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Forms of rarity of tree species in the southern Brazilian Atlantic rainforest

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Abstract The assessment of species rarity considers local abundance (scarce or abundant population), habitat affinity (stenoecious or euryecious species), and geographic distribution (stenotopic or eurytopic species). When analyzed together these variables classify species into eight categories, from common species to those having small populations, unique habitats, and restricted geographic distribution (form 7), as proposed by Rabinowitz in 1981. Based on these categories, it is possible to calculate the frequency of the different forms of rarity of the species present in a given site. The Brazilian Atlantic rainforest is considered a hotspot of the world biodiversity harboring many endemic species, which have restricted geographic distribution. Our objective was to identify the forms of rarity of tree species and their proportions in the southern portion of the Brazilian Atlantic rainforest using Rabinowitz's forms of rarity. All the seven forms of rarity are present in the 846 tree species we analyzed: 46% eurytopic and 54% stenotopic, 73% euryecious and 27% stenoecious, 76% locally abundant and 24% locally scarce species. Eurytopic, euryecious locally abundant species accounted for 41.1%, whereas 58.9% were somehow rare: 4.5% eurytopic, euryecious locally scarce, 0.2% eurytopic, stenoecious locally abundant, 0.1% eurytopic, stenoecious locally scarce, 19.5% stenotopic, euryecious locally abundant, 8.0% stenotopic, euryecious locally scarce, 15.6% stenotopic, stenoecious locally abundant, and 11.0% stenotopic, stenoecious locally scarce. Considering that the most restrictive forms of rarity precedes extinction, the application of Rabinowitz's system

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demonstrated that most tree species of the southern Brazilian Atlantic rainforest are threatened due to their restricted geographic distribution, restriction to a single habitat, reduced local abundance, or even to a combination of these variables.

Keywords Rarity · Tree species · Dense Ombrophilous Atlantic Forest · Phytosociology · Databank

Introduction

Local abundance, habitat preference, and geographic range vary greatly among species, even among related species (Ricklefs 2002), being the main variables used in assessing rarity. Habitat type, taxonomic precision, and persistence over evolutive and ecological time can be considered additional variables in identifying rare species and the restrictions influencing them (Gaston 1994). In 1981, Deborah Rabinowitz suggested that rarity could take on different forms depending on a combination of three main variables (Ricklefs 2002). Considering local abundance, habitat affinity, and geographic range to be independent variables, Rabinowitz et al. (1986) established rarity categories based on their different combinations. When analyzed together, these three variables allow species to be classified into eight categories, in which the first category comprises common species and the eighth category encompasses the most restrictive form of rarity, namely the local endemics. It is possible therefore to calculate the frequency of the different forms of rarity among the species present in a given study area. In order to perform this type of analysis a databank containing sufficient information about the three independent variables is necessary (Rabinowitz et al. 1986). This way of assessing rarity was originally applied to the plant species-poor system of the British Islands (Rabinowitz et al. 1986), but it has also been used in rich systems both for plants in the Amazon forest (Pitman et al. 1999) and for animals all over the world (Yu and Dobson 2000).

A report published by the "Conservation International" indicated that Brazil has the greatest biodiversity among the 17 nations that detain 70% of the plant and animal species on the planet (Mittermeier et al. 1997). Additionally, not only is the absolute number of species high in Brazil, but also the number of endemic plants, which puts this country in first place in terms of global diversity (Dias 1998). Myers (1990) indicated 18 global "hotspots", and the Brazilian Atlantic rainforest stands out among them. Myers et al. (2000) expanded the criteria for selecting "hotspots", but the Brazilian Atlantic rainforest continued deserving a high ranking, in the fourth place.

The Brazilian Atlantic rainforest is also known by other names, e.g. Atlantic Forest *sensu stricto* (s.s.) and Dense Ombrophilous Atlantic Forest Phyto-Ecological Region (Veloso 1992). It originally extended along the Atlantic Coast of Brazil from near the Cape of São Roque in Rio Grande do Norte State until the municipality of Osório in Rio Grande do Sul State (Andrade-Lima 1966). Presently the forest is devastated over most of its range (Silva and Leitão-Filho 1982; Leitão-Filho 1994). The Dense Ombrophilous Atlantic Forest Phyto-Ecological Region is heterogeneous and composed of many different forest formations (Leitão-Filho 1994) and various associated ecosystems (Scarano 2002) whose species diversity can often be greater than that observed in the Amazon Forest (Silva and Leitão-Filho 1982; Martins 1989; Leitão-Filho 1994).

Martins (1991) observed that 9–39% of the species in any survey in the Atlantic rainforest were represented by just a single individual. Scudeller et al. (2001) reported that the Atlantic rainforest in São Paulo State is characterized by a predominance of species with low constancy and restricted distribution. Endemism is very high in the Atlantic rainforest (Gentry 1992; Thomas et al. 1998). In Rabinowitz's rarity system, these endemisms are included under forms 6 and 7, in which species have restricted geographic distributions and occur in scarse populations confined to unique habitats (Kruckeberg and Rabinowitz 1985).

When environments are disturbed by human activities the populations of many species are reduced or become extinct. Therefore certain categories of species must be closely monitored and conservation efforts focused on them. These species are especially vulnerable if their area of occurrence is limited, with one or just a few small populations, or if they have special habitat requirements (Primack and Rodrigues 2001)—that is, if the species are rare according to the classification of Rabinowitz et al. (1986). The most restrictive forms of rarity can be seen as precursors to extinction. It is important to determine which forms of rarity are present in a given phyto-ecological region in order to be able to intensify conservation measures and reserve planning (that can help preserve a group of species), as well as to plan actions that will help conserve individual species—mainly those having known economic value (landscaping, chemical, forestry, food source, etc.), or representing key-species in the ecological community.

Our general objective was to identify the forms of rarity and their proportions among arboreal species in the southern portion of the Brazilian Atlantic rainforest using the rarity classification system developed by Rabinowitz. Considering the high indices of regional endemism already noted for this rainforest (Gentry 1992; Thomas et al. 1998) and the known patterns of species with low constancy and restricted distribution (Scudeller et al. 2001), we expected to find most species with forms of rarity related to restricted geographic range (stenotopy). Given the large proportion of species represented by single individuals (Martins 1991), we also expected that most stenotopic species also presented small population wherever they occurred.

Materials and methods

Databank of the tree taxa of the Atlantic rainforest

We used the FITOGEO databank system (in a Microsoft Access 97 format) that was compiled to manage floristic and phytosociological information (Scudeller and Martins 2003). In order to delimit the Dense Ombrophilous Atlantic Forest Phyto-Ecological Region, we used the area defined by the Brazilian Institute of Geography and Statistics (Veloso 1992).

The creation of a databank to analyze the abundance categories of Atlantic rainforest species involved three steps. The first step was to filter and copy all of the phytosociological tables referring to tree communities in the Atlantic rainforest from the databank used by Scudeller et al. (2001). We defined a phytosociological table as a list of species with their respective phytosociological descriptors presented in any publication found during our bibliographic search (Caiafa and Martins 2007). A bibliographic reference could have more than one phytosociological table, as these could refer to different localities, altitudes, or soil types.

The second step of establishing the databank consisted of adding new phytosociological tables concerning the Atlantic rainforest derived from dissertations, thesis, books, and publications in specialized periodicals. We considered only periodicals with an editorial board and ISSN. Only references published until the beginning of 2005 that indicated the numbers of individuals of each species sampled, the total size of the sample, and the size of the smallest individual sampled were included. We eliminated references that dealt with the initial stages of forest regeneration, as well as those that only furnished information about the most abundant species, or did not include trees, or that stipulated a maximum height for inclusion in the sample. Applying these criteria, we compiled an up-to-date databank with a total of 225 phytosociological tables from 113 bibliographic references.

The third step consisted of verifying valid binomials to assure uniform taxonomic identities. This was done by using specialized literature (such as theses, monographs, and revisions) as well as consulting sites such as W3TROPICOS www.mobot.mobot.org/w3t/search and The International Plant Names Index www.ipni.org/index.html.

Criteria used for including a phytosociological table into the refined databank

Phytosociological surveys have been performed using many different designs and methods (plots or point-quarters, different sizes of the smallest individual sampled, and different sample sizes, plot sizes and sampling techniques). Also, the taxonomic treatments may have been performed with differing degrees of rigor. These differences can influence the results of the metanalysis, as shown by Caiafa and Martins (2007). As such, we adopted certain selection criteria to attain a minimum of homogeneity among the surveys: (1) the survey site had to be located within the Dense Ombrophilous Atlantic Forest Phyto-Ecological Region as delimited by Veloso (1992), independently of the phytogeographic classification adopted by the author of the publication; (2) the publication had to specify the growth habit of the sampled plants (in order to allow us to pick up the tree species from the phytosociological table); (3) the publication had to specify the abundance of each species and the total size of the sample; (4) more than 80% of the taxa sampled had to be identified to the species level; (5) the smallest individual sampled had to have a trunk diameter at breast height (DBH) $\geq$ 4.8 or 5 cm; and (6) the minimum sample size had to be 300 individuals. These criteria are similar to those that have been used by other authors working with metadata in Brazilian phyto-ecological regions (Castro et al. 1999, Scudeller et al. 2001).

After applying these criteria, we were left with only 41 of the 225 surveys available. The criterion that most contributed to the reduction in the number of acceptable surveys was the size of the smallest individual included in the sample (DBH $\geq$ 4.8 or 5 cm). This criterion is very important and must not be ignored, as was demonstrated by Caiafa and Martins (2007). Of these 41 surveys, two were from Bahia State and five from Pernambuco, and hence we decided to analyze only the southern region of the Dense Ombrophilous Atlantic Forest—represented by a total of 34 surveys (Fig. 1, Table 1). The southern portion of the Atlantic rainforest includes the states of the Southern Region (Rio Grande do Sul, Santa Catarina, and Paraná) and those of the Southeastern Region (São Paulo, Rio de Janeiro, Minas Gerais, and Espírito Santo).

Classification of the species into forms of rarity

We used the following criteria to classify the species considering the three variables that define the forms of rarity proposed by Rabinowitz et al. (1986):

Geographic distribution

In order to evaluate whether a given species has a wide (eurytopic) or restricted (stenotopic) geographic distribution, the samples were grouped into 2° latitudinal strips

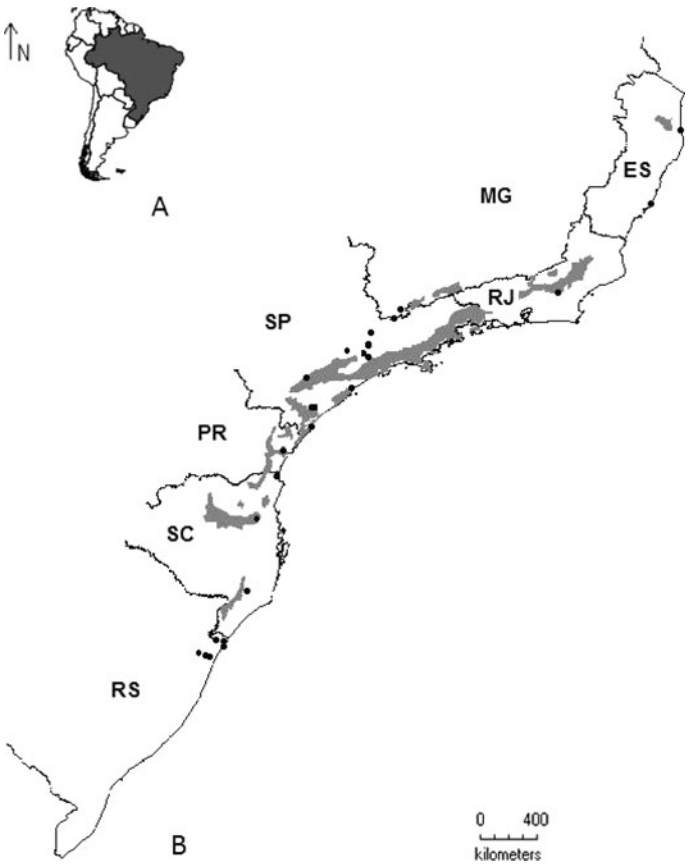

Fig. 1 Position of Brazil in South America (A) and southern Brazil (B).The gray area represents the largest remnants of the Atlantic rainforest.The dots indicate the surveys used in the analysis, and when they are out of the gray area they represent areas bellow the resolution of the map scale. States: *MG* Minas Gerais, *ES* Espírito Santo, *RJ* Rio de Janeiro, *SP* São Paulo, *PR* Paraná, *SC* Santa Catarina e *RS* Rio Grande do Sul

(approximately 220 km N–S) starting from the most northern survey (4° S) until the most southern (30° S), for a total of 13 latitudinal belts defining an extension of approximately 2.860 km. We considered species as eurytopic if they were distributed on three or more latitudinal belts (occurring on an extension greater than 660 km). We considered a species as stenotopic if it was found on at most two latitudinal belts (occurring on an extension of at most 440 km). For this classification of geographic ranges we used the entire dataset for the full extension of the Atlantic rainforest (i.e. all 225 phytosociological tables).

Habitat preference

In order to evaluate the habitat preference of the species we considered as distinct habitats the different forest formations that occur in the Dense Ombrophilous Atlantic Forest Phyto-Ecological Region. Veloso (1992) distinguished the vegetation formations in terms of altitudinal belts: (1) Lowlands (LL), with altitudes up to 100 m a.s.l. between 4° N and 16° S, up to 50 m between 16° S and 24° S, and up to 30 m between 24° S and 32° S;

Table 1 Surveys of the Brazilian Atlantic Rainforest used to assess forms of tree species rarity

PubCod	References	Year	ES	Municipality
20	Florística e fitossociologia de uma Floresta de restinga em Picinguaba (Parque Estadual da Serra do Mar), Município de Utabuta, SP. Naturalia 20:89–105.	1995	SP	Ubatuba
61	Fitossociologia do estrato arbóreo da floresta da reserva biológica do instituto de botanica (São Paulo, SP), Tese de Doutorado em Botânica, USP, São Paulo, SP.	1985	SP	São Paulo
86	Fitossociologia e dinâmica do banco de sementes de populações arbóreas de floresta secundária em São Paulo, SP. Dissertação de Mestrado em Ecologia, USP, São Paulo, SP.	1993	SP	São Paulo
144	Estudo Fitossociológico da Mata de Restinga, no Balneário Rondinha Velha, Arroio do Sal, RS. Dissertação de Mestrado em Botânica, UFRGS, Porto Alegre, RS.	1993	RS	Arroio do Sal
146	Estudo Fitossociológico Comparativo entre duas Áreas com Mata de Encosta no Rio Grande do Sul. Tese de Doutorado em Ecologia e Recursos Naturais, UFSCAR, São Carlos, SP.	1994	RS	Morrinhos do Sul
235	Caracterização florística e fisionômica da floresta atlântica sobre a formação Pariquera-Açu, na Zona da Morraria Costeira do estado de São Paulo. DisseratçÃo de Mestrado em Biologia Vegetal, UNUCAMP, Campinas, SP.	1997	SP	Pariquera-Açu
248	Fitossociologia do componente arbóreo da floresta da restinga da Ilha do Mel, Paranaguá, PR. Publicação ACIESP, 87(3):33–48.	1994	PR	Paranagua
452	Ecologia de um fragmento florestal em São Roque, SP: florística, fitossociologia e silvigênese. Tese de Doutorado em Biologia Vegetal, UNICAMP, Campinas, SP. 234p.	1995	SP	São Roque
453	Ecologia de um fragmento florestal em São Roque, SP: florística, fitossociologia e silvigênese. Tese de Doutorado em Biologia Vegetal, UNICAMP, Campinas, SP. 234p.	1995	SP	São Roque
454	Ecologia de um fragmento florestal em São Roque, SP: florística, fitossociologia e silvigênese. Tese de Doutorado em Biologia Vegetal, UNICAMP, Campinas, SP. 234p.	1995	SP	São Roque
467	Estrutura fitossociológica da floresta semidecídua de altitude do Parque Municipal da Grota Funda (Atibaia, Estado de São Paulo). Acta Botanica Brasilica. 4(2):47–64.1990	1990	SP	Atibaia
477	Dinâmica de população de Virola bicuhyba (SCHOTT) WARB. (Myristicaceae) efitossociologia de floresta pluvial atlântica, sob clima temperado, Blumenau, SC. Tese de Doutorado em Ecologia, USP, São Paulo, SP.	2003	SC	Blumenau
488	Florística e fitossociologia de trecho da Serra da Cantareira, Núcleo Águas Claras, Parque Estadual da Cantareira, Mairiporã, SP. Dissertação de Mestrado em Biologia Vegetal, UNICAMP, Campinas, SP.	2002	SP	Mairiporã
496	Estudo fitossociológico e aspectos fitogeográficos em duas áreas de floresta atlântica de encosta no Rio Grande do Sul. Tese de Doutorado em Ecologia, UFSCAR, São Carlos, SP.	2002	RS	Maquiné
497	Estudo fitossociológico e aspectos fitogeográficos em duas áreas de floresta atlântica de encosta no Rio Grande do Sul. Tese de Doutorado em Ecologia, UFSCAR, São Carlos, SP.	2002	RS	Riozinho
499	Florísitca, fitossociologia e aspectos da dinâmica de um remanescente de mata atlântica na microbacia do rio Novo, Orleans, SC. Tese de Doutorado em Ecologia, UFSCAR, SÃo Carlos, SP.	1995	SC	Orleans

Table 1 continued

PubCod	References	Year	ES	Municipality
500	Composição florística, estrutura fitossociológica e dinâmica da regeneração da floresta atlântica na reserva Volta Velha, Mun. Itapoá, SC. Tese de Doutorado em Ecologia, UFSCAR, São Carlos, SP.	1995	SC	Itapoá
504	Estudo fitossociológicoe análise foliar de um remanescente de mata atlântica em Dom Pedro de Alcântara, RS. Dissertação de Mestrado em Botânica, UFRGS, Porto Alegre, RS.	2001	RS	Dom Pedro de Alcântara
505	Fitossociologia de uma floresta secundária, Maquiné, RS. Dissertação de Mestrado em Botânica, UFRGS, Porto Alegre, RS.	1995	RS	Maquiné
506	Análise fitossociológica de uma comunidade arbórea na floresta ombráfila densa, no Parque Botânico Morro Baú, Ilhota, SC. Dissertação de Mestrado em Biologia Vegetal, UFSC, Florianópolis, SC.	2001	SC	Ilhota
507	Florística das fisionomias vegetacionais e estrutura da floresta alto-montana de Monte Verde, Serra da Mantiqueira, MG. Dissertação de Mestrado em Biologia Vegetal, UNICAMP, Campinas, SP.	2003	MG	Monte Verde
510	Composição florística e estrutura da comunidade arbórea num gradiente altitudinal da mata atlântica. Tese de Doutorado em Biologia Vegetal, UNICAMP, SP.	2001	SP	Ubatuba
512	Composição florística e estrutura do estrato arbóreo de uma Muçununga na Reserva Florestal de Linhares, Espírito Santo. Dissertação de Mestrado em Botânica, UFV, Viçosa, MG.	1998	ES	Linhares
517	Estudo comparativo de dois métodos de amostragem fitossociológica em Caxeitais (floresta ombrófila densa permanentemente alagada). Dissertação de Mestardo em Ciências Florestais, ESALQ, Piracicaba, SP.	1999	SP	Iguape
518	O mosaico vegetacional numa área de floresta contínua da planície litorânea, Parque Estadual da Campina do Encantado, Pariquera-Açu, SP. Revista Brasileira de Botânica, 25(2):161–176.	2002	SP	Pariquera-Açu
519	O mosaico vegetacional numa área de floresta contínua da planície litorânea, Parque Estadual da Campina do Encantado, Pariquera-Açu, SP. Revista Brasileira de Botânica, 25(2):161–176.	2002	SP	Pariquera-Açu
520	O mosaico vegetacional numa área de floresta contínua da planície litorânea, Parque Estadual da Campina do Encantado, Pariquera-Açu, SP. Revista Brasileira de Botânica, 25(2):161–176.	2002	SP	Pariquera-Açu
521	Comparação entre os métodos de quadrantes e parcelas na caracterização da composiçÃo florística e fitossociológica de um trecho de floresta ombrófila densa no Parque Estadual Carlos Botelho, São Miguel Arcanjo, SP. Mestrado Recursos Florestais, ESALQ.	2003	SP	São Miguel Arcanjo
530	Composição, estrutura e similaridade florística de dossel em seis unidades fisionômicas de Mata Atlântica no Rio de Janeiro. Tese de Doutorado em Ecologia, USP, São Paulo, SP.	1998	RJ	Nova Friburgo
539	Composição florística e estrutura do componente arbóreo de um trecho de floresta ombrófila densa de terras baixas, periodicamente alagada, na reserva Volta Velha, Itapoá, SC. Dissertação de Mestrado em Botânica, UFPR, Curitiba, Paraná.	2000	SC	Itapoá
578	Estudos de florestas da restinga da Ilha do Cardoso, Cananéia, São Paulo, Brasil. Boletim do Instituto de Botânica, 11:119–159.	1998	SP	Cananéia
580	Composição florística e estrutura fitossociológica da floresta tropical ombrófila da encosta atlântica no município de Morretes (Paraná). Boletim de Pesquisas Florestais. 18/19:23–30.	1989	PR	Morretes

Table 1 continued

PubCod	References	Year	ES	Municipality
594	ComposiçÃo florísitica e estrutura do componente arbóreo de uma floresta altimontana no município de Camanducaia, Minas Gerais, Brasil. Revista Brasileira de Botânica, 27(1):19–30.	2004	MG	Camaducaia
595	Fitossociologia de uma floresta de restinga no Parque Estadual Paulo César Vinha, Setiba, município de Guarapari (ES). Revista Brasileira de Botânica, 27(2):349–361.	2004	ES	Guarapari

PubCod. code of the publication, *ES* Federation State

(2) Submontane (SB), situated on slopes at altitudes of 100–600 m a.s.l. between 4° N and 16° S, of 50–500 m between 16° S and 24° S, and of 30–400 m between 24° S and 32° S; (3) Montane (M), situated on the top of high plateaus or mountains from 600 to 2000 m a.s.l. between 4° N and 16° S, from 500 to 1500 m between 16° S and 24° S, and from 400 to 1000 m between 24° S and 32° S; and (4) High-montane (HM), situated above the limits established for the Montane formations. The division of the tree flora into altitudinal belts was confirmed by other authors such as Oliveira-Filho and Fontes (2000) and Scudeller et al. (2001). We considered that species would have only a single habitat (stenoecious species) when they occurred in only one of the four forest formations cited above; and we considered species as having various habitats (euryecious species) when they were found to occur in more than one forest formation of the Dense Ombrophilous Atlantic Forest Phyto-Ecological Region. To determine each species habitat preferences we used the complete set of 225 surveys.

Population size

In order to classify the species into abundance categories, we followed Pitman et al. (1999) with modifications according to Martins (1991), who encountered large numbers of species sampled as single individuals in surveys in the Brazilian Atlantic rainforest, and embraced the theory of "singletons" (species represented by just a single individual) and "doubletons" (species represented by only two individuals) proposed by Preston (1962) and developed by Gaston (1994) and other authors. We considered as scarce those species with up to two individuals in any survey analyzed; and as abundant those species sampled with three or more individuals in at least one survey. In this analysis we only considered the refined 34 surveys from the southern portion of the Brazilian Atlantic rainforest that fitted the criteria we established.

After classifying each species according to these three variables, we proceeded to classify the species into the forms of rarity proposed by Rabinowitz et al. (1986). This way we could calculate the proportion of each rarity form in the southern portion of the Dense Ombrophilous Atlantic Forest.

Results

We found all the seven forms of rarity proposed by Rabinowitz et al. (1986) in the southern portion of the Brazilian Atlantic rainforest (Table 2). Of the 846 arboreal species analyzed 46% had wide geographic distribution (eurytopic species) and 54% showed restricted

Table 2 Percentage of Rabinowitz's rarity forms of tree species in the southern sector of the Brazilian Atlantic Rainforest

Geographic distribution	Wide		Restricted	
Habitat preference	Various	Single	Various	Single
Abundant population	41.1 Common	0.2 Form 2	19.5 Form 4	15.5 Form 6
Scarce population	4.5 Form 1	0.1 Form 3	8 Form 5	11 Form 7

geographic distribution (stenotopic species); 73% occurred in various types of habitats (euryoecious species) and 27% occurred only in unique habitats (stenoecious species); 76% were found in locally abundant populations and 24% were locally scarce. Of the total number of species, 380 (45%) were present only in a single sample.

Of the total 846 species found in the 34 surveys we analyzed, 41.1% were common species (Table 3). These can be considered eurytopic, euryoecious locally abundant species. The other 58.9% species were distributed among rarity forms in the following way. A proportion of 4.5% was rare (form 1) because of their overall small population sizes (Table 4). These species are classified as locally scarce, eurytopic euryoecious species. When a species has a wide geographic distribution with abundant populations, but only occurs in a single habitat, it is rare (form 2) due to its unique habitat, that is, it represents a locally abundant, eurytopic stenoecious species. Only two species (0.2%) had this form of rarity: *Andira nitida* Mart. ex Benth. and *Miconia pusilliflora* (DC.) Naud. Species with wide geographic distributions in a single habitat and having scarse populations are rare (form 3) because of the last two characteristics—being locally scarse, eurytopic stenoecious species. Only one species (0.1%) had this form of rarity: *Guettarda viburnoides* Cham. & Schltdl. A proportion of 19.5% was represented by form 4, that is, locally abundant, stenotopic euryoecious species (Table 5). Locally scarse stenotopic, euryecious species (form 5) represented 8% of the rare species (Table 6). Locally abundant stenotopic, stenoecious species (form 6) accounted for 15.6% of the total (Table 7), whereas 11% were represented by the most restrictive form of rarity (form 7): stenotopic, stenoecious species with locally scarse populations (Table 8).

Discussion

Variables of rarity

Species with restricted geographic distributions and occurring in only a single or at most a few surveys (low constancy) predominate in the Atlantic rainforest of São Paulo State (Scudeller et al. 2001). Accordingly, our results showed that stenotopic species predominate in the southern portion of the Atlantic rainforest. As such, estenotopy is the most important variable in determining the rarity of most of the tree species in the southern region of the Atlantic rainforest. The rarity of tree species due to stenotopy may be the principal variable related to the observed decay in floristic similarity with increasing geographic distance that was reported by Scudeller et al. (2001) in the Atlantic rainforest in São Paulo State. We believe that distribution at distances not greater than 440 km would be a conservative belt width to use even in an extensive phyto-ecological region such as the Dense Ombrophilous Atlantic Forest, especially considering the low latitudinal range found by Scudeller et al. (2001) for tree species in São Paulo State.

Table 3 Tree species of the southern sector of the Brazilian Atlantic Rainforest classified as common according to Rabinowitz

Abarema langsdorfii (Benth.) Barneby & Grimes	*Manilkara subsericea* (Mart.) Dubard
Actinostemon concolor (Spreng.) Müll.Arg.	*Maprounea guianensis* Aubl.
Aegiphila sellowiana Cham.	*Margaritaria nobilis* L.f.
Aiouea saligna Meisn.	*Marlierea eugeniopsoides* (D.Legrand & Kausel) D.Legrand
Alchornea glandulosa Poepp.	*Marlierea obscura* O.Berg
Alchornea sidifolia Müll.Arg.	*Marlierea parviflora* O.Berg
Alchornea triplinervia (Spreng.) Müll.Arg.	*Marlierea racemosa* (Vell.) Kiaersk.
Alibertia concolor (Cham.) K.Schum.	*Marlierea silvatica* (Gardner) Kiaersk.
Allophylus edulis A.St.-Hil., Cambess & A.Juss.) Radlk.	*Marlierea tomentosa* Cambess.
Alseis floribunda Schott	*Matayba elaeagnoides* Radlk.
Amaioua guianensis Aubl.	*Matayba guianensis* Aubl.
Amaioua intermedia Mart.	*Maytenus robusta* Reissek
Anadenanthera colubrina (Vell.) Brenan	*Meliosma sellowii* Urb.
Andira anthelmia (Vell.) J.F.Macbr.	*Meliosma sinuata* Urb.
Andira fraxinifolia Benth.	*Miconia budlejoides* Triana
Aniba firmula (Nees & Mart.) Mez	*Miconia cabussu* Hoehne
Annona cacans Warm.	*Miconia cinerascens* Miq.
Aparisthmium cordatum (Juss.) Baill.	*Miconia cinnamomifolia* (DC.) Naud.
Aspidosperma parvifolium A.DC.	*Miconia cubatanensis* Hoehne
Aspidosperma pyricollum Müll.Arg.	*Miconia cubatanensis* Hoehne
Attalea dubia (Mart.) Burret	*Miconia dodecandra* Cogn.
Bathysa meridionalis L.B.Sm. & Downs	*Miconia eichlerii* Cogn.
Blepharocalyx salicifolius (HBK) O.Berg	*Miconia prasina* (Sw.) DC.
Brosimum glazioui Taub.	*Miconia pyrifolia* Naud.
Brosimum guianense (Aubl.) Huber	*Miconia rigidiuscula* Cogn.
Brosimum lactescens (Sp. Moore) C.C.Berg	*Miconia sellowiana* Naud.
Buchenavia kleinii Exell	*Micropholis crassipedicellata* (Mart. & Eichl.) Pierre
Byrsonima ligustrifolia A.St.-Hil.	*Mollinedia schottiana* (Spreng.) Perkins
Bathysa meridionalis L.B.Sm. & Downs	*Mollinedia triflora* (Spreng.) Tul.
Blepharocalyx salicifolius (HBK) O.Berg	*Mollinedia uleana* Perkins
Brosimum glazioui Taub.	*Mouriri chamissoana* Cogn.
Brosimum guianense (Aubl.) Huber	*Myrceugenia campestris* (A.P.DC.) D.Legrand & Kausel
Brosimum lactescens (Sp. Moore) C.C.Berg	*Myrceugenia miersiana* (Gardner) D.Legrand & Kausel
Buchenavia kleinii Exell	*Myrceugenia myrcioides* (Cambess)O.Berg
Byrsonima ligustrifolia A.St.-Hil.	*Myrceugenia pilotantha* (Kiaers.) Landrum
Cabralea canjerana (Vell.) Mart.	*Myrcia acuminatissima* O.Berg
Calophyllum brasiliensis Cambess.	*Myrcia fallax* (Rich.) DC.
Calycorectes australis D.Legrand	*Myrcia glabra* (O.Berg) D.Legrand
Calycorectes psidiiflorus (O.Berg) Sobral	*Myrcia guajavifolia* O.Berg
Calyptranthes concinna DC.	*Myrcia multiflora* (Lam.) DC.

Table 3 continued

Calyptranthes eugeniopsoides D. Legrand & Kausel	*Myrcia pubipetala* Miq.
Calyptranthes grandifolia O.Berg	*Myrcia racemosa* (O.Berg) Kiaersk.
Calyptranthes lucida Mart. ex DC.	*Myrcia richardiana* (O.Berg) Kiaersk.
Calyptranthes strigipes O.Berg	*Myrcia rostrata* DC.
Campomanesia guaviroba (A.P.DC.) Kiaers.	*Myrcia tenuivenosa* Kiaersk.
Campomanesia guazumifolia (Cambess.) O.Berg	*Myrciaria floribunda* (West ex Willd.) O.Berg
Campomanesia xanthocarpa Berg	*Myrciaria tenella* (DC.) O.Berg
Capparis flexuosa (L.) L.	*Myrocarpus frondosus* Allemao
Cariniana estrellensis (Raddi) Kuntze	*Nectandra grandiflora* Nees
Casearia decandra Jacq.	*Nectandra lanceolata* Nees
Casearia obliqua Spreng.	*Nectandra megapotamica* (Spreng.) Mez
Casearia sylvestris Sw.	*Nectandra membranacea* (Sw.) Griseb.
Cecropia glazioui Snethlage	*Nectandra nitidula* Nees
Cecropia pachystachya Trécul	*Nectandra oppositifolia* Nees
Cedrela fissilis Vell.	*Nectandra rigida* (HBK.) Nees
Chrysophyllum gonocarpum (Mart. & Eichl.) Engl.	*Neomitranthes glomerata* (D.Legrand) D.Legrand
Chrysophyllum inornatum Mart.	*Nephelea setosa* (Kaulf.) R.M.Tryon
Chrysophyllum lucentifolium Cronquist	*Ocotea aciphylla* (Nees) Mez
Chrysophyllum marginatum (Hook. & Arn.) Radlk.	*Ocotea brachybotra* (Meisn.) Mez
Chrysophyllum viride Mart. & Eichl.	*Ocotea catharinensis* Mez
Cinnamomum glaziovii (Mez) Kosterm.	*Ocotea daphnifolia* (Meisn.) Mez
Citharexylum myrianthum Cham.	*Ocotea dispersa* (Nees) Mez
Citronella paniculata (Mart.) R.A.Howard	*Ocotea divaricata* (Nees) Mez
Clethra scabra Pers.	*Ocotea elegans* Mez
Clusia criuva Cambess.	*Ocotea glaziovii* Mez
Coccoloba alnifolia Casar.	*Ocotea indecora* (Schott) Mez
Coccoloba warmingii Meisn.	*Ocotea lancifolia* (Schott) Mez
Copaifera langsdorffii Desf.	*Ocotea laxa* (Nees) Mez
Copaifera trapezifolia Hayne	*Ocotea nectandrifolia* Mez
Copaifera trapezifolia Hayne	*Ocotea pulchella* (Nees) Mez
Cordia ecalyculata Vell.	*Ocotea pulchra* Vattimo-Gil
Cordia selllowiana Cham.	*Ocotea silvestris* Vattimo-Gil
Cordia trichotoma (Vell.) Arrab. ex Steud.	*Ocotea teleiandra* (Meisn.) Mez
Couepia venosa Prance	*Ocotea urbaniana* Mez
Coussapoa microcarpa (Schott) Rizzini	*Ormosia arborea* (Vell.) Harms
Coutarea hexandra (Jacq.) K.Schum.	*Ouratea parviflora* Engl.
Croton floribundus Spreng.	*Pachystroma longifolium* (Nees) I.M.Johnst.
Cryptocarya aschersoniana Mez	*Parinari excelsa* Sabine
Cryptocarya moschata Nees	*Pausandra morisiana* (Casar.) Radlk.
Cupania emarginata Cambess.	*Pera glabrata* (Schott) Poepp. ex Baill.
Cupania oblongifolia Mart.	*Persea venosa* Nees
Cupania vernalis Cambess.	*Phytolacca dioica* L.

Table 3 continued

Cyathea delgadii Sternb.	*Pimenta pseudocaryophyllus* (Gomes) Landrum
Cyathea schanschin Mart.	*Piper cernuum* Vell.
Cyathea setosa (Kaulf.) Domin	*Piper gaudichaudianum* Kunth
Cybianthus peruvianus (A.DC.) Miq.	*Piptocarpha angustifolia* Dusen ex Malme
Dalbergia brasiliensis Vogel	*Piptocarpha axilaris* (Less.) Baker
Daphnopsis gemmiflora (Miers) Domke	*Pisonia ambigua* Heimerl.
Dicksonia sellowiana Hook.	*Platymiscium floribundum* Vogel
Diospyros inconstans Jacq.	*Plinia rivularis* (Cambess) A.D.Rotman
Diploön cuspidatum (Hoehne) Cronquist	*Podocarpus sellowii* Klotz. ex. Endl.
Drimys brasiliensis Miers	*Posoqueria acutifolia* Mart.
Duguetia lanceolata A.St.-Hil.	*Posoqueria latifolia* (Rudge) R. & Pavon
Ecclinusa ramiflora Mart.	*Pourouma guianensis* Aubl.
Endlicheria paniculata (Spreng.) J.F.Macbr.	*Pouteria beaurepairei* (Glaz. & Raunkier) Baehni
Eriotheca candolleana (K.Schum.) A.Robyns	*Pouteria bullata* (S.Moore) Baehni
Eriotheca macrophylla (K.Schum.) A.Robyns	*Pouteria caimito* (R. & Pav.) Radlk.
Eriotheca pentaphylla (Vell. emend K.Schum.) A.Robyns	*Pouteria psammophila* (Mart.) Radlk.
Erythroxylum cuspidifolium Mart.	*Pouteria venosa* (Mart.) Baehni
Esenbeckia febrifuga (A.St.-Hil.) A.Juss. ex Mart.	*Protium heptaphyllum* (Aubl.) Marchand
Esenbeckia grandiflora Mart.	*Protium kleinii* Cuatrec.
Eugenia beaurepaireana (Kiaersk.) D.Legrand	*Prunus myrtifolia* (L.) Urb.
Eugenia brasiliensis Lam.	*Pseudobombax grandiflorum* (Cav.) A.Robyns
Eugenia cerasiflora Miq.	*Psidium cattleyanum* Sabine
Eugenia cereja D.Legrand	*Psychotria carthagenensis* Jacq.
Eugenia excelsa O.Berg	*Psychotria erecta* (Aubl.) Standl. & Steyerm.
Eugenia handroana D.Legrand	*Psychotria longipes* Müll.Arg.
Eugenia involucrata O.Berg	*Psychotria mapourioides* DC.
Eugenia leptoclada O.Berg	*Psychotria nuda* (Cham. & Schltdl.) Wawra
Eugenia monosperma Vell.	*Psychotria sessilis* (Vell.) Müll.Arg.
Eugenia multicostata D.Legrand	*Psychotria suterella* Müll.Arg.
Eugenia neoglomerata Sobral	*Pterocarpus rohrii* Vahl
Eugenia neolanceolata Sobral	*Pterocarpus violaceus* Vogel
Eugenia oblongata O.Berg	*Qualea jundiahy* Warm.
Eugenia obovata Poir.	*Quiina glaziovii* Engl.
Eugenia pruinosa D.Legrand	*Rapanea acuminata* Mez
Eugenia punicifolia (Kunth) DC.	*Rapanea coriacea* (Sw.) Mez
Eugenia schuechiana O.Berg	*Rapanea ferruginea* (R. & Pav.) Mez
Eugenia speciosa Cambess.	*Rapanea gardneriana* A.DC.
Eugenia subavenia O.Berg	*Rapanea guianensis* (Aubl.) Kuntze
Eugenia sulcata Spring ex Mart.	*Rapanea parvifolia* A.DC.
Eugenia umbelliflora O.Berg	*Rapanea parvula* (Mez) Otegui
Euterpe edulis Mart.	*Rapanea umbellata* (Mart.) Mez
Faramea marginata Cham.	*Rapanea venosa* (A.DC.) Mez
Ficus clusiifolia Schott	*Rollinia emarginata* Schltdl.
Ficus enormis (Mart. ex Miq.) Miq.	*Rollinia laurifolia* Schltdl.

Table 3 continued

Ficus gomelleira Kunth & Bouché ex Kunth	*Rollinia sericea* (R.E.Fries) R.E.Fries
Ficus insipida Willd.	*Rollinia silvatica* (A.St.-Hil.) Mart.
Ficus organensis (Miq.) Miq.	*Roupala brasiliensis* Klotzsch
Garcinia brasiliensis Mart.	*Roupala rhombifolia* Mart. ex Meisn.
Garcinia gardneriana (Planch. & Triana) Zappi	*Rudgea jasminoides* (Cham.) Müll.Arg.
Geonoma gamiova Barb.Rodr.	*Rudgea recurva* Müll.Arg.
Gomidesia affinis (Cambess.) D.Legrand	*Schefflera morototoni* (Aubl.) Maguire, Steyerm. & Frodin
Gomidesia flagellaris D.Legrand	*Schinus terebinthifolius* Raddi
Gomidesia martiana O.Berg	*Schyzolobium parahyba* (Vell.) Blake
Gomidesia palustris (DC.) Kausel	*Sloanea guianensis* (Aubl.) Benth.
Gomidesia schaueriana O.Berg	*Sloanea monosperma* Vell.
Gomidesia spectabilis (DC.) O.Berg	*Sloanea obtusifolia* (Moric.) K.Schum.
Gomidesia tijucensis (Kiaersk.) D.Legrand	*Solanum inaequale* Vell.
Guapira opposita (Vell.) Reitz	*Solanum pseudoquina* A.St.-Hil.
Guarea guidonia (L.) Sleumer	*Sorocea bonplandii* (Baill.) W.C. Burger, Lanj. & Wess. Boer
Guarea macrophylla Vahl	*Spirotheca rivieri* (Decne.) Ulbr.
Guatteria australis A.St.-Hil.	*Styrax acuminatus* Pohl
Guazuma ulmifolia Lam.	*Syagrus romanzoffiana* (Cham.) Glassman
Heisteria perianthomega (Vell.) Sleumer	*Symplocos celastrinea* Mart. ex Miq.
Heisteria silvianii Schwacke	*Tabebuia cassinoides* (Lam.) A.P.DC.
Hieronyma alchorneoides Allemao	*Tabebuia heptaphylla* (Vell.) Toledo
Hirtella hebeclada Moric. ex DC.	*Tabebuia serratifolia* (Vahl) Nicholson
Hymenaea courbaril L.	*Tabebuia umbellata* (Sonder) Sandwith
Ilex brevicuspis Reissek	*Tapirira guianensis* Aubl.
Ilex dumosa Reissek	*Ternstroemia brasiliensis* Cambess.
Ilex integerrima Reissek	*Tetrastyllidium grandifolium* (Baill.) Sleumer
Ilex paraguariensis A.St.-Hil.	*Tetrorchidium rubrinervium* Poepp.
Ilex pseudobuxus Reissek	*Tibouchina sellowiana* Cogn.
Ilex theezans Mart. ex Reissek	*Trema micrantha* (L.) Blume
Inga capitata Desv.	*Trichilia casarettii* C.DC.
Inga edulis Mart.	*Trichilia elegans* A.Juss.
Inga laurina (Sw.) Willd.	*Trichilia lepidota* Mart.
Inga marginata Willd.	*Trichilia silvatica* C.DC.
Inga sellowiana Benth.	*Trichipteris phalerata* (Mart.) Barrington
Inga sessilis (Vell.) Mart.	*Urera baccifera* (L.) Gaudich. ex Wedd.
Inga striata Benth.	*Vantanea compacta* (Schnizl.) Cuatrec.
Inga vera Willd.	*Vernonanthura discolor* (Spreng.) H.Rob.
Jacaranda micrantha Cham.	*Vernonanthura divaricata* (Spreng.) H.Rob.
Jacaranda puberula Cham.	*Vernonanthura puberula* (Less.) H.Rob.
Jacaratia spinosa (Aubl.) A.DC.	*Virola bicuhyba* (Schott.) Warb.
Lacistema pubescens Mart.	*Virola gardnerii* (A.DC.) Warb.
Lamanonia ternata Vell.	*Vitex megapotamica* (Spreng.) Moldenke
Leandra dasytricha (A.Gray) Cogn.	*Vochysia tucanorum* Mart.

Table 3 continued

Licania kunthiana Hook.f.	*Weinmannia paulliniifolia* Pohl
Licania octandra (Hoffmanns. ex Roem. & Schult.) Kuntze	*Xylopia brasiliensis* Spreng.
Lonchocarpus guillemineanus (Tul.) Malme	*Xylosma pseudosalzmannii* Sleumer
Luehea divaricata Mart. & Zucc.	*Zanthoxylum fagara* (L.) Sarg. Gard. & Forest
Machaerium stipitatum (DC.) Vogel	*Zanthoxylum rhoifolium* Lam.
Magnolia ovata (A.St.-Hil.) Spreng	*Zollernia ilicifolia* (Brongn.) Vog.

Table 4 Tree species of the southern sector of the Brazilian Atlantic Rainforest with Rabinowitz's form 1 of rarity

Albizia polycephala (Benth.) Killip ex Record	*Jacaratia heptaphylla* (Vell.) A.DC.
Allophylus petiolulatus Radlk.	*Lafoensia pacari* A.St.-Hil.
Ardisia guyanensis (Aubl.) Mez	*Licaria armeniaca* (Poepp.) Kosterm.
Bactris setosa Mart.	*Lonchocarpus cultratus* (Vell.) A.M.G.Azevedo & H.C.Lima
Balizia pedicellaris (A.Rich.) Barneby & Grimes	*Lonchocarpus muehlbergianus* Hassl.
Barnebya dispar (Griseb.) W.R.Anderson & B.Gates	*Maclura tinctoria* (L.) D.Don ex Steud.
Bauhinia forficata Link	*Miconia latecrenata* (DC.) Naud.
Brosimum gaudichaudii Trécul	*Neomitranthes obscura* (DC.) N. Silveira
Buchenavia capitata (Vahl) Eichler	*Piper arboreum* Aubl.
Casearia arborea (L.C.Rich.) Urban	*Pradosia lactescens* (Vell.) Radlk.
Cedrela odorata L.	*Protium aracouchini* (Aubl.) Marchand
Cheiloclinium cognatum (Miers) A.C.Sm.	*Randia nitida* (HBK) DC.
Cybistax antisyphilitica (Mart.) Mart.	*Schoepfia brasiliensis* A.DC.
Dahlstedtia pinnata (Benth.) Malme	*Seguieria glaziovii* Briq.
Eugenia uniflora L.	*Senna multijuga* (L.C.Rich.) H.S.Irwin & Barneby
Ficus luschnanthiana (Miq.) Miq.	*Swartzia simplex* (Sw.) Spreng.
Geonoma schottiana Mart.	*Tabebuia chrysotricha* (Mart. ex A.DC.) Standley
Gomidesia anacardiaefolia (Gardner) O.Berg	*Xylosma ciliatifolium* (Clos) Eichler
Gordonia fruticosa (Schrader) H.Keng	*Jacaratia heptaphylla* (Vell.) A.DC.
Inga subnuda Salzm. ex Benth.	

Habitat affinity was the second most important variable affecting the forms of rarity of tree species in the southern portion of the Brazilian Atlantic rainforest. In order to classify habitat requirements as either unique (stenoecy) or varied (euryoecy) we considered the occurrence of each species in a single or in more than one altitudinal formations in the Dense Ombrophilous Atlantic Forest Phyto-Ecological Region according to Veloso (1992). In their analysis of the Atlantic rainforest of São Paulo State, Scudeller et al. (2001) detected a strong altitudinal influence on species distribution and abundance, supporting the results of other authors such as Salis et al. (1995) and Torres et al. (1997). As such, we believe that the criteria we adopted to classify the habitat affinity of tree species include important elements of their ecological niche.

Table 5 Tree species of the southern sector of the Brazilian Atlantic Rainforest with Rabinowitz's form 4 of rarity

Actinostemon communis (Müll.Arg.) Pax	*Maytenus brasiliensis* Mart.
Alibertia myrciifolia Spruce ex K.Schum.	*Maytenus evonymoide*s Reissek
Alsophila sternbergii (Sternb.) D.S.Conant	*Metrodorea nigra* A.St.-Hil.
Aniba viridis Mez	*Miconia valtherii* Naud.
Aspidosperma australe Müll.Arg.	*Miconia willdenowii* Klotzsch
Aspidosperma olivaceum Müll.Arg.	*Micropholis venulosa* (Mart. & Eichl.) Pierre
Aspidosperma polyneuron Müll.Arg.	*Mollinedia clavigera* Tul.
Astrocaryum aculeatissimum (Schott) Burret	*Mollinedia oligantha* Perkins
Aureliana fasciculata (Vell.) Sendtn.	*Myrceugenia glaucescens* (Cambess) D.Legrand & Kausel
Banara parviflora (A.Gray) Benth.	*Myrceugenia kleinii* D.Legrand & Kausel
Beilschmiedia emarginata (Meisn.) Kosterm.	*Myrceugenia ovata* (Hook. & Arn.)O.Berg
Boehmeria caudata Sw.	*Myrceugenia scutellata* D.Legrand
Calyptranthes grandiflora O.Berg	*Myrcia brasiliensis* Kiaersk.
Calyptranthes lanceolata O.Berg	*Myrcia formosiana* DC.
Capsicodendron dinisii (Schwacke) Occhioni	*Myrcia heringii* D.Legrand
Cathedra rubricaulis Miers	*Myrcia laruotteana* Cambess.
Cestrum intermedium Sendtn.	*Myrcia venulosa* DC.
Cestrum schlechtendallii G.Don	*Myrciaria plinioides* D.Legrand
Chamaecrista ensiformis (Vell.) H.S.Irwin & Barneby	*Nectandra leucantha* Nees
Chionanthus micrantha (Mart.) Lozano & Fuentes	*Nectandra psammophyla* Nees
Citronella megaphylla (Mart.) R.A.Howard	*Ocotea bicolor* Vattimo-Gil
Coccoloba latifolia Lam.	*Ocotea corymbosa* (Meisn.) Mez
Croton celtidifolius Baill.	*Ocotea diospyrifolia* (Meisn.) Mez
Croton urucurana Baill.	*Ocotea frondosa* (Meisn.) Mez
Cryptocarya saligna Mez	*Ocotea organensis* (Meisn.) Mez
Dalbergia frutescens (Vell.) Britton	*Ocotea porosa* (Nees) Barroso
Daphnopsis fasciculata (Meisn.) Nevl.	*Ocotea spectabilis* (Meisn.) Mez
Daphnopsis schwackeana Taub.	*Ocotea vaccinioides* (Meisn.) Mez
Dendropanax cuneatus (DC.) Decne. & Planch.	*Ormosia dasycarpa* Jacks.
Diospyros brasiliensis Mart. ex Miq.	*Ouratea multiflora* Engl.
Drimys winteri J.R.Forst. & G.Forst.	*Ouratea semiserrata* (Mart. & Nees) Engl.
Erythrina falcata Benth.	*Oxandra nitida* R.E.Fries
Erythroxylum amplifolium (Mart.) O.E.Schulz	*Parinari brasiliensis* (Schott) Hook.f.
Erythroxylum argentinum O.E.Schulz	*Pera obovata* (Klotsch) Baill.
Eugenia bacopari D.Legrand	*Persea pyrifolia* Nees
Eugenia bimarginata DC.	*Picramnia glazioviana* Engl.
Eugenia convexinervia D.Legrand	*Piptadenia gonoacantha* (Mart.) J.F.Macbr.
Eugenia cuprea (O.Berg) Nied.	*Piptocarpha macropoda* (DC.) Baker
Eugenia gemmiflora O.Berg	*Pouteria peduncularis* (Mart. & Eichl.) Baehni
Eugenia glazioviana (Kiaersk.) D. Legrand	*Protium widgrenii* Engl.
Eugenia kleinii D.Legrand	*Pseudopiptadenia leptostachya* (Benth.) Rauschert
Eugenia melanogyna (D.Legrand) Sobral	*Psidium grandifolium* DC.

Table 5 continued

Eugenia moraviana O.Berg	*Psychotria barbiflora* DC.
Eugenia mosenii (Kasusel) Sobral	*Rapanea hermogenesii* Jung-Mend. & Bernacci
Eugenia neomyrtifolia Sobral	*Rhamnus sphaerosperma* Sw.
Eugenia pluriflora DC.	*Rudgea gardenioides* (Cham.) Müll.Arg.
Eugenia prasina O.Berg	*Schefflera calva* (Cham.) Frodin & Fiaschi
Eugenia ramboi D.Legrand	*Schefflera navarroi* (A.Samp. in Andrade & Vecchi) Frodin & Fiaschi
Eugenia riedeliana O.Berg	*Sclerolobium denudatum* Vogel
Eugenia rostrifolia D.Legrand	*Sebastiania klotzschiana* (Müll.Arg.) Müll.Arg.
Eugenia stictosepala Kiaersk.	*Sebastiania serrata* (Baill. ex Müll.Arg.) Müll.Arg.
Eugenia stigmatosa DC.	*Senna macranthera* (Collad.) H.S.Irwin & Barneby
Eugenia uruguayensis Cambess.	*Sideroxylon obtusifolium* (Roem. & Schultes) T.D.Penn.
Euplassa cantareirae Sleumer	*Simaba cuneata* A.St.-Hil & Tul.
Exostyles venusta Schott	*Simira eliezeriana* Peixoto
Faramea montevidensis (Cham. & Schltdl.) DC.	*Sloanea lasiocoma* K.Schum.
Ficus glabra Vell.	*Solanum bullatum* Vell.
Gochnatia polymorpha (Less.) Cabrera	*Solanum caeruleum* Vell.
Gomidesia fenzliana O.Berg	*Solanum excelsum* A.St.-Hil.
Guapira obtusata (Jacq.) Little	*Solanum leucadendrum* Whalen
Guatteria dusenii R.E.Fries	*Solanum sanctae-katharinae* Dunal
Guatteria nigrescens Mart.	*Solanum swartzianum* Roem. & Schult.
Gymnanthes concolor (Spreng.) Müll.Arg.	*Styrax pohlii* A.DC.
Hedyosmum brasiliense Mart. ex Miq.	*Symplocos falcata* Brand
Hennecartia omphalandra J.Poiss.	*Symplocos laxiflora* Benth.
Hexachlamys itatiaiaensis Mattos	*Symplocos nitidiflora* Brand
Humiriastrum dentatum (Casar.) Cuatrec.	*Symplocos tetrandra* Mart.
Ilex amara (Vell.) Loes.	*Symplocos variabilis* Mart.
Ilex microdonta Reissek	*Tabebuia alba* (Cham.) Sandwith
Ilex taubertiana Loes.	*Tibouchina multiceps* Cogn.
Ixora burchelliana Müll.Arg.	*Tibouchina pulchra* (Cham.) Cogn.
Ixora venulosa Benth.	*Tovomitopsis saldanhae* Engl.
Licania hoehnei Pilg.	*Trichilia claussenii* C.DC.
Lonchocarpus campestris Mart. ex Benth.	*Trichilia pallens* C.DC.
Luehea speciosa Willd.	*Trichilia pallida* Sw.
Machaerium nyctitans (Vell.) Benth.	*Trichilia pseudostipularis* (A.Juss.) C.DC.
Machaerium villosum Vogel	*Trichipteris atrovirens* Langsd. & Fisch.) R.M.Tryon
Macropeplus ligustrinus (Tul.) Perkins	*Vitex polygama* Cham.
Malouetia arborea (Vell.) Miers	*Vochysia bifalcata* Warm.
Marlierea grandifolia O.Berg	*Weinmannia discolor* Gardner
Marlierea reitzii D.Legrand	*Xylopia langsdorffiana* A.St.-Hil. & Tul.
Matayba junglandifolia Radlk.	*Zollernia glabra* (Spreng.) Yakvl.
Maytenus aquifolia Mart.	

Table 6 Tree species of the southern sector of the Brazilian Atlantic Rainforest with Rabinowitz's form 5 of rarity

Abarema brachystachya (DC.) Barneby & Grimes	*Mollinedia widgrenii* A.DC.
Acnistus arborescens (L.) Schltdl.	*Mouriri arborea* Gardner
Ardisia laevigata Blume	*Myrcia obtecta* (O.Berg) Kiaersk.
Casearia commersoniana Camb.	*Myroxylon peruiferum* L.f.
Cecropia hololeuca Miq.	*Nectandra puberula* (Schott) Nees
Ceiba speciosa (A.St.-Hil.) Ravenna	*Ocotea lanata* (Nees) Mez
Centrolobium robustum (Vell.) Mart. ex Benth.	*Ouratea parvifolia* Engl.
Cestrum calycinum Kunth	*Paramyrciaria delicatula* (DC.) Kausel
Chomelia catharinae (L.B.Sm. & Downs) Steyerm.	*Pera leandri* Baill.
Cinnamomum riedelianum Kosterm.	*Phoebe stenophylla* (Meisn.) Mez
Clusia hilariana Planch. & Triana	*Picramnia gardneri* Planch.
Copaifera lucens Dwyer	*Plinia trunciflora* (O.Berg) Kausel
Cordia superba Cham.	*Polyandrococos caudescens* (Mart.) Barb.Rodr.
Coussarea graciliflora (Mart.) Müll.Arg.	*Pouteria guianensis* Aubl.
Croton macrobothrys Baill.	*Psychotria nemorosa* Gardner
Dahlstedtia pentaphylla (Taub.) Burkart	*Roupala longepetiolata* Pohl
Enterolobium contortisiliquum (Vell.) Morong	*Ruprechtia laxiflora* Meisn.
Eugenia blastantha (O.Berg) D. Legrand	*Rustia formosa* Kl.
Eugenia catharinensis D. Legrand	*Sapium glandulosum* (L.) Morong
Eugenia neoverrucosa Sobral	*Savia dictyocarpa* Müll.Arg.
Eugenia platysema O.Berg	*Sclerolobium friburgense* Harms
Euplassa incana (Klotzsch) I.M.Johnston	*Seguieria langsdorffii* Moq.
Inga barbata Benth.	*Solanum mauritianum* Scop.
Inga lenticellata Benth.	*Solanum rufescens* Sendtn.
Machaerium brasiliense Vogel	*Sorocea jureiana* Romaniuc
Machaerium uncinatum (Vell.) Benth.	*Spirotheca passifloroides* Cuatrec.
Marlierea suaveolens Cambess.	*Symplocos trachycarpa* Brand
Maytenus communis Reissek	*Tabebuia impetiginosa* (Mart. ex A.DC.) Mart.
Maytenus obtusifolia Mart.	*Terminalia triflora* (Griseb.) Lillo
Meriania claussenii Triana	*Tibouchina mutabilis* (Vell.) Cogn.
Miconia theizans (Bonpl.) Cogn.	*Tocoyena sellowiana* (Cham. & Schltdl.) K.Schum.
Mollinedia eugeniifolia Perkins	*Trichilia catigua* A.Juss.
Mollinedia fruticulosa Perkins	*Vochysia saldanhana* Warm.
Mollinedia oligotricha Perkins	*Xylosma glaberrimum* Sleumer

Local population size is also an important variable influencing the forms of rarity of tree species in the southern Atlantic rainforest. Our results corroborate other authors, as for example, Scudeller et al. (2001), who concluded that most tree species in the Atlantic Forest s.s. of São Paulo State have restricted ecological niches. Pires and Prance (1977) observed that tree communities of the upland (*terra firme*) Amazon Forest are composed of few locally abundant species and a plethora of locally scarce species. Our results indicated that the same pattern occurs in the southern portion of the Atlantic rainforest.

Table 7 Tree species of the southern sector of the Brazilian Atlantic Rainforest with Rabinowitz's form 6 of rarity

Agonandra excelsa Griseb.	*Mollinedia calodonta* Perkins
Aiouea acarodomatifera Kosterm.	*Mollinedia glabra* (Spreng.) Perkins
Alibertia sessilis (Vell.) K.Schum.	*Myrceugenia acutiflora* (Kiaers.) D.Legrand & Kausel
Allophylus guaraniticus A.St.-Hil.) Radlk.	*Myrceugenia alpigena* (A.P.DC.) Landrum
Annona acutiflora Mart.	*Myrceugenia brevipedicellata* (Burret) D.Legrand & Kausel
Aspidosperma tomentosum Mart.	*Myrceugenia ovalifolia* (O.Berg) Landrum
Baccharis lateralis Baker	*Myrceugenia reitzii* D.Legrand & Kausel
Baccharis oreophila Malme	*Myrcia arborescens* O.Berg
Bactris vulgaris Barb.Rodr.	*Myrcia bergiana* O.Berg
Byrsonima bahiana W.R.Anderson	*Myrcia bicarinata* (O.Berg) D.Legrand
Byrsonima myricifolia Griseb.	*Myrcia hatschbachii* D.Legrand
Calyptranthes clusiifolia (Miq.) O.Berg	*Myrcia insularis* (O.Berg) Kiaersk.
Calyptranthes kleinii D.Legrand	*Myrcia kunthiana* (O.Berg) Kiaersk.
Calyptranthes regeliana O.Berg	*Myrcia obscura* (O.Berg) N.Silveira
Calyptranthes rubella (O.Berg) D.Legrand	*Neomitranthes cordifolia* (D.Legrand) D.Legrand
Casearia selloana Eichler	*Ocotea bragai* Coe-Teixeira
Cecropia cineaea Miq.	*Ocotea lobbii* (Meisn.) Rohwer
Chrysophyllum januariense Eichl.	*Ocotea minarum* (Nees) Mez
Cinnamodendron axillare Endl. ex Walp.	*Ocotea neesiana* (Miq.) Kosterm.
Cinnamomum pickelli (Coe-Teixeira) Kosterm.	*Ocotea notata* (Nees & Mart. ex Nees) Mez
Coccoloba ovata Benth.	*Ocotea tabacifolia* (Meisn.) Rohwer
Colubrina glandulosa Perkins	*Ocotea tristis* (Nees) Mez
Connarus regnellii Schellenb.	*Ocotea velloziana* (Meisn.) Mez
Crataeva tapia L.	*Ocotea venulosa* (Nees) Baitello
Cyphomandra sycocarpa (Mart. & Sendtn.) Sendtn.	*Opuntia brasiliensis* (Willd.) Haw.
Daphnopsis coriacea Taub.	*Peltophorum dubium* (Spreng.) Taub.
Daphnopsis racemosa Griseb.	*Pilocarpus pennatifolius* Lem.
Dulacia singularis Vell.	*Piptocarpha tomentosa* Baker
Erythroxylum oxypetalum O.E.Schulz	*Plinia brachybotra* Sobral
Erythroxylum vacciniifolium Mart.	*Plinia complanata* M.L.Kawas. & B.Holst
Eugenia bahiensis DC.	*Plinia pauciflora* M.L.Kawas. & B.Holst
Eugenia cambucarana Kiaersk.	*Pouteria coelomatica* Rizzini
Eugenia candolleana DC.	*Protium icicariba* (DC.) Marchand
Eugenia capitulifera O.Berg	*Qualea glaziovii* Warm.
Eugenia catharinae O.Berg	*Quiina magellano-gomezii* Schwacke
Eugenia cyclophylla O.Berg	*Rapanea loefgrenii* (Mez) Imkhan.
Eugenia dodoniifolia Cambess.	*Rapanea quaternata* Hassl.
Eugenia egensis DC.	*Rauvolfia mattfeldiana* Markgr.
Eugenia neotristis Sobral	*Rhodostemonodaphne capixabensis* Baitello & Coe-Teix.
Eugenia olivacea O.Berg	*Rudgea reticulata* Benth.
Eugenia pyriformis Cambess.	*Rudgea villiflora* K.Schum.

Table 7 continued

Eugenia racemosa DC.	*Schefflera selloi* (Marchal) Frodin & Fiaschi
Eugenia rostrata O.Berg	*Sebastiania commersoniana* (Baill.) L.B.Sm. & Downs
Ficus cyclophylla (Miq.) Miq.	*Sebastiania edwalliana* Pax & Hoffm.
Guapira asperula (Standl.) Lundell	*Seguieria floribunda* Benth.
Hymenaea rubriflora Ducke	*Sessea brasiliensis* Toledo
Inga edwallii (Harms) T.D.Penn.	*Siphoneugena densiflora* O.Berg
Inga virescens Benth.	*Siphoneugena guilfoyleiana* C.Proença
Ixora gardneriana Benth.	*Sloanea alnifolia* Mart.
Jacaranda obovata Cham.	*Solanum cinnamomeum* Sendtn.
Kielmeyera albopunctata Saddi	*Solanum euonymoides* Sendtn.
Kielmeyera petiolaris Mart. & Zucc.	*Solanum johannae* Bitter
Leandra carassana (DC.) Cogn.	*Stillingia oppositifolia* Baill. ex Müll.Arg.
Leucochloron incuriale (Vell.) Barneby & Grimes	*Strigilia glabrata* (Schott) Miers
Lithraea brasiliensis Marchand	*Strychnos acuta* Progel
Lithraea molleoides (Vell.) Engl.	*Symplocos frondosa* Brand
Luehea grandiflora Mart. & Zucc.	*Tabebuia elliptica* (A.P.DC.) Sandwith
Macropeplus dentatus (Perkins) I.Santos & Peixoto	*Tapirira marchandii* Engl.
Matayba discolor Radlk.	*Tibouchina fissinervia* Cogn.
Maytenus cassineformis Reissek	*Tibouchina schwackei* Cogn.
Maytenus salicifolia Reissek	*Tibouchina trichopoda* Baill.
Maytenus schumanniana Loes.	*Tovomitopsis paniculata* (Spreng.) Planch. & Triana
Miconia jucunda (DC.) Triana	*Vochysia magnifica* Warm.
Miconia petropolitana Cogn.	*Weinmannia organensis* Gardner
Miconia rubiginosa (Bonpl.) DC.	*Xylopia laevigata* (Mart.) R.E.Fries
Mollinedia argyrogyna Perkins	

Forms of rarity

Our results differed from those reported by Pitman et al. (1999) and Rabinowitz et al. (1986). Pitman et al. (1999) investigated the forms of rarity in little more than 1,500 ha of the lowland rainforest in Peru and analyzed two different matrices: one considering the species occurring in two or more surveys, and another considering the species occurring in three or more surveys. In the study of Rabinowitz et al. (1986) concerning the flora of the British Isles, 15 ecological and taxonomic "judges" classified the species according to rarity variables in order to minimize possible bias in the analyses—which were made by adopting conservative and a liberal criteria. In both studies common species occurred in greater proportions, and some forms of rarity were not found: Pitman et al. (1999) did not find stenotopic species (forms 4–7) and Rabinowitz et al. (1986) did not find some forms of rarity, which varied according to the conservative or liberal criterion used. Differently from Pitman et al. (1999), who examined only a single forest formation, we considered the forms of rarity in the entire southern sector of the Dense Ombrophilous Forest Phyto-Ecological

Table 8 Tree species of the southern sector of the Brazilian Atlantic Rainforest with Rabinowitz's form 7 of rarity

Aegiphila brachiata Vell.	*Miconia inconspicua* Miq.
Aegiphila obducta Vell.	*Miconia octopetala* Cogn.
Albizia edwallii (Hoehne) Barneby & Grimes	*Miconia tristis* Spring
Allophylus puberulus (Cambess.) Radlk.	*Mollinedia elegans* Tul.
Annona acutifolia Saff. ex R.E.Fries	*Mollinedia micrantha* Perkins
Aspidosperma camporum Müll.Arg.	*Myrceugenia foveolata* (O.Berg) Sobral
Campomanesia schlechtendaliana (Berg) Nied.	*Myrcia guianensis* (Aubl.) DC.
Casearia rupestris Eichler	*Myrcia selloi* (Spreng.) N.Silveira
Cassia ferruginea (Schrad.) Schrad. ex DC.	*Myrcia sosias* D.Legrand
Celtis iguanea (Jacq.) Sarg..	*Nectandra debilis* Mez
Celtis spinosa Spreng.	*Ocotea hoehnii* (Nees) Mez
Cestrum sessiliflorum Sendtn.	*Ocotea nutans* (Nees) Mez
Chionanthus trichotomus (Vell.) P.S.Green	*Ocotea suaveolens* (Meisn.) Benth. & Hook.f. ex Hieron.
Cinnamomum hirsutum Lorea-Hernandez	*Ormosia micrantha* Ducke
Clusia spiritu-sanctensis G.Mariz & Weinberg	*Ottonia martiana* Miq.
Coccoloba declinata Mart.	*Pachystroma ilicifolium* Müll.Arg.
Critoniopsis stellata (Spreng.) H.Rob.	*Pilocarpus spicatus* A.St.-Hil.
Croton klotzschii (Didr.) Baill.	*Piptocarpha regnelii* (Sch.Bip.) Cabrera
Cyathea dichromatolepsis (Fee) Domin	*Plinia edulis* (Vell.) Sobral
Cybianthus cuneifolius Mart.	*Podocarpus lambertii* Klotz. ex. Endl.
Dalbergia foliolosa Benth.	*Rauia nodosa* (Engl.) Kallunki
Daphnopsis brasiliensis Mart. & Zucc.	*Rhamnidium elaeocarpum* Reissek
Dasyphyllum spinescens (Less.) Cabrera	*Rhodostemonodaphne macrocalyx* (Meisn.) Rohwer ex Madriñán
Erythrina crista-galli L.	*Rolliniopsis parviflora* (A.St.-Hil.) Saff.
Escallonia bifida Link & Otto	*Roupala sculpta* Sleumer
Esenbeckia leiocarpa Engl.	*Salacia elliptica* (Mart. ex Roem. & Schult.) G.Don
Eugenia brevipedunculata Kiaersk.	*Sapium klotzschianum* (Müll. Arg.) Huber
Eugenia burkartiana (D.Legrand) D.Legrand	*Schefflera anomala* (Taub.) Frodin
Eugenia linguaeformis O.Berg	*Sclerolobium pilgerianum* Harms
Euplassa itatiaiae Sleumer	*Sebastiania brasiliensis* Spreng.
Euplassa legalis (Vell.) I.M.Johnston	*Senna silvestris* (Vell.) H.S.Irwin & Barneby
Faramea porophylla (Vell.) Müll.Arg.	*Senna tropica* (Vell.) H.S.Irwin & Barneby
Ficus hirsuta Schott	*Siphoneugena dussii* (Krug & Urban) C.Proença
Genipa americana L.	*Solanum diploconos* (Mart.) Bohs
Heterocondylus alatus (Vell.) R.M.King & H.Rob.	*Solanum erianthum* D.Don
Holocalyx balansae Micheli	*Solanum fragrans* Hook.
Huberia glazioviana Cogn.	*Solanum pabstii* L.B.Sm. & Downs
Inga heterophylla Willd.	*Tabernaemontana hystrix* Steud.
Inga lanceifolia Benth.	*Tibouchina fothergillae* Cogn.
Inga lentiscifolia Benth.	*Verbenoxylum reitzii* (Moldenke) Tronc.
Inga platyptera Benth.	*Vernonanthura ferruginea* (Less.) H.Rob.

Table 8 continued

Licania hypoleuca Benth.	*Vochysia rectiflora* Warm.
Lonchocarpus nitidus (Vogel) Benth.	*Vochysia selloi* Warm.
Machaerium paraguariense Hassl.	*Zanthoxylum monogynum* A.St.-Hil.
Marlierea laevigata (DC.) Kiaersk.	*Zanthoxylum naranjillo* Griseb.
Maytenus litoralis Car.-Okano	*Zanthoxylum rugosum* A.St.-Hil & Tul.
Maytenus ubatubensis Car.-Okano	

Region, which included different forest formations. Differently from Rabinowitz et al. (1986), who considered all the different plant formations in England, whether forest or not, we considered only rainforest formations. As such, the different criteria used as well as the different study focuses would explain the different results found. One of the most important obstacles to our analysis of rarity was related to problems of taxonomic identification, mainly the large proportion of unknown taxa in the Dense Ombrophilous Atlantic Forest (Caiafa and Martins 2007).

In order to classify the species according to their affinity for the habitat, we adopted the division of the Atlantic rainforest into formations according to Veloso (1992). The heuristics of this procedure was based on various authors, such as Salis et al. (1995), Torres et al. (1997) and Scudeller et al. (2001), who found great consistency in the classification system adopted by the Brazilian Institute of Geography and Statistics IBGE. More studies will be necessary in the Dense Ombrophilous Atlantic Forest Phyto-Ecological Region to investigate variations in species abundance, as the existing surveys do not provide adequade sampling density (Caiafa and Martins 2007). Additionally, the criteria we used to classify the geographic distribution of the species as wide or restricted was subjective. Scudeller et al. (2001) considered species constancy as well as latitudinal range in investigating geographic distribution. In our study, we opted for a subjective division into two-degree latitudinal belts, as it was not possible to use relative constancy. Some species have low relative constancy but a discontinuous distribution, implying that low constancy does not indicate restricted geographic distribution. Oliveira-Filho and Fontes (2000) reported a north–south differentiation in the Atlantic rainforest that was probably caused by variations in temperature and rainfall regimes. We do not know, however, how much of this variation is included within the two-degree latitudinal belts we used to classify the geographic distribution of the species.

Rabinowitz's approach to classify the forms of rarity involves a certain degree of subjectivity in attributing dichotomic states to each variable of geographic range, habitat preference, and local abundance, whereas these variables are known to vary continuously (Gaston 1994; Pitman et al. 1999). Attributing dichotomic states to continuous variables may imply in classifying some species as common when they are otherwise rare and vice versa. It could be convenient to modify Rabinowitz's rarity classification system in future studies to consider the effects of continuous variations in those variables. However, in spite of some criticism (Gaston 1994; Pitman et al. 1999), Rabinowitz's system represents the first solid approach to rarity that includes and systematizes many concepts that otherwise are sparse throughout the literature. We conclude that the application of Rabinowitz's rarity classification system to the Brazilian Atlantic rainforest confirms stenotopy as the main form of rarity, and also indicates that many tree species are currently threatened due to their restricted geographic distribution, unique habitats, reduced local abundance, or because of a synergism among these variables.

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