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INSTITUTO DE BIOLOGIA

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"A vegetação arbórea em um gradiente altitudinal no Morro do Cuscuzeiro, Ubatuba (SP): uma análise florística, fitossociológica e fitogeográfica"

Este exemplar corresponde à redação final
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RICARDO BERTONCELLO
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KYamamoto

Dissertação apresentada ao Instituto de Biologia para obtenção do Título de Mestre em Biologia Vegetal

Orientadora: Profa. Dra. Kikyo Yamamoto

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“A gente só consegue as coisas na vida quando realmente queremos”

(Ciro Béjar Barbosa 1980-2001)

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RESUMO GERAL

A classificação e a delimitação das diferentes formações fitogeográficas que ocorrem no domínio da Mata Atlântica nas regiões Sul e Sudeste do Brasil constituem um desafio para botânicos, ecólogos e fitogeógrafos. A distribuição atual destas formações está relacionada ao histórico de ocupação das áreas e a complexos gradientes ambientais, que ocorrem nos sentidos horizontal (latitudinal, longitudinal e edáfico) e vertical (altitudinal). Visando a contribuir para o conhecimento das formações florestais que integram a Mata Atlântica, este trabalho foi realizado no Morro do Cuscuzeiro (Ubatuba-SP) com os objetivos de: (1) descrever as variações florísticas e estruturais nas comunidades arbóreas em função da altitude, e verificar se existe uma Floresta Nebular que possa ser discriminada por parâmetros florísticos e estruturais; e (2) verificar a situação fitogeográfica das comunidades encontradas neste local no contexto da Mata Atlântica nas regiões Sul e Sudeste do Brasil. O Morro do Cuscuzeiro se situa no Núcleo Picinguaba do Parque Estadual da Serra do Mar (23° 18' 14" S e 44° 47' 16" W) e possui 1277m de altitude. O gradiente altitudinal foi representado por amostras de quatro cotas altimétricas, 820m, 970m, 1120m e 1270m, obtidas em 10 parcelas de 10 x 10 m em cada cota, exceto na mais alta que foi dividida em duas 'sub-cotas' com 5 parcelas cada. O critério de inclusão amostral da flora arbórea foi de 15 cm de CAP (exceto nas duas 'sub-cotas' superiores, 10 cm de CAP). Em sentido base-topo, foi verificada diminuição na riqueza, na diversidade, na altura, no diâmetro e no volume das árvores, e aumento na densidade. Uma mudança abrupta na composição da comunidade arbórea foi detectada a 1120m, acima da qual aparece uma formação que identificamos como Floresta Nebular, em substituição à floresta de encosta da Serra do Mar, que ocorre abaixo daquela altitude. As espécies destas duas formações florestais foram inseridas em uma matriz de 1546 espécies registradas em 112 levantamentos de 78 localidades do domínio da Mata Atlântica nas regiões Sul e Sudeste do Brasil. As análises multivariadas resultaram em cinco grupos de levantamentos: 1-Florestas Nebulares; 2- Florestas da província costeira (posteriormente sub-dividido em (a) Florestas de encosta e (b) Florestas de topo de morro e florestas da planície costeira); 3-Florestas de Araucária; 4-Florestas Semi-decíduas; e 5- Florestas Semi-decíduas Montanas. As formações encontradas no Morro do Cuscuzeiro foram incluídas nos grupos das Florestas Nebulares (de 1120m e 1270m) e das florestas de encosta da província costeira (820m e 970m), o que reforçou os resultados da análise dos dados locais, mostrando que pequenas diferenças em altitude podem resultar em mudança abrupta na composição das comunidades, evidenciada pela presença de espécies de distribuição disjunta que são compartilhadas com outras formações de Florestas Nebulares das regiões Sul e Sudeste do país.

Palavras chave: análise multivariada, fitogeografia, comunidades vegetais, Floresta Nebular, Floresta Ombrófila Densa, florística, gradiente altitudinal, Mata Atlântica, Morro do Cuscuzeiro, Serra do Mar, Ubatuba

ABSTRACT

The classification and delimitation of different vegetational formations into a phytogeographic system in Brazil has been a challenge to ecologists, botanists, and phytogeographers. The current distribution of these formations is related to historical process of land use and complex environment gradients, occurring in horizontal (latitude, longitude and edafic) and vertical (altitude) ways. The aims of this study were (a) to describe the changes in floristic composition and structure of tree species along an elevational gradient on Morro do Cuscuzeiro, Ubatuba (SP), and to verify the occurrence of a Cloud Forest that can be discriminated by floristic and structural paremeters; and (b) to analyze the phytogeographic position of the communities found in this mountain in relation to other surveys of the Atlantic Rain Forest domain in Southern and Southeastern Brazil. Mountain Cuscuzeiro is located in the Serra do Mar State Park (at 23° 18' 14" S, 44° 47' 16" W it is 1277m in height). A survey of tree species was made in four elevational levels, 820m, 970m, 1120m, and 1270m, using 10 samples of 10x10m on each level, except on the higher one, which was sub-divided in two sub-levels whith five samples on each. The sampling criterion was 4,8cm of DBH (except in the two higher sub-levels, where 3,2cm of DBH was used). The analysis resulted in consistent groups at the different levels, indicating a strong altitude influence on the floristic composition. An abrupt change of the vegetation was identified at 1120m, from where a typical Ombrophilous Dense Forest (slope forest from 820m to 970m) shifted into a Cloud Forest formation (1120m to 1270m). These two formations were inserted in a matrix made by a total of 1546 species of 112 surveys from 78 locations of Atlantic Rain Forest domain in southern and southeastern Brazil. The multivariate analysis resulted in five groups of samples: 1- The Cloud Forest; 2- The coastal province (further subdivided into (a) the slope forests and (b) a subgroup composeded by the mountaintop and the coastal plain forests); 3- The Araucaria Forest; 4- The Semi-Deciduous Forest; and 5- The Montane Semi-Deciduous Forest. The formations found on Mt. Cuscuzeiro were included in the groups of the Cloud Forest (from 1120m to 1270m) and of the Coastal Province (from 820m to 970m), which reinforced the results of the local elevational gradient analysis, showing that minor changes on altitude can lead to abrupt changes in community composition due to the occurrence of species with disjunct distribution that are shared with other Cloud Forest formations of southern and south-eastern Brazil.

Key words: Atlantic Forest, Cloud Forest, critical altitude, elevational gradient, floristic, phytogeography, plant community, Mountain Cuscuzeiro, multivariate analysis, Ombrophilous Dense Forest, Serra do Mar, Ubatuba

SUMÁRIO

INTRODUÇÃO GERAL

Mata Atlântica

A Mata Atlântica figura entre as florestas mais ameaçadas do planeta (Myers et *al*. 2000). Originalmente ocupava cerca de 12% do território brasileiro, estendendo-se do Rio Grande do Norte ao Rio Grande do Sul (Câmara 2005). Atualmente, restam apenas 11,73% da vegetação original do bioma, que se encontra bastante fragmentado e sobre forte "efeito de borda", dos quais a parte mais bem conservada se encontra sobre o complexo cristalino da Serra do Mar no sudeste brasileiro (Ribeiro *et al*. 2009).

Trata-se de um bioma constituído por diversas formações vegetais cujas delimitações ainda são objeto de debate na literatura (Scudeller 2001, Joly 1999, Oliveira Filho & Fontes 2000). De acordo com a definição legal (lei federal n° 11426/06), a Mata Atlântica é composta pelas seguintes formações vegetais: Floresta Ombrófila Densa; Floresta Ombrófila Mista, também denominada de Mata de Araucárias; Floresta Ombrófila Aberta; Floresta Estacional Semidecidual; e Floresta Estacional Decidual, bem como os manguezais, as vegetações sobre a restinga, campos de altitude, brejos interioranos e os encraves florestais do Nordeste ("Matas de Brejo"). No meio acadêmico, nota-se uma tendência de se chamar a Floresta Ombrófila Densa de "Mata Atlântica *sensu strictu*" e o conjunto de todas as formações como "Mata Atlântica *sensu latu*" (Ivanauskas 2000). Dentre os vários sub-tipos florestais, a Mata Atlântica também compreende a "Floresta Nebular" em altitudes elevadas. Este tipo de denominação, que é também aplicado em outras partes do mundo, deve-se apenas ao fato de estar frequentemente coberto por nuvens, e não possui, pelo menos por enquanto, uma definição específica baseada em elementos florísticos ou em características estruturais.

O bioma da Mata Atlântica é caracterizado pela alta riqueza e diversidade de espécies arbóreas que o compõe em escala local, com ocorrência de grande número de espécies raras no local e/ou com distribuição restrita (Caiafa 2008, Scudeller *et al.* 2001), especialmente nas florestas situadas nas encostas da Serra do Mar, onde a diversidade é maior quando comparada às ditas florestas do planalto (Oliveira-Filho & Fontes 2000).

As diferentes formações florestais são resultantes de complexos gradientes ambientais decorrentes das variações latitudinal (variação norte-sul), longitudinal (*e.g.* distância do oceano), edáfica, e altitudinal que, direta ou indiretamente, também podem causar variação na pluviosidade. Como os locais de transição podem ser tanto graduais quanto abruptos, a vegetação também pode apresentar diferenciações graduais ou abruptas de acordo com as variações ambientais correlacionadas (Oliveira-Filho & Fontes 2000).

Aplicação de análises multivariadas em estudos fitogeográficos

O grande número de espécies presentes no domínio da Mata Atlântica, além das muitas variáveis ambientais, faz da análise multivariada um instrumento essencial para a compreensão de seus complexos padrões florísticos (Salis *et al.* 1995). Contribuições importantes têm sido produzidas pela após a introdução deste tipo de análise em estudos brasileiros que contemplam a Mata Altlântica *sensu latu* (Silva & Shepherd 1986, Torres 1989, Salis 1995, Ivanauskas 2000 and Oliveira Filho & Fontes 2000, Scudeller 2001). Espera-se que a aplicação das mesmas possa ajudar a preencher, ainda mais, lacunas importantes no conhecimento da Mata Atlântica, em especial naquelas que concernem às

Florestas Nebulares e à Floresta Ombrófila Densa em diferentes altitudes. Atualmente, há nas regiões sul e sudeste do país um número consistente de levantamentos que podem possibilitar uma boa distinção florística e/ou fitossociológica das fisionomias através da aplicação deste tipo de análise.

Gradiente altitudinal

O estudo de gradientes altitudinais em montanhas tropicais propicia um excelente sistema experimental “desenhado pela natureza” (Körner 2000), uma vez que as diferenças climáticas decorrentes do efeito de grandes distâncias latitudinais são comprimidas na área de uma montanha, onde os efeitos associados às mudanças de temperatura podem ser percebidos em pequenas distâncias. Mas este tipo de estudo ainda é escasso na Floresta Ombrófila Densa no Brasil e pouco se sabe, em especial, sobre a florística e a estrutura das áreas mais elevadas da Serra do Mar (Scudeller *et al.* 2001), e como elas variam conforme a altitude.

Até o momento, os poucos estudos realizados na Serra do Mar indicam uma tendência de diminuição da riqueza com o aumento da altitude (Blum 2006, Custódio-Filho 2002, Sanchez 2001, Roderjan 1994); esta tendência também é comumente relatada para outras regiões tropicais e temperadas (Aiba & Kitayama 1999, Gentry 1995, Liberman et *al.* 1996, Odland 1999, Sruatek & Kolbek 1994, Vázquez & Givinish 1998). Mas, apesar do consenso sobre a diminuição de riqueza com o aumento da altitude, ainda não está claro se as espécies situadas nas áreas mais elevadas da Serra do Mar constituem um sub-conjunto da comunidade situada na encosta, ou se formam uma comunidade distinta, com funcionamento ecológico peculiar. Esta é a questão que nos colocamos no que se refere às

”Florestas Nebulares” que ocorrem em áreas de altitudes elevadas no sul e sudeste brasileiros.

O aquecimento global e a Floresta Nebular

Pesquisas sobre as Florestas Nebulares se tornam particularmente cruciais se levarmos em consideração as possíveis mudanças climáticas. As Florestas Nebulares estão relacionadas à freqüente exposição às nuvens ou à neblina que resultam na entrada de grande quantidade de água no sistema, através do processo de condensação denominado por alguns autores como precipitação horizontal (Stadtmüller 1987). O aquecimento na média da temperatura global acarretaria uma elevação na formação do banco de nuvens orográficas e/ou no aumento da evapo-transpiração, levando a uma dupla perturbação no ambiente, relacionada tanto às mudanças no micro-clima quanto à possibilidade de invasão pelas espécies de cotas altimétricas inferiores (Still *et al.* 1999) que, atualmente, não estão aptas à competição em um ambiente mais frio e freqüentemente recoberto por nuvens. Grande parte das espécies de topo de morro estão sujeitas a desaparecerem em um futuro iminente (Colwell et *al.* 2008) devido às possíveis mudanças no atual equilíbrio dinâmico das Florestas Nebulares. Em conseqüência, poderá ocorrer perda de biodiversidade, mudança na faixa altitudinal de ocorrência das espécies, ampliação da área de ocorrência de espécies hoje limitadas a alititudes menores, e possível desaparecimento das Florestas Nebulares (Foster 2001).

Objetivo da tese

Considerando-se que observações preliminares no Morro do Cuscuzeiro (Ubatuba, SP), que é uma das maiores elevações junto à costa norte do estado de São Paulo, indicaram seu topo frequentemente envolto por nuvens, sugerindo a ocorrência de uma Floresta Nebular, este trabalho foi realizado com dois objetivos básicos:

a) Descrever as variações florísticas e estruturais nas comunidades arbóreas ao longo de um gradiente altitudinal no trecho superior do Morro do Cuscuzeiro (Ubatuba-SP) para verificar a ocorrência de formações florestais que sejam florística e/ou fitossociologicamente distintas e delimitáveis altitudinalmente. Em particular, nosso interesse reside em verificar se existe uma Floresta Nebular que possa ser caracterizada pelos seus elementos florísticos e/ou pela sua estrutura.

b) Analisar a situação fitogeográfica das comunidades encontradas no trecho estudado no ítem (a) em relação a outras comunidades florestais inseridas no domínio da Mata Atlântica nas regiões Sul e Sudeste do Brasil.

Organização da tese

Esta tese está organizada em dois capítulos que foram escritos com a intenção de serem publicados como artigos independentes. Pretende-se condensar mais os capítulos para adequá-los às dimensões das publicações de fato, mas por ora, optamos por manter a estrutura mais detalhada e a riqueza de ilustrações por se tratar de partes de uma tese. O primeiro capítulo foi redigido no formato da revista "Journal of Tropical Ecology" e é intitulado "Floristic and structural composition of the arboreal flora of a mountain in the Atlantic Forest in southeastern Brazil". Este capítulo teve como objetivo principal analisar, em escala local, as diferenças nas comunidades arbóreas encontradas ao longo de um gradiente altitudinal na Serra do Mar. O segundo capítulo foi redigido no formato da revista "Journal of Biogeography" e é intitulado " A Floristic similarity analysis of Atlantic Forests in southern and southeastern Brazil". Este capítulo teve como objetivo principal analisar, em escala regional, as relações fitogeográficas entre as formações identificadas no capítulo 1 e outros levantamentos compilados da literatura, situados no domínio da Mata Atlântica na região Sul e Sudeste do Brasil.

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CAPÍTULO 1

FLORISTIC AND STRUCTURAL COMPOSITION OF THE ARBOREAL FLORA OF A MOUNTAIN IN THE ATLANTIC FOREST IN SOUTHEASTERN BRAZIL

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Abstract

Elevation gradients are scarcely studied in the Brazilian coastal Atlantic Forest. There is little known about floristic and structural composition in high elevation areas of this slope forest. The existence of critical altitudes as turning points to the vegetation's features is still a debate in the literature. The structure, the composition, and the richness of wood species along an elevational gradient were analysed. The existence of critical altitude was also a focus. A survey was made on five elevational levels (E-820m, D-970m, C-1120m, B-1200m, and A-1270m) on Mt. Cuscuzeiro (23˚ 18' 14" S and 44˚ 47' 16" W), which is 1277m in height. Ten samples (10x10m) were established on each of the levels E, D, and C, and five samples on each of the levels B and A. The sampling criterion was 4.8cm of D.B.H (levels C, D, and E) and 3.2 cm of D.B.H (levels A and B). From level E to level A was observed a decrease of species richness, tree height, diameter, and volume, and an increase in density. The analysis resulted in consistent groupings at the different levels, indicating a strong influence of the altitude on the floristic composition. An abrupt change of the vegetation was identified at 1120m, from where a typical Ombrophilous Dense Forest (Slope Forest) shifted into a Cloud Forest formation.

Key words: Atlantic Forest, Cloud Forest, critical altitude, elevational gradient, Mountain Cuscuzeiro, Ombrophilous Dense Forest, plant community, Serra do Mar, Ubatuba

Introduction

The Atlantic Rain Forest is among the most threatened biomes on earth. Since the Portuguese arrived in Brazil it has been vastly deforested throughout different economic cycles: sugar cane plantation, cattle raising, gold exploration, coffee plantation, and industrialization (Dean 1996). More recently, there has been deforestation for the building of high income vacation houses and of unauthorized low income constructions on the coastal areas (Mantovani 2000). Nowadays, over a 100 million people live in more than 3000 cities in areas originally covered by this forest, which has only ca. 12% remaining. Most of the remaining vegetation is fragmented in small patches of forest, highly influenced by the edge effect. And the larger continuum is formed by the very steep slopes of the "Serra do Mar" in the southeastern region (Ribeiro *et al*. 2009). It has been declared a Biosphere Reserve by UNESCO and a conservation super priority Hot Spot by Myers *et al.* (2000), due to its critical endangered status and the high levels of endemism.

Since the domain comprises different environmental gradients (e.g. rainfall, duration of the dry season, altitude, and distance from the ocean), there are distinct vegetacional formations, which makes it difficult to establish their boundaries (Joly 1999, Scudeller 2001, Oliveira Filho & Fontes 2000). However, recent studies have shown that the coastal province constitutes a conspicuous formation, very different from the inland plateau and from the other formations in this domain (Bertoncello *et al*. 2009 -see Chapter 2-, Scudeller 2001).

The steep slopes of the Serra do Mar create a barrier to the humid southeast trade winds from the ocean, leading to an increasing in rainfall. Also, the elevational gradient forms a more heterogeneous environment. These factors make the flora there much richer than the inland plateau forest (Oliveira-Filho & Fontes 2000). However, although close to the main research centers in Brazil, the flora on the higher areas of the Serra do Mar is still scarcely studied. For example, in a large review made by Scudeller *et al*. (2001), there was not a single survey from the slopes of the Serra do Mar in São Paulo state between altitude 350m and 700m, and the only survey from higher areas was made by Mantovani *et al*. (1990) in Salesópolis. After that Sanchez (2001) carried out a survey in higher areas of the Serra do Mar and only recently, Neto (2007) carried out a survey in three forests on the top of the Serra do Mar in São Paulo state. There is a lack of knowledge about species composition in higher areas, and how changes can happen in the floristic composition and structure along the elevational gradient in the Brazilian coastal slope forests, especially up to the summit.

The need for research in high elevational areas, especially on the tropical mountaintops, becomes more crucial if global warming is indeed approaching. Cloud Forests of the top of the mountains may be experiencing the dual stresses of changing microclimates and invading species from lower elevations, which would be driven in part by changes in the height of orographic cloud bank formation in the dry season and/or increased evapo-transpiration (Still *et al*. 1999). A high proportion of mountaintop species is expected to disappear in the imminent future (Colwell *et al*. 2008) as the coming climate changes appear very likely to upset the current dynamic equilibrium of the cloud forest leading to biodiversity loss, altitude shifts in species' ranges and subsequent community reshuffling, and possibly forest death (Foster 2001).

The studies of the elevational gradients are scarce in the Brazilian coastal Atlantic Forest. There are only a few thesis that yet have not been published (e.g. Blum 2006, Custódio-Filho 2002, Roderjan 1994, Sanchez 2001). So far, these studies have indicated a common trend of decreasing diversity along with increasing altitude in the Serra do Mar slopes, which is also common in both tropical and temperate ecosystems worldwide (Aiba & Kitayama 1999, Gentry 1995, Liberman *et al.* 1996, Odland 1999, Sruatek & Kolbek 1994, Vázquez & Givinish 1998).

In gradient studies, there has been a lot of debate whether or not there are discrete communities associated with different elevational levels. Many authors have claimed the existence of a critical altitude, from where an abrupt change in plant communities' composition would happen. For instance On Mt. Kilimanjaro in east Africa, Hemp (2006) detected significant discontinuities occurring simultaneously in different taxa (trees, shrubs, epiphytes, lianas and herbs) that were correlated with altitude, temperature, and soil acidity. Humidity (influenced by stable cloud condensation belts) and minimum temperature were considered key factors in the discontinuities. On Mt. Kinabalu in Borneo, Kitayama (1992) detected four discrete elevational vegetation zones correlated to climate characteristics, such as temperature and water availability. But discrete communities were not detected on mountains in Israel, Costa Rica and Mexico (Auerbach & Shmida 1993, Lieberman *et al.* 1996, Vázquez & Givinish 1998).

In southeastern Brazil, Sanchez (2001) found three discrete elevational zones from sea level to 1000m on Mt. Corisco. Roderjan (1994) and Blum (2006) also detected elevational zonation in the vegetation analyzed in the southern Brazilian mountains of the state of Paraná. Moreover, the official Brazilian vegetation classification by the Brazilian Institute of Geography and Statistic (IBGE) assumes that the Atlantic Ombrophilous Dense Forest of the Serra do Mar slopes is classified into different sub-formations according to elevational variation (Veloso *et al.* 1991), which in turn would reflect different discrete communities. Torres (1989) and Salis *et al*. (1995) using multivariate analysis detected the existence of two distinct clusters of samples in the inland plateaus of the state of São Paulo: one group containing forests in higher areas (above 700m) with a colder climate and another group formed of forests of lower altitude (500-700m).

In this study, we aim to address the following questions: How do structure, composition and richness of wood species vary along the elevational gradient studied on Mt. Cuscuzeiro? Are there critical elevational zones where vegetation changes occur at the study site?

Study Site

Mt. Cuscuzeiro is located in south-eastern Brazil, on the boarder of the states of São Paulo and Rio de Janeiro, in Ubatuba city, at coordinates 23˚ 18’ 14” S and 44˚ 47’ 16” W (Datum SAD’69). It is 1277m in height and sits approximately 4 Km from the Atlantic Ocean. Mt. Cuscuzeiro and Mt. Corisco form a valley with slopes of varying grades (ca. 700m high). The slopes are relatively gentle between the sea and the valley, but they become very steep between the valley and the summit. Mt. Cuscuzeiro appears as an isolated peak on the landscape (Figure 1).

Mt. Cuscuzeiro is inserted on the mountain slopes of “Serra do Mar” (Mountain Range of the Sea), a 1500 km long system of mountain ranges and escarpments in Southeastern Brazil, running parallel to the Atlantic Ocean coast, from the state of Santa Catarina to Espírito Santo. The main escarpment forms the boundary between the coastal plain and the inland plateau, which is higher and closer to the sea in this area. Geologically, the Serra do Mar belongs to the massive crystalline rock platform (Mantovani 2003) that forms eastern South America and is tectonically very stable.

The most extensive remains of the Atlantic Ombrophilous Dense Forest (commonly called the Atlantic Rain Forest *sensu strictu*) are on Serra do Mar (Mantovani 2003). It is protected by a State Park covering 3150km^2 in São Paulo state. According to the local people, selective logging of wood species had happened on Mt. Cuscuzeiro on a small scale until around 60 years ago. But apparently, there has not been exploration above 1000m, probably because the tree height and width are reduced; hunting and palm heart logging are also scarce there; tourism is practically nonexistent and access is very restricted (more than six hours of walking up steep hills).

The climate is very warm and humid, characterized by Af type (sensu Köeppen 1948), with more than 2200mm of pluviosity per year, mean annual temperature higher than 18° C, and no dry season. Since there are no weather stations on higher levels, we can only deduce that the temperature is lower, in accordance with the common knowledge that it declines about 0,6 °C each 100m, and that the humidity is considerably higher, as we noticed during the field works, due to the clouds that frequently swath the slopes and peaks.

Methods

A total of 40 samples 10x10m were located between 820m and 1270m on Mt. Cuscuzeiro (see pictures of the levels on appendix II). On the top of the mountain, at 1270m height (level A), were located five samples, with 20m of horizontal distance from each other, which covered all extension of this level. At the second plateau of Mt. Cuscuzeiro, approximately 1200m height (level B), another five samples were located, covering almost all the feasible surface, with 20m horizontal distance from each other. Because of the reduced feasible surface on these two top plateaus, the location of the samples on the higher level was splitted into levels A and B, each containing five samples. At 1120m, 970m and 820m (respectively levels C, D and E) another 10 samples were located on each level, all of them on northwest facing slopes.

The sampling criteria of this study included all the tree species ≥ 4.8cm D.B.H. (diameter at breast height -1.3m height). However, in order to have a better characterization of levels A and B, all tree species ≥ 3.2cm D.B.H. were also included. All vouchers were collected, pressed, wetted with 70% alcohol and kept in plastic bags for several days during the field trips, during the years of 2006, 2007 and 2008. The specimens collected were dried and deposited in the Herbarium of

Campinas State University (UEC). Most of the species identification was made by the first author using specialized literature and through comparison of exsiccates in the major Brazilian southeastern herbaria. In some cases, we got help from specialists, as like as Myrtaceae (M. Sobral), Symplocaceae (J.L.M. Aranha Filho), Melastomataceae (R. Goldemberg), Lauraceae (J.B. Baitello), and others. The circunscription of families' sensu APG (Angioperm Phylogeny Group, 2003) was adopted.

The phytosociological analyses were carried out by using the Fitopac program (Shepherd 2007). A collector curve and a collector curve of rare species were made (rare species is defined here as those that appear only once trough the inventory) with 100 randomly generated curves for comparison. We made a Correspondence Analysis (CA) and a Principal Components analysis (PCA). A Similarity Analysis, using Bray-Curtis index, for both Mean Average Group (UPGMA) and Ward`s Method was made. A three dimensional image of the first three axes was generated by the program VRML in order to help visualize all the samples in a multidimensional space. In addition, a two way indicator species analyses (TWINSPAN) was carried out and a list of indicators and preferential species was generated.

Results

A total of 165 species and 47 families were found at the study site (see annex for species list). 81.8% of the taxa sampled was identified at species level, 10.3% at genus level and 7.8% remains identified only at the family level. The majority of undetermined species belongs to families like Myrtaceae and Lauraceae, which reflects the lack of taxonomic knowledge in these families (Scudeller *et al.* 2001, Siqueira 1994). This may be due to the high indices of diversity and endemism in the Atlantic Rain Forest (Gentry 1992) combined with the lack of collections in Serra do Mar at higher altitudes.

Two new species for the family Myrtaceae (*Calyptranthes* sp. nov and Myrtaceae sp. nova, M. Sobral pers.comm.) were collected, as well as a new species of Symplocaceae (*Symplocos* sp. nova) (J.L.M. Aranha Filho pers. comm.). There were collections of a species that could possibly be a new species from the family Monimiaceae (A.L. Peixoto pers. comm.). Although already collected on other studies, two species not yet described by science were collected: *Quina aff. Magalanogomezi* (sp. nova) (Quinaceae) and *Ouratea* sp. (Ochnaceae) (K. Yamamoto pers. comm.). There were also two new records for São Paulo state: *Stephanopodium* cf. *blanchetianum* Baillon (Dichapetalaceae) (G.T. Prance pers. comm.) and *Ilex* cf. *congonhina* (Aquifoliaceae) (M. Groppo pers. comm.).

Myrtaceae (41 species), Lauraceae (17) Rubiaceae (16), and Melastomataceae (11) were the richest families (in number of species) on all levels (Figure 2). At the levels A,B,C (from 1270m to 1120m), Myrtaceae was the richest family (20), followed by Lauraceae (9), Melastomataceae (6), Rubiaceae (5), and by two families that occur exclusively in these upper levels, Myrsinaceae (4) and Aquifoliaceae (3). At the levels D and E (970m and 820m), Myrtaceae was also the richest family (33), followed by Rubiaceae (14) Lauraceae (12), Leguminosae (8) and Melastomataceae (5).

The collector's curve for all samples shows that species richness decreases with altitude (Figure 3). The normal curve is separated from all the curves randomly generated, which means that species are not equally distributed along the gradient. Factors correlated with altitude are very likely to be influencing their distribution. The normal line tends to stabilize rapidly on the first five samples (level A), becomes steeper on the next 15 samples (levels B and C), and stabilizes at the end of the level C. From this point, the line steeps again towards the levels D and E, indicating higher species richness in these lower areas.

The curve of rare species proportion is shown in Figure 4. At levels A and B (samples 1-10), it stabilizes rapidly indicating that for each new species found there is another species already coollected. Level C (samples 10-20) shows a new incoming of rare species indicating more diversity, although stabilizing towards the end. There is a great discontinuity between the levels C and D, suggesting changes in floristic composition from levels [A, B, C] to [D, E]. At the levels D and E, there is another income of rare species showed by a very steep line, and again stabilizing by the end, indicating great diversity and some floristic similarity between these two lower levels.

It is clear that altitude strongly influences floristic and structural patterns above level D: there is a decrease of species richness, tree height, diameter, volume, numbers of individuals, diversity (H') and equability (Pielou), associated with the increased number of stems at breast height (branching) and density (Table 1). Levels E and D show a similar number of individuals (157 and 158), and from level C to the top (B and A) this number increases to 231 and 262 (for inclusion criteria D.B.H ≥ 4.8cm). On the other hand, DBH and tree height decline with increasing altitude. Levels E and D show a higher average diameter, height, and volume, and a much higher maximum diameter, height, and volume of the trees. These results point to a similar structure on levels E and D and a changing on these patterns from C, towards levels B and A. Changes on structure start on level C and are amplified towards levels B and A.

The dominant woody species tend to be much smaller and thinner at the top of Mt. Cuscuzeiro, so floristic and structural analyses of the gradient where also carried out with a broader inclusion criteria at the levels A and B (D.B.H ≥ 3.2cm). There was not a great difference among the analyses, so we only show part of them. In the broader inclusion criteria (D.B.H ≥3.2cm), five species (*Hedyosmum brasiliensis* Mart., *Meriania* sp., *Mollinedia* sp., *Ocotea vaccinioides* (Meis.) Rohwer and *Podocarpus sellowii* Klotz.) and 82 individuals were added, increasing the density of woody species (from 1460 to 2380ha^{-1} on level A; from 3780 to 4500 ha^{-1} on level B; and from 2620 to 3440 ha^{-1} on level A and B together). This result gives a better picture of what was actually observed because the other criteria excluded most of the thinner individuals that are part of the dominant strata in those higher levels.

The Correspondence Analyses (CA) clustered the samples consistently on each level (explanation percentage 5.32 and 7.16%), especially concerning A, B and C; however, D and E were slightly less consistent (Figure 5). When considering the broader inclusion criteria, the CA (explanation percentage 5.32 and 7.49%) amplified the dissimilarity among samples on levels D and E, as well as the similarity of A and B (Figure 6). The explanation percentage of the first two axes, although not very high, is considerably higher than a random distribution (2.5% each axis, for 40 samples). These results indicate a strong influence of the elevational gradient on the abundance and composition of the species. The PCA analyses (data not shown) was vulnerable to the gradient effect (the arch effect as described by Kent & Coker 1992), disturbing the interpretation as the extremities were approached. The dissimilarity between D and E suggests an effect of another gradient occurring within the major elevational one. The visualization of the three dimensional image (VRML) reinforced the view of a second gradient affecting levels D and E (data not shown).

The dendrograms produced by similarity analysis make a clear separation of the two groups, formed by [A, B, C] and [D and E] (Figures 8 and 9). In the first group, both dendrograms show level A (top of the Serra do Mar) clearly separated from B and C, except for sample AIII. In the second group, both dendrograms show samples from levels D and E mixed, reinforcing the existence of a second gradient influencing their distributions.

The two-way indicator species analysis (TWINSPAN) also makes a clear distinction between groups [A, B, C] and [D and E], as shown in the dendrogram of resulting groups in Figure 9, and by the preferential species for division 1 and 2 made by TWINSPAN in Table 2. The Importance Value on each level of the indicator species on divisions 1, 2, and 3 is shown in Figure 10, which corroborates the idea of a major discontinuity between groups [A, B, C] and [D and E]. Only ca. 18% of the species occurs in both groups. Moreover, it shows the presence of the dominant species on higher levels and a more equal distribution on lower levels.

Discussion

Diversity

At the study site, the diversity index (H') exceeds normal expectation (Kent & Coker 1992, Magurram 1989) due to the great ß diversity that is a result of the floristic distinction inherent to each elevational level. Such great arboreal diversity has been seen elsewhere in the few elevational gradient studies carried out in the Atlantic Ombrophilous Dense Forest (Blum 2006, Custódia-Filho 2002, Sanchez 2001). Although Tabarelli & Mantovani (1999) have claimed that the Atlantic Ombrophilous Dense Forest does not support great diversity of woody species, its floristic complexity in the São Paulo State is greater than expected for arboreal communities in general (Scudeller *et al.* 2001).

The available data from 36 tropical Andean sites show that for high altitude areas (from 1500m to 2900m), Lauraceae has most of the species of all the woody families, followed by Melastomataceae and Rubiaceae (Gentry 1995). These three families were also among the richest at the higher levels on Mt. Cuscuzeiro, but Myrtaceae was the richest, as it was at the lower elevational levels. This was expected because many authors have already pointed out Myrtaceae as the richest family in the Atlantic Forest (Blum 2006, Ivanauskas 1997, Koehler 2001, Oliveira-Filho & Fontes 2000, Roderjan 1994, Sanchez 2001, Tabarelli & Mantovani 1999). Besides, the Brazilian coast is most likely the dispersion centre of the family (Mori *et al.* 1983), which has been considered as an indicator of well conserved forests (Tabarelli & Mantovani 1999).

Despite the fact that southeastern Brazil, especially Ubatuba (SP), is one of the most collected spots in the country (Shepherd 2005), there is still a considerable fraction of diversity yet to be discovered and described, particularly at higher altitudes of the Serra do Mar, due to access restrictions because of the very steep slopes. We have found many arboreal species not yet described by science and some new records for the state of São Paulo, likewise Sanchez (2001) who had found about nine new arboreal species on Mt. Corisco, just across the valley from the present study site. Falkenberg (2003) also found several new species at high altitudes in the south Brazil, and Gentry (1992) reported Andean spots with great amounts of undescribed species.

The decreasing of diversity with the increasing of altitude that occurs on Mt. Cuscuzeiro, within the elevational range examined, is a trend not only seen in the Brazilian Atlantic Forest (Blum 2006, Roderjan 1994, Sanchez 2001), but also on many mountains, in both tropical (Aiba & Kitayama 1999, Gentry 1995, Liberman *et al*. 1996, Vázquez & Givinish 1998) and temperate ecosystems worldwide (Odland 1999, Sruatek & Kolbek 1994). The elevational narrowing of land area might be related to this trend (Körner 2000). Because of the larger area of lower elevational zones, there is a) a greater total amount of solar energy, resources and population number, b) more refugia and more space for species with larger home ranges, c) greater diversity of environments, and d) greater potential for serving as a target for potential immigrations (Lomolino 2001). However, it seems reasonable that this decrease of richness is also driven by other factors because there is also a strong floristic differentiation associated with changes in altitude.

Within the decreasing of diversity there was an increase in species turnover along the elevational gradient on Mt. Cuscuzeiro (see CA showed in Figures 5 and 6) as it was predicted by Jazen (1967) for tropical mountains, indicating that most of its species have narrow ecological niches. Only one species appeared on all elevational levels (*Alibertia myrcifolia*) but with low values of abundance and importance. Horizontal turnover within each elevational level was greater at lower altitudes, showing that low elevation forest are not only locally more diverse, but spatially more patchy, as seen in Mexico by Vázquez & Givinish (1998). The altitude had minor effect on the distributions of the lower elevational samples (D and E). There was influence of another gradient, which might be conditioned by other factors, e.g. changes in soil characteristics, as the TWINSPAN analyses clustered them into two groups (groups 3 and 3' shown on Figure 9) which approached a horizontal relationship (Figure 11).

Critical Altitude

The differentiation between groups formed by levels [A,B,C] and [D,E] was demonstrated by the TWINSPAN analysis and reinforced by the Similarity Analysis and the Correspondence Analysis. Moreover, both the collector curve and the collector curve of rare species show a discontinuity between these groups, which is also represented in Figure 10. These results indicate the existence of very distinct communities in these two different levels. On Mt. Cuscuzeiro, the critical altitude for the appearance of a distinctive floristic and structural community is about 1120m.

Significant discontinuities in the community, reflecting critical altitudinal zones, were observed by other authors in Africa and Borneo (Hemp 2006, Kitayama 1992) and in the Brazilian Atlantic Forest (Blum 2006, Roderjan 1994, Sanches 2001, Veloso *et al*. 1991). A comparison of steep and gentle slopes in a semiarid part of Ethiopia revealed that there was more discontinuity in the vegetational changing caused by altitude along the steep slope than along the gentle slope (Beals 1969).

It worth noticing that within these two different zones observed on Mt. Cuscuzeiro, there is still a continuous change in the vegetation. On lower elevational levels [D,E] there is an influence of a horizontal gradient, as already described. Within the upper levels [A,B,C], there is a differentiation correlated with altitude and topography, with continuous changes in diversity, structure and floristic composition.

The Slope Forest (levels D and E)

The preferential species of levels D and E (division 1' of table 2) are typical species of a well conserved slope forest. The richest families are Myrtaceae, Lauraceae and Rubiaceae (Figure 2). The large number of rare species seen at lower elevational levels is frequent elsewhere because this forest is characterised by the predominance of species with low constancy and restricted distribution (Caiafa 2008, Scudeller *et al*. 2001). The species there have a gradual turnover and the altitude did not show a great influence on their distribution. Structurally, levels D and E are very similar. They have lower density compared to the higher areas. The physiognomy is composed by large trees and a large variety of ombrophilous species on the understory (especially from the family Rubiaceae, which is far more frequent on the lower levels) and young dominant trees. These areas contain the tallest trees of the study site (25m and 28m on levels D and E, respectively), which can be related to the lower percentage of branched trees at breast height (Table 1), as they might be growing upwards toward the sun light rather than trying to occupy a larger lower area through branching.

Manilkara subsericea (Sapotaceae) appears as a preferential species of the slope forest at the TWINSPAN analysis; it is one of the most important species (high IVI, see Figure 12) on levels D and E, especially due to it´s large volume. Many other trees appear with both high IVI and as preferential species on the TWINSPAN division, for example *Parinari excelsa* and *Licania hoehnei* (Chrysobalanaceae), *Posoqueria latifolia* and *Amaioua intrermedia* (Rubiaceae), *Mollinedia boracensis* (Monimiaceae) and *Inga lancifolia* (Leguminosae). *Euterpe edulis* (palm heart), a frequent species all over the slope coastal forests, only occurred on levels D and E at the study site.

In general, the slope forests are very diverse and with no dominant species (Mantovani 1996, Sanchez 2001), which lead to high equability and diversity indexes (see Table 1).

A Cloud Forest in the Atlantic Forest (levels A, B and C)

The preferential species of the community at levels A, B, C (division 1 and 2 on figure7 and table 2) are typically associated with Tropical Cloud Forest in southern and south-eastern Brazil, e.g. *Drimys brasiliensis, Myrceugenia* spp., *Ilex theezans, Weinmannia humilis, Gordonia fruticosa, Pimenta pseudocaryophyllus, Symplocos* spp., *Clusia criuva, Guapira opposita, Ouratea vaccinioides, Rapanea gardneriana, Ocotea curucutuensis, Ocotea* spp., *Blepharocalyx salicifolius* (Arzolla *et al*. 2009, Falkemberg & Voltolini 1995, IBGE 1990, Klein 1979, Koehler *et al*. 2002, Mantovani *et al*. 1990, Meireles 2003, Portes & Galvão 2002, Roderjan 1994). At the genus level, there is some similarity with the vegetations occurring above 1500m in Andean, Central American, and Mexican forests, where a distinctive group of taxa appears, e.g. *Rapanea, Ilex, Ocotea, Clusia* and *Weinmannia*, which also barely overlap with those of lowland tropical forest (Gentry 1995). Webster (1995) considers diagnostic of Neotropical Cloud Forest, genera such as *Drymis, Hedyosmum, Weinmannia, Clethra, Podocarpus, Meliosma, Meriania, Ilex, Clusia, Myrsine, Miconia* and *Prunus*. All of them were found on levels A,B,C (from 1120m to 1270m) of our study site (*Meliosma* did not meet the inclusion criteria of our study, but it was collected).

Apart from the floristic similarity of arboreal species, the similarity of other life forms and physiognomic characteristics among Tropical Cloud Forests is important to note. For instance, there is an abundance of bamboo (*Chusquea* sp.), Bromeliaceae, mosses and lichens (at the summit, Bromeliaceae and mosses even cover the soil surface). There is a significant diminishing in tree height and an increasing in the number of branches as they become more twisted. The soil is shallow with much litter on the surface. These general patterns are commonly seen elsewhere in Tropical Cloud Forests (Falkemberg & Voltolini 1995, Stadtmüller 1987).

Although Cloud Forests around the world are commonly associated with higher elevational limits varying between 1500m and 2500m (Stadtmüller 1987), the presence of Cloud Forests in such low altitude on Mt. Cuscuzeiro can be explained by the mountain mass elevation effect (Massenerhebung), which means the occurrence in small isolated peaks, especially those in or near the sea of vegetation types that are physiognomically and sometimes floristically similar to those at higher altitudes on large mountain masses (Flenley 1994). Mt. Cuscuzeiro is an isolated peak within the mountain slopes of the Serra do Mar, which are very close to the sea in south-eastern Brazil, creating a barrier to the humid south-eastern trade winds from the ocean. The adiabatic ascent of moist air causes condensation at certain elevations and thus produces clouds (Stadtmüller 1987), which frequently remain stagnate over the vegetation on high slopes of Serra do Mar. Thus, the Cloud Forest there occurs under the influence of frequent fog and heavy orographic rainfall. Cloud Forests occur bellow 1000m in the Lesser Antilles (Beard 1949), Puerto Rico (Weaver 1972) and about 700m in southern Brazil (Falkemberg & Voltolini 1995, Falkemberg 2003), although infrequently described in literature.

The fog's effect on the vegetation

The fog's effect on the vegetation has several consequences. There is a larger entry of water into the ecosystem conditioned by the condensation process of the humidity of clouds or fog on vegetation, which is called horizontal precipitation (Stadtmüller 1987). Although in extremely rainy climates the relative values are only between 7.2% and 18% of rainfall equivalent, during the dry season the values are extremely high and can even exceed those of the rainfall

(Stadtmüller 1987). Furthermore it has been claimed that some leaves can directly absorb water from fog (Cavalier & Golstein 1989) and the assemblages of epiphytic bryophytes, vascular epiphytes, litter and humus are responsible for a large amount of N absorbed (Clarck *et al*.1998). Apparently the water absorption by leaves also happens at higher altitudes of Serra do Mar (Oliveira *et al*. 2007), for both tree and epiphytes.

The association of low temperature and high moisture in the soil leads to a slow mineralization process (Grubb 1971, Marrs *et al*. 1988), resulting on a litter accumulation at the cloud forest vegetation zone, as seen on levels A,B,C but especially on level A. Several nutrients, mainly N and P, decrease remarkably with increasing altitude on tropical mountains (Sanches 2001, Soethe *et al*. 2008, Tanner *et al*. 1998). Thus, the growth on the higher altitudes of Mt. Cuscuzeiro may be limited by natural supplies of N and P (Grubb 1971, Marrs *et al*. 1988, Tanner *et al.* 1990). In Argentina, the influence of clouds leads to a unique discontinuity in the elevational gradient in biological characteristics of the soil, not expected by rainfall and temperature changes alone (Abril & Bucher 2008). In southern Brazil, Roderjan (1994) found a close relationship between soil characteristics and Cloud Forest vegetation, which may be conditioned by the frequency of fog.

It has been affirmed that cloud cover constrains photosynthetic process by limiting available photosynthetically active radiation and wetting the abaxial surface of foliage (Letts & Mulligan 2005). But Flenley (1994) argued that total insolation (UV-B light) may be increased by up to 70% through reflection from clouds, which would explain the stunted growth, short internodes, and thick small leaves (xeromorphic aspect) of Tropical Cloud Forests. This is the exact opposite of what would be expected from plants growing in conditions of high humidity and low insolation, where they would become etiolated. It is a meaningful observation we made in Mt. Cuscuzeiro that especially in autumn, it is common to have one or two weeks of totally clear sky, with high maximum temperatures and relatively constant winds. This situation accelerates the transpiration, thus leading to some degree of drought stress, and vegetation must be able to resist sunburn or occasional excess transpiration (Leight 1975), which could also explain the xeromorphic aspect of the vegetation.

A Dwarf Cloud Forest on the Cuscuzeiro summit (level A)

Level A (summit) is the extreme of the Cloud Forest formation, where the vegetation has a very xeromorphic aspect with stunted stature, thick leaves, and twisted trunks with many branches, resembling a 'bonsai' physiognomy. The soil is often covered by a thick layer of organic matter, with a great abundance of ephyphytes, facultative bromelias, mosses and liquens. According to Leigh (1975), epiphytes compete for space on the ground of mountain summits because the climate provides so little power for drawing nutrients from the ground that being rooted in soil is of little use except for support. On the steep rocky faces just below the summit, there is rocky vegetation, as seen in several places in southern Brazil ("vegetação rupícula" sensu Falkemberg 2003).

Many factors have been related to the stunted growth, like saturated soils and reduced transpiration, insufficient drainage of the soil and physiological desiccation, nutrient leaching combined with low temperatures and frequent cloud cover, reduced transpiration, shallow soils, and reduced solar radiation (see Weaver *et al.* 1973). However, the major difference from the vegetation of the summit (level A) to the Cloud Forest of levels B and C is likely to be its exposure to strong winds. For instance, sample AIII that was allocated in a valley, which was therefore less exposed to winds, was clustered with samples from levels B and C in the similarities analysis and with sample BI on division 4 of TWINSPAN analysis. We found that the tallest trees on the top of Mt. Cuscuzeiro occur in protected ravines and on leeward slopes, and the shortest trees occur on windswept ridges. This has been seen elsewhere on tropical mountains, as described by Howard (1970) and Weaver *et al.* (1973). A less developed ontogenetic structure makes plants able to cope better with wind effects (Cordero 1999).

The increasing in branching (Table 1) is also a common pattern on Cloud Forest (Falkemberg 2003, Roderjan 1994) and may be a response to strong winds, so that a possible damage would occur only to a part of the plant and it can also help to stabilize. The umbrella-like crown is often described in Cloud Forests (Falkemberg 2003, Richards 1996), where tree crowns are designed to minimize the cooling effects of wind (Leigh 1975). They are remarkable on the top of Mt. Cuscuzeiro, especially in *Weinmania humilis.* Many authors have accepted the effect of strong winds on growth in exposed sites (Grubb 1977, Lawton 1982, Leight 1975). Weaver *et al.* (1973) points out that slow transpiration, combined with mechanical wind pruning is a major cause of tree height reduction and suggests that leathery texture may be an adaptive feature to prevent defoliation during peak wind velocities, rather than reduce transpiration as in some habitats. Furthermore, according to Table1, density in level A is lower than in levels B and C. This is due to the abrupt stature reduction at the summit. Even when considering the broader inclusion criteria, a considerable number of woody plants, with bonsai-like physiognomy often less than two or three meters height, were not included in the inventory. Even though, these plants were mostly of the same species collected and that were the dominant tree species of the samples. Using an inclusion criterion of 1.8m in height, Weaver (1972) also found a density of about 15000 ind. ha^{-1} in a physiognomically similar forest in Puerto Rico.

This particular vegetation frequently forms the upper limits of tropical mountain forests, or covers the summits and ridges of isolated and exposed mountains. It has received many names by different authors, such as Elfin Woodlands, Montane Woodlands, Elfin Thicket, Mossy Forest, Mountains Moss Forest, Mossy Mountain Forest, Dwarf Forest, Dwarf Cloud Forest, Elfin Forest, Wind Forest (see Stadtmüller 1987) and Pygmy Forest (Werner 1993). Regardless, some authors include this vegetation in cloud forests, while others have a tendency to exclude it (Stadtmüller 1987). Cased on TWINSPAN and similarity analysis we considered the summit vegetation at our study site as a sub-type of Cloud Forest because it is under the influence of dense and frequent clouds which, apart from other factors, play an important ecological role (Stadtmüller 1987). Therefore, we adopted the name “Dwarf Cloud Forest” for this particular kind of vegetation. The preferential species for the Dwarf Cloud Forest on Mt. Cuscuzeiro are those represented by division (2) of Table 2. Its species diversity is low when compared to levels B and C. However, there are some species that are exclusive to this formation on Mt. Cuscuzeiro. Besides, it has a couple of dominant species, as seen in other studies in Brazil (Falkemberg 2003), *Ouratea vaccinioides* (IVI 49,16 for the broader criteria) and *Symplocos* sp. nov. (IVI 46,67 for the broader criteria) in our case. These species were considered respectively as indicator species of Cloud Forest (division 1) and Dwarf Cloud Forest (division 2) in TWINSPAN analysis (Table 2 and Figure 7).

The archipelagic distribution

We believe that *Symplocos* sp. nova is endemic to a few mountain tops restricted to Mt. Cuscuzeiro adjacencies because the genus *Symplocos* has many endemic species restricted to mountain summits in Brazil, e.g. *S. glaziovii* Brand*, S. microstyla* Aranha, P.W. Fritsch & Almeda and *S. angulata* Brand (Aranha Filho *et al.* 2007). Taking into consideration that Neotropical Cloud Forests are characterised by their archipelagic distribution (Luna-Vega *et al.* 2001), many other species have disjunct distributions (Meirelles 2003). The biological isolation of these communities on different ‘islands’ inserted in a tropical forest matrix is known to be responsible for an extremely high level of endemic species (Gentry 1992, Gentry 1995, Luna-Vega *et al.* 2001). Populations separated by altitude in the tropics will experience reduced gene flow leading to greater genetic divergence, setting up the conditions that favor accelerated rates of allopatric speciation (Ghalambor *et al.* 2005).

Final considerations

The results presented in this paper show a great floristic discontinuity at approximately 1120m on Mt. Cucuzeiro, above which a discrete community appears: a Cloud Forest formation. Although not as rich as the lowland forest, it still has a great number of woody species and endemisms, due to suitability for speciation, leading to a raise in ß diversity. Neotropical Cloud Forests are considered among the world´s most threatened ecosystems (Hamilton *et al.* 1995), and the Atlantic Forest itself, where this particular Cloud Forest sits, is one of the most threatened tropical forests (Myers *et al*. 2000). Furthermore, research and preservation should account to its importance to the hydrological cycle (Stadtmüller 1987) and the impacts of a possible imminent global climate change (Pounds *et al.* 1999). This formation is under serious risk of disappearing as a consequence of changes in the height of orographic cloud bank formation (Still et *al*. 1999). As stressed by Gentry (1995) and Myers *et al.* (2000), this should be a key conservation ecosystem for the global environmental agenda.

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FIGURES AND TABLES

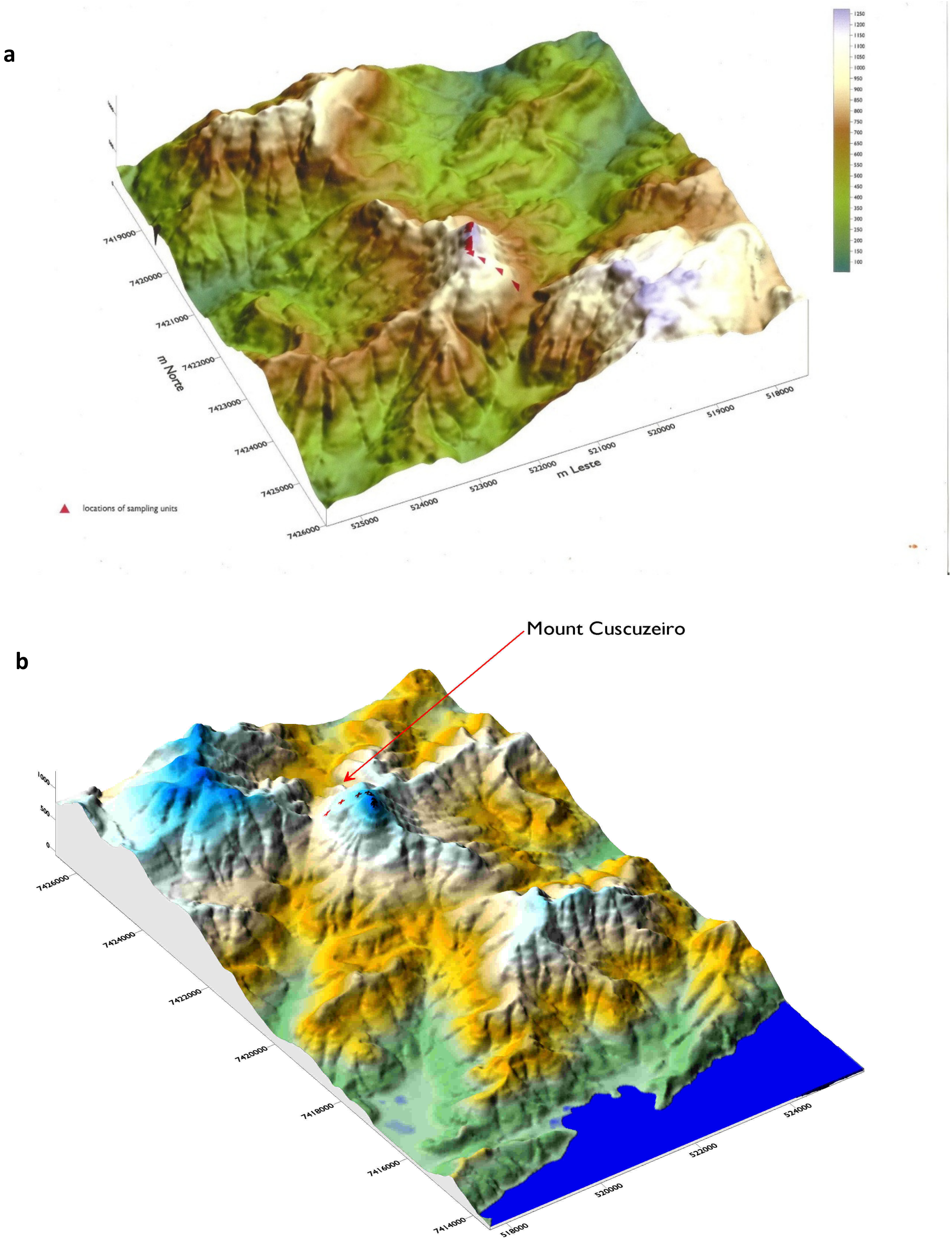

Figure 1 (a and b). Location of the plots on an image of Mount Cuscuzeiro and sorrounding area.

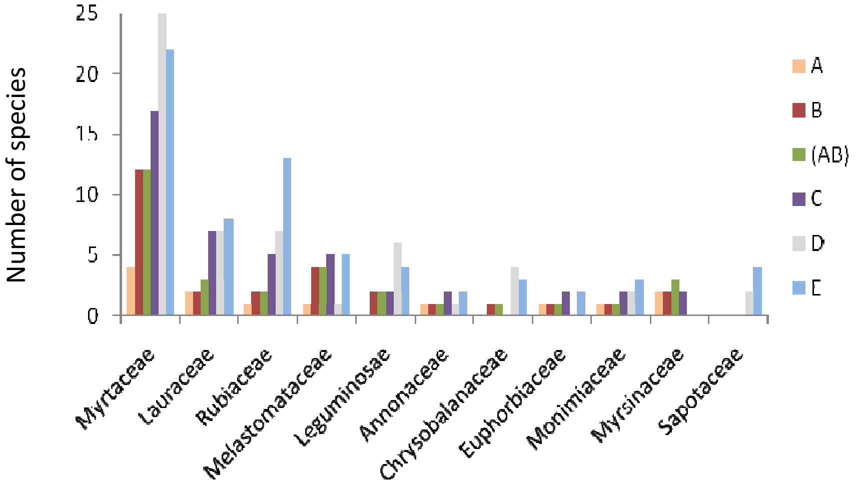

Figure 2. Richness of species on the different elevational levels on Mt. Cuscuzeiro in Ubatuba, southeastern Brazil. A=1270m; B=1200m; (AB)= 1270m and 1200m; c= 1120m; D=970m; E= 820m.

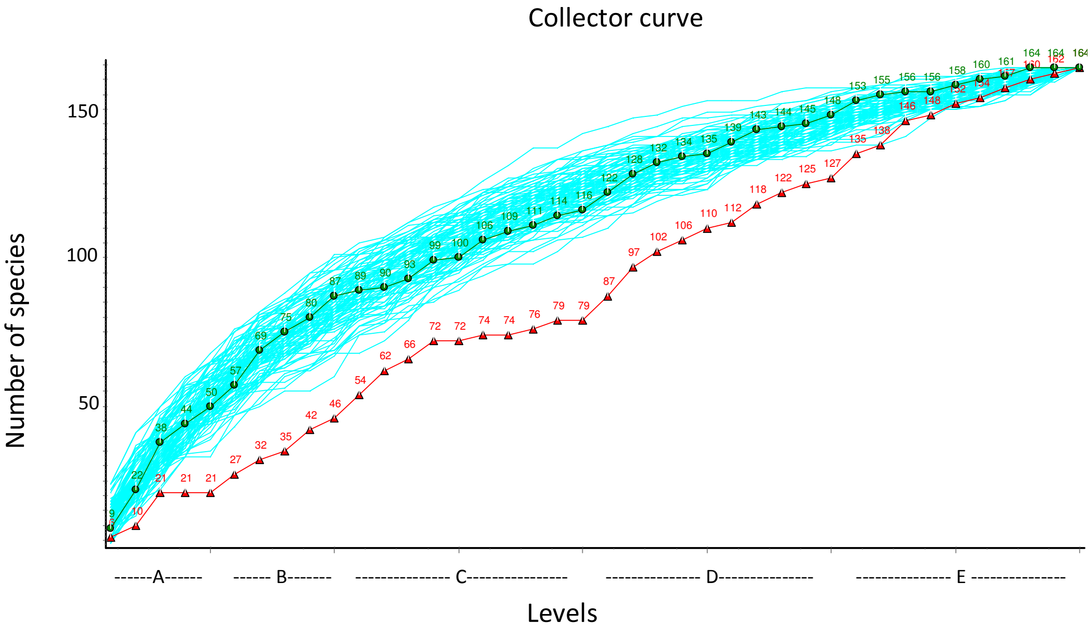

Figure 3. Collector curve of species on the different elevational levels on Mt. Cuscuzeiro in Ubatuba, southeastern Brazil. A=1270m; B=1200m; C= 1120m; D=970m; E= 820m. The bottom line is the “normal line”. The top line is “the normal line inverted” and the blue lines represent 99 randomly generated lines.

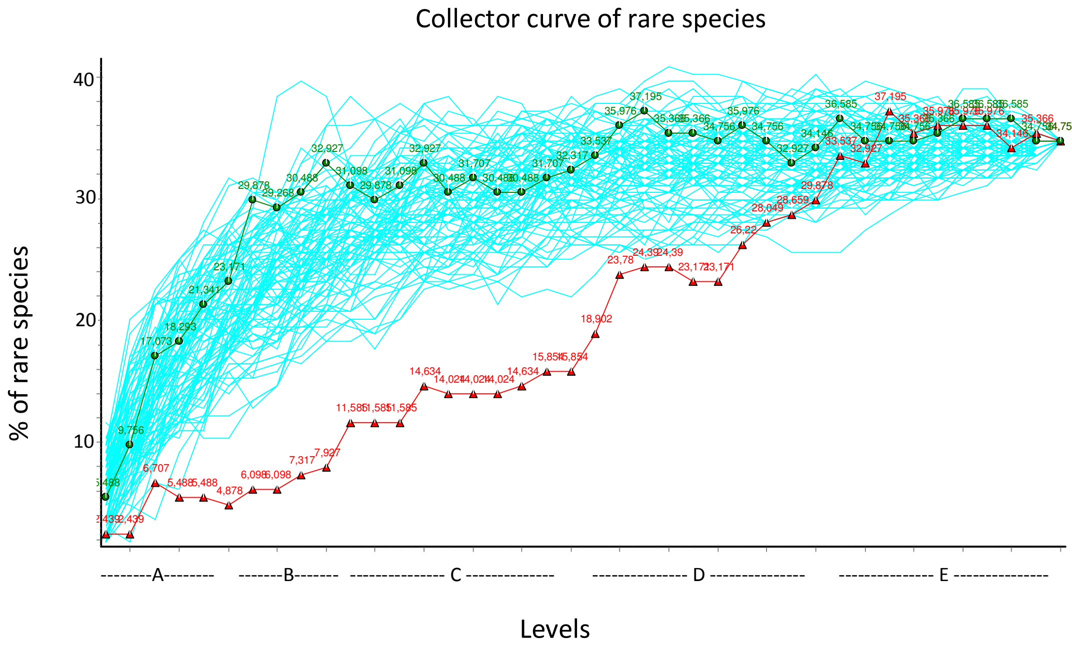

Figure 4. Colector curve of rare species on the different elevational levels on Mt. Cuscuzeiro in Ubatuba, southeastern Brazil. A=1270m; B=1200m; C= 1120m; D=970m; E= 820m. The bottom line is the "normal line". The top line is "the normal line inverted" and the blue lines represent 99 randomly generated lines.

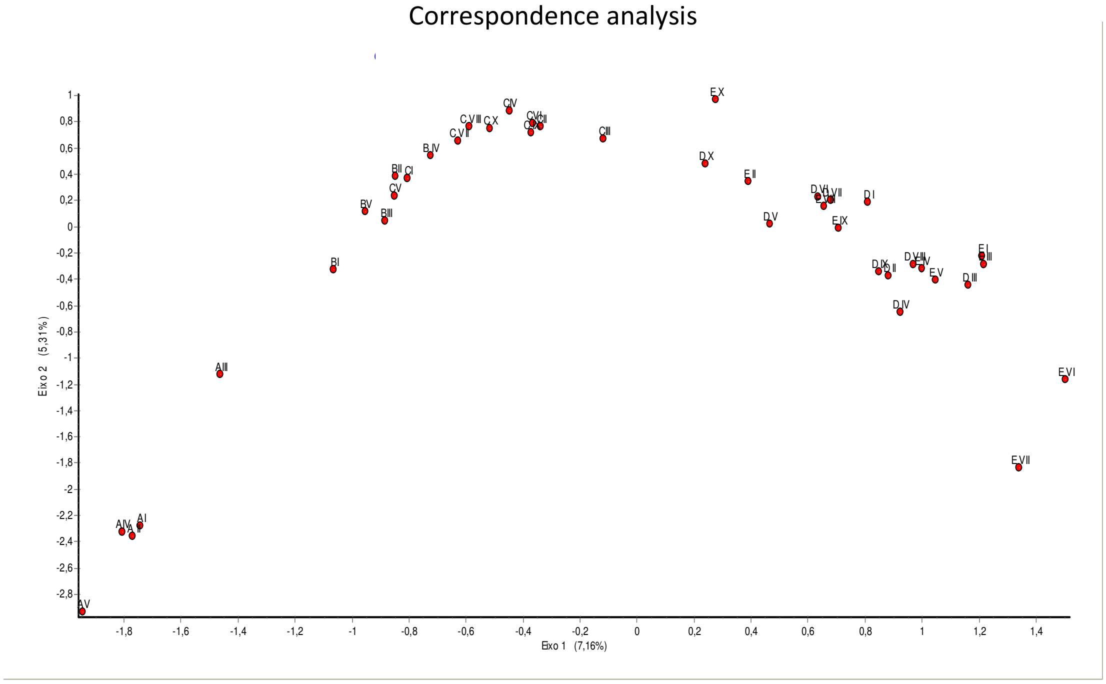

Figure 5. First axis of the Correspondence Analysis (CA) for tress ≥ 4,8cm dbh along the elevational gradient on Mt. Cuscuzeiro, in Ubatuba, southeastern Brazil. A=1270m; B=1200m; c= 1120m; D=970m; E= 820m

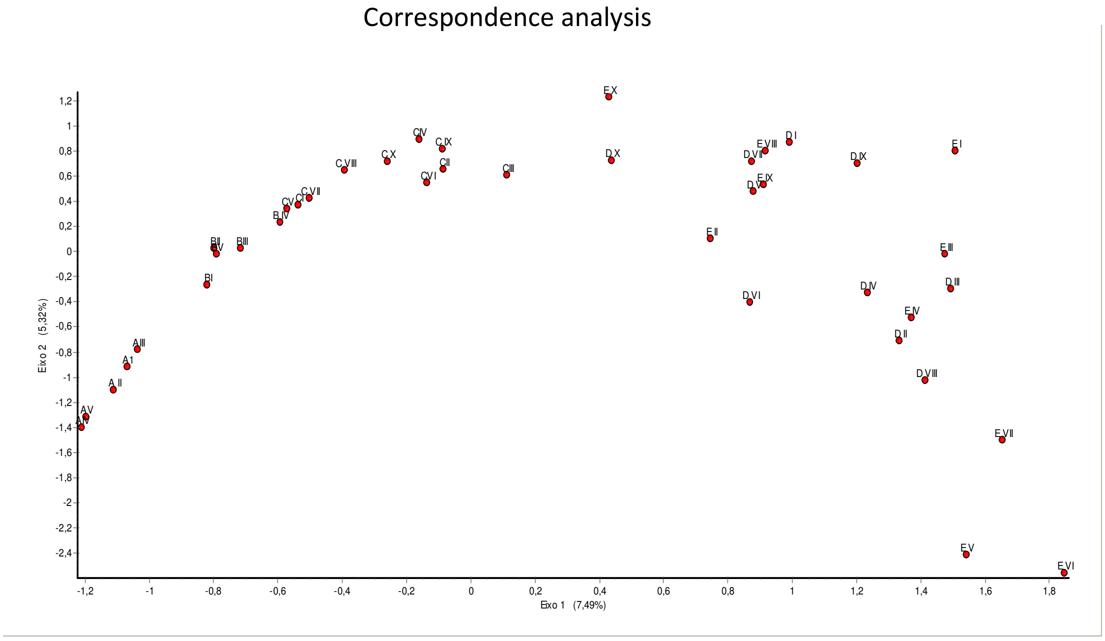

Figure 6. First axis of the Correspondence Analysis (CA) for tress ≥ 3,2cm dbh on levels A and B, and trees ≥ 4,8cm dbh on levels C, D and E, along the elevational gradient on Mt. Cuscuzeiro, in Ubatuba, southeastern Brazil. A=1270m; B=1200m; C= 1120m; D=970m; E= 820m.

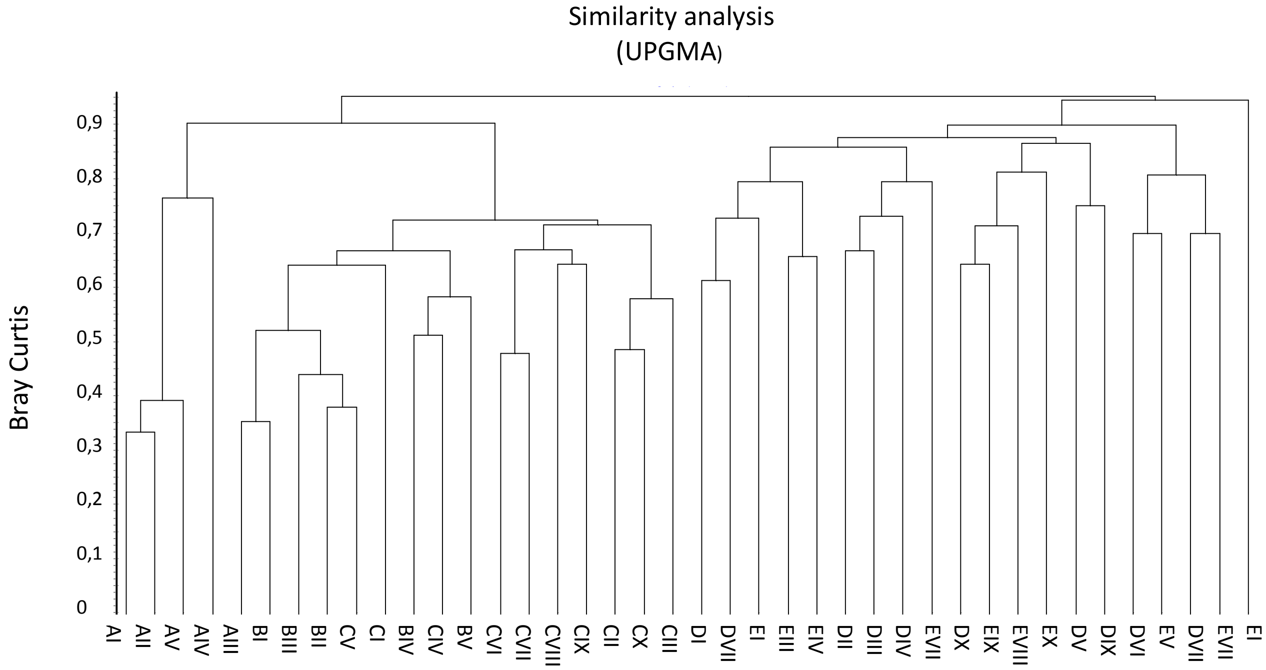

Figure 7: Similarity analysis for mean average group (UPGMA), using Bray Curtis index for tree ≥ 4,8cm dbh along the elevational gradient on Mt. Cuscuzeiro, in Ubatuba, southeastern Brazil. A=1270m; B=1200m; C= 1120m; D=970m; E= 820m.

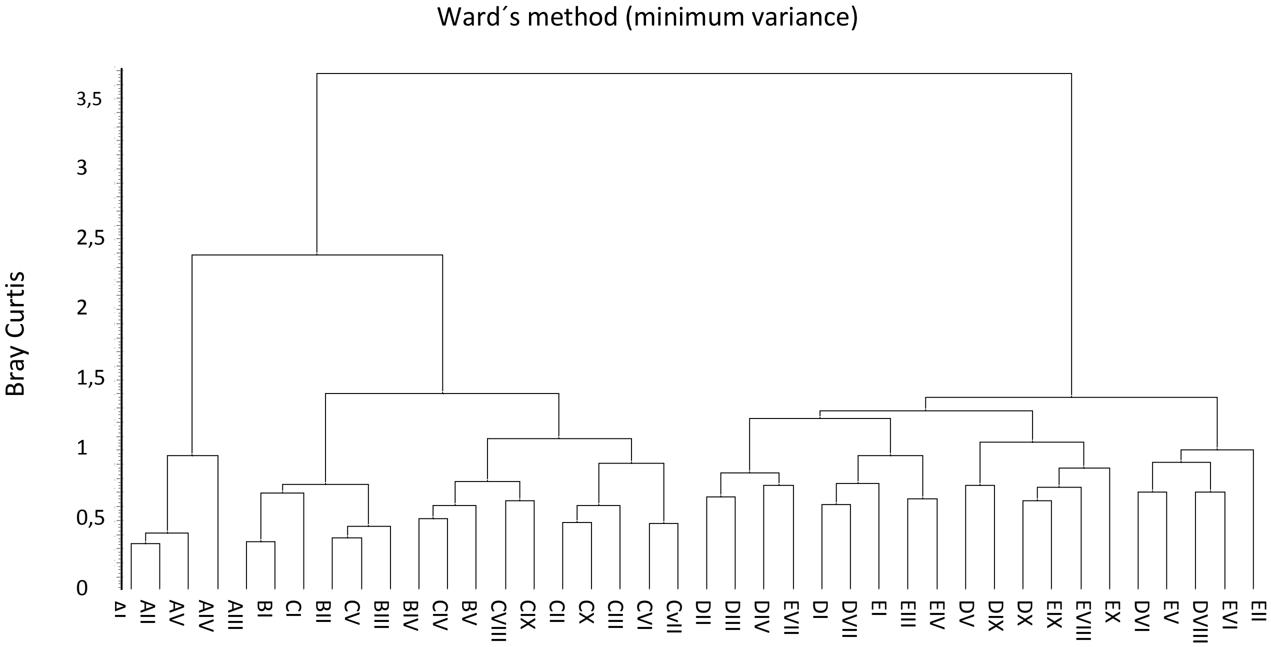

Figure 8. Similarity analysis for Ward´s method (minimum variance), using Bray Curtis index for tree ≥ 4,8cm dbh along the elevational gradient on Mt. Cuscuzeiro, in Ubatuba, southeastern Brazil. A=1270m; B=1200m; C= 1120m; D=970m; E= 820m.

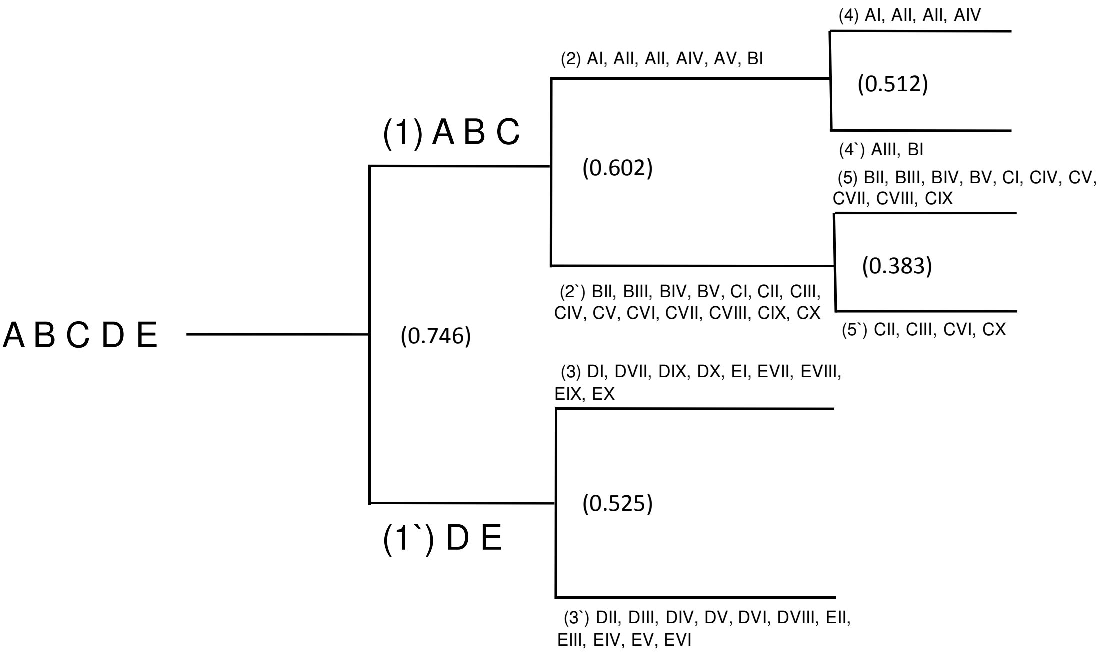

Figure 9. Dendogram representing the groups formed by TWINSPAN analysis using the samples from the elevational gradient on Mt.Cuscuzeiro. The eigenvalue for each division is showed in parentheses. A=1270m; B=1200m; C= 1120m; D=970m; E= 820m.

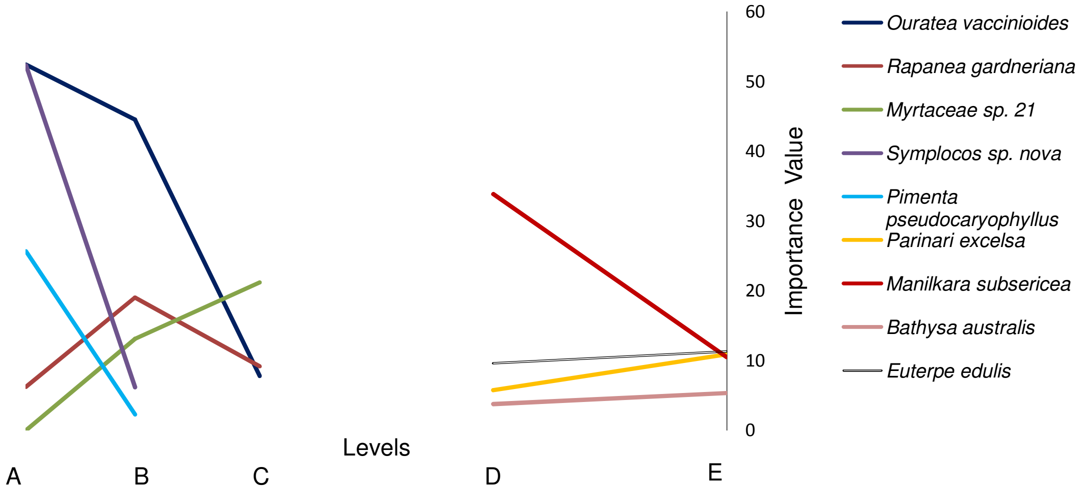

Figure 10. The Importance Value of the indicator species pointed out by TWINSPAN analysis, on divisions 1, 2, and 3. A=1270m; B=1200m; c= 1120m; D=970m; E= 820m.

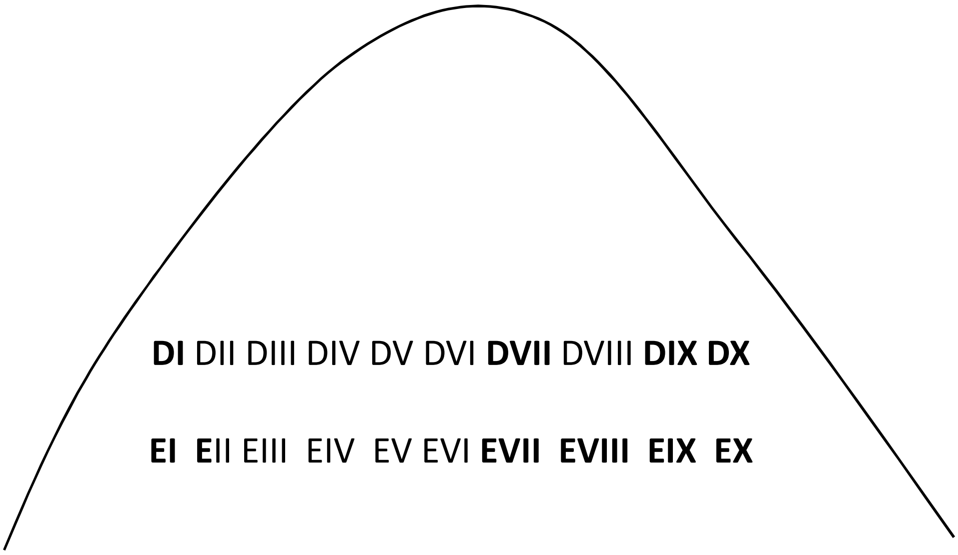

Figure 11- Representation of the samples allocation on Mt. Cuscuzeiro. Samples in bold represent group 3 of the TWINSPAN division. The non bold samples represent group 3’ of TWINSPAN division

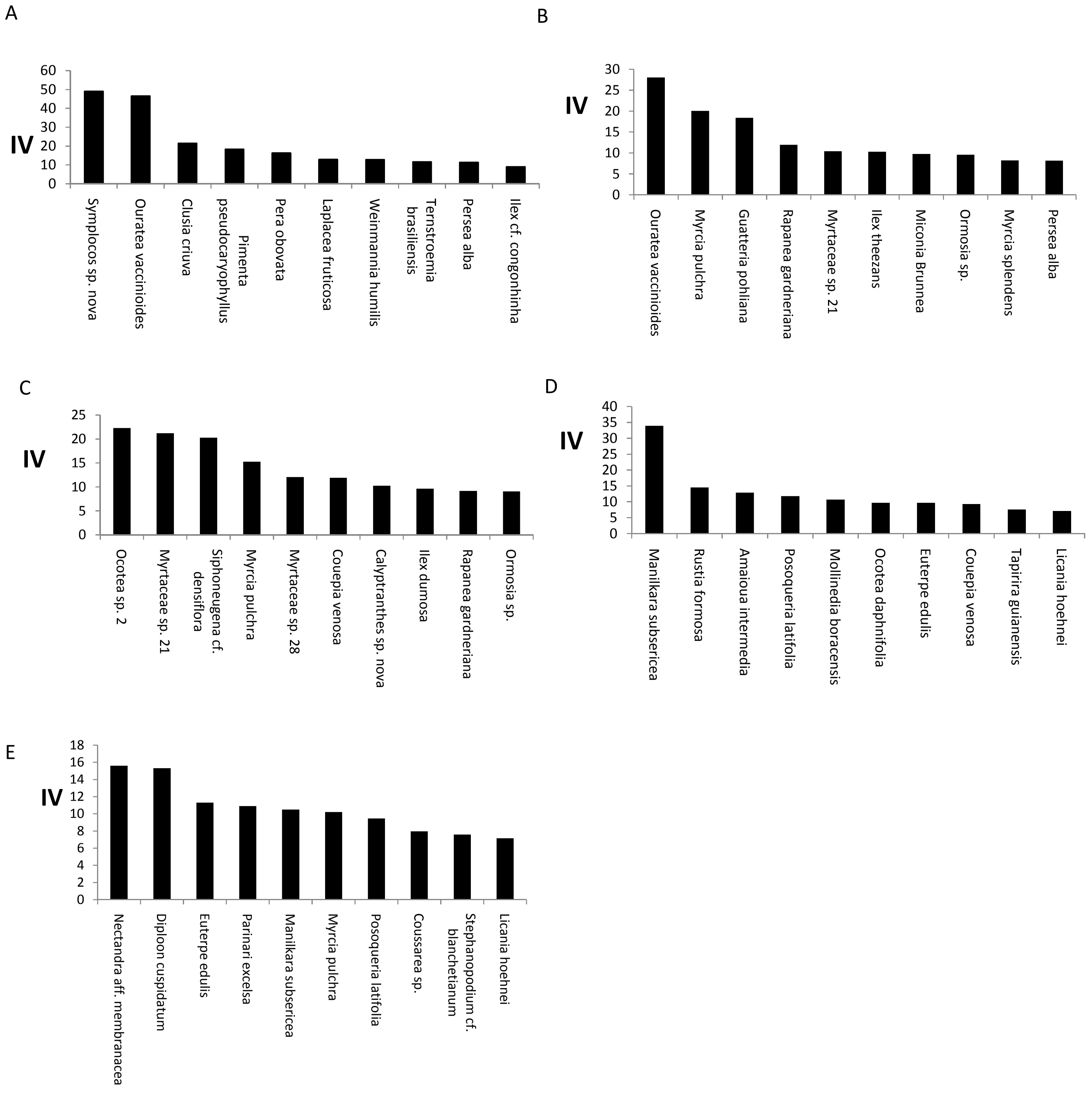

Figure 12. Species with the higher Index of Importance Value (IV) from samples of Mt. Cuscuzeiro on different altitudinal levels. A=1270m; B=1200m; c= 1120m; D=970m; E= 820m.

Table 1- Phytossociological parameters for the five elevational levels on Mt. Cuscuzeiro. A=1270m; B=1200m; C= 1120m; D=970m; E= 820m. D.B.H ≥ 4.8cm for levels A, B, C, D, and E. The density os individuals/ha is represented for inclusion criteria D.B.H ≥ 3.2cm in parenthesis.

	Elevational levels						
Parameters	**A**	**B**	**(AB)**	**C**	**D**	**E**	**TOTAL**
Number of individuals	73	189	262	231	157	158	809
Number of species	21	39	46	61	71	87	165
Number of samples	5	5	10	10	10	10	40
Density (ind/ha)	1460(2380)	3780(4500)	2620(3440)	2310	1570	1580	2022,5
Diameter - medium (cm)	8,72(3,3)	9,88(4,4)	9,56(4,2)	12,95(8)	13,24(11,4)	14,25(12,7)	12,19(9,2)
Diameter - maximum (cm)	18,44	28,65	28,65	50,93	98,68	72,81	98,68
Height - medium (m)	4,37(1,7)	5,77(1,5)	5,38(1,7)	7,62(2,7)	9,91(4,7)	10,61(5,1)	7,93(4,1)
Height - maximum (m)	10	11	11	19	25	28	28
Volume - medium (m^3)	0,03(0,04)	0,06(0,07)	0,05(0,07)	0,18(0,3)	0,40(1,6)	0,52(1,3)	0,25(0,9)
Volume – maximum (m^3)	0,24	0,53	0,53	2,24	19,12	8,78	19,12
Percentage of branches	53,43	24,34	32,44	21,65	10,83	5,06	17,49
Índex Shannon-Weiner	2,60	3,09	3,24	3,73	3,98	4,23	4,53
Equability	0,85	0,84	0,85	0,91	0,94	0,95	0,89

Table 2 Species of each group formed by TWINSPAN. The indicator species of each division are in bold type.

1	1'	2	2'
Ouratea vaccinioides	*Posoqueria latifolia*	**_Symplocos_ sp. nova**	*Miconia brunnea*
Symplocos sp. nova	*Licania hoehnei*	*Persea alba*	*Rapanea gardneriana*
Persea alba	*Mollinedia boracensis*	***Pimenta pseudocaryophyllus***	*Couepia venosa*
Pimenta pseudocaryophyllus	*Myrceugenia* cf. *miersiana*	*Clusia criuva*	*Myrcia pulchra*
Clusia criuva	*Manilkara subsericea*	*Weinmannia humilis*	*Drymis brasiliensis*
Miconia brunnea	*Euterpe edulis*	*Laplacea fruticosa*	*Ormosia* sp.
Pera obovata	*Ocotea dispersa*	*Ilex* cf. *congonhina*	*Swartzia flaemingii*
Guatteria pohliana	*Amaioua intermedia*	*Pera obovata*	*Rapanea lancifolia*
Psychotria patentinrvia	*Inga lancitfolia*		*Siphoneugena* cf. *densiflora*
Rapanea gardneriana	*Parinari excelsa*		*Myrtaceae* sp. 21
Ilex theezans			*Myrceugenia ovalifolia*
Calyptranthes sp. nova			*Alibertia myrcifolia*
Myrcia pulchra			*Calyptranthes* sp. Nov
Drymis brasiliensis			*Eugenia excelsa*
Ormosia sp.			*Ocotea curucutuensis*
Siphoneugena cf. *densiflora*			*Humiriastrum dentatum*
Myrtaceae sp. 21			*Guapira oppositta*
Myrceugenia ovalifolia			*Ocotea paranapiacabensis*
Alibertia myrcifolia			*Ocotea* sp. 2
Ocotea curucutuensis			*Pachira calophylla*
Humiriastrum dentatum			*Myrtaceae* sp. 17
Ocotea sp. 2			*Ilex dumosa*
Pachira calophylla			*Blepharocalyx salicifolius*
Ilex dumosa			*Ilex dumosa*
			Beilschmiedia sp.
			Ocotea sp. 1
			Guatteria glabrescens

APPENDIX I. List of tree species ≥ 3,2 cm dbh on levels A and B and ≥ 4,8cm dbh on levels C, D and E, found on five elevational levls on Mt. Cuscuzeiro, in Ubatuba, southeastern Brazil. A=1270m; B=1200m; C= 1120m; D=970m; E= 820m.

Famíly		**A**	**B**	**C**	**D**	**E**
Annacardiaceae	*Tapirira guianensis* Aubl.				X	
Annonaceae	*Guatteria australis* A. St. Hill					X
	Guatteria pohliana Schltdl.	X	X	X		
	Duguetia salicifolia R. E. Fr.				X	X
Apocynaceae	*Aspidosperma olivaceum* Müll. Arg.				X	X
	Aspidosperma spruceanum Benth. Ex Müll. Arg.					X
Aquifoliaceae	*Ilex* cf. *congonhinha* Loes.	X				
	Ilex dumosa Reissek			X		
	Ilex theezans Mart. ex Reissek.	X	X	X		
Araliaceae	*Schefflera angustissima* (Marchal) Frodin					X
Arecaceae	*Euterpe edulis* Mart.				X	X
Bignoniaceae	*Tabebuia vellosoi* Toledo	X				
Boraginaceae	*Cordia sellowiana* Cham.				X	X
Canellaceae	*Cinnamodendron dinisii* (Schwacke) Occhioni				X	
Cardiopteridaceae	*Citronella megaphylla* (Miers) Howard				X	
Celastraceae	*Maytenus robusta* Reiss.				X	
	Salacia sp.			X		X
Chlorantaceae	*Hedyosmum brasiliensis* Mart.	X				
Chrysobalanaceae	*Couepia venosa* Prance		X	X	X	
	Hirtella hebeclada Moric. ex DC.				X	X
	Licania hoehnei Pilger			X	X	X
	Parinari excelsa Sabine				X	X
Clethraceae	*Clethra scabra* Pers.	X				
Clusiaceae	*Clusia criuva* Cambess.	X	X	X	X	
Cunnoniaceae	*Weinmannia humilis* Engl.	X				
	Weinmannia paulliniifolia Pohl ex Ser.		X			
Dichapetalaceae	*Stephanopodium* cf. *blanchetianum* Baillon					X
Ericaceae	*Gaylussacia densa* Cham.	X	X			
Euphorbiaceae	*Alchornea glandulosa* Poepp. & Endl.					X
	Pera obovata (Klotzsch) Baill.	X	X	X		
	Sapium glandulatum (Vell.) Pax			X		
Humiriaceae	*Humiriastrum dentatum* (Casar.) Cuatrec.		X	X		
Lauraceae	*Aiouea acaradomatifera* Koest.			X		
	Beilschmiedia sp.			X		X
	Cryptocarya mandioccana Meisn.					X
	Nectandra aff. *Membranacea* (Sw.) Griseb.					X
	Ocotea aff. *puberula* (Rich.) Nees			X		X
	Ocotea curucutuensis Baitello		X	X		

Appendix. Continued.

		A	B	C	D	E
	Ocotea daphnifolia (Meisn.) Mez				X	
	Ocotea dispersa (Ness) Mez				X	X
	Ocotea elegans Mez				X	X
	Ocotea glaziovii Mez					X
	Ocotea paranapiacabensis Coe-Teixeira			X		
	Ocotea rariflora (Meisn.) Baitello				X	
	Ocotea sp. 1			X		
	Ocotea sp. 2			X	X	X
	Ocotea vaccinioides (Meisn.) Rohwer	X	X			
	Persea alba Nees.	X	X	X		
	Lauraceae sp. 1				X	
	Lauraceae sp. 2				X	
Leguminosae (Mimosoidae)	*Inga capitata* Desv.					X
	Inga lancifolia Benth				X	X
	Inga sessilis (Vell.) Mart.				X	
(Papilionoideae)	*Swartzia flaemingii* Raddi		X	X		
	Myrocarpus frondosus Allemao				X	X
	Ormosia sp.		X	X	X	X
	Pseudopiptadenia leptostachya (Benth.) Rauschert.				X	
	Leguminosae sp. 5				X	
Malpighiaceae	*Byrsonima ligustrifolia* A. Juss.			X		X
Malvaceae	*Pachira calophylla* (K. Schum.) Fern. Alonso.			X		
Melastomataceae	*Behuria insignis* Cham.			X		
	Henrietella sp.					X
	Huberia ovalifolia DC.		X			
	Meriania sp.		X			
	Miconia brasiliensis Sprug.					X
	Miconia brunnea DC	X	X	X		
	Miconia cabucu Hoehne					X
	Miconia chartaceae Triana				X	X
	Miconia fasciculata Gardner		X	X		
	Miconia tristis Spring ex Mart.			X		
	Tibouchina mutabilis (Vell.) Cogn.					X
	Tibouchina sp.			X		
Meliaceae	*Cabralea canjerana* (Vell.) Mart.					X
	Cedrela fissilis Vell.					X
	Trichilia silvatica C. DC.					X
Monimiaceae	*Mollinedia boracensis* Peixoto			X	X	X
	Mollinedia oligantha Perkins			X	X	X
	Mollinedia sp.	X	X			
	Mollinedia uleana Perkins					X
Moraceae	*Brosimum glaziovii* Laubert					X

Appendix. Continued.		**A**	**B**	**C**	**D**	**E**
Myrsinaceae	*Rapanea gardneriana* (A.DC.) Mez	X	X	X		
	Rapanea hermogenesii Jung-Mend. & Bernacci	X				
	Rapanea lancifolia (A.DC.) Mez		X			
	Rapanea umbellata (Mart.) Mez			X		
Myrtaceae	*Blepharocalyx salicifolius* (Kunth) O.Berg			X		
	Calyptranthes grandifolia O.Berg				X	X
	Calyptranthes lucida Mart. ex DC.				X	X
	Calyptranthes sp. nova	X	X	X		X
	Calyptranthes sp. 1	X	X	X		X
	Eugenia batingabranca Sobral					X
	Eugenia cf. *brasiliensis* Lam.					X
	Eugenia cf. *melanogyna* (D.Legrand) Sobral				X	X
	Eugenia cf. *ternatifolia* Cambess.				X	X
	Eugenia excelsa O.Berg		X	X	X	X
	Eugenia fusca O.Berg				X	
	Eugenia neoglomerata Sobral				X	
	Eugenia oblongata O.Berg				X	
	Eugenia sp.			X		X
	Marlierea cf. *affinis* (O.Berg) D.Legrand				X	X
	Myrceugenia cf. *miersiana* (Gardner) D.Legrand & Kausel			X	X	X
	Myrceugenia cf. *seriatoramosa* (Kiaersk.) D.Legrand & Kausel			X		
	Myrceugenia ovalifolia (O.Berg) Landrum		X	X	X	
	Myrceugenia sp.					X
	Myrcia brasiliensis Kiaersk.					X
	Myrcia pubipetala Miq.				X	
	Myrcia pulchra (O.Berg) Kiaersk.		X	X	X	X
	Myrcia sp.	X	X	X		
	Myrcia spectabilis DC.				X	
	Myrcia splendens (Sw.)DC.		X			
	Myrciaria floribunda (H.West ex Willd.) O.Berg				X	X
	Myrciaria tenella (DC.) O.Berg			X		
	Neomitranthes cf. *glomerata* (D.Legrand) D.Legrand			X	X	X
	Pimenta pseudocaryophyllus (Gomes) Landrum	X	X			
	Plinia rivularis (Cambess.) Rotman					X
	Myrtaceae sp. 17			X	X	
	Myrtaceae sp. 18				X	
	Myrtaceae sp. 20		X		X	X
	Myrtaceae sp. 21		X	X		
	Myrtaceae sp. 23				X	
	Myrtaceae sp. 24			X	X	X
	Myrtaceae sp. 25				X	
	Myrtaceae sp. 28		X	X	X	X

Appendix. Continued.

		A	B	C	D	E
	Myrtaceae sp. 9				X	
	Myrtaceae sp. 32				X	X
Nyctaginaceae	*Guapira* cf. *hirsuta* (Choisy) Lundell				X	X
	Guapira oppositta (Vell.) Reitz	X	X	X		
Ochnaceae	*Ouratea parviflora* (DC.) Baill.			X	X	
	Ouratea sp. nova			X		
	Ouratea vaccinioides (A. St.- Hil. & Tul.) Engl.	X	X	X		
Olacaceae	*Heisteria silvianii* Schwacke			X	X	X
Podocarpaceae	*Podocarpus sellowii* Klotz.		X			
Polygonaceae	*Coccoloba alnifolia* Casar.				X	
Quiinaceae	*Quina* aff. *magalanogomezi* (sp nova)					X
Rubiaceae	*Alibertia myrcifolia* (Spruce) K. Schum.	X	X	X	X	X
	Alibertia sp.					X
	Amaioua intermedia Mart. ex Roem. & Schult.				X	X
	Bathysa australis (A.St.-Hil.) Benth. & Hook.f.				X	X
	Bathysa gymnocarpa K. Schum.					X
	Coussarea sp.				X	X
	Ixora heterodoxa Müll. Arg.					X
	Posoqueria latifolia (Rudge) Roem. & Schult.			X	X	X
	Psychotria hastisepala Müll. Arg.			X		
	Psychotria nemorosa Gardner					X
	Psychotria patentinervia Müll. Arg.					X
	Psychotria sp.	X	X	X		
	Psychotria suterella Müll. Arg.				X	
	Rudgea jasminoides (Cham.) Müll.Arg.					X
	Rustia formosa Klotzch			X	X	X
	Simira sp.					X
Rutaceae	*Zanthoxylum rhoifolium* Lam.					X
Sabiaceae	*Meliosma* cf. *sellowii* Urban.					X
Sapindaceae	*Matayba intermedia* Radlk.			X	X	
Sapotaceae	*Diploon cuspidatum* (Hoehne) Cronquist					X
	Ecclinusia ramiflora Mart.				X	X
	Manilkara subsericea (Mart.) Dubard				X	X
	Pouteria cf. *caimito* Radlk.					X
Styracaceae	*Styrax martii* Seub.		X			
Symplocaceae	*Symplocos* sp. nova	X	X			
	Symplocos variabilis Mart. ex Miq.		X			X
Theaceae	*Gordonia fruticosa* (Schrad.) Kobuski	X				
	Ternstroemia brasiliensis Cambess.	X	X			
Verbenaceae	*Vitex megapotamica* (Spreng.) Moldenke	X		X		
Vochysiaceae	*Vochysia magnifica* Warm.		X			
	Vochysia laurifolia Warm.					X

Appendix. Continued.

		A	B	C	D	E
Winteraceae	*Drymis brasiliensis* Miers.		X	X		

APPENDIX II- Pictures of the study site


1


2


3


4


5


6

APPENDIX II. Continued.

Vegetation physionomy on Mt. Cuscuzeiro: 1- Mt. Cuscuzeiro overview; 2- Level A; 3- Level A, 4- Level B; 5- Level B; 6- Level C; 7- Level D; 8- Level E; 9 and 10- overall view from level A

CAPÍTULO 2

A FLORISTIC SIMILARITY ANALYSIS OF ATLANTIC FORESTS IN SOUTH AND SOUTHEAST BRAZIL

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ABSTRACT

AIM: We aimed to address the following questions: 1- What is the floristic similarity between the two different types of vegetation found on Mt. Cuscuzeiro (Bertoncello 2009) and other forest formations in southern and south-eastern Brazil? 2- Do the Cloud Forests constitute a particular phytogeographic formation, or are they only a subset of the surrounding community?

LOCATION: Southern and south-eastern Brazil, in the Atlantic Rain Forest Domain.

METHODS: We compiled data into a binary floristic matrix from 78 locations (112 surveys and 1546 species) of southern and south-eastern Brazil, and carried out the following analysis: UPGMA, DCA, PCO, DCA and TWINSPAN.

RESULTS: We found five groups of samples: 1- The Cloud Forest; 2- The Coastal Province (subdivided into (a) the slope forests and (b) a subgroup formed by the mountaintop and the coastal plain forests); 3- The Araucaria Forest; 4- The Semi-Deciduous Forest; and 5- The Montane Semi-Deciduous Forest. The preferential and indicator species to each group are shown.

MAIN CONCLUSION: The Mt. Cuscuzeiro Forest from 1120m to 1270m was included into the Cloud Forest group which, in turn, formed a particular phytogeographic formation. The Mt. Cuscuzeiro forest from 820m to 970m was included into the group of Slope Forestf of the coastal province. A valuable floristic ground for the Brazilian south eastern phytogeography was provided.

Key words: Atlantic Rain Forest, Cloud Forest, Ombrophilous Dense Forest, arboreal flora, multivariate analysis, phytogeographic system

INTRODUCTION

Since Brazil has about 16 to 20% of the total phanerogamic flora of the world (Shepherd 2005) and it occupies a major part of the South American continent, with a total area of 8.514.876,599 Km² (IBGE 2008), the classification of the different vegetational formations into a phytogeographical system in this country has been a major challenge to ecologists, botanists, and phytogeographers.

The first classification system for Brazilian vegetation was published by Martius (1840). He divided the country into five 'provinces', according to their landscape and floristic features, which were named after nymphs from Greek mythology. Dryades, the nymph of the forests, was the one chosen to represent the forests east of the Andes and South of the Amazon, which is now generically known as the Atlantic Forest. This 'province'originally covered an area of ca. 1.300.000,00 Km², ranging from the state of Rio Grande do Norte to Rio Grande do Sul, and from the eastern coast of Brazil to the Central Brazilian "Planalto" and parts of Paraguay and Argentina (Câmara 2005). Today, the Atlantic Forest is among the most threatened biomes on earth with only ca. 12% of its original vegetation cover, but highly fragmented (Ribeiro *et al*. 2009) and is considered a "super priority Hot Spot" for conservation purposes (Myers *et al.* 2000).

However, a number of authors have expressed the view that it is misleading to treat the whole of the Atlantic Forest as a single, homogeneous forest type, and that it would be better treated as a biome containing a far more complex group of vegetation types, with distinct ecological processes and floristic domains; therefore, it could not be adequately represented by a single name. For example, Joly *et al.* (1992) and Salis *et al.* (1995) considered the inland "Planalto" Forest as floristically and phenologically distinct from the coastal forest. Salis *et al*. (1995) also consider the "Planalto" Forest to contain two floristically distinct groups of forests, one group containing forests of higher altitudes (above 700m) with a cooler and more humid climate, and another group containing forests of lower altitudes (500-700m). In parallel, Joly *et al*. (1991) consider that the coastal forest is divided into three floristic and physiognomically distinct forests: one on the coastal plain, another on the slopes of the coastal mountain range ("Serra do Mar") and another at higher altitudes.

The official Brazilian vegetation classification system (Veloso *et al.* 1992) follows the parameters of the "International classification and mapping of vegetation" (UNESCO 1973), where the coastal forest is classified as Ombrophilous Dense Forest (together with the Amazon Forest), and it is associated with high temperatures and rainfall, without a biological drought season. The 'Planalto' Forest is classified as Semideciduous Forest ("Floresta Estacional Semidecidual"), which is associated with two distinct seasons, with high rainfall in the summer and physiological drought in the winter and a mean temperature below 15°C. The formations are then classified into different sub-formations according to altitudinal variation, which in turn would reflect different discrete communities. For the state of São Paulo, depending on the formation, they can be further sub-divided into: Alluvial Forest (along rivers, on floodplains), Lowland Forest, Sub-Montane Forest, Montane Forest, and Upper-Montane Forest.

The differing views of the extent of the Atlantic Rain Forest lead to a bitter political dispute after this formation was granted strict legal protection by the 1988 Brazilian Constitution and declared a Biosphere Reserve by UNESCO (Oliveira-Filho & Fontes 2000). But in legal aspects, both the decree 750/93 and the law that revoked the decree, defined the Atlantic Rain Forest as a complex of different vegetational formations, such as Ombrophilous Dense Forest (Coastal Forest), Semideciduous Forest (Planalto Forest), Araucaria Forest, Deciduous Forest, Ombrophilous Open Forest, and the associated ecosystems Mangroves, "Restinga" Vegetation, High Altitude

Grasslands, Inland Swamps and forest enclaves of the Northeast, which are represented on the official IBGE map (Atlantic Rain Forest Law n° 11428/06).

Although it has been legally defined for conservational purposes, there is still an academic debate about the classification of the vegetational types and their limits (Joly *et al.* 1999). Some sites on the inland plateau, not too far from the ocean, have been given different denominations by different authors. For example, Baitello & Aguiar (1982) and Gandolfi *et al.* (1995) respectively described two localities near São Paulo city, "Serra da Cantareira" and "Guarulhos", as Semideciduous Forest, while Gomes (1992), Roizman (1993), and Tomasulo (1995), denominated the same two localities near São Paulo and one at Mogi das Cruzes, as Ombrophilous Dense Forest. Applying a cluster analysis to several surveys from the coastal province and the plateau, Ivanauskas (2000) concluded that "Serra da Cantareira", "Serra da Mantiqueira", "Carlos Botelho", and "Mogi das Cruzes" areas would best be described as "transition areas".

The Restinga Vegetation has also been a matter of a political debate after CONAMA Resolution 303/02 declared it to be a Permanent Preservation Area (where logging and building are not allowed), when it is located on the coastal plain within 300m from the limits of the high tide. There is very little consensus about what defines the Restinga Vegetation (Assis 1999), and even legal resolutions from the government institutions have contradictory definitions (e.g. CONAMA Resolution 07/96 and CONAMA Resolution 303/02). For some authors, the Restinga Vegetation embraces all different vegetation formations that occur on the coastal plains (Rizini 1979, CONAMA Resolution 303/02), while for others it would be confined to areas with direct marine influence, and the remaining vegetation on the coastal plain would be Lowland Ombrophilous Dense Forest (Veloso et *al*. 1992). From the geological standpoint, Souza *et al.* (2008) argue that the term "Restinga" should not be used for sites on the coastal plain in the way that it has been used in legal resolutions and in some academic publications. For these authors, Restinga should be restricted to sandy deposits by current coastal dynamic processes. In the present study we will use the term “Restinga” vegetation in the broad sense, including all the forests on the coastal plain, as defined by CONAMA Resolution 07/96.

High altitude areas are scarcely studied in Brazil. The information available on the biogeography of the tropical mountains of Brazil is very restricted and fragmented (Ab’Saber 1989). Information on diversity and species composition is still lacking in Brazil, and little is known about the floristic relationship among Brazilian Cloud Forests and other high-altitude vegetation types. It is not clear whether they form a single vegetation type or if they are only a subset of the surrounding formations with similar physiognomies (Falkemberg 2003). Recent studies show that there are Cloud Forests on the Serra do Mar in the states of Paraná (e.g. Roderjan 1994, Rocha 1999, Koehler *et al*. 2002), Santa Catarina, and Rio Grande do Sul (Falkenberg 2003) and on the Serra da Mantiqueira, in the state Minas Gerais (Meirelles 2003 and Meirelles & Shepherd, unpublished data), but there is a lack of information about the areas of the Serra do Mar in São Paulo. Mantovani *et al.* (1990) call the vegetation there “Mountain-top Forest” (“mata de topo de morros”), although they admit that the vegetation there is the same type as those denominated by Klein (1980) as “Matinha Nebular” (Cloud Forest). Neto (2007) also called the three forests studied as “Mountain-top Forest ” and used this name as a synonym for Upper Montane Forest, the same used by Veloso *et al.* (1992) for this vegetation type. The latter author affirms that this forest type only appears above 1500m in São Paulo, although the Serra do Mar does not reach such a high altitude in this state.

In order to investigate the changes occurring at higher altitudes in the vegetation complex covering the Serra do Mar, we carried out a study on Mt. Cuscuzeiro, which at 1277m in height – is close to the altitudinal limit for the coastal range - and is located in south-eastern Brazil, on the border of the states of São Paulo and Rio de Janeiro, in Ubatuba municipality, at coordinates 23˚ 18’ 14” S and 44˚ 47’ 16” W (Datum SAD’69), approximately 4Km inland from the Atlantic Ocean (Bertoncello 2009 – chapter 1). We found two discrete communities, one being a Tropical Cloud Forest, from 1120m to 1270m (here called ABC survey), and another an Ombrophilous Dense Montane Forest, from 820m to 970m (here called the DE survey).

The aim of the present study is to investigate the relationship between the communities found in this survey and those found in previous surveys on coastal and higher altitude forests in SE Brazil and to attempt to reach a better understanding of the forest types that can be recognized in this vegetation complex. In this study, we compiled data from a number of surveys from southern and south-eastern Brazil and aimed to address the following questions: 1-What is the floristic similarity between the two different types of vegetation found on Mt. Cuscuzeiro and the other formations in southern and south-eastern Brazil? 2--Do the Cloud Forests form a specific phytogeographic formation, or do they contain only a subset of the species found in the surrounding, lower-altitude forests?

METHODS

A binary floristic matrix from 78 locations of southern and south-eastern Brazil, including the states of Minas Gerais, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul (Fig. 1) was used as a basis for the calculation of similarities. We included data for woody species from surveys and floristic lists with at least 70% of the species identified, and we excluded those species whose identification still has to be confirmed (“cf.”, “aff.”, etc.).

Surveys including different altitudinal levels or different formations were sub-divided and analyzed separately. After the matrix was complete, all names were checked to avoid synonyms and illegitimate names on the websites www.mobot.org, www.nybg.org, and ww.inpi.org, and on regional Floras and recent taxonomic revisions. Species not found in these references were excluded from the analysis.

The final matrix contained a total of 112 surveys (including those that were subdivided by differing altitudes or formations) and 1546 species. The locations, abbreviations used, altitudes, and authors are summarized in Table 1.

Data Analyses- Similarity between surveys was estimated using the Jaccard index, and the resulting matrix analyzed using standard clustering techniques such as Group Average (UPGMA) and others in order to define the floristic groups formed by the surveys. Groups were also obtained from a divisive method, Two Way Indicator Species Analysis (TWINSPAN) and the results compared. The latter also provided a list of preferential and indicator species for each division.

The relationship between surveys and species was also investigated using ordination, including Correspondence Analysis (CA), a Detrended Correspondence Analysis (DCA), and a PCO analysis of the Jaccard matrix. Three dimensional representations of the data (using VRML) were generated to help visualize the relationships between the samples (data not shown). All the analyses were made through the program FITOPAC 1.6.4 (Shepherd 2007) and an as yet unreleased preliminary version 2.0.0 of this program (Shepherd, 2009).

RESULTS

Elimination of Rare Species- Due to the high numbers of species that appear only in a single or very few surveys, the effect of removal of species occurring in less than 5 surveys was investigated, to determine whether their absence would adversely affect the subsequent analyses. Initial Clustering, CA, PCO, and DCA analyses were performed on both matrices. The resulting dendograms generated by cluster analysis were identical, and the ordinations were very similar, but the one without the rare species had a higher proportion of explained variance. So, we excluded the rare species and all subsequent analyses used a final matrix of 572 species in 112 surveys. Tests were also made excluding species that occurred in less than ten surveys and in less than 20 surveys (data not shown) resulting in similar patterns, showing that the major patterns observed were very robust and that the rarer species apparently add little useful information. But the < 5 survey exclusion limit was considered more adequate to avoid loss of finer details of composition.

In the analyses below, names were given to the groups formed. They are used informally, only to distinguish the different vegetation groups in this article.

UPGMA - The UPGMA analysis (Fig. 2) created a well established group of Cloud Forests of southern and south-eastern Brazil that included the ABC [1120m to 1270m] block of the Mt. Cuscuzeiro forest. Inside this group there were three subdivisions of the Cloud Forests, from Santa Catarina, from Rio de Janeiro/Minas Gerais, and from Paraná, with Mt. Cuscuzeiro ABC block attatched to the latter group. The DE block from the slope of Mt. Cuscuzeiro [820m and 970m] was clustered into a distinct group (Slopes) that, together with another group containing samples from the top of the “Serra do Mar” and the forests of the coastal plain (Top-Plain), formed the Ombrophilous Dense Forest group. Two other groups were formed at similar branching levels in the dendrogram. One of these groups, that appears to be linked to the Ombrophilous Dense Forest block, contains four surveys carried out on Salesópolis in different locations: on the top of the Serra do Mar (SL1), on a valley (SL2), on high slopes facing the Atlantic Ocean (SL3), and facing the inland plateau (SL4). The other group, formed by three surveys from the “Campo Rupestre” of Minas Gerais, is also close to the block of Ombrophilous Dense Forests. Despite the commom sense that this group does not show clear affinities with this kind of forest, tha UPGMA showed same relationship between them, which is very intriguing. In the remaining analyses, this small group appears as closely related to montane forest or occupying an intermediate position. So, its affinities as shown in the UPGMA should be considered somewhat anomalous.

Three other distinct groups were formed: one containing samples of Araucaria Forest; one with a Semi-deciduous Forest from below ca. 700m; and a last Montane Semi-deciduous Forests from above ca. 700m.

TWINSPAN - The groups formed by the TWINSPAN analysis (see dendogram on Fig. 3 and the preferential and indicator species in table 2) largely corroborate the UPGMA results, with some minor changes. A Cloud Forests group (group 1) was formed with exactly the same surveys, but the Mt. Cuscuzeiro ABC block was clustered with a subgroup with samples from Santa Catarina, Rio de Janeiro, and Minas Gerais, rather than together with the Paraná Forests.

The Mt. Cuscuzeiro DE (slopes) block was clustered into the Ombrophilous Dense Forest group (group 4), which remained very similar to that formed by UPGMA, the only difference being the exclusion of the mountain-top forest of Intervales (SP-ITV) and the inclusion of one sample from Salesópolis (SL2), that was clustered within the other Salesópolis surveys in the UPGMA analysis. The sample from the Serra da Cantareira (SP-CT) was clustered within the Semi-deciduous Montane Forests by the UPGMA analysis, but here it was included in the Ombrophilous Dense Forest group. Group 4 (Ombrophilous Dense Forest) was further subdivided into two subgroups, one containing samples from the Slope forests and the other containing samples from the coastal plain and the mountaintop forests.

An Araucaria Forest group (group 2) was also formed, but some surveys belonging to this group in the UPGMA analysis (MG-BO1, SP-CJD, PR-PN, and RS-SFP) were clustered within the

Montane Semi-deciduous Forest, and one survey (PR-TI) from the Semi-deciduous group was included.

The group formed by “Campos Rupestres” was split and fitted into two distinct subgroups of Montane Semi-deciduous Forest (group 5).

Of all the groups recognized in the cluster analysis, the Montane Semi-deciduous Forest was the group that showed most discrepancies in relation to UPGMA, with the inclusion of samples of Araucaria Forest, “Campo Rupestre” and samples SP-SL1, SP- SL3, SP-SL4 and SP-ITV, and the exclusion of samples MG-AIU, SP-AG, SP-GU, SP-SP, SP-AT, MG-LA, MG-IT, and SP-MO that were clustered within the Semi-deciduous Forest (group 4). But all of them, except SP-MO, formed a distinct subgroup (3b) in the TWINSPAN analysis.

Ordination - These analyses (DCA and PCO) resulted in relatively similar ordinations that largely corroborated the groups formed by UPGMA and TWINSPAN (Figs 4 and 5). Correspondence Analysis was also carried out (data not shown) and the results were very similar to the PCO analysis. The DCA gave a better spread of the samples and groups and provided the best visualization. Ordination analysis, especially DCA, showed that the Mt. Cuscuzeiro Cloud Forest (ABC) is close to the border of the Cloud Forest cluster and the mountaintop forests of the Serra do Mar. In fact, depending on the viewing angle in three dimensional images (data not shown) it appears to be closer to one or another, illustrating its intermediate nature and a bilateral floristic influence. The Paraná Cloud Forests appear in a very compact aggregation in the PCO analysis and the sample ABC is separated from this aggregation.

The Ombrophilous Dense Forest samples form a conspicuous cluster, containing the Mt Cuscuzeiro slope Forest (DE). However, there is some differentiation, with the samples from the mountaintops and the coastal plain, located to the right in Fig. 4 (PCO), closer to the Cloud Forest cluster and to some Montane Semi-deciduous samples. This gradient is clearer when vizualized in three dimensional representations of the DCA, and all samples from Carlos Botelho (SP-CB 05, SP-CB2, SP-CB4, SP-CB6, SP-CB 8, and SP-CB 10) are clustered on the extreme of this gradient, forming a subgroup itself.

The Semi-deciduous Forests also appear as a conspicuous group, but there is a small cluster of samples that were considered as Montane Semi-Deciduous Forest in the UPGMA analysis and as Semi-Deciduous Forest in the TWINSPAN analysis, that appears on the midway between those in both DCA and PCO analysis. Although they were considered a Semi-deciduous Forest, they formed a separate subgroup in the TWINSPAN analysis (see group 3b in Fig. 3). The samples MG-CP1 and MG-SP2 (which formed the subgroup of "Espinhaço" in the UPGMA analysis) were located close to this group.

All of the samples excluded by TWINSPAN from the UPGMA Araucaria Forest group (MG-BO1, SP-CJD, PR-PN, and RS-SFP) are located close to the core of Araucaria Forest in both DCA and PCO analysis. Sample PR-TI, which was included in Araucaria Forest by TWINSPAN, is more isolated than those that were excluded, specialy in the PCO analyze, suggesting that it may have been misclassified and not belong to this group.

The Salesópolis samples were widely scattered in both analysis. Sample SP-SL1, that is from near the top of the Serra do Mar, is closer to other mountaintop forests. Sample SP-SL2, from a valley, is closer to the coastal slope forests. Samples SP-SL3 and SP-SL4, both from the slopes but close to the top of the Serra do Mar, were grouped respectively with the slope forest facing the Atlantic Ocean and with the inland plateau forests. In the DCA, sample SP-SL3 appeared closer to some montane samples, mainly from São Paulo, while SP-SL4 was closer to montane samples principally from Minas Gerais.

The Montane Forests formed a more heterogeneous group, with some samples approaching the Ombrophilous Dense Forest, some approaching the Semi-Deciduous Forest, and some approaching the Araucaria Forest. Samples SP-CJD and MG-BO3 were clustered among samples from the Cloud Forest, the Araucaria Forest and the Montane Forest groups.

DISCUSSION

The similar patterns found in the different methods applied suggest that the results obtained are quite robust and unlikely to be profoundly modified by addition of limited numbers of new samples. The inclusion of ABC and DE in different groups, found in all the different methods applied in the broader scale study, corroborates the result obtained on a smaller scale on Mt. Cuscuzeiro (Chapter 1). UPGMA and TWINSPAN created a conspicuous group of southern and south-eastern Brazilian Cloud Forests, supporting the idea of a distinct phytogeographic unit with characteristic species that are shown in table 2. Apparently the Paraná Cloud Forests form a well-defined group and the Cloud Forests of Serra da Mantiqueira (MG), Aparados da Serra (SC) and Itatiaia (RJ) form another. The position of ABC is not well defined between these subgroups. Although ABC shows a close relationship with the forests from the top of the Serra do Mar, as we would expect because they occur on the same geological base and are geographically and climatically close, it is also clustered within the Cloud Forest group.

This makes the higher levels of Cucuzeiro Mountain (ABC) a very interesting area from biogeographic perspective. It may be a consequence of historical factors responsible for the disjunct distribution of species from high altitudinal areas of southern and south eastern Brazil, as suggested by Meireles (2003). Palinological records from central and south-eastern Brazil prove that climatic changes of the Pleistocene had a strong impact on the distribution of the forest physiognomies as well on the species composition and distribution (Joly *et al.* 1999). In the beginning of the Holocene (10000 to 7000 years BP), the climate was cold and dry, but it became cold and humid about 4000 years BP (Ledru *et. al* 1988). This fact led to an expansion of the Araucaria Forest ca. 2500 years BP in areas like Campos de Jordão in the state of São Paulo (Behling 1997). Likewise, the Cloud Forest may have reached larger areas of southern and south-eastern Brazil at this time, which was later diminished and restricted to higher and colder regions with particular cloud stagnation conditions, characterizing their archipelagic distribution in the Neotropical region (Luna-Vega *et al.* 2001).

It seems that altitude is playing a major role in its floristic composition, and that there may be a critical altitude for cloud forest formation because this area is higher than the other forests sampled along the top of the Serra do Mar. To our knowledge, the only other study carried out at similar altitudes on the Serra do Mar of São Paulo state is the survey made by Mantovani *et al.* (1990) on the mountaintop forest in Salesópolis (1200m), but this was not clustered with the Cloud Forest group in our analyses.

Within the Cloud Forest group, ABC has the lowest altitude. The presence of Cloud Forests at such low altitude on Mt. Cuscuzeiro is explained by the mountain mass elevation effect (Massenerhebung), which means the occurrence of physiognomically and sometimes floristically similar vegetation types at higher altitudes on large mountain masses than on small isolated peaks, especially those in or near the sea (Flenley 1994). This may explain why some high altitude areas in the state of Minas Gerais were not clustered within the Cloud Forests. On the other hand, in Salesópolis, the absence of species that characterized the Cloud Forest group may be related to historical factors (the species never arrived there) or to the local topography that does not favour frequent cloud cover as much as Mt. Cuscuzeiro. However, in the DCA and PCO analysis, sample SL1 sits just outside the Cloud Forest group.

The critical altitude is probably determined by a range of factors correlated with altitudinal variation, with cloud frequency and it's consequences (Chapter 1) amongst the most important variables. Level DE on Mt. Cuscuzeiro, despite being on the same mountain and only 150m below ABC, was clustered within the Ombrophilous Dense Forest group, that includes slope forests of Serra do Mar, either from neighboring or farther areas of the southern coast of São Paulo.

The coastal forest was represented by three groups in the UPGMA dendogram, the first formed by all slope samples and SP-RES M (Ombrophilous Dense Forest); the second formed by two subgroups, one containing the forests on the coastal plain (Restinga Forest) and the other containing samples from the top of the Serra do Mar; and a third group, comprised of the Salesópolis samples, which will be discussed later. This pattern was very similar to that encountered by Ivanauskas *et al.* (2000), although they had only the Salesópolis survey representing the forests from the top of the Serra do Mar. The distinctive phytogeographic formation of the coastal forest has also been shown by Scudeller *et al.* (2001) using quantitative data and multivariate analysis. They recognized two floristic-structural groups: Coastal Province and Atlantic Plateau. Oliveira Filho & Fontes (2000) found a geographic gradient with change in composition correlated with increassing penetration into the interior of the continent. This gradient corresponds to a major climatic variation, with an increase in the dry season duration that, in turn, is responsible for the distinction between the coastal province and the plateau ("plananlto") forests. According to these authors, this transition is abrupt in São Paulo due to the proximity to the sea of the mountain ranges and the very strikingly steep descent from summit to sea level in a very short (horizontal) distance. The mountains in São Paulo are closer to the coast and higher compared to the northern Atlantic Forest where the transition is more gradual.

Leitão Filho (1982) suggested that the coastal forest from northern half of the São Paulo coast is different from the southern half due to differences in climate, especially because of the occurrence of frost in the south. But the results of Scudeller *et al.* (2001) using multivariate methods indicated that there is no distinct separation between the north and south in the Atlantic Ombrophilous Dense Forest in São Paulo. These authors suggested that there might be segregation into altitudinal classes of tree species in the coastal province, but there were no published surveys to reinforce their ideas at the time.

Our results support the idea of segregation into altitudinal classes in the coastal province, but it seems much more related to local physical environmental changes, because the main changes are in the transition from the coastal plain to the slope forests and from the slope forests to the top of the Serra do Mar, as observed by Ivanauskas *et al.* (2000).

Within the slope forests, we can also observe altitudinal segregation as has been seen by other authors in São Paulo (Custódia-Filho 2002, Sanchez 2001). For example, in the UPGMA, sample DE was clustered with sample SP-PIC 10 in a single subgroup. This sample site is at about the same altitude (800-1000m) and is geographically close to Mt. Cuscuzeiro, separated by a single valley, so their proximity is not unexpected; but the remaining altitudinal levels (600m, 300m, and 100m) from the same site formed another subgroup. The samples from the southern coastal province at diverse altitudes below 300m were clustered into yet another subgroup. Therefore, so far it seems likely that there are two altitudinal groups in the slope forests, one up to 800m and the other above 800m. This pattern was also seen by Sanchez (2001). The results of Custódia-Filho (2002) also indicated that samples from 1000m separated from the others.

Contrary to the results of Scudeller *et al.* (2001), we found samples from the southern coastal province of São Paulo clustered into a subgroup, indicating some separation between north and south in the Atlantic Ombrophilous Dense Forest, as suggested by Leitão-Filho (1982). Oliveira Filho & Fontes (2000) found this differentiation on a broader scale, comparing samples from the northern and southern Brazilian coast, for both the coastal Ombrophilous Dense Forest and the Semi-deciduous Forest. On the other hand, samples from the coastal plain did not show any distinction between the northern and southern halves of São Paulo coast in our results.

Ivanauskas *et al.* (2000) considered samples from Carlos Botelho as transitional from the coastal forest to the “Planalto” Forest (Semideciduous Forest). Our results showed it to be part of the coastal forest, but it does show some differences from the other samples, as it forms a specific subgroup, that is best visualized using the three dimensional image from the DCA. These samples are still from the Serra do Mar, but at this location, the mountain range bends inland, far from the coast, and its flora is probably influenced by climatic conditions closer to those of the “planalto” forests. The Serra da Cantareira (a forest-covered mountain range close to São Paulo city) was also classified as a transitional area by Ivanauskas *et al.*(2000), coinciding with our results, since it was the only survey clustered within the Montane Forests in the UPGMA that was included in the coastal province forests in the TWINSPAN analysis. The Intervales sample (SP-ITV) was first clustered with the top of mountains from the Serra do Mar by UPGMA, but TWINSPAN analysis clustered it with the Montane group, which also indicates that it may be influenced by the “planalto” forests, as it is located ca. 100km from the ocean.

Sample SP-RES M was the only survey from the coastal plain that clustered with the slope samples. This is probably because it is the furthest site from the ocean (ca. 20km), where the coastal plain is older because ocean regression happened earlier there. The forest there had more time to evolve and the soil may have more continental influence than the sandy soils near the sea. We also did not expect sample SP-UBA IAC to be clustered with RG-TG in the UPGMA, as the first is located in Ubatuba, around elevation 180m, closer to many other samples, and RJ-TG is some distance away in the state of Rio de Janeiro.

The second group (group 4a of TWINSPAN division) was formed by two subgroups, one of samples from the coastal plain and other of samples from the top of the Serra do Mar (excluding Salesópolis). These samples constitute two distinct groups as pointed out by Neto (2007), but they are related at a higher level, at least from the viewpoint of qualitative floristic data. Moreover, these groups have similar physiognomy (Neto 2007).

Our results show that the coastal plain forest (Restinga) is different from the slope forest, as suggested by Ivanauskas *et al.* (2001). Since a very small fraction of the Restinga forests are protected by State Parks in São Paulo, these are among the most threatened areas in the country, because of deforestation for the building of high cost vacation houses and of unauthorized low cost constructions, especially along the central and northern parts of the coast (Mantovani 2000). Therefore, we believe that legal protection against deforestation should be reinforced. However, our data does not permit inferences about CONAMA Resolution 303/02 which declared an extension of 300m from the limits of the high tide on the coastal plain as a Permanent Preservation Area. Studies on a smaller scale are necessary to address this question.

The Salesópolis group is very intriguing. Although the surveys of this group were made on Serra do Mar, not far from the ocean, they formed a group by themselves, located close to the slope and top/plain forests in the UPGMA. Scudeller *et al.* (2001) found these samples to be in the Atlantic Plateau group rather than in the Coastal Province, as would be expected, at least for samples SP-SL1 (top), SP-SL2 (valley), and SP SL3 (Atlantic Ocean facing slopes). In the TWINSPAN analysis, sample SP-SL2 was clustered within the Ombrophilous Dense Forest, probably due to its locally moist conditions. The DCA ordination of these samples is easier to interpret. The valley sample was located close to the slope samples; the mountain-top sample between the other mountain tops and the Cloud Forests, close to sample ABC; the Atlantic facing slope sample was clustered close to samples of the Montane group in the rain shadow of the leeward side of the Serra do Mar; and the sample from the plateau facing slope was located close to the more extreme inland Montane samples, mostly from Minas Gerais. From their location and the authors' description, we believe these samples belong to the coastal province, but their insertion among other samples is still not understood.

The inland plateau formed a conspicuous group (Semi-deciduous Forest) of most of the samples from below ca. 700m. The samples from above ca. 700m were mostly clustered in the Montane group. The existence of this floristic distinct group of forests from higher areas of inland São Paulo was already indicated by Torres (1989) and Salis *et al.* (1995). Although Salis *et al.* (1995) claimed that the Semi-deciduous group of inland São Paulo is very heterogeneous, they formed a very well established cluster in our analysis. On the other hand, different patches can be visualized in the Montane group (see DCA). There is a cluster of samples floristically closer to the coastal province (e.g. Macaé de Cima, São José do Campos and Serra da Cantareira), another cluster more similar to the Semi-deciduous forest (a small cluster that was actually grouped in the Semi-deciduous by TWINSPAN, e.g.MG-AIU, SP-AG, SP-GU, SP-SP, SP-AT, MG-LA, MG-IT, and SP-MO) a cluster of a more typical Montane Forest made by samples mostly from Minas Gerais, and some samples with close similarity to the Araucaria Forest (MG-BO1, SP-CJD, PR-PN, and RS-SFP), that were clustered with the Araucaria Forest by UPGMA but not by TWINSPAN.

Altitude is considered an important phytogeographic gradient (Oliveira Filho & Fontes 2000). The increasing elevation tends to cluster samples from distinct locations, explaining the patchy Montane distribution on the DCA Figure. Samples from the same location but with elevation intervals on the surveys were clustered into different groups. For example, RJ- IT1, at higher elevation, was considered as a Cloud Forest, and RJ-IT2 (lower elevation) was considered as a Montane Forest. Sample SP-JP 1 (1170m) was considered as a Montane Forest, while SP-JP2 (870m) was considered as a Semi-Deciduous Forest (although separated from the others in the UPGMA, probably because it is located higher than the rest of the group).

It is important to mention that our results do not match with the official Brazilian Map of Vegetation (IBGE 1993). For example, many sites on the inland plateau of the state of São Paulo (e.g the sourroundings of Campinas region) are considered Ombrophylous Dense Foret on the IBGE map but were clearly classified as Semi Deciduous Forest in our analysis, in which the Ombrophylous Dense Forests were showed to be closely related to the Serra do Mar.

The multivariate analyses presented in this article may have been influenced to some extent by unidentified species (especially of Myrtaceae), occasional misidentification, different criteria of inclusion, and different sucessional stages (often not reported by authors). Moreover, the list of species that characterizes the groups provided here is not definitive. However, we believe that the patterns presented here are very consistent and robust as they show quite similar and compatible results among the different methods applied. In spite of this, we do not intend to propose a new classification system here since we believe that this would still be premature. Although the broad outlines of a classification system for forests of southeastern Brazil are now clearer to some extent, the limits of some of the formations are as yet not well determined and the extent of internal variation is largely unknown in some formations, particularly in the slope forests where altitudinal and local variation depending on aspect and declivity still requires to be thoroughly investigated. The puzzling similarity between the coastal plains/restinga forests and the mountain-top forests also merit further attention.

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Figures and tables

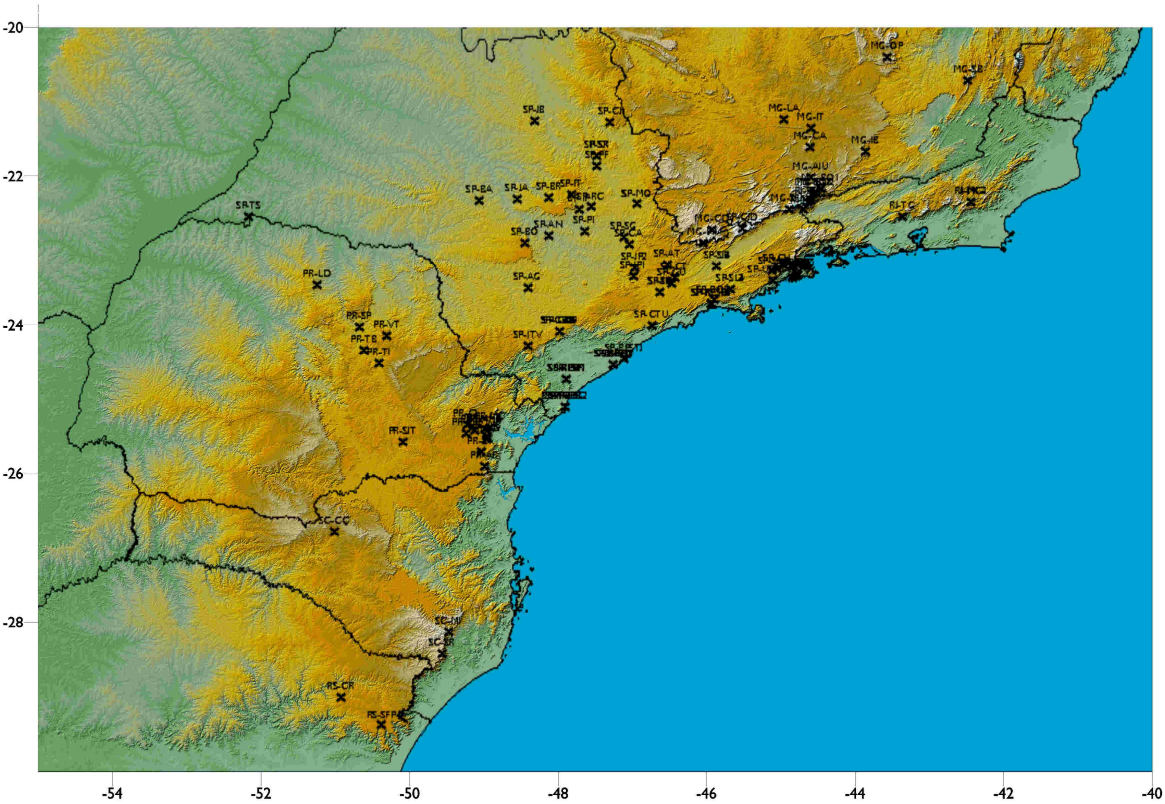

Figure 1: Topography map of south and southeastern of Brazil with the sites of the surveys used in this article. The abbreviations used are represented on table 1.

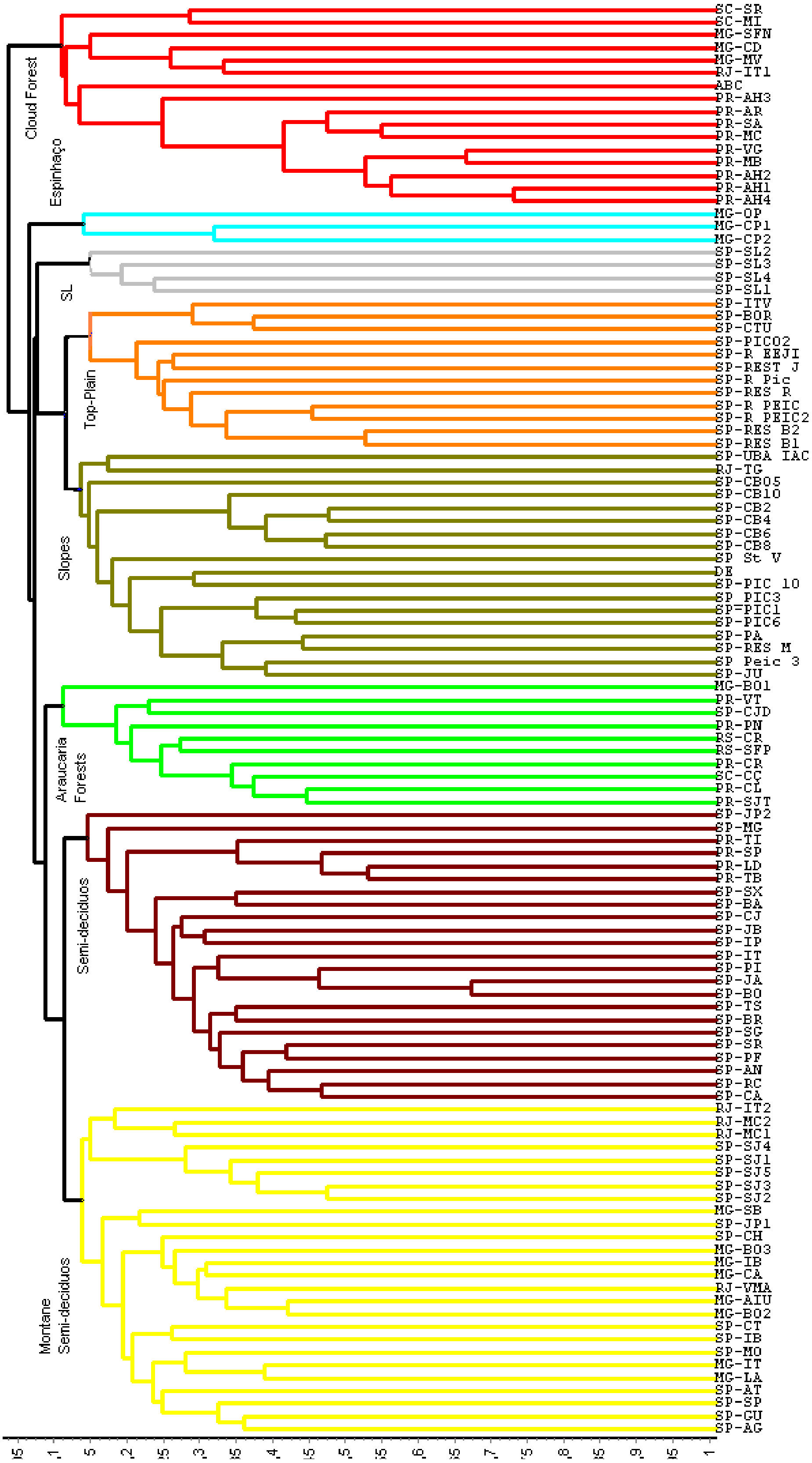

Figure 2. Similarity Analysis using Jaccard index for Mean Average Group (UPGMA) using surveys from south and southeastern Brazil. In yellow: Montane Semi-deciduous; in brow brown: Semi-deciduous; in green:Araucaria Forest;in dark green: Ombrophylous Dense Forest (slpoe forest); in orange: mountaintop and seaplain forests (dark green and orange forme the costal province group); in grey: samples from Saelsópolis; in bleu: Samples from "Serra do Espinhaço"; in red: Cloud Forest.

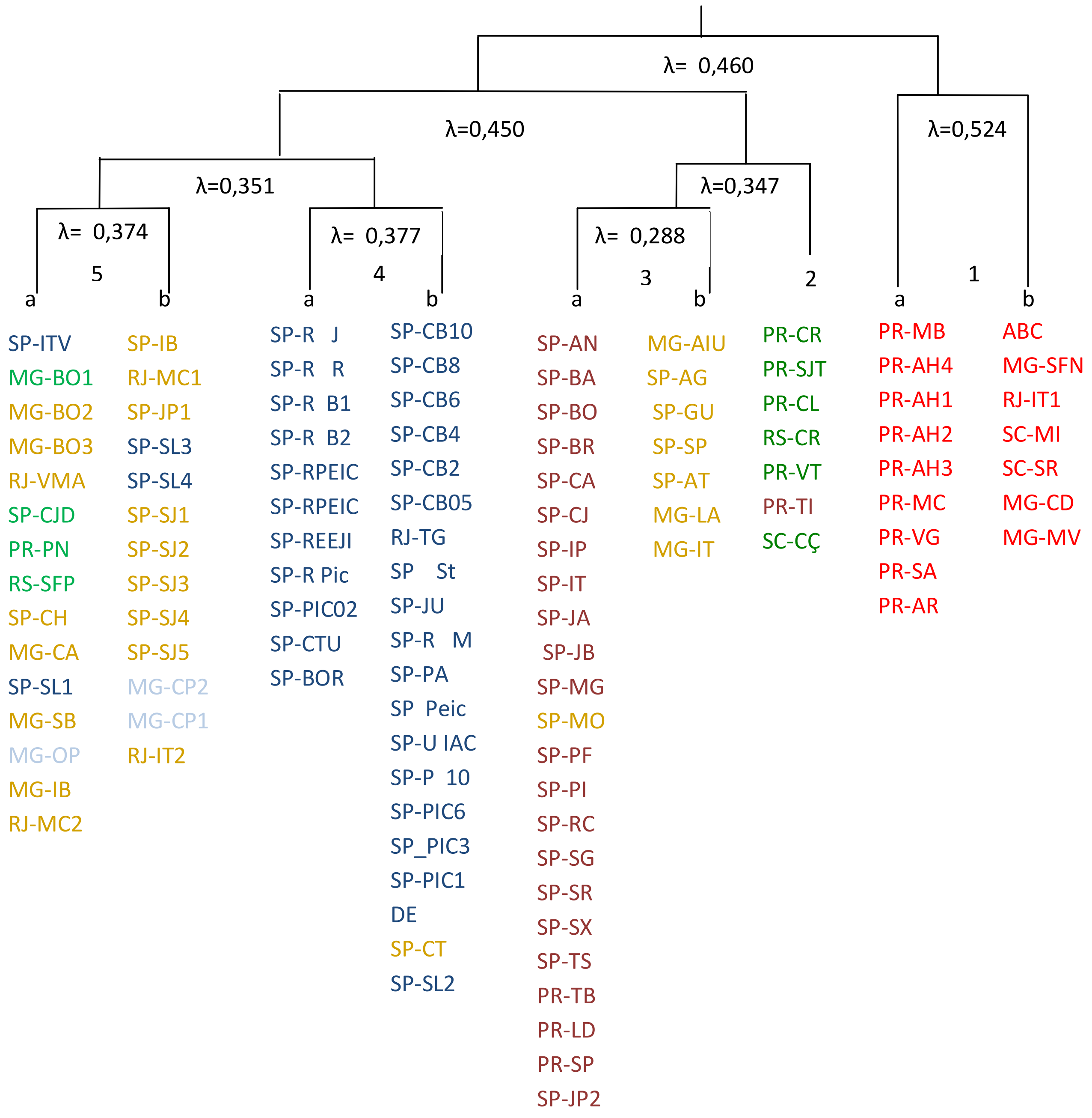

Figure 3. Dendogram containing groups formed by TWINSPAN divisions using samples from south and southeastern Brazil. The colors correspond to the groups formed by UPGMA (considering slope, top-plain and Salesópolis as only one group). The eigenvalues are represented by λ.

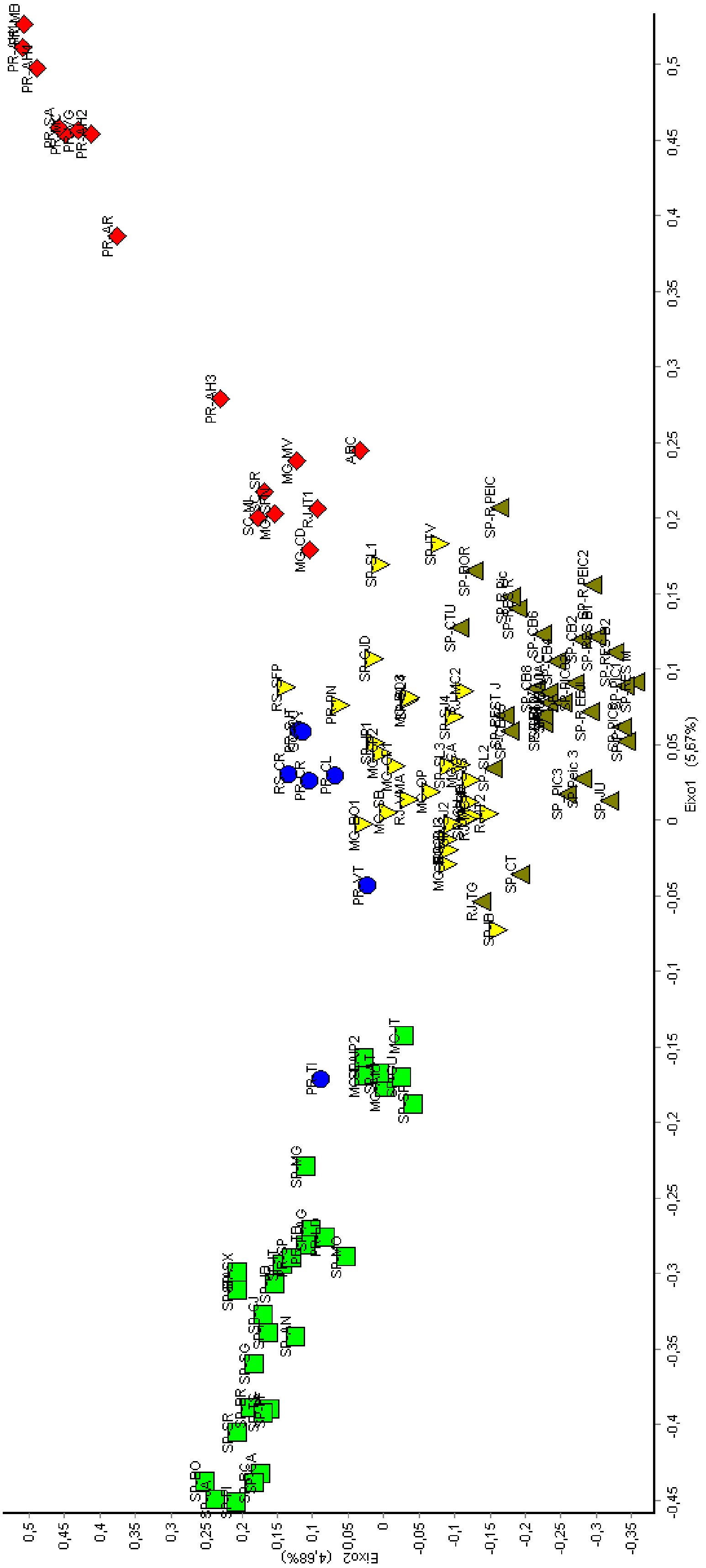

Figura 4: Axis 1 and 2 of the PCO analysis using samples from south and southeastern Brazil. The color corresponde to the groups formed by TWINSPAN

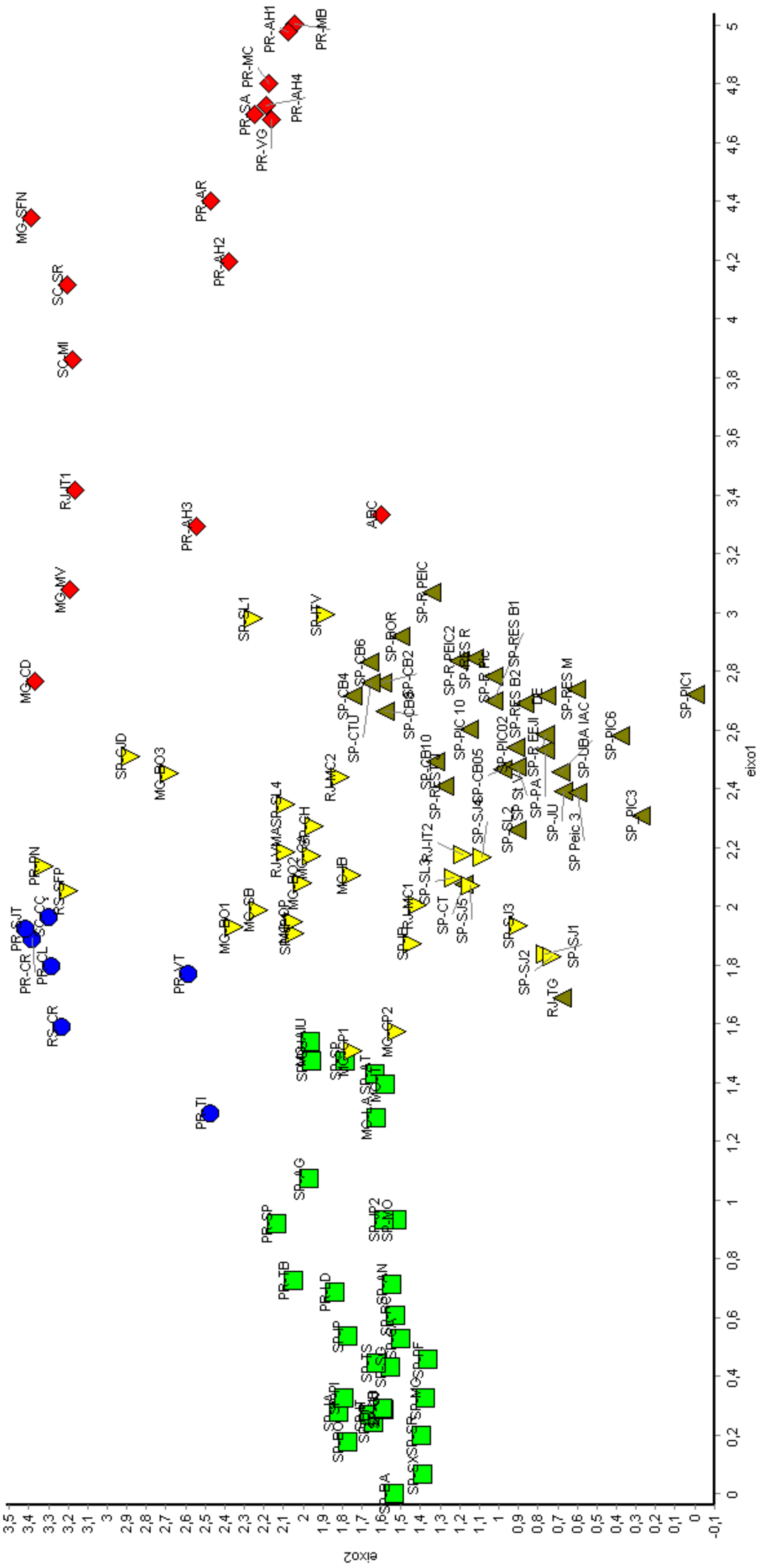

Figure 5: Axis 1 and 2 of the DCA analysis using samples from south and southeastern Brazil. The color correspond to the groups formed by TWINSPAN

Table 1-Locations, abbreviations used, altitudes, and authors of the surveys from south and southeastern Brazil used in this paper (NP=not provided).

ST.	**STUDY SITE**	**ABBREV.**	**ALT. (m)**	**REFERENCE**
MG	Airuoca	MG-AIU	1100	Pereira *et al.* (2006)
MG	Bocaina de Minas	MG-BO1	1135	Pereira *et al.* (2006)
MG	Bocaina de Minas	MG-BO2	1300	Pereira *et al.* (2006)
MG	Bocaina de Minas	MG-BO3	1450	Pereira *et al.* (2006)
MG	Carrancas	MG-CA	1500	Oliveira-Filho *et al*. (2004)
MG	Camanducaia	MG-CD	1900	França & Stehmann (2004)
MG	Serra do Cipó	MG-CP1	1200	Meguro *et al.* (1996)
MG	Serra do Cipó	MG-CP2	1200	Meguro *et al.* (1996)
MG	Serra do Ibitipoca	MG-IB	1390-1490	Carvalho *et al.* (2000)
MG	Itutinga	MG-IT	920	Berg & Oliveira-Filho (2000)
MG	Lavras	MG-LA	925	Oliveira-Filho *et al.* (1994)
MG	Monte Verde	MG-MV	1840-1920	Meireles (2008)
MG	Ouro Preto	MG-OP	1280-1450	Werneck *et al.* (2000)
MG	Serra do Brigradeiro	MG-SB	1410	Ribeiro (2003)
MG	Serra Fina	MG-SF	2300	Meireles & Shepherd (2008)
RJ	Tinguá	RG-TG	650-900	Rodrigues (1996)
RJ	Serra do Itatiaia	RJ-IT1	NP	Schumm (2006)
RJ	Serra do Itatiaia	RJ-IT2	NP	Guedes-Bruni (1989)
RJ	Macaé de Cima	RJ-MC1	1100	Guedes-Bruni (1989)
RJ	Macaé de Cima	RJ-MC2	1100	Guedes-Bruni (1989)
RJ	Visconde de Mauá	RJ-VMA	1200	Pereira *et al*. (2006)
SP	Pariquera-Açu	SP- PA	25-30	Ivanauskas (1997)
SP	Ubatuba (Picinguaba)	SP- Pic02	Planície	Sanchez (2001)
SP	Ubatuba (Picinguaba)	SP- Pic1	100	Sanchez (2001)
SP	Ubatuba (Picinguaba)	SP- Pic10	1000	Sanchez (2001)
SP	Ubatuba (Picinguaba)	SP- Pic3	300	Sanchez (2001)
SP	Ubatuba (Picinguaba)	SP- Pic6	600	Sanchez (2001)
SP	Iguape (Juréia)	SP- R EEJI	Planície	Neto (2007)
SP	Santa Virgínia	SP- St V	870-1100	Tabarelli (1997)
SP	Ubatuba (Picinguaba)	SP-ABC	1120-1270	Bertoncello (2009)
SP	Angabuta	SP-AG	600	Torres (1989)
SP	Anhembi	SP-AN	500	Cesar & Leitão-Fillho (1990)
SP	Atibaia	SP-AT	1150	Grombone *et al.* (1989)
SP	Bauru	SP-BA	570	Cavassan *et al.* (1984)
SP	Botucatu	SP-BO	600	Gabriel (1990)
SP	Salesópolis - Boracéia	SP-BOR	850	Neto (2007)
SP	Brotas	SP-BR	530	Salis *et al.* (1994)
SP	Campinas	SP-CA	700	Mathes *et al.* (1998)
SP	Carlos Botelho	SP-CB 05	50	Custódio-Filho (2002)
SP	Carlos Botelho	SP-CB 10	1000	Custódio-Filho (2002)
SP	Carlos Botelho	SP-CB 2	200	Custódio-Filho (2002)
SP	Carlos Botelho	SP-CB 4	400	Custódio-Filho (2002)

Table 1. Continued.

SP	Carlos Botelho	SP-CB 6	600	Custódio-Filho (2002)
SP	Carlos Botelho	SP-CB 8	800	Custódio-Filho (2002)
SP	Cunha	SP-CH	1300	Aguiar *et al*. (2001)
SP	Cajuru	SP-CJ	550	Meira-Neto & Bernacci (1986)
SP	Campos do Jordão	SP-CJD	1500	Los (2004)
SP	Serra da Cantareira	SP-CT	850-1200	Baitello *et al.* (1992)
SP	São Paulo	SP-CTU	800-850	Neto (2007)
SP	Ubatuba (Picinguaba)	SP-DE	820-970	Bertoncello (2009)
SP	Guarulhos	SP-GU	900	Gandolfi (1991)
SP	São Paulo	SP-IB	700	Struffaldi de Vuono (1985)
SP	Ipeúna	SP-IP	600	Mantovani *et al*. (1986)
SP	Itirapina	SP-IT	750	K-Henriques & Joly (1994)
SP	Iporanga - Ribeirão Grande	SP-ITV	1000	Neto (2007)
SP	Jaú	SP-JA	556	Nicolini (1990)
SP	Jaboticabal	SP-JB	595	Pinto (1989)
SP	Serra do Japi	SP-JP1	1170	Rodrigues *et al.* (1989)
SP	Serra do Japi	SP-JP2	870	Rodrigues *et al.* (1989)
SP	Iguape (Juréia)	SP-JU	50-300	Mantovani (19930
SP	Mogi Guaçu	SP-MG	600	Gibbs & Leitão-Filho (1978)
SP	Mogi Guaçu	SP-MO	600	Mantovani *et al*. (1989)
SP	Cananéia (Ilha do Cradoso)	SP-Peic 3	100-150	Melo (2000)
SP	Porto Ferreira	SP-PF	550	Bertoni & Martins (1987)
SP	Piracicaba	SP-PI	600	Catharino (1989)
SP	Cananéia (Ilha do Cardoso)	SP-R Peic1	Planícies	Neto (2007)
SP	Cananéia (Ilha do Cradoso)	SP-R Peic2	Planícies	Sampaio *et al.* (2005)
SP	Ubatuba (Picinguaba)	SP-R Pic	Planície	Neto (2007)
SP	Rio Claro	SP-RC	630	Pagano & Leitão-Filho (1987)
SP	Pariquera-Açu	SP-RES M	Planície	Sztuzman & Rodrigues (2002)
SP	Pariquera-Açu	SP-RES R	Planície	Sztuzman & Rodrigues (2002)
SP	Bertioga	SP-RESB1	Planície	Martins *et al.* (2008)
SP	Bertioga	SP-RESB2	Planície	Martins *et al.* (2008)
SP	Iguape (Juréia)	SP-REST J	Planície	Carvalhes (1997)
SP	Campinas	SP-SG	700	Tamashiro *et al*. (1986)
SP	São José do Campos	SP-SJ1	740	Silva (1989)
SP	São José do Campos	SP-SJ2	790	Silva (1989)
SP	São José do Campos	SP-SJ3	840	Silva (1989)
SP	São José do Campos	SP-SJ5	1040	Silva (1989)
SP	Salesópolis	SP-SL1	800-1200	Mantovani *et al.* (1990)
SP	Salesópolis	SP-SL2	800-1200	Mantovani *et al.* (1990)
SP	Salesópolis	SP-SL3	800-1200	Mantovani *et al.* (1990)
SP	Salesópolis	SP-SL4	800-1200	Mantovani *et al.* (1990)
SP	São Paulo	SP-SP	700	Rossi (1987)
SP	Santa Rita do Passa Quatro	SP-SR	700	Martins (1991)
SP	Santa Rita do Passa Quatro	SP-SX	600	Bertoni *et al*. (1988)
SP	Teodoro Sampaio	SP-TS	600	Baitello *et al*. (1988)
SP	Ubatuba (IAC)	SP-UBA IAC	160-190	Silva (1990)

Table 1. Continued.

PR	Anhangava	PR-AH1	1300-1400	Roderjan (1994)
PR	Anhangava	PR-AH2	1200-1300	Roderjan (1994)
PR	Anhangava	PR-AH3	1000-1200	Roderjan (1994)
PR	Morro do Anhangava	PR-AH4	1460	Koehler *et al*. (2002)
PR	Colombo	PR-CL	920	Silva & Marconi (1990)
PR	Curitiba	PR-CR	900	Neto *et al*. (2002)
PR	Londrina	PR-LD	700	Soares-Silva & Barroso (1992)
PR	Marumbi	PR-MB	1385	Rocha (1999)
PR	Mãe Catira	PR-MC	1590	Koehler *et al*. (2002)
PR	Pinhais	PR-PN	900	Seger *et al*. (2005)
PR	Serra do Salto	PR-SA	1390	Koehler *et al*. (2002)
PR	São João do Triunfo	PR-SJT	780	Sanquetta *et al*. (2002)
PR	Sapopema	PR-SP	780	Silva *et al*. (1995)
PR	Telêmaco Borba	PR-TB	600	Nakajima *et al*. (1996)
PR	Tibagi	PR-TI	700	Dias *et al*. (1998)
PR	Morro do Vigia	PR-VG	1545	Koehler *et al*. (2002)
PR	Ventania	PR-VT	1000	Estevan (2006)
SC	Caçador	SC-CÇ	1100	Negrelle & Silva (1992)
SC	Morro da Igreja	SC-MI	1710	Falkenberg (2003)
SC	Serra do Rio do Rastro	SC-SR	1400	Falkenberg (2003)
RS	Criúva	RS-CR	860	Neto *et al*. (2002a)
RS	São Francisco de Paula	RS-SFP	930	Narvaes *et al.* (2005)

Table 2: Preferencial species for the groups formed by TWINSPAN. The indicator species of each group are represented in bold.

Cloud Forest	**Araucaria Forest**	**Ombrophilous Dense Forest**	**Montane Forest**	**Semi-deciduous**	**Forest**
Blepharocalyx salicifolius	*Allophylus edulis*	*Alibertia myrciifolia*	*Aegiphila obducta*	*Acacia polyphylla*	*Ixora venulosa*
Citronella paniculata	*Allophylus guaraniticus*	*Allophylus petiolulatus*	*Allophylus edulis*	*Actinostemon concolor*	*Jacaranda macrantha*
Clethra uleana	***Araucaria angustifolia***	*Amaioua intermedia*	*Annona cacans*	*Actinostemon klotzschii*	*Jacaratia spinosa*
Drimys brasiliensis	*Banara tomentosa*	*Andira fraxinifolia*	*Araucaria angustifolia*	*Aegiphila sellowiana*	*Lonchocarpus cultratus*
Eugenia neomyrtifolia	*Campomanesia xanthocarpa*	*Aparisthmium cordatum*	*Aspidosperma parvifolium*	*Agonandra excelsa*	*Machaerium brasiliense*
Gomidesia sellowiana	*Capsicodendron dinisii*	*Astrocaryum aculeatissimum*	*Bathysa australis*	*Alchornea glandulosa*	*Machaerium hirtum*
Gordonia fruticosa	*Casearia lasiophylla*	*Attalea dubia*	*Casearia decandra*	*Aloysia virgata*	*Machaerium nyctitans*
Ilex amara	*Citronella gongonha*	*Bactris setosa*	*Casearia obliqua*	*Amaioua guianensis*	*Machaerium villosum*
Ilex microdonta	*Clethra scabra*	*Balizia pedicellaris*	*Cecropia hololeuca*	*Annona cacans*	*Maclura tinctoria*
Ilex taubertiana	*Cupania vernalis*	*Bathysa meridionalis*	*Cedrela fissilis*	*Aspidosperma cylindrocarpon*	*Maytenus aquifolia*
Meliosma selowii	*Dalbergia brasiliensis*	*Brosimum guianense*	*Croton floribundus*	*Aspidosperma polyneuron*	*Maytenus robusta*
Myrceugenia alpigena	*Erythrina falcata*	*Byrsonima ligustrifolia*	*Dalbergia frutescens*	*Aspidosperma ramiflorum*	*Metrodorea nigra*
Myrceugenia ovata	*Eugenia uniflora*	*Calophyllum brasiliense*	*Daphnopsis fasciculata*	*Astronium graveolens*	*Mollinedia widgrenii*
Myrcia obtecta	*Gordonia fruticosa*	*Calyptranthes grandifolia*	*Drimys brasiliensis*	*Balfourodendron riedelianum*	*Myrocarpus frondosus*
Myrcia richardiana	*Ilex amara*	*Calyptranthes lucida*	*Eremanthus erythropappus*	*Bastardiopsis densiflora*	*Myroxylon peruiferum*
Ocotea catharinensis	*Ilex brevicuspis*	*Campomanesia guaviroba*	*Eugenia involucrata*	*Bauhinia forficata*	*Nectandra oppositifolia*
Ocotea daphnifolia	*Ilex paraguariensis*	*Cariniana estrellensis*	***Gordonia fruticosa***	*Calyptranthes lucida*	*Ocotea corymbosa*
Persea pyrifolia	*Ilex theezans*	*Chionanthus filiformis*	*Guatteria nigrescens*	*Campomanesia guaviroba*	*Ocotea diospyrifolia*
Pimenta pseudocaryophyllus	*Jacaranda puberula*	*Chrysophyllum flexuosum*	*Ilex paraguariensis*	*Campomanesia guazumifolia*	*Ocotea elegans*
Podocarpus sellowii	*Lonchocarpus subglaucescens*	*Citronella megaphylla*	*Lamanonia ternata*	*Cariniana estrellensis*	*Ocotea odorifera*
Rapanea altomontana	*Matayba elaeagnoides*	*Copaifera trapezifolia*	*Machaerium nyctitans*	*Cariniana legalis*	*Ormosia arborea*
Rhamnus sphaerosperma	*Maytenus evonymoides*	*Coussapoa microcarpa*	*Meriania claussenii*	*Casearia gossypiosperma*	*Peltophorum dubium*
Siphoneugena reitzii	*Maytenus ilicifolia*	*Cryptocarya moschata*	*Miconia inconspicua*	*Cassia ferruginea*	*Pera glabrata*
Solanum sanctaecatharinae	*Mollinedia clavigera*	***Cupania oblongifolia***	*Miconia latecrenata*	*Cecropia pachystachya*	*Picramnia ramiflora*

(Cont.) Table 2: Preferencial species for the groups formed by TWINSPAN. The indicator species of each group are represented in bold.

Cloud Forest	Araucaria Forest	Ombrophilous Dense Forest	Montane Forest	Semi-deciduous Forest	
Symplocos corymboclados	*Myrceugenia miersiana*	*Dahlstedtia pinnata*	*Miconia sellowiana*	*Ceiba speciosa*	*Pilocarpus pauciflorus*
Symplocos falcata	*Myrcia laruotteana*	*Ecclinusa ramiflora*	*Micropholis crassipedicellata*	*Celtis iguanaea*	*Piper amalago*
Tabebuia catarinensis	*Myrcia multiflora*	*Eriotheca pentaphylla*	*Myrcia eriopus*	*Centrolobium tomentosum*	*Piptadenia gonoacantha*
Tibouchina reitzii	*Nectandra grandiflora*	*Eugenia cuprea*	*Myrcia laruotteana*	*Chrysophyllum gonocarpum*	*Platycyamus regnellii*
Weinmannia humilis	*Nectandra lanceolata*	*Eugenia lanceolata*	*Myrcia rostrata*	*Colubrina glandulosa*	*Platypodium elegans*
Weinmannia paulliniifolia	*Ocotea porosa*	*Eugenia oblongata*	*Ocotea corymbosa*	*Conchocarpus pentandrus*	*Prockia crucis*
	Ocotea puberula	*Eugenia stictosepala*	*Ocotea puberula*	*Copaifera langsdorffii*	*Protium heptaphyllum*
	Piptocarpha axillaris	*Eugenia stigmatosa*	*Persea pyrifolia*	*Cordia americana*	*Pseudobombax grandiflorum*
	Rapanea gardneriana	*Eugenia subavenia*	*Picramnia glazioviana*	*Cordia ecalyculata*	*Qualea jundiahy*
	Rollinia emarginata	*Eugenia umbelliflora*	*Piptocarpha axillaris*	*Cordia sellowiana*	*Randia armata*
	Sapium glandulatum	***Euterpe edulis***	*Piptocarpha macropoda*	*Cordia trichotoma*	*Rhamnidium elaeocarpum*
	Schinus terebinthifolia	***Garcinia gardneriana***	*Podocarpus lambertii*	*Coutarea hexandra*	*Rollinia sylvatica*
	Sebastiania brasiliensis	*Gomidesia fenzliana*	*Protium widgrenii*	***Croton floribundus***	*Savia dictyocarpa*
	Sloanea lasiocoma1	*Gomidesia spectabilis*	***Prunus myrtifolia***	*Croton urucurana*	*Seguieria langsdorffii*
	Solanum sanctaecatharinae	*Guarea macrophylla*	*Pseudobombax grandiflorum*	*Cryptocarya aschersoniana*	*Senna macranthera*
	Styrax leprosus	*Heisteria silvianii*	***Psychotria vellosiana***	*Cryptocarya moschata*	*Senna multijuga*
	Symplocos celastrinea	***Hirtella hebeclada***	***Rapanea coriacea***	*Dendropanax cuneatus*	*Siparuna guianensis*
	Vernonanthura discolor	*Humiriastrum dentatum*	*Rapanea gardneriana*	*Diatenopteryx sorbifolia*	*Sloanea monosperma*
	Vitex megapotamica	*Inga edulis*	***Rapanea umbellata***	*Duguetia lanceolata*	*Solanum granuloso-leprosum*
	Xylosma pseudosalzmannii	*Jacaranda puberula*	*Rollinia dolabripetala*	*Endlicheria paniculata*	*Solanum lepidotum*
		Manilkara subsericea	*Rollinia sylvatica*	*Enterolobium contortisiliquum*	*Strychnos brasiliensis*
		Marlierea obscura	*Sapium glandulatum*	*Esenbeckia febrifuga*	*Styrax pohlii*
		Marlierea tomentosa	*Solanum cinnamomeum*	*Esenbeckia grandiflora*	*Sweetia fruticosa*
		Matayba elaeagnoides	*Solanum leucodendron*	*Eugenia florida*	*Syagrus romanzoffiana*
		Matayba juglandifolia	*Solanum pseudoquina*	*Euterpe edulis*	*Tabernaemontana hystrix*
		Miconia rigidiuscula	*Solanum swartzianum*	*Ficus enormis*	*Tapirira guianensis*
		Mollinedia schottiana	*Tapirira obtusa*	*Ficus pertusa*	*Tapiria obtusa*
		Myrceugenia myrcioides	*Tibouchina arbórea*	*Galipea jasminiflora*	*Terminalia glabrescens*

(Cont.) Table 2: Preferencial species for the groups formed by TWINSPAN. The indicator species of each group are represented in bold.

Ombrophilous Dense Forest	**Montane Forest**	**Semi-deciduous Forest**	
Myrcia multiflora	*Tibouchina sellowiana*	*Gallesia integrifolia*	*Trema micrantha*
Myrcia pubipetala	*Vernonanthura discolor*	*Genipa americana*	*Trichilia casarettii*
Neomitranthes glomerata	*Vernonanthura divaricata*	*Gomidesia affinis*	*Trichilia catigua*
Ocotea catharinensis	*Vochysia magnifica*	*Guapira opposita*	*Trichilia clausseni*
Ocotea dispersa	*Vochysia schwackeana*	*Guarea guidonia*	*Trichilia elegans*
Ocotea glaziovii	*Vochysia tucanorum*	*Guarea kunthiana*	*Trichi pall*
Ormosia arborea		*Guarea macrophylla*	*Urera baccifera*
Ouratea parvifolia		*Guatteria nigrescens*	*Vernonanthura divaricata*
Parinari excelsa		*Guazuma ulmifolia*	*Vernonanthura phosphorica*
Pera glabrata		*Hirtella hebeclada*	*Vitex polygama*
Pouteria psammophila		*Holocalyx balansae*	*Vochysia tucanorum*
Psychotria nuda		*Hymenaea courbaril*	*Xylopia brasiliensis*
Pterocarpus rohrii		*Inga marginata*	*Zanthoxylum caribaeum*
Rapanea ferruginea		*Inga striata*	*Zanthoxylum monogynum*
Rapanea venosa		*Inga vera*	*Zanthoxylum riedelianum*
Rollinia sericea		*Ixora gardneriana*	*Zeyheria tuberculosa*
Rustia formosa			
Schefflera angustissima			
Sloanea guianensis			
Syagrus pseudococos			
Tabebuia cassinoides			
Tapirira guianensis			
Tetrastylidium grandifolium			
Trichilia silvatica			
Vantanea compacta			
Virola bicuhyba			
Xylopia langsdorfiana			

CONSIDERAÇÕES FINAIS

Os resultados do capítulo 1 indicaram a existência de uma mudança abrupta na vegetação a partir de 1120m de altitude, o que ocasiona a existência de duas comunidades distintas na faixa altitudinal analisada. Embora em algumas situações a literatura demonstre a inexistência de uma altitude crítica para a mudança na composição da vegetação, o presente trabalho demonstra que isso ocorre no Morro do Cuscuzeiro, provavelmente devido à proximidade do mar que gera a cobertura frequente por nuvens que, juntamente com a ação do vento e a topografia da porção superior da montanha (com declividade acentuada), parecem condicionar a ocorrência da Floresta Nebular. As particularidades de cada área parecem estar associadas à existência ou não de altitudes críticas, bem como a faixas altimétricas mais ou menos elevadas onde estas ocorreriam. O Morro do Cuscuzeiro apresentou uma constituição florística bastante peculiar devido ao aparecimento de uma Floresta Nebular na sua porção superior (de 1120m até 1270m), fato não comumente descrito na literatura, seja pela escassez de estudos em áreas elevadas da Serra do Mar, seja pela singularidade das condições ambientais que levaram ao estabelecimento desta comunidade no local. Entre os 820m e os 970m, foi detectada a presença de Floresta Ombrófila Densa Montana (ou mata de encosta), onde foram observados uma maior riqueza de espécies, maior diâmetro, altura e volume das árvores, e menor densidade.

O capítulo 2 analisou os dados obtidos no capítulo 1 em um contexto mais amplo. As análises realizadas em escala regional corroboraram os resultados do capítulo 1, obtidos em escala local, uma vez que as comunidades previamente estabelecidas foram inseridas em uma matriz de levantamentos do Sul e Sudeste do Brasil e se agregaram em grupos bastante distintos. A comunidade situada acima dos 1120m se agrupou com outras Florestas Nebulares geograficamente distantes, enquanto a comunidade situada entre os 820m e os 970m se agrupou com os levantamentos da província costeira, em especial com aqueles realizados na encosta da Serra do Mar do estado de São Paulo, seja no litoral norte ou no litoral sul.

As Florestas Nebulares são ainda pouco conhecidas no Brasil (Falkemberg & Voltolini 1995) e sua existência parece estar relacionada à constante presença de neblina (Stadtmüller 1987), o que as coloca num *status* crítico frente às perspectivas de aquecimento global (Still *et al.* 1999, Foster 2001, Colwell *et al.* 2008). Neste sentido, são urgentes os esforços da comunidade científica para conhecer e entender a composição florística, estrutural, e a dinâmica desta vegetação, além das características fisiológicas particulares das espécies que a compõe, conhecimentos estes que poderão servir como base para a conservação destas comunidades, seja esta *in situ* ou ex situ.

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