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ORIGINAL ARTICLE – Conservation of Nature

Flora and Structure of Mata Santa Elisa: an Environmental Patrimony in Campinas, SP

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Abstract

Tropical forests include remnants that should be characterized and monitored for long-term conservation. With this in mind, we performed a survey of the floristic composition and structure of the Mata Santa Elisa (Campinas, SP), and compared it to other fragments of semi-deciduous seasonal forest in the municipality. In Mata Santa Elisa, 506 living arboreal specimens were found, belonging to 100 species, 75 genera and 32 families. At the time of this work, the fragment was well-preserved and contained exclusive species and those of economic interest or potential, highlighting its importance in the region.

Keywords: biodiversity, tropical forest, conservation.

1. INTRODUCTION AND OBJECTIVES

Tropical forests have great biodiversity, containing between 70% and 90% of all plant species; they are among the most complex, fragile and threatened ecosystems in the world (Mittermeier et al., 2005). As such, the conservation of tropical forests is of particular interest.

Maintaining well-preserved large areas is essential to mitigating the loss of biodiversity. However, consideration should also be given to preserving small, fragmented areas that may contain relatively high levels of local biodiversity (Arroyo-Rodriguez et al., 2009). These fragments are inserted in different matrices, and they are usually understudied, despite their biological importance due to a high concentration of the remaining information of the Atlantic Forest (Ribeiro et al., 2009).

Mata Santa Elisa (Campinas, SP) is an urban remnant of semi-deciduous seasonal forest, registered in 1991 and defined as a municipal environmental patrimony. This municipality has native vegetation cover consisting of fragments of forest, cerrado and small stretches of rock vegetation (Torres et al., 2014), which has been reduced to 2.55% of its total area. In 1988 and 1994, fires were recorded in Mata Santa Elisa, and invasive exotic species such as *Megathyrsus maximus* (Jacq.) B. K. Simon & S. W. L. Jacobs and *Urochloa decumbens* (Stapf) R.D.Webster, respectively known as "capim-colonião" and "braquiária," increased in the border and neighborhood of the fragment after this occurrence (personal observations). Studies of the flora and structure of 15 different areas in Campinas, with the same physiognomy as the Mata Santa Elisa, found 47 to 151 tree species (H' diversity of 2.47 to 4.06). However, to date, studies of Mata Santa Elisa have not been conducted. Thus, the objective of this work was to characterize the arboreal component of Mata Santa Elisa and to verify its conservation status, given its importance in relation to the flora of the municipality.

2. MATERIALS AND METHODS

The Mata Santa Elisa (Figure 1), located in the Centro Experimental Central of the Instituto Agronômico de Campinas (IAC), has a total area of 14.81 ha (Souza et al., 2015). The municipality has two climates: subtropical hot with dry winter (Cwa) and subtropical hot without dry season (Cfa) (Rolim et al., 2007). The forest, as well as most of the municipality, is categorized under the Cwa climate, with an

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average annual rainfall of 1.381 mm (Ferreira et al., 2007). The local relief is smooth wavy to wavy, with an altitude of about 670 m, and predominantly typical dystrophic Red Latosol (Ferreira et al., 2007). Prior to this study, the last fire to occur in Mata Santa Elisa was in 1994.

We established fifty 10 × 10 m (0.5 ha; Figure 1) plots for a floristic and phytosociological survey. This survey was conducted between 2008 and 2009, approximately 15 years after the last recorded fire. All individuals, including standing dead trees, with breast height diameters (DBH) greater or equal to 4.8 cm were plated. Specimens were numbered, after having measured all the multiple stems that met the minimum diameter for inclusion.

Collection, processing of botanical material and incorporation into the IAC Herbarium collection followed the usual standards for this type of study. We made the identifications following the pertinent literature, comparisons with herbarium collections and expert consultations.

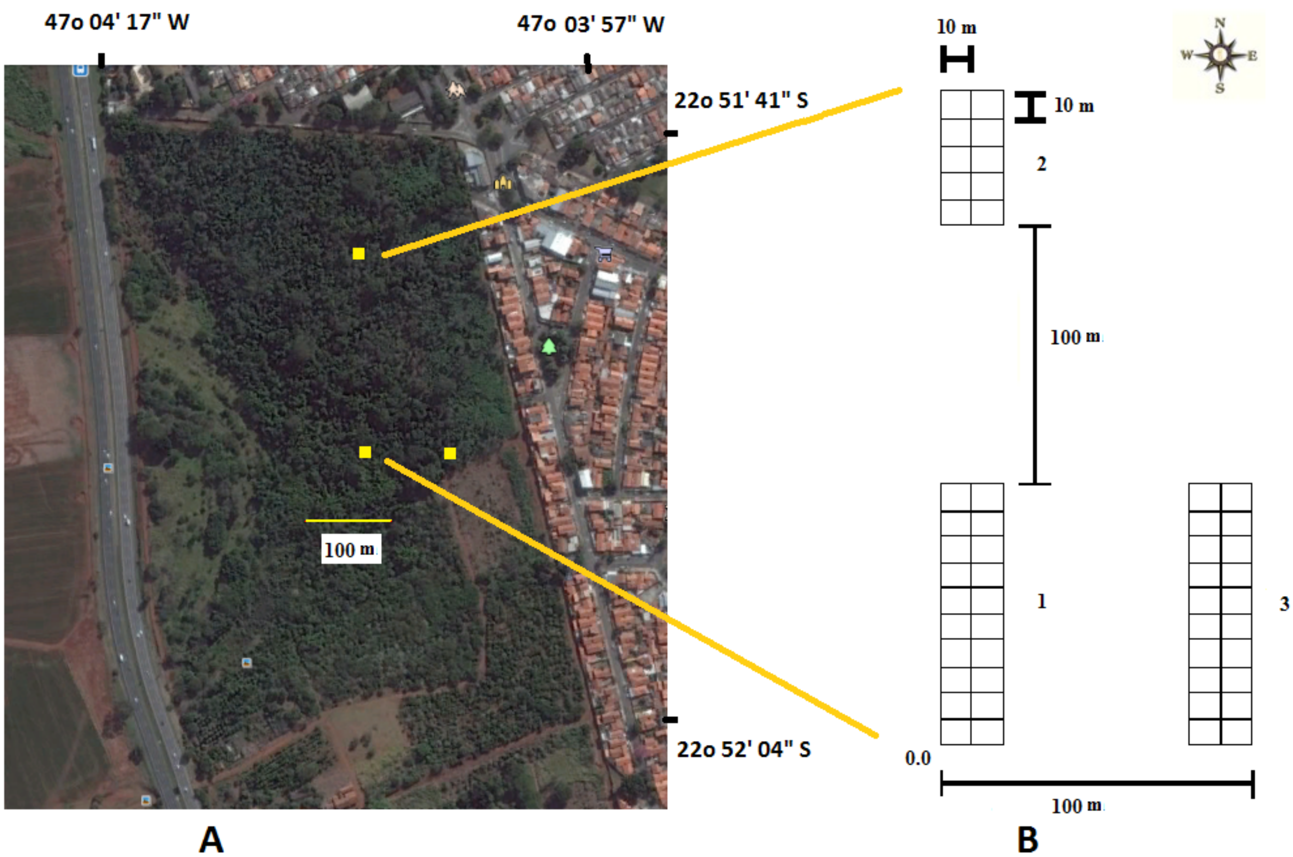

Figure 1. Location of the sample area.
(a) Mata Santa Elisa (Campinas, SP) and the sample sets (yellow); (b) arrangement of plots.

Table 1. Surveys used in the comparison to the semi-deciduous forest in Mata Santa Elisa, Campinas, SP.

Loc	Forest Fragment	Area (ha)	Method DBH (cm)	Reference	tSpp	nSpp	Trees (live trees.ha^{-1})	Basal area (m^2.ha^{-1})	H'	J	Coordinates[2] (S/W)
CE	Mata Santa Elisa – **SEl**	14.8	P – ≥ 4,8	This study	100	83	1012.0	27.26	3.82	0.83	22° 51' 48" 47° 04' 06"
	Bosque dos Alemães – **BAl**	2.0	C – ≥ 4,8	Cielo-Filho & Santin, 2002	105	72	926.0	-	3.45	-	22° 53' 25" 47° 04' 05"
	Bosque dos Jequitibás – **Bje**	10.0	C – ≥ 10,0	Matthes et al., 1987	151	102	783.0	-	3.71	-	22° 54' 30" 47° 03' 00"

Table 1. Continued...

Loc	Forest Fragment	Area (ha)	Method DBH (cm)	Reference	tSpp	nSpp	Trees (live trees.ha^{-1})	Basal area (m^2.ha^{-1})	H'	J	Coordinates[2] (S/W)
NE	Small 1– **1Peq**	12.4	Q – ≥ 10,0	Santos et al. 2007	103	90	960.1	55.8	4.03	0.87	22° 54' 30" 46° 54' 00"
	Small 2– **2Peq**	13.2	Q – ≥ 10,0	Santos et al. 2007	85	73	689.3	25.7	3.61	0.81	22° 47' 10" 47° 00'15"
	Small 3 – **3Peq**	13.4	Q – ≥ 10,0	Santos et al. 2007	47	47	912.3	40.6	2.47	0.61	22° 48' 40" 46° 57' 55"
	Average 1 – **1Med**	19.9	Q – ≥ 10,0	Santos et al. 2007	98	93	681.5	30.9	3.96	0.86	22° 52' 30" 46° 54'10"
	Average 4 – **4Med**	25.2	Q – ≥ 10,0	Santos et al. 2007	97	84	757.4	35.8	3.79	0.83	22° 48' 20" 46° 53' 50"
	Large 1 **1Gra**	41.8	Q – ≥ 10,0	Santos et al. 2007	104	93	678.6	35.4	4.06	0.87	22° 47' 40" 46° 56' 30"
	Large 2 **2Gra**	63.3	Q – ≥ 10,0	Santos et al. 2007	65	62	484.7	37.6	3.29	0.79	22° 45' 10" 46° 56' 30"
	Ribeirão Cachoeira 1 – **RCa1**	244.9	Q – ≥ 10,0	Santos et al. 2007	97	90	515.0	27.7	3.80	0.83	22° 50' 00" 46° 55' 35"
	Ribeirão Cachoeira 2 – **RCa2**	244.9	Q – ≥ 10,0	Santos et al. 2007	98	88	558.8	30.9	3.98	0.87	22° 49' 40" 46° 56' 15"
	Ribeirão Cachoeira 3 – **RCa3**	244.9	Q – ≥ 10,0	Santos et al. 2007	90	81	665.9	35.2	3.70	0.82	22° 49' 55" 46° 55' 05"
	Ribeirão Cachoeira 4 – **RCa4**	244.9	P – ≥ 4,8	Cielo-Filho & Martins, 2016[1]	119	93	1080.0	24.2	3.79	-	22° 50' 00" 46° 55' 35"
	Fazenda São Vicente – **SVi**	70.0	P – > 4,8	Bernacci & Leitão Filho,1996[1]	84	71	1510.0	33.7	3.53	-	22° 49' 25" 46° 59' 05"
NW	Reserva Santa Genebra (2004) – **SGe**	251.7	P – ≥ 4,8	Farah et al., 2014[1]	112	90	1096.0	19.2	3.71	0.79	22° 49' 15" 47° 06' 35"

Loc: city region; CE: center; NE: northeast; NW: northwest; C: census; P: parcels; Q: quadrant point; tSpp: number of species; nSpp: number of species used in the comparison; DBH: diameter at breast height; H': diversity; J: equability; -: no data available; 1: data provided by authors; 2: verified (and adjusted where necessary) in Google Earth.

We checked species for valid names, spelling and authors in Flora do Brasil 2020, and organized them by family according to the Angiosperm Phylogeny Group IV classification system (2016), with an indication of subfamilies in Fabaceae (LPWG, 2013). We classified native species as pioneers or not pioneers, and exposed them to a dispersion syndrome (Barbosa et al., 2015). When no classification was found for a particular species, we investigated the standard and used it at the generic level.

We analyzed the usual phytosociological parameters, Shannon's diversity index (H') and the Pielou equability index (J). We performed the calculations using FITOPAC 2.0 (Shepherd, 2008). And compared the results to 15 other forest fragments (Table 1) of semi-deciduous seasonal forest in the city of Campinas at 600-700 m altitude.

We verified the species names and revised their identifications when the material was available in the herbarium and a possible identification problem had been detected. Morphospecies were considered, since there was no possibility of dubiety with species in the other considered surveys (*Coccoloba* sp) (Cielo Filho & Martins, 2016; Santos et al., 2007). For species with undefined identifications ("cf." or "aff."), we considered them to be the species mentioned, provided that it was not mentioned in the survey itself.

We constructed a presence/absence matrix for species demonstrating at least three occurrences. We also built a quantitative data matrix (absolute density) for the 45 species with the highest Importance Value Index (IVI), or with the highest coverage value index (CVI) in the absence of frequency. We used Principal Coordinates Analysis as the ordering method, simple Euclidean distances for qualitative data and Bray Curtis coefficients for quantitative data (Felfili et al., 2011). We used the Mantel test, within the PC-ORD program, to verify the correlation between floristic composition and the geographic distance between the fragments (McCune & Mefford, 1999).

3. RESULTS

In the Mata Santa Elisa, we found 556 arboreal specimens (1.112 trees.ha^{-1}), including 506 living individuals (1.012 trees.ha^{-1}) belonging to 100 species, 75 genera and 32 families (Table 2). The most species-rich families were Fabaceae (23 species), Meliaceae (eight species), Rutaceae and Lauraceae (six species) and Euphorbiaceae, Malvaceae and Myrtaceae (represented by five species each). Five of these families were also the most abundant in the area: Euphorbiaceae (258 individuals.ha^{-1}, 25.49% of live trees), Fabaceae (256, 25.30%), Malvaceae (122, 12.05%), Meliaceae (60, 5.93%) and Myrtaceae (42, 4.15%).

Table 2. Families (in phylogenetic order) and species found in the Mata Santa Elisa, with their respective popular names and reference numbers in the IAC Herbarium (No. IAC).

Family/Species	Popular name	No. IAC	DA (trees.ha^{-1})	FA (%)	DoA (m^2.ha^{-1})	Suc.	Dis.
MAGNOLIIDS							
PIPERACEAE							
Piper amalago L.	falso-jaborandi	32056	2	2	< 0.01	np	zoo
Piper arboreum Aubl.	fruto-de-morcego	48217	2	2	0.01	**np**	**zoo**
Piper claussenianum (Miq.) C.DC.	jaborandi-tremedor	48097	4	4	0.07	**np**	**zoo**
ANNONACEAE							
Annona mucosa Jacq.	araticum	19714	2	2	0.01	np	zoo
Annona sylvatica A.St.-Hil.	araticum-do-mato	46828	2	2	0.08	p	zoo
Guatteria australis A.St.-Hil.	pindaúva-preta	44513	12	10	0.22	np	zoo
SIPARUNACEAE							
Siparuna guianensis Aubl.	siparuna	21313	2	2	0.01	**np**	**zoo**
LAURACEAE							
Cryptocarya aschersoniana Mez	canela-batalha	46967	2	2	0.01	np	zoo
Endlicheria paniculata (Spreng.) J.F.Macbr.	canela-do-brejo	46801	4	4	0.04	np	zoo
Nectandra megapotamica (Spreng.) Mez	canelinha	46604	4	4	0.04	np	zoo
Nectandra oppositifolia Nees	canela-amarela	46533	2	2	0.01	p	zoo
Ocotea diospyrifolia (Meisn.) Mez	canela-louro	44909	2	2	0.05	np	zoo
Ocotea puberula (Rich.) Nees	canela	24169	4	4	0.02	np	zoo
EUDICOTS							
FABACEAE (Caesalpinioideae)							
Albizia polycephala (Benth.) Killip ex Record	angico-branco	31869	4	4	0.07	np	aut
Cassia ferruginea (Schrad.) Schrad. ex DC.	chuva-de-ouro	26822	4	4	0.01	np	aut
Dimorphandra exaltata Schott	cereja-do-mato	19699	2	2	0.02	**np**	**ane**
Inga marginata Willd.	ingá-feijão	42704	6	6	0.02	np	zoo
Inga striata Benth.	ingá	18060	10	10	0.12	p	zoo
Peltophorum dubium (Spreng.) Taub.	canafístula	32949	6	6	0.01	p	aut
Piptadenia gonoacantha (Mart.) J.F.Macbr.	pau-jacaré	28650	54	30	1.29	p	aut
Schizolobium parahyba (Vell.) Blake	guapuruvu	25539	30	26	0.24	exo	exo
Senegalia polyphylla (DC.) Britton & Rose	monjoleiro	28620	4	4	0.1	p	aut
Senegalia tenuifolia (L.) Britton & Rose	unha-de-gato		4	4	0.06	**p**	**aut**
Senna macranthera (DC. ex Collad.) H.S.Irwin & Barneby	fedegoso	11248	2	2	0.01	p	aut
Tachigali denudata (Vogel) Oliveira-Filho	angá		4	4	0.08	np	ane
FABACEAE (Cercidoideae)							
Bauhinia forficata Link	pata-de-vaca	32021	26	12	0.14	p	aut
Bauhinia longifolia (Bong.) Steud.	unha-de-vaca	32999	2	2	< 0.01	p	aut

Table 2. Continued...

Family/Species	Popular name	No. IAC	DA (trees.ha^{-1})	FA (%)	DoA (m².ha^{-1})	Suc.	Dis.
FABACEAE (Detarioideae)							
Hymenaea courbaril L.	jatobá	28643	2	2	0.01	np	zoo
FABACEAE (Faboideae)							
Andira anthelmia (Vell.) Benth.	angelim-amargoso	18170	2	2	0.01	np	zoo
Centrolobium tomentosum Guillem. ex Benth.	araribá	46403	48	36	0.4	np	ane
Lonchocarpus cultratus (Vell.) A.M.G.Azevedo & H.C.Lima	embira-de-sapo	41732	4	4	0.05	**np**	**aut**
Machaerium hirtum (Vell.) Stellfeld	barreiro	19846	6	6	0.05	np	ane
Machaerium nyctitans (Vell.) Benth.	pico-de-pato	46449	2	2	0.01	np	ane
Machaerium stipitatum Vogel	pau-de-malho	46445	28	20	0.48	np	ane
Muellera campestris (Mart. ex Benth.) M.J. Silva & A.M.G. Azevedo	embirinha	20157	2	2	< 0.01	np	aut
Sweetia fruticosa Spreng.	sucupirana	41332	6	4	0.02	np	ane
ROSACEAE							
Prunus myrtifolia (L.) Urb.	coração-de-negro	44910	2	2	0.03	np	zoo
RHAMNACEAE							
Colubrina glandulosa Perkins	saraguagi-vermelho	44006	8	8	0.09	p	zoo
CANNABACEAE							
Celtis pubescens (Kunth) Spreng.	grão-de-galo	46799	4	4	0.03	**p**	**zoo**
Trema micrantha (L.) Blume	crindiúva	34804	8	8	0.13	p	zoo
URTICACEAE							
Cecropia glaziovii Snethl.	embaúba	49016	22	16	0.34	p	zoo
Cecropia pachystachya Trécul	embaúba	46522	12	10	0.21	p	zoo
CHRYSOBALANACEAE							
Hirtella hebeclada Moric. ex DC.	macucurana	33033	2	2	0.01	np	zoo
SALICACEAE							
Casearia gossypiosperma Briq.	pau-de-espeto	46450	14	14	0.33	p	zoo
Casearia sylvestris Sw.	guassatonga	46530	2	2	0.01	p	zoo
EUPHORBIACEAE							
Alchornea glandulosa Poepp. & Endl.	maria-mole	44603	18	16	0.22	p	zoo
Croton floribundus Spreng.	capixingui	46976	88	36	1.95	p	aut
Croton piptocalyx Müll.Arg.	caixeta	49488	116	38	2.2	p	aut
Croton rottlerifolius Baill.		37568	18	10	0.04	**p**	**aut**
Gymnanthes klotzschiana Müll.Arg.	branquilho	44511	16	8	0.08	p	aut
COMBRETACEAE							
Terminalia triflora (Griseb.) Lillo	capitãozinho	31435	2	2	0.01	np	ane
MYRTACEAE							
Campomanesia guaviroba (DC.) Kiaersk.	gabiroba	46551	2	2	0.03	np	zoo
Campomanesia sp.	gabiroba		2	2	0.01	**np**	**zoo**
Eugenia acutata Miq.	guamirim	45763	18	12	0.19	np	zoo
Myrcia splendens (Sw.) DC.	guamirim-de-folha-fina	45105	14	14	0.08	np	zoo
Psidium sartorianum (O.Berg) Nied.	araçá-gigante	46977	6	4	0.02	**np**	**zoo**
ANACARDIACEAE							
Astronium graveolens Jacq.	guaritá	53588	22	14	0.1	np	ane
Mangifera indica L.	manga	25518	14	12	1.21	exo	exo
Tapirira obtusa (Benth.) J.D.Mitch.	copiúva	29377	2	2	0.01	np	zoo

Table 2. Continued...

Family/Species	Popular name	No. IAC	DA (trees.ha^{-1})	FA (%)	DoA (m^2.ha^{-1})	Suc.	Dis.
SAPINDACEAE							
Allophylus edulis (A.St.-Hil. et al.) Hieron. ex Niederl.	fruta-do-pombo	32020	2	2	< 0.01	p	zoo
Cupania vernalis Cambess.	camboatá	46969	2	2	< 0.01	np	zoo
Matayba elaeagnoides Radlk.	caqui-do-mato	46509	4	2	0.28	np	zoo
Matayba juglandifolia (Cambess.) Radlk.	camboatã-branco	43216	2	2	0.01	np	zoo
RUTACEAE							
Esenbeckia febrifuga (A.St.-Hil.) A. Juss. ex Mart.	mamoninha	32019	8	4	0.04	np	aut
Galipea jasminiflora (A.St.-Hil.) Engl.	gramixinga	47508	6	4	0.02	np	aut
Metrodorea stipularis Mart.	chupa-ferro	44005	8	8	0.03	np	aut
Zanthoxylum acuminatum (Sw.) Sw.		46360	2	2	< 0.01	p	zoo
Zanthoxylum monogynum A.St.-Hil.	juvá	46565	2	2	0.02	np	zoo
Zanthoxylum rhoifolium Lam.	mamica-de-porca	5193	4	4	0.08	np	zoo
MELIACEAE							
Cabralea canjerana (Vell.) Mart.	canjerana	46539	22	18	0.2	np	zoo
Cedrela fissilis Vell.	cedro	46540	6	6	0.1	np	ane
Guarea guidonia (L.) Sleumer	marinheiro	46541	4	2	0.01	np	zoo
Guarea kunthiana A.Juss.	canjambo	46542	4	4	0.1	np	zoo
Trichilia casaretti C.DC.	catiguá	42170	6	6	0.02	np	zoo
Trichilia claussenii C.DC.	quebra-machado	46546	2	2	0.04	np	zoo
Trichilia elegans A.Juss.	catiguazinho	33006	6	6	0.09	np	zoo
Trichilia pallida Sw.	baga-de-morcego	39850	10	10	0.05	np	zoo
MALVACEAE							
Ceiba speciosa (A.St.-Hil.) Ravenna	paineira	46517	4	4	0.03	np	ane
Eriotheca candolleana (K.Schum.) A.Robyns	embiruçu-do-litoral	45690	6	6	0.03	np	ane
Guazuma ulmifolia Lam.	mutamba	44597	86	54	0.63	P	zoo
Luehea divaricata Mart. & Zucc.	açoita-cavalo	46511	20	16	0.3	np	ane
Pseudobombax grandiflorum (Cav.) A.Robyns	embiruçu	28651	6	6	0.02	np	ane
CARICACEAE							
Carica papaya L.	mamoeiro	8109	6	4	0.23	exo	exo
Jacaratia spinosa (Aubl.) A.DC.	mamãozinho	31907	2	2	0.01	np	zoo
NYCTAGINACEAE							
Guapira opposita (Vell.) Reitz	flor-de-pérola	46457	2	2	< 0.01	np	zoo
Pisonia ambigua Heimerl	maria-faceira	46559	2	2	0.01	np	zoo
LECYTHIDACEAE							
Cariniana estrellensis (Raddi) Kuntze	jequitibá-branco	33008	14	12	2.81	np	ane
Cariniana legalis (Mart.) Kuntze	jequitibá-rosa	7263	4	4	5.21	np	ane
SAPOTACEAE							
Chrysophyllum gonocarpum (Mart. & Eichler ex Miq.) Engl.	guatembú-de-leite	32180	2	2	0.01	np	zoo
PRIMULACEAE							
Myrsine balansae (Mez) Otegui	capororoca	46456	6	6	0.02	p	zoo
BIGNONIACEAE							
Zeyheria tuberculosa (Vell.) Bureau ex Verl.	ipê-tabaco	46582	12	8	1.14	**np**	**ane**

Table 2. Continued...

Family/Species	Popular name	No. IAC	DA (trees.ha^{-1})	FA (%)	DoA (m^2.ha^{-1})	Suc.	Dis.
RUBIACEAE							
Coutarea hexandra (Jacq.) K.Schum.	quina	46561	2	2	0.01	np	ane
Guettarda viburnoides Cham. & Schltdl.	veludo	45134	2	2	0.03	np	zoo
BORAGINACEAE							
Cordia trichotoma (Vell.) Arráb. ex Steud.	louro-pardo	31952	2	2	0.04	np	ane
BIGNONIACEAE							
Jacaranda micrantha Cham.	caroba	41514	2	2	0.01	p	ane
VERBENACEAE							
Aloysia virgata (Ruiz & Pav.) Juss.	tamanqueiro	46966	2	2	0.01	p	ane
LAMIACEAE							
Aegiphila integrifolia (Jacq.) Moldenke	pau-de-gaiola	35326	8	4	0.07	p	zoo
CARDIOPTERIDACEAE							
Citronella paniculata (Mart.) R.A.Howard	congonha	18772	4	4	0.04	np	zoo
ASTERACEAE							
Vernonanthura divaricata (Spreng.) H.Rob.	pau-toucinho	21323	2	2	0.01	**p**	**ane**
ARALIACEAE							
Dendropanax cuneatus (DC.) Decne. & Planch.	maria-mole	44903	2	2	0.01	p	zoo

DA: absolute density; FA: absolute frequency; DoA: absolute dominance; Suc: succession category (P: pioneer and NP: non-pioneer); Dis: dispersion syndrome (ane: anemochorous, aut: autochorous and zoo: zoochorous); exo: exotic species; gray color: succession or dispersion syndrome not present in Barbosa et al. (2015), standard at the gender level.

Eleven families (Siparunaceae – magnoliids, Rosaceae, Chrysobalanaceae, Combretaceae, Sapotaceae, Boraginaceae, Bignoniaceae, Verbenaceae and Cardiopteridaceae – eudicots) and the eudicotiledon species Nyctaginaceae and Rubiaceae (two species each) were represented by only one individual (2 individuals.ha^{-1}). Standing dead trees were represented by 50 individuals (100 trees.ha^{-1}, 8.99%). Euphorbiaceae (51 individuals species.ha^{-1}), Malvaceae (24), Urticaceae (17), Anacardiaceae (13), Bignoniaceae (12) and Fabaceae (11) had the highest mean number of individuals per species per hectare.

The most abundant species were "caixeta" (*Croton piptocalyx*, 116 individuals.ha^{-1}, 11.46%), followed by "capixingui" (*Croton floribundus*, 88, 8.70%), "mutamba" (*Guazuma ulmifolia*, 86, 8.50%), "pau-jacaré" (*Piptadenia gonoacantha*, 54, 5.34%) and "araribá" (*Centrolobium tomentosum*, 48, 4.74%). The Shannon's diversity index was 3.82 and the Pielou equability index was 0.83 (considering only living individuals). In Mata Santa Elisa, 66 species were classified as non-pioneers, 30 were pioneers and three were exotic, two of which were invasive (I3N Brasil, 2016). Although the number of non-pioneer species was higher, their abundance (412 individuals.ha^{-1}, 40.71%) was lower than that of the pioneer species (542, 53.56%).

With respect to the 10 species with the highest IVI (Figure 2), seven are among the most abundant species, with 10 or more individuals sampled (20 or more individuals.ha^{-1}). *Croton piptocalyx*, *C. floribundus* and *Piptadenia gonoacantha* had high IVIs due to their density and dominance (70-80% total), whereas density and frequency were the largest contributions (70-80% total) from *Guazuma ulmifolia*, *Centrolobium tomentosum*, *Schizolobium parahyba* ("guapuruvu") and *Machaerium stipitatum* ("pau-de-malho"). *Cariniana legalis* ("jequitibá-rosa"; 96%) and *C. estrellensis* ("jequitibá-branco"; 80%) obtained their IVIs almost exclusively due to their dominance, which was also very strong (63%) for *Mangifera indica* ("mangueira").

In addition, "jequitibás" had the highest dominance averages per individual (1.30 and 0.20 m^2.ha^{-1}, respectively), which represented at least twice that of other species (< 0.01 m^2.ha^{-1} to *Peltophorum dubium* or 0.10 m^2.ha^{-1} to *Zeyhera tuberculosa*). Among these species (Figure 2), four were classified as pioneers (*C. piptocalyx, C. floribundus, G. ulmifolia and P. gonoacantha*), four as non-pioneers (*C. legalis, C. estrellensis, M. stipitatum and C. tomentosum*) and the other two as exotic (*S. parahyba and M. indica*). When considering CVI, we observed changes in the positions, in relation to IVI, of *C. legalis* (96% of CVI due to dominance, moving from second to first), *C. estrellensis* (90%, from fifth to fourth), *M. indica* (79%, from eighth to seventh) and *Zeyhera tuberculosa* (81%, from eleventh to ninth).

Trees (Figure 3) were predominately 5 to 10 m in height (about 62.5%), with some emergent individuals (> 20 m) exceeding the regular forest canopy for more light (e.g. *Zeyheria tuberculosa*, *Cariniana legalis*). The arithmetic mean was 12.6 cm. The estimated basal area was 27.26 $m^2.ha^{-1}$.

The matrix based on absolute density data consisted of 199 species (https://figshare.com/s/b5b304a83795bd3afb04). The ordering analysis resulted in a 42% explanation of the first two axes (Figure 4) and 11% of the third axis (figure not shown). Through this analysis, it was possible to observe separation between the studied remnants. The Mata Santa Elisa showed greater similarity with the Bosque dos Alemães, remaining to the left side of the graph. Still on the left side, in the upper part, there were three fragments of environmental protection area of Campinas (Pequenos 1 and 3 and Ribeirão Cachoeira, Sample 2), besides Fazenda São Vicente, Bosque dos Jequitibás and Reserva Santa Genebra. The other eight fragments of the Campinas APA remained condensed in a single cluster.

Trichilia clausseni (−0.8) and *Esenbeckia leiocarpa* Engl. (0.8) were highly correlated with the first axis. *Myrcia splendens* (−0.8), *Copaifera langsdorffii* Desf., *Ocotea corymbosa* (Meisn.) Mez, *Piptadenia gonoacantha* and *Leucochloron incuriale* (Vell.) Barneby & J.W.Grimes (−0.7) were correlated with the second axis. Qualitative analyses showed less explanatory power (28% in the two main axes, considering the Euclidean distances), indicating that the floristic composition of the fragments is the same, except in the structure of the tree community.

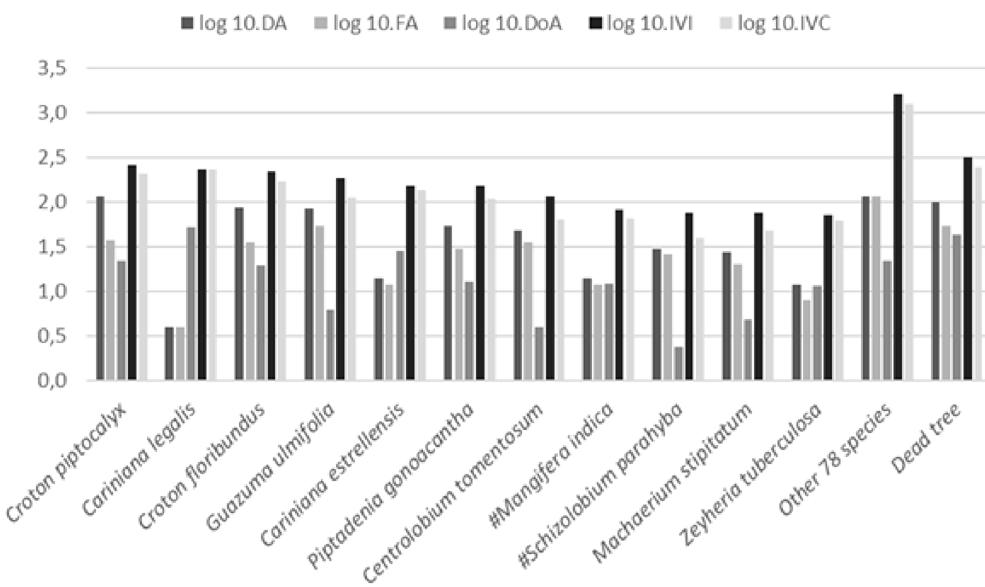

Figure 2. Mata Santa Elisa species and standing dead trees in IVI order. Log: log base 10; DA: absolute density; FA: absolute frequency, 10: 10 times; DoA: absolute dominance; IVI: importance value index; IVC: coverage value index; #: exotic species.

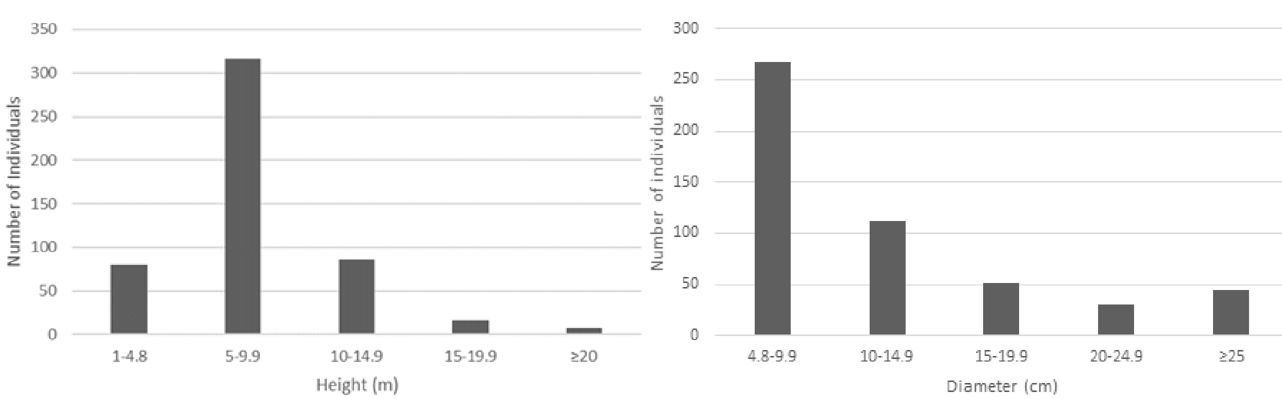

Figure 3. Distribution of height and diameter classes of trees in the Mata Santa Elisa.

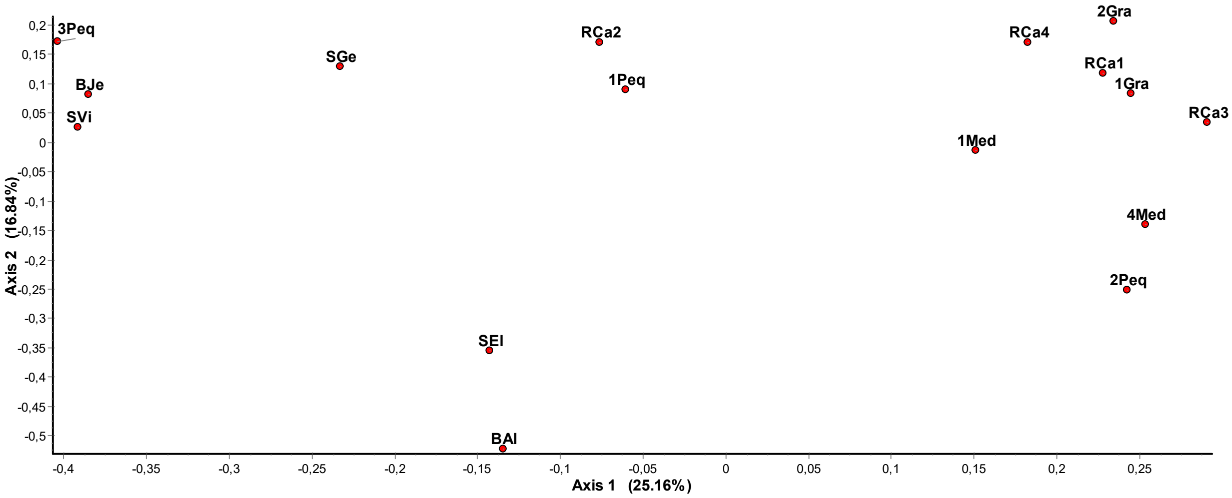

Figure 4. Analysis of principal coordinates using the Bray Curtis coefficient of the 45 species with the highest IVI of the selected fragments in Campinas, SP. Fragment forest codes are the same as in Table 1.

Although the Mantel test indicated a positive association between geographic distance and density matrices ($r = 0.2046$; Z observed = 0.1738E+00; $t = 1.6986$), the p value was high ($p = 0.09$), indicating that the association was not significant. Thus, we must assume that the floristic similarity between the areas is not determined by the proximity between them.

4. DISCUSSION

Mata Santa Elisa was subject to disturbance factors, including fires, which could have decharacterized its vegetation. Fabaceae, which was the richest and had the second highest IVI, is cited as one of the most important in terms of number of species in other states in the southeast (Bernacci et al., 2006; Medeiros et al., 2016; Pennington et al., 2009). The other families that have been highlighted by their number of species (Meliaceae, Rutaceae, Lauraceae, Euphorbiaceae, Myrtaceae and Malvaceae) or their IVIs (Euphorbiaceae, Lecythidaceae, Malvaceae and Meliaceae) are frequently observed in inventories of semi-deciduous seasonal forest (Oliveira-Filho & Fontes, 2000).

Croton piptocalyx, the most abundant species with a high IVI, as well as *Piptadenia gonocantha*, *Guazuma ulmifolia* and *C. floribundus*, are pioneers; they are generally heliophytes (Tabarelli, 1997) and function to recover disturbed environments, as is the case for this studied fragment (Rodrigues, 1995). *Centrolobium tomentosum* and *Machaerium stipitatum,* also abundant and with high IVI values, are both early secondary species, related to the intermediate stage of succession (Gandolfi et al., 1995). The two "jequitibás" species (*Cariniana legalis* and *C. estrellensis*) are characteristic of mature forest areas (Gandolfi et al., 1995). In this successional mosaic, the high density of pioneer species indicates young forest stretches (Gandolfi et al., 1995). On the other hand, the survival and longevity of large trees, such as "jequitibás," allows for the occurrence of reproductive events and increases the possibility of maintaining these populations in the area.

Still, it should be noted that two exotic invasive species are among the species with the highest IVIs in the Mata Santa Elisa, and the occurrence of both species represents anthropic interference in the forest. The occurrence of *Mangifera indica* may be due to humans discarding their seeds, since all the sampled individuals were close to local trails. *Schizolobium parahyba* was planted in the area by IAC researchers between 2006 and 2008. Although they have not been studied since, *Schizolobium parahyba* have developed in the forest (Dr. Wilson Barbosa, CEC Director, Fazenda Santa Elisa, 2007-2012 – personal information).

The species that correlated with the PCO axes were abundant in all or most of the similar fragments from the Mata Santa Elisa (Bosque dos Alemães, Bosque dos Jequitibás, Reserva Santa Genebra etc.), but were not abundant in the other fragments of the environmental protection area of Campinas in general. However, some of these species were not sampled in Mata Santa Elisa, namely: *Trichilia clausseni*, *Esenbeckia leiocarpa*, *Copaifera langsdorfii*, *Ocotea corymbosa*, *Leucochloron incuriale,* and *Syagrus romanzoffiana*. All are zoocorous species except for *Leucochloron incuriale,* which can be reintroduced or their populations increased in the area.

Schizolobium parahyba was abundant only in the Mata Santa Elisa, which is another indication that it is not a native species. This species has been at risk and caused conflict with neighboring municipalities due to the fall of branches or plants (personal observation), whereas surveys (Abreu et al., 2014) show that the species is invasive in areas of semi-deciduous seasonal forest, displacing successional forest species and modifying the composition and structure of the vegetation; this justifies the suppression of "guapuruvu" individuals, as well as "mangueira" and other exotic species, in Mata Santa Elisa.

Among the compared fragments, *Annona mucosa*, *Celtis pubescens*, *Terminalia triflora*, *Croton rottlerifolius*, *Albizia polycephala*, *Inga striata*, *Tachigali denudata*, *Piper claussenianum* and *Matayba juglandifolia* were sampled exclusively in the Mata Santa Elisa. In addition, the forest also contained noble wood species (e.g. *Cedrela fissilis, Hymenaea courbaril*) with economic, medicinal and aromatic potentials, among other properties (Perigo et al., 2016; Souza et al., 2015). Thus, this highlights the importance of Mata Santa Elisa in terms of species of interest and general biodiversity. Even small fragments of forest can be good representatives of local biodiversity and, in addition, preserve a good percentage of regional biodiversity (Arroyo-Rodriguez et al., 2009).

In Mata Santa Elisa, we observed patterns of abundant concentration of a few species and the occurrence of a large number of species represented by few individuals. These patterns are observed in inventories of semi-deciduous seasonal forests (Oliveira-Filho & Fontes, 2000) and in tropical forests; species have preferential environments and their abundance increases in the places where most of their biotic and abiotic requirements are met (Kreft & Jetz, 2007).

Through the H' and J indices, we confirmed that the tree community has high diversity and low dominance. Index values were close to those of well-preserved areas of the region, such as Ribeirão Cachoeira Forest and Fazenda São Vicente. In the histogram distribution of diameters, the lowest class contained the highest frequency of individuals, and in general, the number of individuals decreased as the diameter classes increased, following a typical distribution for tropical forests (Felfili et al., 2011).

Based on the floristic and vegetation parameters at the time of this study, we would categorize Mata Santa Elisa as being at an advanced stage of regeneration, according to the CONAMA No. 1 (1994) legislation. Main diameter was the only evaluated parameter that was lower than that established for advanced stage regeneration. Analysis of satellite images indicated the advanced regeneration of Mata Santa Elisa from 1991 to 2011 (Andrade & Sanches, 2011); these images showed that forest cover had increased in comparison to 1991 (the tipping point), even with the fire in 1994.

Mata Santa Elisa is located in the State of São Paulo, administered by the Secretariat of Agriculture, which includes sustainability in its mission (Veiga et al., 2006). In addition, the use of forest fences is a key factor in the prevention of forest fires. After this study, a new fire hit Mata Santa Elisa, possibly caused by the fall of lantern balloons, and affected about half of its area (Campinas, 2014). In 2015-2016, financial difficulties hampered the maintenance of firebreaks, which compromised fire protection and relief to the forest. Fortunately, since 2017, the change of the Municipal Secretariat for Public Works, in the vicinity of the forest, has made this maintenance possible (personal observation).

The remaining fragments of semi-deciduous seasonal forest account for only 7.1% of the original cover in the state (Ribeiro et al., 2009), further highlighting the importance of Mata Santa Elisa. These forest fragments are fundamental in the qualitative recovery of the landscape, with an aim towards sustainability and quality of life for the population. Data presented here can act as an important reference for new studies of the composition and structure of Mata Santa Elisa, which are expected to occur momentarily.

5. CONCLUSIONS

In 2007, the Mata Santa Elisa fragment had high diversity and low dominance, as well as species of economic interest or potential. The conservation of the remnant represents a refuge for species that found adequate conditions to establish themselves and develop stable populations, contributing to the preservation of the flora of the region. The relative protection of the area due to its tipping and its location on state property did not prove to be sufficiently effective, as it did not prevent the occurrence of fires in the area. As such, there is a need for other fire prevention measures, such as environmental education for the local community, trained personnel, and equipment for fire control to guarantee its long-term sustainability. In this study, we observed the urgency of monitoring forest dynamics and the suppression of invasive alien species to increase the preservation of the native vegetation of this valuable forest fragment.

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