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Research Article

An Ecological Comparison of Floristic Composition in Seasonal Semideciduous Forest in Southeast Brazil: Implications for Conservation

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We examined floristic patterns of ten seasonal semideciduous forest sites in southeastern Brazil and conducted a central sampling of one hectare for each site, where we took samples and identified all individual living trees with DBH (diameter at breast height, 1.30 m) $\geq$ 4.8 cm. Arboreal flora totaled 242 species, 163 genera, and 58 families. Fabaceae (38 species) and Myrtaceae (20 species) were families with the largest number of species. Only *Copaifera langsdorffii* and *Hymenaea courbaril* occurred at all sites. Multivariate analysis (detrended correspondence analysis and cluster analysis) using two-way indicator species analysis (TWINSPAN) indicated the formation of a group containing seven fragments in which *Siparuna guianensis* was the indicator species. This analysis revealed that similarities between studied fragments were due mainly to the successional stage of the community.

1. Introduction

The extent of seasonal semideciduous forests (SSFs) in Brazil is underestimated because of its naturally fragmented distribution [1, 2]. Semideciduous seasonal forests occur along the contact zone between Atlantic forest and the diagonal of opened formations [3–5], comprising three different scenarios: (1) in northeastern Brazil, the SSFs form a marked belt (<50 km) in transition between the coastal rainforest and semiarid formations (*Caatinga*), but also occur in enclaves of montane forests, the altitude marsh [6, 7]; (2) the transition between the Cerrado and the coastal Atlantic forest in southeastern Brazil involves an extensive occurrence of SSFs to the south, up to the east of Paraguay and northeast of Argentina, forming a complex mosaic with the Cerrado vegetation in the west; (3) in southeastern Brazil, a large Araucaria forest confronts subtropical coastal Atlantic forest, and the SSF appear to the west and south as a transition to the *Chaco* forests, and to the southeast with fields or the southern pampas [8, 9], and beyond disjunct areas located in Mato Grosso and Tocantins states [10].

In southeast Brazil, SSFs are distributed widely in sites with a seasonal rainfall regime, characteristic of the Atlantic forest and Cerrado domains. In the Atlantic forest domain, SSF is the predominant typology, and in the Cerrado domain, SSF occurs in enclaves, associated with permanent or intermittent watercourses [12] and should be regarded as *lato sensu* Atlantic forest, since it presents a floristic-structural identity similar to forests of the Atlantic forest domain [12].

Semideciduous seasonal forests suffered the same degradation process as other Brazilian ecosystems. Since the 1970s, there was an accelerated replacement of natural vegetal formations to pasture and use for agriculture, transforming extensive areas into an important agriculture area for grain and fruit production and livestock [13]. This rural reorganization was determined by the II National Development Plan (NDP), which collaborated for a modern agricultural deployment. With increasingly intense adoption of mechanization and land use, SSFs were drastically reduced, with only a few remaining in Southeast Brazil.

Table 1: Information of ten seasonal semideciduous forest fragments in southeastern Brazil analyzed regarding regional tree flora composition.

Site	Counties	Area (ha)	Latitude (S)	Longitude (W)	Altitude (m.a.s.l.)
1	Araguari	200	18° 29′ 50″	48° 23′ 03″	680
2	Ipiaçu	40	18° 43′ 39″	49° 56′ 22″	530
3	Monte Carmelo	119	18° 44′ 59″	47° 30′ 56″	910
4	Uberaba	70	19° 40′ 35″	48° 02′ 12″	790
5	Uberlândia	17,5	18° 40′ 26″	48° 24′ 32″	600
6	Uberlândia	30	18° 57′ 03″	48° 12′ 22″	880
7	Uberlândia	22,3	19° 08′ 39″	48° 08′ 46″	930
8	Uberlândia	16	19° 10′ 04″	48° 23′ 41″	800
9	Uberlândia	35	18° 55′ 40″	48° 03′ 51″	890
10	Uberlândia	20	18° 51′ 35″	48° 13′ 53″	890

Table 2: Number of families and species, Shannon diversity index (H'), and Pielou evenness index (J') from ten sites of seasonal semideciduous forest in southeastern Brazil.

Site	Families	Species	H'	J'
1	32	78	3,442	0,79
2	38	98	3,97	0,866
3	27	50	2,924	0,747
4	34	88	3,275	0,733
5	33	79	3,366	0,768
6	37	86	3,705	0,832
7	37	73	3,471	0,809
8	36	98	3,778	0,824
9	38	103	3,868	0,836
10	41	88	3,509	0,784
Total	58	242	4,616	0,840

Habitat fragmentation transforms the original landscape into different dynamic units that continually modify its structure [14]. Furthermore, the occurrence of disturbance histories on different scales and heterogeneity environmental landscapes can influence the species composition of forest fragments [15] and form species richness patterns according to the fragment successional stage [16, 17].

Therefore, owing to the similar process of disturbance in southeastern Brazilian forest formations and being located in the same catchment area, it is expected that the remaining SSF will have the same floristic pattern.

This work aims to analyze the floristic composition and regional richness in the arboreal species of ten fragments of SSF in southeastern Brazil, in order to answer the following questions: (1) what is the alpha diversity in sampled fragments? (2) is there a floristic pattern that represents the SSF in the studied region? (3) is the beta diversity in SSF similar to patterns found in other tropical forests?

2. Material and Methods

2.1. Floristic, Geographic, and Climate Data. We elaborate a floristic list from the tree species compilation in ten semideciduous seasonal forest fragments (according to Veloso classification [18]), distributed in five counties of southeastern Brazil (Table 1). Studied sites are located in the extreme west of Minas Gerais state, defined by geographic coordinates 18° 29′–19°40′ S and 47°30′– 49°53′ W (Figure 1).

The studied region is part of a relief global set, named the "Domain of Central Brazil Tropical Plateaus" by Ab'Saber [19], and the "Plateaus and elevated plains of the Paraná sedimentary basin" by the RADAM project [20]. The soils in the studied areas are predominantly red nonferric latossols (LV) [21]. The predominant climate in the studied region is tropical savanna (Aw Megathermic), characterized, according to Köppen classification [22], by rainy summers and dry winters. The clearly seasonal climate has two well-defined seasons, where the winter season (April to September) has approximately six months of drought, and the summer season (October to March) is warm and rainy. The average annual temperature lies between 23°C and 25°C, with July the month with the lowest average temperature (16°C). The annual rainfall ranges from 1160 to 1460 mm [23].

2.2. Data Collection and Analysis. We conducted a central sampling of one hectare from each fragment of SSF, in an attempt to exclude edge effect and to obtain uniform samples, avoiding the ecotones of the adjacent formations. Central sampling gave priority to sites without the influence of watercourses (gallery forest), savanna formations (*cerrado sensu stricto*), and others forestry formations (dry seasonal forest and *cerradão*), since these vegetation contact areas vary considerably between fragments and would lead to changes in the species listing of each area. In each central sampling, all individual living trees with a DBH (diameter at breast height, 1.30 m) of ≥ 4.8 cm were recorded and identified.

We identified the species using literature, queries in herbarium, and specialists. For specific binomial formation, we employed the w3 Tropicos database [24]. We deposited fertile material to the Uberlandia Federal University herbaria (*Herbarium Uberlandensis*: HUFU). Vegetative samples of all species were deposited at the Laboratory of Plant Ecology at the same university. Species were classified into families, according to the Angiosperm Phylogeny Group III system [25].

We compiled all species present in the inventories to undertake the floristic composition analysis. We carried

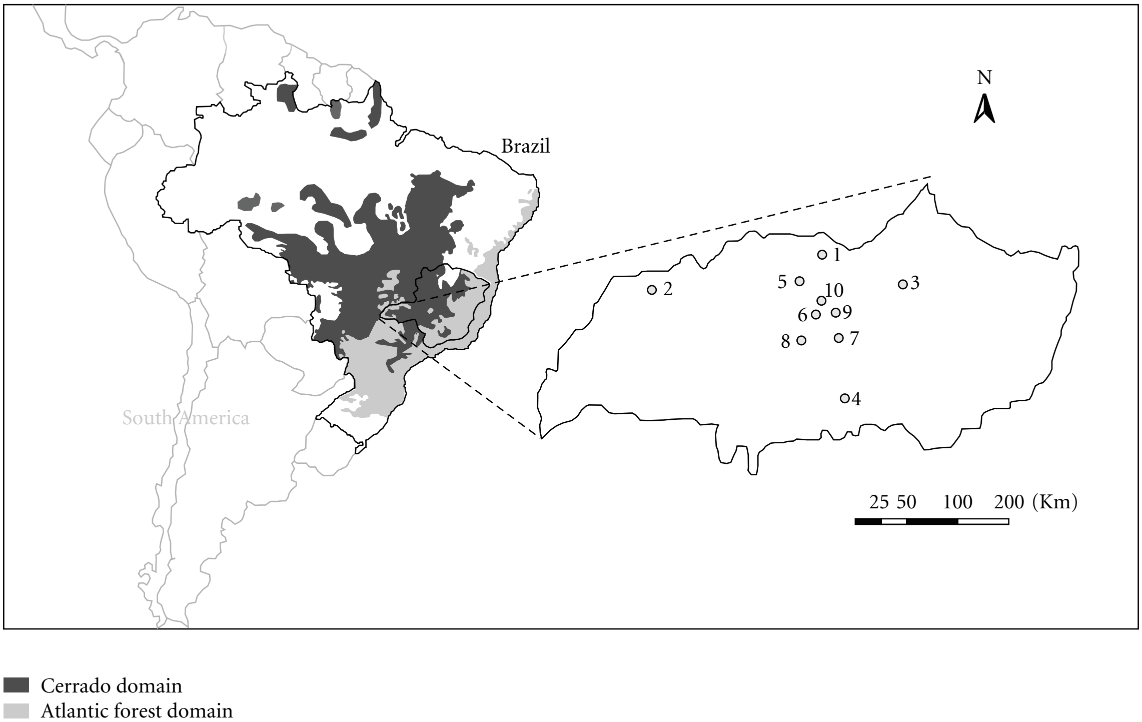

Figure 1: Location of the ten sites of seasonal semideciduous forest studied in the region of Triângulo Mineiro, Minas Gerais state, southeastern Brazil.

out the analysis by preparing a binary database (presence/absence), containing the tree species listed in each fragment. We only considered individual trees identified at the species level in this database composition. For the Alpha diversity evaluation, we used the Shannon diversity index (H') and the Pielou evenness index (J').

We used the binary database for the measurement of richness analysis, and also for the total number of species projection, we used first- and second-order, nonparametric jackknife estimators, in addition to Chao and Chao 2 estimators, which were capable of projecting total species richness from the samples of species richness [26], with 5,000 randomizations. We conducted the analysis using the EstimateS 8.0 program [27].

2.3. Multivariate Analyses. We did similarity and sorting analysis utilizing the FITOPAC SHELL 1.6.4 program [28], using an absolute density matrix for the species of ten sites, considering only those species with two or more occurrences, since species that had just one occurrence did not contribute to the floristic site ordering for floristic similarity. For categorical floristic data (presence and absence), we analyzed the similarity between sites, using the same absolute density matrix, transformed into presence/absence. We used the Sørensen similarity coefficient [29] and the unweighted pair group method with arithmetic mean (UPGMA) for a dendrogram graphical representation.

We applied multivariate analysis to quantitative tree species floristic data (abundance) present in all the compared fragments. For this, we realized a data ordination by using the detrended correspondence analysis (DCA, [30]). In addition, to define predominantly the indicator and preferred species of the floristic groups, based on frequency and density (species with $n \geq 5$ individuals), we used dichotomous hierarchical division using TWINSPAN (two-way indicator species analysis, [31]), from an absolute data matrix and its frequency at the 10 sites, with a cut level of 0, 2, 5, and 10. These analyses were made by PC-ord for Windows program version 4.0 [32].

3. Results

A total of 242 species, distributed in 165 genera and 58 families, were found in the SSF (Table 2). Families with a higher species richness were Fabaceae (*sensu lato*) (38 species), subdivided into Fabaceae Faboideae (20), Fabaceae Mimosoideae (11), Fabaceae Caesalpinioideae (5) and Fabaceae Cercideae (2), Myrtaceae (20 species), Rubiaceae (13), Annonaceae (11), Moraceae (10), Lauraceae (9), Meliaceae (9), and Malvaceae (8). These eight families showed a great contribution to the regional tree diversity, covering 48.8% of the species. Twenty-six families were represented by only one species. Annonaceae, Apocynaceae, Combretaceae, Fabaceae, Mimosoideae, Fabaceae, Faboideae, Lauraceae, Myrtaceae, Meliaceae, Rubiaceae, Salicaceae, Sapindaceae, and Sapotaceae were found at all ten studied sites.

Most well-represented genera are in Fabaceae Faboideae (13), Rubiaceae (13), Myrtaceae (10), Annonaceae (8), and Euphorbiaceae, Fabaceae Mimosoideae, and Malvaceae, with seven genera each. Approximately 30% of families were

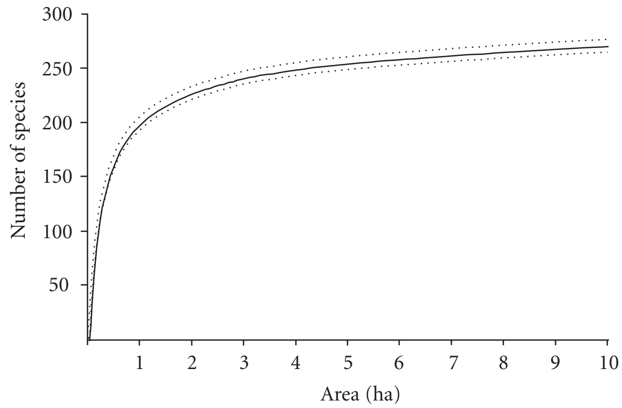

Figure 2: Sampling sufficiency designed by "jackknife" estimator for the ten sites of seasonal semideciduous forest in southeastern Brazil. Dashed line: standard deviation.

represented by only one genus. The best represented genera in terms of species number were *Aspidosperma*, *Machaerium*, and *Ficus*, with seven species each, followed by *Ocotea*, *Cordia*, *Inga*, *Trichilia,* and *Casearia* with four species each.

The total species richness, designed by jackknife estimators 1 and 2 and Chao 1 and 2 estimators, showed a similar pattern (273, 284, 285, and 268 species, resp.). Results suggest high regional tree species richness. The 242 species found approximates of richness designed for estimators, demonstrating sampling sufficiency among the ten hectares studied (Figure 2).

The Shannon's diversity index (H') for each site showed diversity values between 2.92 and 3.97, with the Pielou's evenness index (J') between 0.73 and 0.87 (Table 2). However, when we considered the ten sites as a single sample, Shannon's diversity index (H') was 4.62, and Pielou's evenness index was 0.84. This value can be attributed to the sampling covering quite heterogeneous sites, allowing differences in remnant structure and floristic composition and, consequently, increasing beta diversity.

Only *Copaifera langsdorffii* and *Hymenaea courbaril* were presented with the highest frequency in distribution, reaching 100% of occurrence at the sites (Table 3). However, 75 species occurred in at least five studied fragments, highlighting *Cordiera sessilis*, *Apuleia leiocarpa*, *Casearia gossypiosperma*, *Cheiloclinium cognatum*, *Ixora brevifolia*, *Luehea grandiflora*, *Protium heptaphyllum, Sweetia fruticosa,* and *Terminalia glabrescens* which occurred in nine sites, and can be indicated as characteristic SSF species (Table 3). On the other hand, 31.8% (77) of species occurred at only one site.

The floristic similarity analysis between sites showed a similar pattern in seven of the ten sites examined (Figure 3). Accordingly, there was the formation of a floristically cohesive group (Group 1), where sites 3, 6, 7, 8, 9, and 10 were presented with values exceeding 0.5, indicating sites that were floristically similar. Also, a second group was formed with sites 1 and 4, whereas site 2 was floristically different from all the other sites (Figure 3).

Detrended correspondence analysis, DCA, presented eigenvalues of 0.61 and 0.25 in the two first ordination axes,

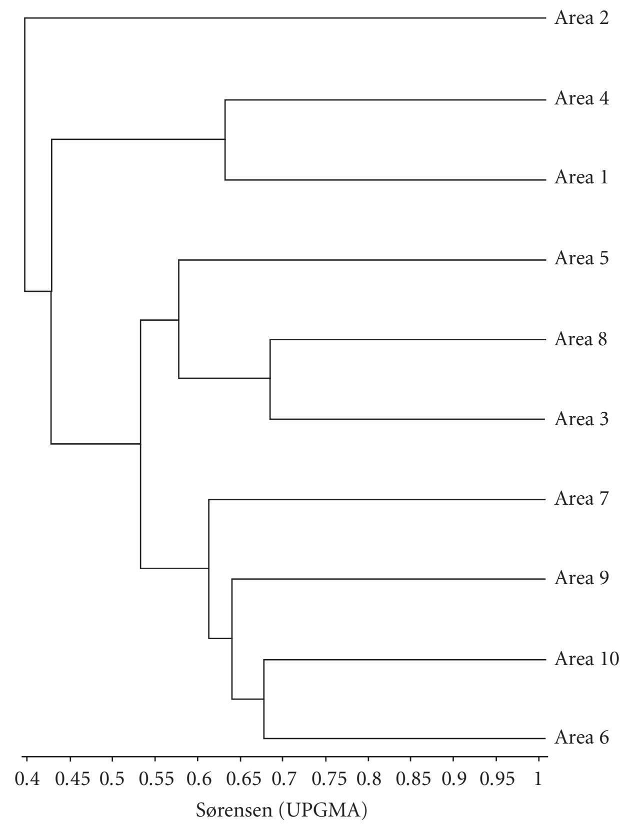

Figure 3: Dendrogram of similarity (Sørensen coefficient) produced by cluster analysis (UPGMA connection method) of tree species composition among the ten sites of seasonal semideciduous forest in southeastern Brazil.

explaining about 85% of the total data variation (Figure 4). The diagram demonstrated a large group formed from seven sites. Structural ordination, on the left, contemplates the same sites forming Group 1 by grouping analysis. These seven sites indicate the floristic pattern representative of the studied SSF. The second DCA axis was associated strongly with the sampled fragments' conservation degree. The group formed on the center left is characterized by intermediate conservation stages, while other sites on the top right are characterized by more advanced conservation stages (Group 2). On the lower right is the initial stage (site 2). Therefore, the three fragments on the right do not form a cohesive group. In addition, these three sites are those that are more distant from each other. Thus, the structural floristic similarity of the seven areas above may have been established on a geographical position basis. The division made by TWINSPAN corroborated the ordination results by DCA and the Sørensen coefficient (Figure 3).

The first division by TWINSPAN separated the seven SSF representative sites in this region from the three other fragments, owing to the absence of *Siparuna guianensis*, a species regarded as an indicator, which only occurs in the group formed on the other side of the dichotomy (Figure 5). In the second division, sites 3 and 8 were separated from the other fragments (Figure 5). The lower levels of division by TWINSPAN do not reveal new groups that make sense.

Table 3: Species list sampled in ten sites of seasonal semideciduous forest of southeastern Brazil. NI = number of individuals; RF = frequency in the ten studied fragments; *First record for the Triangulo Mineiro region, **First record for the Minas Gerais state in seasonal semideciduous forests, according [11].

Families/Species	NI	RF (%)
Anacardiaceae		
Astronium fraxinifolium Schott ex Spreng.	18	40
Astronium nelson-rosae Santin	257	60
Lithraea molleoides (Vell.) Engl.	9	20
Myracrodruon urundeuva Allemão	42	40
Tapirira guianensis Aubl.	37	20
Tapirira obtusa (Benth.) J.D.Mitch.	85	50
Annonaceae		
Annona cacans Warm.	29	50
Annona montana Macfad.*	1	10
Cardiopetalum calophyllum Schltdl.	6	40
Duguetia lanceolata A. St.-Hil.	222	60
Guatteria australis A. St.-Hil.*	28	10
Porcelia macrocarpa (Warm.) R. E. Fr.*	1	10
Rollinia sylvatica (A. St.-Hil.) Mart.	5	30
Unonopsis lindmanii R. E. Fr.	102	40
Xylopia aromatica (Lam.) Mart.	31	60
Xylopia brasiliensis Spreng.	37	40
Xylopia sericea A. St.-Hil.	1	10
Apocynaceae		
Aspidosperma cuspa (Kunth) S. F. Blake ex Pittier	10	10
Aspidosperma cylindrocarpon Müll. Arg.	25	40
Aspidosperma discolor A. DC.*	294	50
Aspidosperma olivaceum Müll. Arg.	8	10
Aspidosperma parvifolium A. DC.*	28	50
Aspidosperma polyneuron Müll. Arg.	8	30
Aspidosperma subincanum Mart. ex A. DC.	19	50
Aquifoliaceae		
Ilex cerasifolia Reissek	3	10
Araliaceae		
Aralia warmingiana (Marchal) J. Wen	12	30
Dendropanax cuneatus (DC.) Decne. & Planch.	14	20
Schefflera morototoni (Aubl.) Maguire et al.	29	80
Arecaceae		
Acrocomia aculeata (Jacq.) Lodd. ex Mart.	5	10
Asteraceae		
Piptocarpha macropoda Baker	6	30
Bignoniaceae		
Handroanthus serratifolia (Vahl) Nicholson	22	70
Jacaranda cuspidifolia Mart. ex A. DC.	2	20
Jacaranda macrantha Cham.*	4	20
Tabebuia impetiginosus (Mart. ex DC.) Mattus	2	20
Tabebuia roseoalba (Ridl.) Sandwith	13	20
Boraginaceae		
Cordia alliodora (Ruiz & Pav.) Oken**	1	10
Cordia sellowiana Cham.	52	50
Cordia superba Cham.	13	10
Cordia trichotoma (Vell.) Arrab. ex Steud.	5	20

Table 3: Continued.

Families/Species	NI	RF (%)
Burseraceae		
Protium heptaphyllum (Aubl.) Marchand	282	90
Cannabaceae		
Celtis iguanaea (Jacq.) Sarg.	30	60
Trema micrantha (L.) Blume	3	20
Cardiopteridaceae		
Citronella paniculata (Mart.) R.A.Howard	4	10
Caricaceae		
Jacaratia spinosa (Aubl.) A. DC.	4	20
Celastraceae		
Cheiloclinium cognatum (Miers.) A. C. Sm.	407	90
Maytenus floribunda Reissek*	71	60
Maytenus robusta Reissek	4	10
Maytenus sp.	5	10
Salacia elliptica (Mart. ex Schult.) G. Don	1	10
Chrysobalanaceae		
Hirtella glandulosa Spreng.	51	40
Hirtella gracilipes (Hook. f.) Prance	72	50
Hirtella racemosa Lam.	11	10
Clusiaceae		
Calophyllum brasiliense Cambess.	1	10
Garcinia brasiliensis Mart.	64	60
Combretaceae		
Terminalia argentea (Cambess.) Mart.	2	10
Terminalia glabrescens Mart.	202	90
Terminalia phaeocarpa Eichler	56	60
Cunoniaceae		
Lamanonia ternata Vell.	12	20
Ebenaceae		
Diospyros hispida A. DC.	108	50
Elaeocarpaceae		
Sloanea monosperma Vell.	19	40
Erythroxylaceae		
Erythroxylum daphnites Mart.	6	10
Erythroxylum deciduum A. St.-Hil.	3	10
Euphorbiaceae		
Acalypha gracilis (Spreng.) Müll. Arg.**	7	20
Alchornea glandulosa Poepp. & Endl.	20	30
Mabea fistulifera Mart.	25	10
Maprounea guianensis Aubl.	32	40
Micrandra elata Müll. Arg.	118	10
Pera glabrata (Schott) Poepp. ex Baill.	12	20
Sapium glandulosum (L.) Morong	5	30
Fabaceae caesalpinoideae		
Apuleia leiocarpa (Vogel) J. F. Macbr.	114	90
Cassia ferruginea (Schrad.) Schrad. ex DC.	9	30
Copaifera langsdorffii Desf.	155	100
Hymenaea courbaril L.	119	100
Peltophorum dubium (Spreng.) Taub.*	2	20
Sclerolobium paniculatum Benth.	3	10

Table 3: Continued.

Families/Species	NI	RF (%)
Fabaceae cercideae		
Bauhinia rufa (Bong.) Steud.	9	40
Bauhinia ungulata L.*	20	50
Fabaceae faboideae		
Andira fraxinifolia Benth.	7	20
Andira ormosioides Benth.*	1	10
Centrolobium tomentosum Guillem. ex Benth.	1	10
Dipteryx alata Vogel	5	20
Lonchocarpus cultratus (Vell.) Az.-Tozzi & H. C. Lima	11	30
Machaerium acutifolium Vogel	7	30
Machaerium brasiliense Vogel	69	70
Machaerium hirtum (Vell.) Stellfeld	25	30
Machaerium nyctitans (Vell.) Benth.	2	10
Machaerium opacum Vogel	1	10
Machaerium stipitatum (DC.) Vogel	20	60
Machaerium villosum Vogel	62	60
Myroxylon peruiferum L. f.	1	10
Ormosia arborea (Vell.) Harms	23	70
Platycyamus regnellii Benth.	50	30
Platypodium elegans Vogel	32	70
Pterodon emarginatus Vogel	2	10
Sweetia fruticosa Spreng.	69	90
Vatairea macrocarpa (Benth.) Ducke	1	10
Zollernia ilicifolia (Brongn.) Vogel	21	40
Fabaceae Mimosoideae		
Acacia polyphylla DC.	37	70
Albizia niopoides (Spruce ex Benth.) Burkart	23	30
Albizia polycephala (Benth.) Killip ex Record	5	10
Anadenanthera colubrina (Vell.) Brenan	67	20
Calliandra foliolosa Benth.	5	10
Enterolobium contortisiliquum (Vell.) Morong	9	40
Inga laurina (Sw.) Willd.	9	50
Inga marginata Willd.	10	10
Inga sessilis (Vell.) Mart.*	44	60
Inga vera Willd.	84	40
Piptadenia gonoacantha (Mart.) J. F. Macbr.	167	50
Lacistemataceae		
Lacistema aggregatum (P. J. Bergius) Rusby**	3	20
Lamiaceae		
Aegiphila sellowiana Cham.	11	50
Vitex polygama Cham.	6	20
Lauraceae		
Cryptocarya aschersoniana Mez	212	70
Endlicheria paniculata (Spreng.) J. F. Macbr.	3	10
Nectandra cissiflora Nees	44	30
Nectandra megapotamica (Spreng.) Mez	29	50
Nectandra membranacea (Sw.) Griseb.*	81	40
Ocotea corymbosa (Meisn.) Mez	136	70
Ocotea minarum (Nees) Mez	4	10
Ocotea pulchella Mart.	8	10
Ocotea spixiana (Nees) Mez	51	40

Table 3: Continued.

Families/Species	NI	RF (%)
Lecytidaceae		
Cariniana estrellensis (Raddi) Kuntze	51	70
Lythraceae		
Lafoensia densiflora Pohl	1	10
Malpiguiaceae		
Byrsonima laxiflora Griseb.	12	40
Malvaceae		
Apeiba tibourbou Aubl.	4	30
Ceiba speciosa (A. St.-Hil.) Ravenna	19	40
Eriotheca candolleana (K. Schum.) A. Robyns	28	50
Guazuma ulmifolia Lam.	49	50
Luehea divaricata Mart.	6	20
Luehea grandiflora Mart. & Zucc.	199	90
Pseudobombax tomentosum (Mart. & Zucc.) A. Robyns	3	20
Quararibea turbinata (Sw.) Poir.*	5	10
Melastomataceae		
Miconia cuspidata Mart. ex Naudin	1	10
Miconia latecrenata (DC.) Naudin	10	30
Miconia minutiflora (Bonpl.) DC.*	7	10
Meliaceae		
Cabralea canjerana (Vell.) Mart.	7	40
Cedrela fissilis Vell.	16	40
Guarea guidonia (L.) Sleumer	23	50
Guarea kunthiana A. Juss.	19	20
Trichilia catigua A. Juss.	165	80
Trichilia claussenii C. DC.	130	20
Trichilia elegans A. Juss.	55	70
Trichilia pallida Sw.	28	70
Monimiaceae		
Mollinedia widgrenii A. DC.	6	30
Moraceae		
Ficus clusiifolia Schott*	2	10
Ficus guaranitica Chodat	6	40
Ficus obtusiuscula (Miq.) Miq.	1	10
Ficus pertusa L. f.*	1	10
Ficus trigona L. f.	3	20
Ficus sp1	1	10
Ficus sp 2	1	10
Maclura tinctoria (L.) Steud.	4	30
Pseudolmedia laevigata Trécul	5	20
Sorocea bonplandii (Baill.) W. C. Burger et al.	9	40
Myristicaceae		
Virola sebifera Aubl.	127	80
Myrtaceae		
Calyptranthes clusiifolia O. Berg	5	30
Calyptranthes widgreniana O. Berg	7	20
Campomanesia guazumifolia (Cambess.) O. Berg	1	10
Campomanesia velutina (Cambess.) O. Berg	93	70
Eugenia florida DC.	190	50
Eugenia involucrata DC.	42	40

Table 3: Continued.

Families/Species	NI	RF (%)
Eugenia ligustrina (Sw.) Willd.	27	30
Eugenia subterminalis DC.*	20	20
Gomidesia lindeniana O. Berg	1	10
Myrcia splendens (Sw.) DC.	11	60
Myrcia tomentosa (Aubl.) DC.	9	40
Myrciaria glanduliflora (Kiaersk.) Mattos & D. Legrand**	106	40
Myrciaria tenella (DC.) O. Berg	2	10
Psidium longipetiolatum D. Legrand**	2	10
Psidium rufum DC.	12	40
Psidium sartorianum (O. Berg) Nied.	41	50
Siphoneugena densiflora O. Berg	133	60
Syzygium jambos (L.) Aston.*	1	10
Myrtaceae 1	1	10
Myrtaceae 2	1	10
Nyctaginaceae		
Guapira opposita (Vell.) Reitz	28	10
Guapira venosa (Choisy) Lundell	54	40
Neea hermaphrodita S. Moore**	12	10
Ochnaceae		
Ouratea castaneifolia (DC.) Engl.	12	50
Olacaceae		
Heisteria ovata Benth.	113	60
Oleaceae		
Chionanthus trichotomus (Vell.) P. S. Green	3	10
Opiliaceae		
Agonandra brasiliensis Miers ex Benth. & Hook.	24	50
Phyllanthaceae		
Margaritaria nobilis L. f.	27	70
Phyllanthus acuminatus Vahl	2	10
Piperaceae		
Piper amalago L.	4	10
Piper arboreum Aubl.	2	10
Polygonaceae		
Coccoloba mollis Casar.	9	40
Primulaceae		
Ardisia ambigua Mez	25	30
Myrsine coriacea (Sw.) Roem. & Schult.	2	10
Myrsine leuconeura Mart.	2	20
Myrsine umbellata Mart.	15	20
Proteaceae		
Roupala brasiliensis Klotzsch	31	80
Rhaminaceae		
Rhamnidium elaeocarpum Reissek	34	50
Rubiaceae		
Amaioua guianensis Aubl.	35	40
Chomelia pohliana Mull. Arg.	14	40
Cordiera sessilis (Vell.) Kuntze	404	90
Coussarea hydrangeifolia (Benth.) Müll. Arg.	32	60
Coutarea hexandra (Jacq.) K. Schum.	21	70
Faramea hyacinthina Mart.	43	50
Genipa americana L.	1	10

Table 3: Continued.

Families/Species	NI	RF (%)
Guettarda viburnoides Cham. & Schltdl.	29	50
Ixora brevifolia Benth.	131	90
Machaonia brasiliensis (Hoffmanss. ex Humb.) Cham. & Schltdl.*	2	10
Rudgea viburnoides (Cham.) Benth.	11	50
Simira sampaioana (Standl.) Steyerm.*	47	70
Tocoyena formosa (Cham. & Schltdl.) K.Schum.	1	10
Rutaceae		
Galipea jasminiflora (A. St.-Hil.) Engl.*	142	10
Metrodorea nigra A. St.-Hil.	10	20
Metrodorea stipularis Mart.	6	10
Pilocarpus spicatus A. St.-Hil.*	1	10
Zanthoxylum riedelianum Engl.	11	30
Salicaceae		
Casearia gossypiosperma Briq.	172	90
Casearia grandiflora Cambess.	218	40
Casearia rupestris Eichler	8	10
Casearia sylvestris Sw.	65	60
Prockia crucis P. Browne ex L.	5	20
Xylosma prockia (Turcz.) Turcz.*	1	10
Sapindaceae		
Allophylus edulis (A. St.-Hil., Cambess. & A.Juss.) Radlk.	1	10
Allophylus racemosus Sw.	8	30
Cupania vernalis Cambess.	78	80
Dilodendron bipinnatum Radlk.	10	20
Magonia pubescens A. St.-Hil.	2	10
Matayba elaeagnoides Radlk.**	39	40
Matayba guianensis Aubl.	105	70
Sapotaceae		
Chrysophyllum gonocarpum (Mart. & Eichler) Engl.	69	40
Chrysophyllum marginatum (Hook. & Arn.) Radlk.	161	20
Micropholis venulosa (Mart. & Eichler) Pierre	61	30
Pouteria gardneri (Mart. & Miq.) Baehni	42	70
Pouteria torta (Mart.) Radlk.	128	80
Siparunaceae		
Siparuna guianensis Aubl.	407	70
Styracaceae		
Styrax camporum Pohl	35	50
Symplocaceae		
Symplocos pubescens Klotzsch ex Benth.*	8	10
Urticaceae		
Cecropia pachystachya Trécul	11	30
Urera baccifera (L.) Gaudich. ex Wedd.	10	10
Verbenaceae		
Aloysia virgata (Ruiz & Pav.) A. Juss.	3	20
Vochysiacaeae		
Callisthene major Mart.	62	40
Qualea dichotoma (Mart.) Warm.	5	30
Qualea jundiahy Warm.*	39	60
Vochysia magnifica Warm.	114	30
Vochysia tucanorum Mart.	5	10

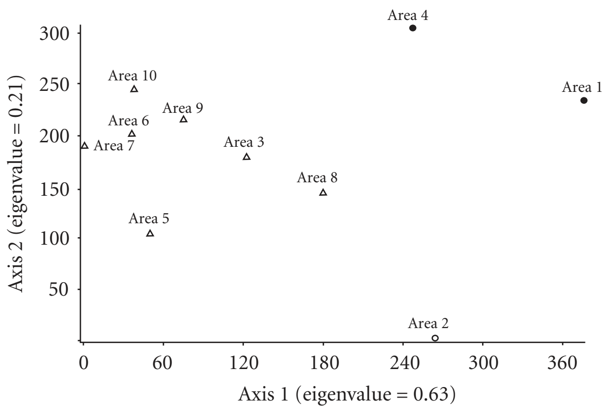

Figure 4: Ordination diagram in first two axes of detrended correspondence analysis (DCA) of ten sites of seasonal semideciduous forest in southeastern Brazil. Symbols correspond to floristic groups 1 (△), 2 (•), and 3 (o).

4. Discussion

Studies conducted in areas of SSF in Brazil presented Fabaceae, Myrtaceae, Rubiaceae, Annonaceae, Lauraceae, and Meliaceae as the families with greater species richness [33–36]. In São Paulo state SSF, as well as the greater richness of families found in this study, there is also an emphasis on Melastomataceae and Solanaceae [37, 38]. In northeastern Brazil, the most prominent families in terms of species number in SSF sites are Fabaceae Mimosoideae, Euphorbiaceae, Fabaceae Faboideae, Myrtaceae, and Rubiaceae [39]. The pattern in families and genera richness found here corroborates that described by Oliveira Filho and Fontes [40] for SSF domains in southeastern Brazil, with significant tree species richness in Fabaceae (all subfamilies), Lauraceae, Myrtaceae, Moraceae, and Rubiaceae and genres *Aspidosperma*, *Ficus*, *Machaerium,* and *Ocotea*.

Copaifera langsdorffii and *H. courbaril* are wide-ranging adaptive species, occurring in various forest formations of the Cerrado region, as well as in other geographical provinces in Brazil and are, therefore, considered to be habitat generalists [41]. *Apuleia leiocarpa* and *Luehea grandiflora* are also among the most frequent species of SSF, according to a study presented by Ferreira Júnior et al. [42], which brought together 15 studies in southeastern Brazil. The tree species composition studied in SSF showed a relationship with lowland seasonal forests of Brazil's eastern Minas Gerais state, based on the indicator species analysis made by Oliveira-Filho and Fontes [40]. Of the 57 species identified by these authors as eastern Minas Gerais region indicators, 36 (63.1%) were recorded in the sample sites presented here. This data corroborates the idea that interior SSF fragments may have a floristic connection with the Atlantic forest that is able to expand its distribution in sites with strong seasonality by means of gallery forests [43].

The presence of unique species to each location highlights the heterogeneity between samples (sites), reflected in increased beta diversity. We should point out that the limited number of individuals in some populations may impair the biological conservation of many species, causing serious difficulties for their preservation. However, some species, such as *Galipea jasminiflora* and *Micrandra elata,* occurred in only one fragment, but with a high density. This observation acquires relevance in terms of plant population conservation. The conservation of the remaining forest, with different structures and consequent higher beta diversity, can be a relevant parameter to the decision for choosing priority areas for conservation in SSF [44].

Diversity values are among those frequently found for SSF and Atlantic rainforest, which generally vary between 3.2 and 4.2 [45]. However, they are lower than those found in other tropical forests [46]. The lower values for evenness found in fragments indicate a relatively high concentration in density of a small number of species, which dominate the tree community. The predominance of a few species, in number or biomass in a community (also known as ecological dominance), is not uncommon in tropical forests [47].

A variation in similarity values occurs as a result of different conditions in the use and historic occupation of each fragment and acts as an important force capable of modifying plant communities through spatial and temporal heterogeneity, thus determining the community composition and structure [16, 48]. The separation of site 2 from other areas, along with Group 2, can be related to different stages of forest succession. Site 2 presents in an initial successional stage owing to an intense human processes. This fragment, although situated in the countryside, reveals recent historical disturbance as a result of selective logging and the presence of cattle, and the surrounding matrix is formed entirely by agricultural sites [49]. Selective logging enables the creation of gaps within the fragment and the establishment of pioneering species. As Whitmore states [47, 50], pioneer trees and shrubs need high light and temperature intensities for seed germination and seedling establishment and growth. Group 2 (sites 1 and 4) is formed by the more well-preserved fragments among those studied and is characterized by the presence and dominance of individuals with a large basal area. In fragment 4, for example, *Micrandra elata* was sampled with a density of 118 $\text{ind}\cdot\text{ha}^{-1}$ and a basal area of 24.51 $\text{m}^2\cdot\text{ha}^{-1}$ [51], whereas in fragment 1, *Psidium sartorianum* was the species with the highest dominance [52].

Although the floristic similarity between the fragments can be related to the geographical proximity, as already reported by MaCdonald et al. [53], we verified that similarity relations between studied sites are established mainly as a result of the community successional stage. This same pattern was also found by Durigan et al. [17]; that is, within the same vegetal formation, communities at similar stages of the successional process tend to have similar flora.

This analysis showed high beta diversity of the studied SSF arboreal flora, mainly as a result of the coverage of heterogeneous areas in relation to fragments at a successional stage. The largest SSF sampling in the Cerrado domain led to the registration and distribution of several plant populations, which had previously only been described for the Atlantic forests domain, demonstrating not only a lack of studies

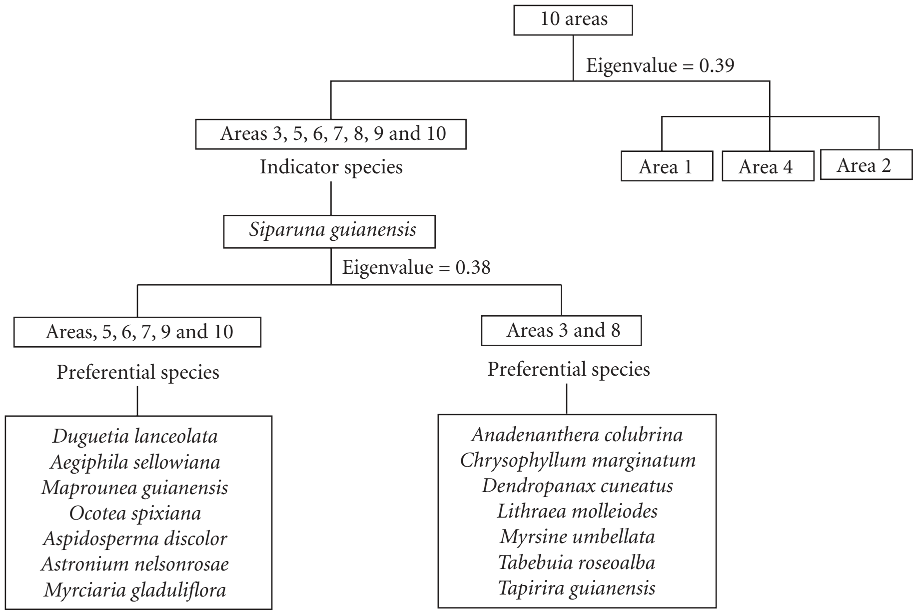

Figure 5: Classification by TWINSPAN of ten sites of seasonal semideciduous forest in southeastern Brazil.

like this, but also corroborating the idea of strong floristic connections with rainforests in the east of the country [40].

The fragmentation process started in the 1970s in the studied region of Brazil, especially as a result of the incentive given to landowners by the public authority for the advancement of occupied areas for agricultural and livestock activities, which had a direct consequence for the formation of many smaller forest fragments. Fragmentation possibly created similar processes in forests' successional development, which has conditioned a floristic pattern as found for seven of the ten sites surveyed.

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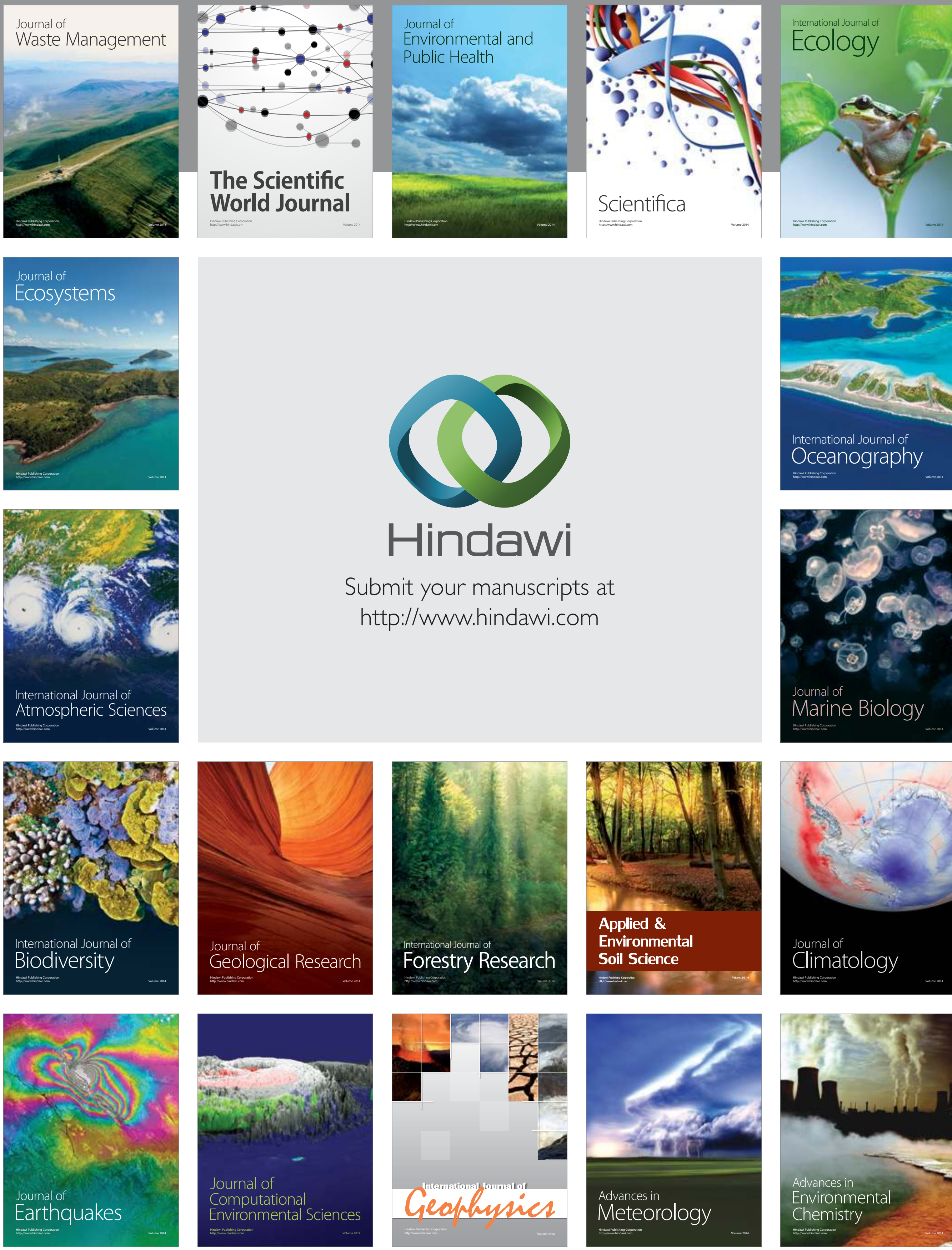

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