arn.	-	P	X	X
	Mikania micrantha Kunth	VJP 3240	-	-	-
	M. stenophylla W.C. Holes		SNM 870	-	-
	Praxelis clematidea (Griseb.) R.M. King & H. Rob.	VJP 8251	-	-	-
	Urolepis hecatantha (DC.) K.M. King & H. Rob.	P	-	-	-
	Vernonanthura brasiliana (L.) H. Rob.	P	P	-	-
Bignoniaceae	*Handroanthus heptaphyllus* Mattos	P	-	-	-
	Tabebuia insignis (Miq.) Sandwith	-	AP 6574	-	X
Boraginaceae	*Euploca filiformis* (Lehm.) J.I.M. Melo & Semir	AP 5765	-	-	-
Burmanniaceae	*Burmannia capitata* (Walter ex J.F. Gmel.) Mart.	-	AP 2198	-	-
	B. flava Mart.	-	AP 2172		
Burseraceae	*Protium heptaphyllum* (Mart.) Marchand	VJP 8262	-	-	-
Bromeliaceae	*Bromelia balansae* Mez	P	-	-	
Cabombaceae	*Cabomba furcata* Schult. & Schult. f.	VJP 8233	SNM 1546	-	-
Campanulaceae	*Lobelia aquatica* Cham.	-	SNM 1528	-	X
	L. anceps L. f.	-	P	X	
Cannaceae	*Canna glauca* L.	VJP 8274	-	-	-
Capparidaceae	*Cleoserrata paludosa* (Willd. ex Eichler) Iltis	AP 14185	-	-	-
Celastraceae	*Hippocratea volubilis* L.	AP 13437	P	-	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Celastraceae	*Salacia elliptica* (Mart. ex Schult.) G. Don	AP 5431	-	-	-
Chrysobalanaceae	*Hirtella gracilipes* (Hook. f.) Prance	-	AP 6511	-	-
	Licania parvifolia Huber	P	-	-	-
Clusiaceae	*Calophyllum brasiliense* Cambess.	AP 14181	P	-	-
	Garcinia brasiliensis Mart.	AP 14461	-	-	-
Combretaceae	*Combretum lanceolatum* Pohl	P	-	-	-
	C. rotundifolium Aubl.	VJP 3690	-	-	-
Commelinaceae	*Commelina schomburgkiana* Klotzsch	VJP 3712	-	-	-
	Murdannia gardneri (Seub.) G. Brückn.	VJP 1451	P	-	-
Convolvulaceae	*Aniseia martinicensis* (Jacq.) Choisy	VJP 8896	SNM 852	-	-
	Ipomoea alba L.	P	-	-	-
	I. chiliantha Hallier f.	P	-	-	-
	Ipomoea rubens Choisy	P	-	-	-
	Merremia umbellata (L.) Hallier f.	AP 5812	-	-	-
Costaceae	*Costus arabicus* L.	P	-	-	-
Cucurbitaceae	*Melothria candolleana* Cogn.	AP 13434		-	-
	Psiguria ternata (M.J. Roem.) C. Jeffrey	P	AP 2414	-	
Cyperaceae	*Ascolepis brasiliensis* (Kunth) Benth. ex C.B. Clarcke	AP 5898	P	-	
	Bulbostylis cf. *fluviatilis* Kral & Davidse	-	SNM 789	-	-
	Cyperus compressus L.	AP 5337	-		
	C. cornelii-ostenii Kük.	AP 5834	-		
	C. giganteus Vahl	VJP 8246	-	-	
	C. haspan L.	AP 5892	P	-	X
	C. odoratus L.	VJP 3709	SNM 874	-	-
	C. prolixus Kunth	-	SNM 828	-	-
	C. surinamensis Rottb.	VJP 3708	P	-	-
	Eleocharis acutangula (Roxb.) Steud.	P	SNM 799	-	X
	E. elegans (Kunth) Roem. & Schult.	VJP 8228	P	-	-
	E. filiculmis Kunth	-	SNM 795	-	-
	E. interstincta (Vahl) Roem. & Schult.	VJP 8648	P	-	-
	E. minima Kunth	VJP 8229	SNM 812	-	-
	E. mutata (L.) Roem. & Schult.	P	P	-	-
	E. plicarhachis (Griseb.) Svenson	VJP 7893	P	-	-
	Eleocharis sp.	-	SNM 784	-	-
	Fimbristylis dichotoma (L.) Vahl	VJP 8612	SNM 844	-	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Cyperaceae	*Fuirena umbellata* Rottb.	VJP 8269	P	-	X
	Killinga brevifolia Rottb.	AP 5822	AP 2559	-	-
	Lipocarpha humboldtiana Nees	AP 5864	AP 2375	-	-
	Oxycaryum cubense (Poepp. & Kunth) Lye	VJP 5726	-	-	-
	Rhynchospora brevirostris Griseb.	-	SNM 813	-	-
	R. corymbosa (L.) Britton	VJP 8219	-	-	-
	R. emaciata (Nees) Boeckeler	-	AP 2567	X	X
	R. globosa (Kunth) Roem. & Schult.	-	P	-	-
	R. hirta (Nees) Boeckeler		AP 2485		
	R. tenuis Link	VJP 8261	-	-	-
	R. trispicata (Nees) Schrad. ex Steud.	AP 5768	SNM 819	-	-
	R. velutina (Kunth) Boeckeler	VJP 4117	SNM 823	-	-
	Scleria gaertneri Raddi	VJP 8679	SNM 825		
	S. hirtella Sw.	P	P		
	S. leptostachya Kunth		AP 2484		
	S. lithosperma (L.) Sw.	-	P	-	-
	S. macrophylla J. Presl & C. Presl	-	SNM 838	X	X
	S. microcarpa Nees ex Kunth	-	P	-	-
	S. secans (L.) Urb.	P	-	-	-
Dilleniaceae	*Curatella americana* L.	-	VJP 2418	-	-
	Davilla nitida (Vahl) Kubitszi	-	SNM 834	X	X
	Doliocarpus dentatus (Aubl.) Standl.	P	-	-	-
Dioscoreaceae	*Dioscorea hassleriana* Chodat	-	P	-	-
Droseraceae	*Drosera communis* A. St.-Hil.	-	SNM 1549	X	-
	D. sessilifolia A. St.-Hil.	-	AP 2199	-	-
Eriocaulaceae	*Eriocaulon sellowianum* Kunth	-	P	X	-
	Paepalanthus chiquitensis Herzog	AP 13465	AP 2232		
	Philodice hoffmannseggii Mart.	-	SNM 816	-	-
	Syngonanthus caulescens (Poir.) Ruhland	-	P	-	-
	S. gracilis (Bong.) Ruhland	VJP 3679	SNM 804	-	X
Erythroxylaceae	*Erythroxylum anguifugum* Mart.	AP 13459	AP 1300	-	-
Euphorbiaceae	*Alchornea castaneifolia* (Willd.) A. Juss.	P	-	-	-
	A. discolor Poepp.	AP 13453	AP 2414	-	-
	Caperonia castaneifolia (L.) A. St.-Hil.	AP 5747	AP 2573	-	-
	Sapium obovatum Klotzsch ex Müll. Arg.	AP 5407	AP 2565	-	X
Fabaceae	*Aeschynomene fluminensis* Vell.	VJP 8238	P	-	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Fabaceae	*A. sensitiva* Sw.	VJP 8237	SNM 821	-	-
	Albizia inundata (Mart.) Barneby & J.W. Grimes	P	-	-	-
	Ancistrotropis peduncularis (Kunth) A. Delgado	-	AP 16357	-	-
	Andira inermis (W. Wright) DC.	AP 13876	-	-	-
	Calopogonium caeruleum (Benth.) C. Wright	AP 14187	-	-	-
	C. mucunoides Desv.	-	P	-	-
	Cassia grandis L. f.	P	-	-	-
	Clitoria falcata Lam.	P	P	-	-
	Desmodium barbatum Benth.	P	SNM 876	-	-
	D. cajanifolium (Kunth) DC.	-	AP 16355	X	X
	D. scorpiurus (Sw.) Desv.	-	SNM 859	-	-
	Erythrina fusca Lourt.	AP 13438	-	-	-
	Inga vera subsp. *affinis* (DC.) T.D. Penn.	AP 14176	-	-	-
	Machaerium amplum Benth.	AP 4773	-	-	-
	Mimosa pellita Humb. & Bonpl. ex Willd.	AP 5835	-	-	-
	Pterocarpus michelii Britton	AP 13445	-	-	-
	*Senna aculeata (*Pohl ex Benth.) H.S. Irwin & Barneby	P	-	-	-
	S. alata (L.) Roxb.	P	-	-	-
	S. pendula (Willd.) H.S. Irwin & Barneby	AP 14189	-	-	-
	Stylosanthes acuminata M.B. Ferreira & Souza Costa	-	SNM 867	-	-
	Vigna longifolia (Benth.) Verdc.	AP 14178	SNM 863	-	-
Gentianaceae	*Chelonanthus alatus* (Aubl.) Pulle	-	SNM 947	X	X
	Coutoubea ramosa Aubl.	AP 13215	-	-	-
	Schultesia heterophylla Miq.	AP 5850	AP 2210		
Heliconiaceae	*Heliconia marginata* (Griggs) Pittier	VJP 8116	P	-	-
	H. psittacorum L. f.	P	P	-	-
Hydrocharitaceae	*Egeria najas* Planch.	VJP 8234	-	-	-
	Limnobium laevigatum (Humb. & Bonpl. ex Willd.) Heine	VJP 8880	-	-	-
	Najas microcarpa K. Schum.	VJP 8245	-	-	-
Hydroleaceae	*Hydrolea spinosa* L.	VJP 8877	SNM 862	-	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Lamiaceae	*Cantinoa carpinifolia* (Benth.) Harley & J.B.F. Pastore	-	SNM 854	X	-
	Hyptis balansae Briq.	-	SNM 1501	X	X
	H. brevipes Poit.	VJP 8265	P	-	-
	H. conferta Pohl ex Benth.		SNM 814	X	
	H. crenata Pohl ex Benth.	-	SNM 944	-	-
	H. dumetorum Morong	-	SNM 781	-	X
	H. lorentziana O. Hoffm.	VJP 8239	SNM 861	-	-
	H. lappacea Benth.	AP 5797	-	-	-
	H. sinuata Pohl ex Benth.	-	SNM 969	-	X
	Vitex cymosa Bertero	P	-	-	-
Lauraceae	*Cassytha filiformis* L.	-	SNM 841	-	-
	Nectandra amazonum Nees	P	-	-	-
	N. gardneri Meisn.	-	SNM 833	X	X
	Ocotea diospyrifolia (Meisn.) Mez	P	-	-	-
Lentibulariaceae	*Genlisea repens* Benj.	-	SNM 1571	X	X
	Utricularia breviscapa Wright ex Griseb.	P	P	-	-
	U. erectiflora A. St.-Hil. & Girard	-	SNM 1502	X	X
	U. foliosa L.	AP 5806	-	-	-
	U. gibba L.	VJP 8232	SNM 803	-	-
	U. hydrocarpa Vahl	-	SNM 1504	-	-
	U. lloydii Merl ex F. Lloyd	-	SNM 1557	X	-
	U. nana A. St.-Hil. & Girard	-	P	-	-
	U. nervosa G. Weber ex Benj.	-	SNM 1503	X	X
	U. nigrescens Sylvén	-	P	X	-
	U. olivacea Wright ex Griseb.	-	P	X	-
	U. pusilla Vahl	-	SNM 947	X	-
	U. simulans Pilg.	-	SNM 800	-	-
	U. subulata L.	-	SNM 943	X	-
	U. trichophylla Spruce ex Oliv.	-	SNM 946	X	-
	U. tricolor A. St.-Hil.	-	SNM 1505	X	X
Limnocharitaceae	*Hydrocleys nymphoides* (Willd.) Buchenau	VJP 8879	VJP 8879	-	-
	H. parviflora Seub.		AP 6189		
Lythraceae	*Cuphea odonellii* Lourteig	-	SNM 791	-	-
	C. retrorsicapilla Koehne	AP 7623	P	-	-
	Rotala mexicana Cham. & Schltdl.	-	SNM 871	-	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Malpighiaceae	*Byrsonima cydonifolia* A. Juss.	P	AP 2370	-	-
Malvaceae	*Byttneria genistella* Triana & Olanch.	VJP 8635	AP 2489		
	B. palustris Cristóbal	-	SNM 1508	-	-
	B. rhamnifolia Benth.	P	-	-	-
	Corchorus argutus L.	-	SNM 868	-	-
	Hibiscus furcellatus Desr.	VJP 8221	-	-	-
	Hibiscus sororius L. f.	VJP 8252	SNM 847	-	-
	Melochia simplex A. St.-Hil.	VJP 8902	SNM 866	-	-
	M. villosa (Mill.) Fawc. & Rendle	P	AP 2583	-	-
	Pavonia laetevirens R.E. Fr.	P	-	-	-
	Peltaea riedelii (Gürcke) Standl.	AP 5400	AP 7658	-	-
Marantaceae	*Thalia geniculata* L.	AP 5816	SNM 864	-	-
Mayacaceae	*Mayaca fluviatilis* Aubl.	P	SNM 824	-	-
	M. sellowiana Kunth	-	SNM 1510	X	-
Melastomataceae	*Acisanthera alsinaefilia* Triana	AP 5873	P	-	-
	A. divaricata Cogn.	-	SNM 882	-	-
	A. limnobios (DC.) Triana	P	SNM 794	-	-
	Clidemia hirta (L.) G. Don	-	P	-	-
	Desmoscelis villosa (Aubl.) Naudin	-	SNM 844	-	-
	Macairea radula (Bonpl.) DC.	-	SNM 1516	X	-
	Miconia albicans (Sw.) Triana	-	SNM 796	-	-
	M. prasina (Sw.) DC.	AP 5312	SNM 822	-	-
	Poteranthera pusilla Bong.		AP 2224	X	
	Pterolepis trichotoma (Rottb.) Cogn	-	SNM 1514	X	-
	Rhynchanthera grandiflora (Aubl.) DC.	AP 8013	SNM 858	-	-
	R. novemnervia DC.	VJP 8250	SNM 830	-	-
	R. ursina Naudin	-	SNM 1518	X	-
	Siphanthera arenaria (DC.) Cogn.	-	SNM 856	-	-
	S. foliosa (Naudin) Wurdack	-	SNM 1515	X	-
	Tibouchina gracilis (Bonpl.) Cogn.	AP 13466	SNM 1220	-	-
	Trembleya phlogiformis DC.	-	SNM 780	X	-
Meliaceae	*Trichilia pallida* Sw.	AP 13432	-	-	-
	T. stellato-tomentosa Kuntze	P	-	-	-
Menispermaceae	*Cissampelos pareira* L.	VJP 3649	AP 2570	-	-
	Odontocarya tamoides (DC.) Miers	AP 5339	SNM 873	-	-
Menyanthaceae	*Nymphoides indica* (L.) Kuntze	-	P	-	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Molluginaceae	*Mollugo verticillata* L.	AP 5391	SNM 840	-	-
Moraceae	*Ficus adhatodifolia* Schott ex Spreng.	P	P	-	-
	F. lutschnatiana (Miq.) Miq.	AP 13448	-	-	-
	F. pertusa L. f.	AP 13451	AP 2431	-	-
Myristicaceae	*Virola sebifera* Aubl.	-	SNM 786	X	-
Myrsinaceae	*Myrsine umbellata* Mart.	-	P	X	-
Myrtaceae	*Calyptranthes lucida* Mart. ex DC.	AP 13446	-	-	-
	Eugenia florida DC.	AP 5310	P	-	-
	Psidium guineense DC.	P	P	-	-
Nymphaeaceae	*Nymphaea amazonum* Mart. & Zucc.	VJP 8235	VJP 2957	-	-
	N. gardneriana Planch.	P	P	-	-
Ochnaceae	*Ouratea castaneifolia* (DC.) Engl.	AP 14188	-	-	-
	Sauvagesia erecta L.	VJP 8260	P	-	-
	S. racemosa A. St.-Hil.	-	SNM 1520	X	X
	S. tenella Lam.		AP 2222		
Onagraceae	*Ludwigia affinis* (DC.) O. Hara	P	-	-	-
	L. elegans (Cambess.) H. Hara	VJP 8217	-	-	-
	L. grandiflora (Michx.) Zardini	VJP 8884	-	-	-
	L. helminthorhiza (Mart.) H. Hara	AP 5729	-	-	-
	Ludwigia inclinata (L. f.) P.H. Raven	P	P	-	-
	L. leptocarpa (Nutt.) H. Hara	VJP 8242	-	-	-
	L. nervosa (Poir.) O. Hara	VJP 8244	SNM 1522	-	-
	L. octovalvis (Jacq.) P.H. Raven	VJP 8866	P	-	-
	L. sedoides (Humb. & Bonpl.) H. Hara	VJP 8254	-	-	-
	L. tomentosa (Cambess.) O. Hara	VJP 8873	SNM 843	-	-
Orchidaceae	*Cyrtopodium paludicolum* Hoehne	-	SNM 1559	X	X
Orobanchaceae	*Melasma stricta* (Benth.) Hassl.	-	SNM 1523	-	-
Passifloraceae	*Passiflora misera* Kunth	VJP 8241	-	-	-
Phyllanthaceae	*Hieronyma alchornoides* Allemão	-	SNM 785	X	-
	Phyllanthus stipulatus Webster	VJP 8595	SNM 811	-	-
Piperaceae	*Piper fuligineum* Kunth	-	P	X	X
	P. macedoi Yunck.	-	VJP 11442	-	-
Plantaginaceae	*Angelonia salicarifolia* Bonpl.	VJP 3752	-	-	-
	Bacopa arenaria (J.A. Sm.) Edwall	P	AP 6193	-	-
	B. australis V.C. Souza	VJP 8231	-	-	-
	B. myriophylloides (Benth.) Wettst.	VJP8258	SNM 805	-	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Plantaginaceae	*B. monnierioides* (Cham.) B.L. Rob.	VJP 8259	SNM 1526	-	-
	B. reflexa (Benth.) Edwall	-	SNM 1561	-	-
	B. salzmannii (Benth.) Wettst. ex Edwall	VJP 8230	SNM 1525	-	-
	B. stricta (Schrad.) Wettst. ex Edwall	AP 5365	SNM 839	-	-
	Scoparia dulcis L.	AP 13470	AP 2286	-	-
Poaceae	*Acroceras zizanioides* (Kunth) Dandy	AP 5807	AP 5907	-	-
	Andropogon bicornis L.	VJP 8895	AP 2556	-	-
	A. hypogynus Hack.	P	AP 2367	-	-
	A. leucostachyus Kunth	-	SNM 798	-	-
	A. virgatus Desv.	P	AP 2219	-	-
	Anthaenantia lanata (Kunth.) Benth.	-	AP 2357	-	-
	Arundinella hispida (Humb, & Bonpl. ex Willd.) Kuntze	P	-	-	-
	Axonopus leptostachyus (Flüggé) Hitchc.	AP 5837	AP 1104	-	-
	A. siccus (Nees) Kuhlm.	-	SNM 808	-	X
	Coleataenia stenodes (Griseb.) Soreng	P	AP 1125	-	-
	Cyphonanthus discrepans (Döll)	-	AP 2909		
	Digitaria ciliaris (Retz.) Koeler	-	SNM 855	-	-
	Echinochloa crus-galli (L.) P. Beauv.	AP 5769	-		
	Echinolaena gracilis Swallen	-	SNM 820	-	-
	Eragrostis rufescens Schrad. ex Schult.	-	SNM 885	-	-
	Eriochrysis warmingiana (Hack.) Kuhlmann	-	P	X	X
	Gymnopogon burchelii (Munro ex Döll) Munro	-	P	X	-
	G. fastigiatus Nees	-	AP 2220		
	Hymenachne amplexicaulis (Rudge) Nees	AP 5351	P	-	-
	H. donacifolia (Raddi) Chase	VJP 8683	-	-	-
	H. pernambucencis (Spreng.) Zuloaga	AP 5778	-	-	-
	**Hyparrhenia rufa* (Nees) Stapf	-	SNM 845	-	-
	Imperata tenuis Hack.	VJP 2730	AP 2557	-	-
	Leersia hexandra Sw.	P	P	-	-
	Loudetia flammida (Trin.) C.E. Hubb.	-	SNM 846	-	-
	Louisiella elephantipes (Nees ex Trin.) Zuloaga	P	-	-	-
	Luziola bahiensis (Steud.) Hitchc.	-	P		
	L. fragilis Swallen	VJP 1702	AP 6185	-	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Poaceae	*Mnesithea aurita* (Steud.) de Koning & Sosef	P	SNM 829	-	-
	Oedochloa procurrens (Nees ex Trin.) C. Silva & R.P. Oliveira (*Ichnanthus*)	Valls 10394	AP 2497		
	Oplismenus hirtellus (L.) P. Beauv.	AP 5401	-	-	-
	Otachyrium versicolor (Döll) Henrard	-	SNM 851	-	-
	Panicum caaguazuense Henrard	-	P	X	-
	P. dichotomiflorum Michx.	AP 5751	VJP 8605		
	**P. repens* L.	P	SNM 842	-	-
	P. spectabile Nees ex Trin.	-	SNM 820		-
	P. trichanhum Nees	VJP 3659	-		
	Paspalum atratum Swallen	-	P	-	-
	P. ellipticum Döll	-	SNM 1577	-	-
	P. fasciculatum Willd. ex Flüggé	P	-	-	-
	P. lineare Trin.	-	AP 2354		
	P. maculosum Trin.	-	SNM 1535	X	-
	P. morichalense Davidse, Zuloaga & Filgueiras	-	SNM 853	-	-
	P. multicaule Poir.	-	P		
	P. plicatulum Michx.	P	AP 2359	-	-
	P. repens Bergius	Valls 10414		-	-
	P. stellatum Humb. & Bonpl. ex Flüggé	-	SNM 783	-	-
	Reimarochloa acuta (Flüggé) Hitchc.	AP 5347	AP 2474	-	-
	Rhytachne rottboellioides Desv. ex Ham.	-	AP1123		
	Rugoloa hylaeica (Mez) Zuloaga	P	-	-	-
	R. polygonata (Schrad.) Zuloaga	VJP 8893	-	-	-
	Saccharum asperum (Nees) Steud.	-	SNM 827	X	X
	S. villosum Steud.	-	SNM 826	X	X
	Sacciolepis angustissima (Hochst. ex Steud.) Kuhlm.		AP 2211		
	S. myuros (Lam.) Chase	P	SNM 801	-	-
	S. vilvoides (Trin.) Chase	-	P	-	-
	Schizachyrium gracilipes (Hack.) A. Camus	-	SNM 790	X	-
	S. microstachyum Roseng.	-	P	-	-
	Setaria parviflora Kerguelen	AP 5794	AP 2364	-	-
	Stephostachys mertensii (Roth) Zuloaga & Morrone	P	AP 6660	-	-

Appendix. (Continue)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Poaceae	*Sorghastrum setosum* (Griseb.) Hitchc.	AP 5893	AP 2494	-	-
	Steinchisma laxum (Sw.) Zuloaga	AP 5568	AP 2473	-	-
	Trichanthecium parvifolium (Lam.) Zuloaga & Morrone	-	SNM 802	-	-
	**Urochloa humidicola* (Rendle) Morrone & Zuloaga	P	P	-	-
Polygalaceae	*Polygala appendiculata* Vell.	-	SNM 787	-	-
	P. grazielae Marques	-	SNM 787	X	-
	P. tenuis DC.	P	AP 2277		
	P. timoutoides Chodat	-	SNM 1540	-	-
	P. timoutou Aubl.	-	SNM 880	-	-
Polygonaceae	*Polygonum acuminatum* Kunth	VJP 3662	-	-	-
	P. ferrugineum Wedd.	P	-	-	-
	P. hydropiperoides Michx.	VJP 8272	-	-	-
	P. punctatum Elliot	AP 3815	SNM 857	-	-
	Triplaris americana L.	AP 13433	-	-	-
Pontederiaceae	*Eichhornia azurea* (Sw.) Kunth	VJP 2915	AP 6191	-	-
	E. crassipes (Mart.) Solms	VJP 2916	-	-	-
	Pontederia cordata L.	AP 5761	P		
	P. parviflora Alexander	VJP 8227	SNM 1511	-	-
	P. rotundifolia L. f.	VJP 8881	-	-	-
	P. subovata (Seub.) Lowden	VJP 8236	-	-	-
Rubiaceae	*Alibertia edulis* (Rich.) A. Rich.	AP 6543	P	-	-
	Amaioua glomerulata (Lam. ex Poir.) Delprete & C. Persson	AP 13202	-	-	-
	Borreria latifolia (Aubl.) K. Schum.	-	SNM 884	-	-
	B. pulchristipula (Bremek.) Bacigalupo & E.L. Cabral	-	P	X	X
	Cephalanthus glabratus (Spreng.) K. Schum.	AP 14180	-	-	-
	Coccocypselum lanceolatum (Ruiz & Pav.) Pers.	-	SNM 1556	X	-
	Diodia kuntzei K. Schum.	AP 5346	AP 2236	-	-
	D. radula (Willd. & Hoffmanns. ex Roem. & Schult.) Cham. & Schltdl.	-	P	X	-
	Genipa americana L.	AP 5327	-	-	-

Appendix. (Conclusion)

Family	Species	Site 1	Site 2	Exclusive to site 2	Moreira *et al*. (2015)
Rubiaceae	*Limnosipanea palustris* (Seem.) Hook.f.	-	SNM 1509	X	-
	Psychotria carthagenensis Jacq.	AP 5425	SNM 1542	-	-
	Sabicea aspera Aubl.	AP 5786	P	-	-
	Sipanea biflora (L. f.) Cham. & Schtdl.	AP 14186	-	-	-
Rutaceae	*Zanthoxylum rigidum* Humb. & Bonpl. *ex* Willd.	P	-	-	-
Salicaceae	*Banara arguta* Briq.	AP 5375	-	-	-
	Cardiospermum halicacabum L.	AP 5745	P	-	-
Sapindaceae	*Paullinia pinnata* L.	AP 5783	P	-	-
Smilacaceae	*Smilax fluminensis* Vell.	P	AP 16354	-	-
Solanaceae	*Schwenckia americana* L.	-	SNM 815	-	-
	S. juncoides Chodat	-	SNM 815	X	-
	Solanum nigrescens M. Martens & Galeotti	VJP 8903	-	-	-
Typhaceae	*Typha domingensis* Pers.	VJP 8275	-	-	-
Urticaceae	*Cecropia pachystachya* Trécul	P	P	-	-
	Urera aurantiaca Wedd.	P	-	-	-
Vitaceae	*Cissus erosa* Rich.	AP 5736	AP 2517	-	-
	C. spinosa Cambess.	VJP 8247	P	-	-
	C. verticillata (L.) Nicolson & C.E. Jarvis	P	-	-	-
Vochysiaceae	*Vochysia divergens* Pohl	P	P	-	-
Xyridaceae	*Xyris jupicai* L.C. Rich.	VJP 8264	P	-	-
	X. macrocephala Vahl	-	SNM 807	X	
	X. savanensis Miq.	P	SNM 817	-	-
	X. schizachne Mart.	-	SNM 1544	X	-