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Research Article

Secondary Forest Succession in the Mata Atlantica, Brazil: Floristic and Phytosociological Trends

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This study aimed at understanding the dynamics of ecological processes and the use of secondary forests in Santa Catarina state (Brazil). The data base for these studies was formed through forest inventories carried out in the three forest types of the state. The results of this study demonstrate that the patterns of diversity are very similar among the three forest types; however, the species compositions among the types are quite different. A total of 343 woody species belonging to 73 families were found in the 24,000 m^2 sampling area, revealing the potential role of secondary forest in the conservation of biodiversity at the landscape scale. As expected, a small set of pioneer species dominates young secondary forests with shade-tolerant species becoming structurally important after 30 years. The patterns of forest structure and species diversity observed in study largely conform to the postagricultural secondary succession observed for many tropical forests.

1. Introduction

The continuing loss of primary tropical forests makes secondary forests increasingly important for maintaining biodiversity across large forested landscapes [1–4], while also providing for environmental services and sustainable economic development [5–7]. Today, less than 25% of the original forest area in Santa Catarina state (Brazil) remains, mostly as small fragments of secondary forest in a mosaic intermixed with other land uses [8]. Most secondary forests in Santa Catarina and throughout much of the Mata Atlântica are privately held and result from fallow rotations in a dynamic agricultural system [9]. The recovery potential of such secondary forests is influenced by many interacting factors including the length and intensity of past land use, parcel size, soil conditions and landscape position, local climate regimes, proximity to forest seed sources, the presence or absence of seed banks, and dispersal agents, and interactions among regenerating species [10–16].

The important roles that secondary forests can play in conservation and economic development are poorly understood in Brazil. Even well-intentioned Brazilian laws governing forest protection and use can be counter-productive to conservation. Recent laws that define a “forest” in terms of arbitrary structural characteristics have led small farmers to shorten fallow periods so that secondary forest succession does not proceed to the point where it is recognized as “forest”. This avoids federal/state restrictions on forest harvesting or land conversion [17] with the result that secondary forests which could contribute to biodiversity conservation while providing a range of nontimber forest products are now less likely to develop. The landscape increasingly is held only in the earliest stages of forest succession before being cropped again.

We focused on the successional dynamics of secondary forests in the youngest age classes that prevail across this landscape in order to suggest alternative definitions of “forest” that recognize their important values in conservation and economic development. In this paper we describe the regeneration patterns that occur in secondary forests of Santa Catarina on parcels having diverse cultivation histories and variable fallow periods. Anthropogenic disturbances such as forest clearing for agriculture are generally more intensive/severe than those arising from natural disturbances, but early stages of forest succession appear to be dominated in both instances by a small number of common woody species in well-defined stages typical of large gaps [16, 18, 19]. The specific objectives of this study were to examine the patterns of species diversity and abundance as well as the transitions during which woody species are added and removed during the early phases of secondary forest succession.

2. Methods

2.1. Study Areas. The study was carried out on 48 small farms in the counties of Anchieta, Garuva, Concórdia, Três Barras, Caçador and São Pedro de Alcântara, Santa Catarina, Brazil (Figure 1). These areas included three different vegetation formations common to the Mata Atlântica of Santa Catarina, seasonal deciduous forest, mixed ombrophylous forest and dense ombrophylous forest [20] recognized and protected by Brazilian Law no. 11.426/2006.

2.1.1. Seasonal Deciduous Forest (SDF). This forest type occurs in the Uruguay River basin at elevations ranging from 200 to 600 meters with an annual precipitation of 1.800 mm/yr [21–24]. It is characterized by a closed canopy dominated by Lauraceae and emergent deciduous species, mostly Fabaceae and a subcanopy dominated by *Sorocea bonplandii*, *Gynnanthes concolor* and *Trichilia* species; epiphytes are poorly represented in comparison with the dense ombrophylous forest [21].

2.1.2. Mixed Ombrophylous Forest (MOF). This forest type is distributed across plateaus at approximately 500 meters elevation upwards on slopes rising to 1600 meters above sea-level with annual precipitation ranging from 1,600 to 2,100 mm [20]. This moist forest is characterized by a supercanopy dominated by *Araucaria angustifolia*, with subcanopy layers rich in species of Lauraceae, Myrtaceae, and Fabaceae [25, 26].

2.1.3. Dense Ombrophylous Forest (DOF). This forest was formerly common in coastal regions at elevations below 500 meters. The forest is characterized by hot temperatures, heavy rainfall (annual precipitation ranges from 1,500 to 2,000 mm) and an evergreen canopy dominated by Lauraceae and Myrtaceae with an abundance of epiphytes and palms [18, 26].

2.2. Data Collection and Analysis. We inventoried a total of eighty 10 m × 10 m plots in the dense ombrophylous forest (Garuva and São Pedro de Alcântara sites), and forty 20 m × 10 m plots in each of the seasonal deciduous forest (Anchieta and Concórdia sites), and mixed ombrophylous forest (Três Barras and Caçador sites) types (a total of 160 plots covering 24,000 m^2). Based on physiognomic features, together with land ownership information, we sited 160 plots distributed across four successional stages (after Klein [18]: shrubby stage (0–8 years), small tree stage (8–15 years), Arboreal Stage (15–30 years) and advanced arboreal stage (30–60 years)). All woody plants taller than 1.5 m were identified and measured for DBH (diameter at breast height = 1.3 m) and total height. Plant identifications were made with reference to the Angiosperm Phylogeny Group (APG) classification updated in APG II [27], and the expertise of Prof. Ademir Reis (Federal University of Santa Catarina and Curator of the Barbosa Rodriguez Herbarium) and Prof. Marcos Sobral (BHCB—Herbarium of the Botany Department at the Federal University of Minas Gerais).

Species richness (number of species), Shannon-Wiener's index of diversity (H'), evenness (J), Simpson's diversity index (D), "importance value" (IV) and absolute frequency were estimated using the FITOPAC 1 software package [28]. Rarefaction curves (Sobs) constructed using 100 randomized orders and the Chao1, Jackknife and Bootstrap estimators were derived using EstimateS 6.0 software [29]. Differences in values of stem density and basal area among stages were tested by one-way ANOVA with Tukey's multiple comparison tests using the STATISTICA 6.0 software package [30].

3. Results

A total of 13,548 woody plants were identified on the 160 plots, representing 343 species from 73 families (the appendix). The most common families represented (number of species in parentheses) were the Myrtaceae (38), Fabaceae (33), Asteraceae (27), Lauraceae (27), Rubiaceae (20) and Melastomataceae (17). Forty-four species were common to all three forest types, representing around 13% of the species total, leading to a similarity estimate of about 10%.

The dense ombrophylous forest (DOF) type contained 66% (230) of all the species recorded for all forest types. Our sampling design placed more but smaller plots in the DOF formation and this likely introduced a slight bias towards finding more species in this forest type. When the differences in plot number and area sampled are accounted for (DOF2 in Table 2), we estimate that the dense ombrophylous forest type would still include 59% (204) of the species identified. The seasonal deciduous forest and mixed ombrophylous forest types were very similar in their estimated species richness but markedly less rich than the dense ombrophylous forest type.

The secondary succession process in all three forest types was characterized by an increase in (1) species richness, (2) evenness scores, and (3) Shannon-Wiener diversity index values. Only the Simpson's diversity index values decreased over time during the formation of taxonomically more diverse and structurally more complex communities (Table 2).

Despite the relatively high species richness that our sampling revealed in these secondary forests, the rarefaction curves (Sobs) and other estimators of richness (Chao1, Jack2 and Bootstrap; Figure 2) suggest that our sampling only found about three-fourths (75% in SDF, 71% in MOF and

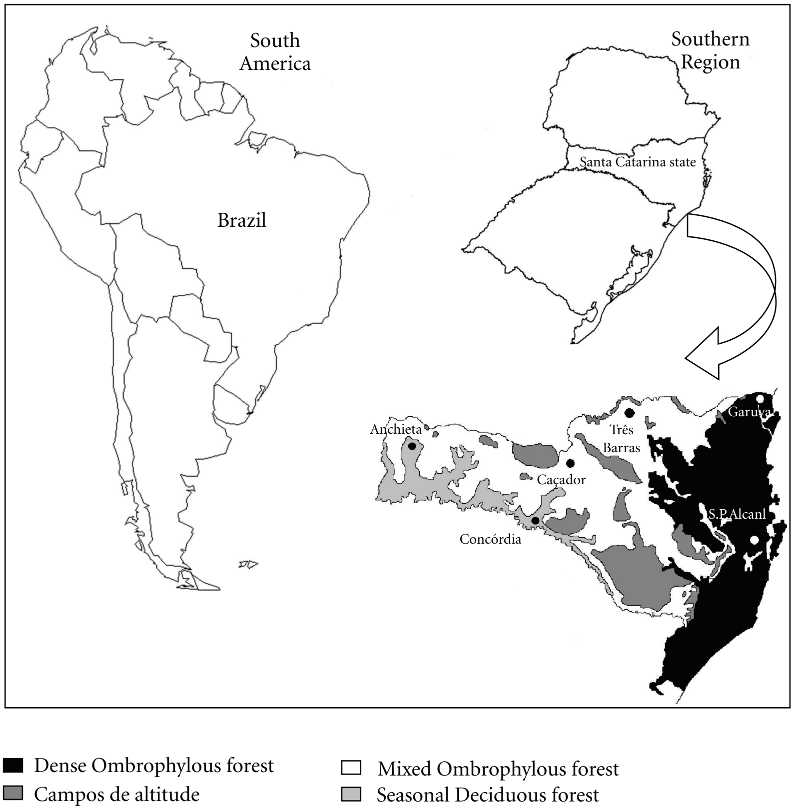

Figure 1: Santa Catarina phytogeographic map, adapted from Klein [25].

Table 1: Family and species richness and the number of species common to three forest types in the Mata Atlântica of Santa Catarina, Brazil.

	SDF	MOF	DOF	All forests
Families	46	45	55	73
Species	135	135	230	343
Common species	SDF/MOF	MOF/DOF	DOF/SDF	SDF/MOF/DOF
	14	19	20	44

78% in DOF) of the maximum number of species expected to be present in these forest types.

Species composition for all three forest types changed with changes in the length of the preceding fallow period (Table 3). Although all three forests are marked by high species diversity, a few species dominate each stage of succession as demonstrated by the large Importance Values (Table 3), but this tendency decreases with increasing succession. As an example, the shrubby stage of all three forest types is dominated by *Baccharis dracunculifolia* and a few other species, while the small tree stage in the MOF and DOF types is dominated by *Myrsine coriaceae* and a few other species *Nectandra lanceolata* (SDF), *Mimosa scabrela* (MOF) and *Miconia cinnamomifolia* (DOF) dominated the Arboreal Stage and species such as *Nectandra megapotamica* (SDF), *Ocotea puberula* (MOF) and *Hyeronima alchorneoides* (DOF) dominated the advanced arboreal stage of each type.

During the early stages of secondary succession, species such as *Trema micrantha* (SDF) and *Tibouchina trichona* (DOF) had low absolute frequencies but they had high densities and/or dominance when they occurred. In the advanced arboreal stages typical understory species such as *Cupania vernalis*, *Allophylus edulis* (SDF and MOF) and *Euterpe edulis* (DOF) all had high frequencies of occurrence. Most species with large Importance Values were common or abundant in only one or two successional stages but were quickly replaced by other species during succession. However, a few persisted, for example, *Tibouchina pulchra* was common in three successional stages in the DOF.

4. Discussion

The sampling method used identified those species most common to the early successional stages of secondary forest regeneration in three forest types of the Mata Atlântica. The high number of species (230) found in the dense ombrophylous forest was not unexpected, as this forest type represents some 82% of all arboreal species found in Santa Catarina [26].

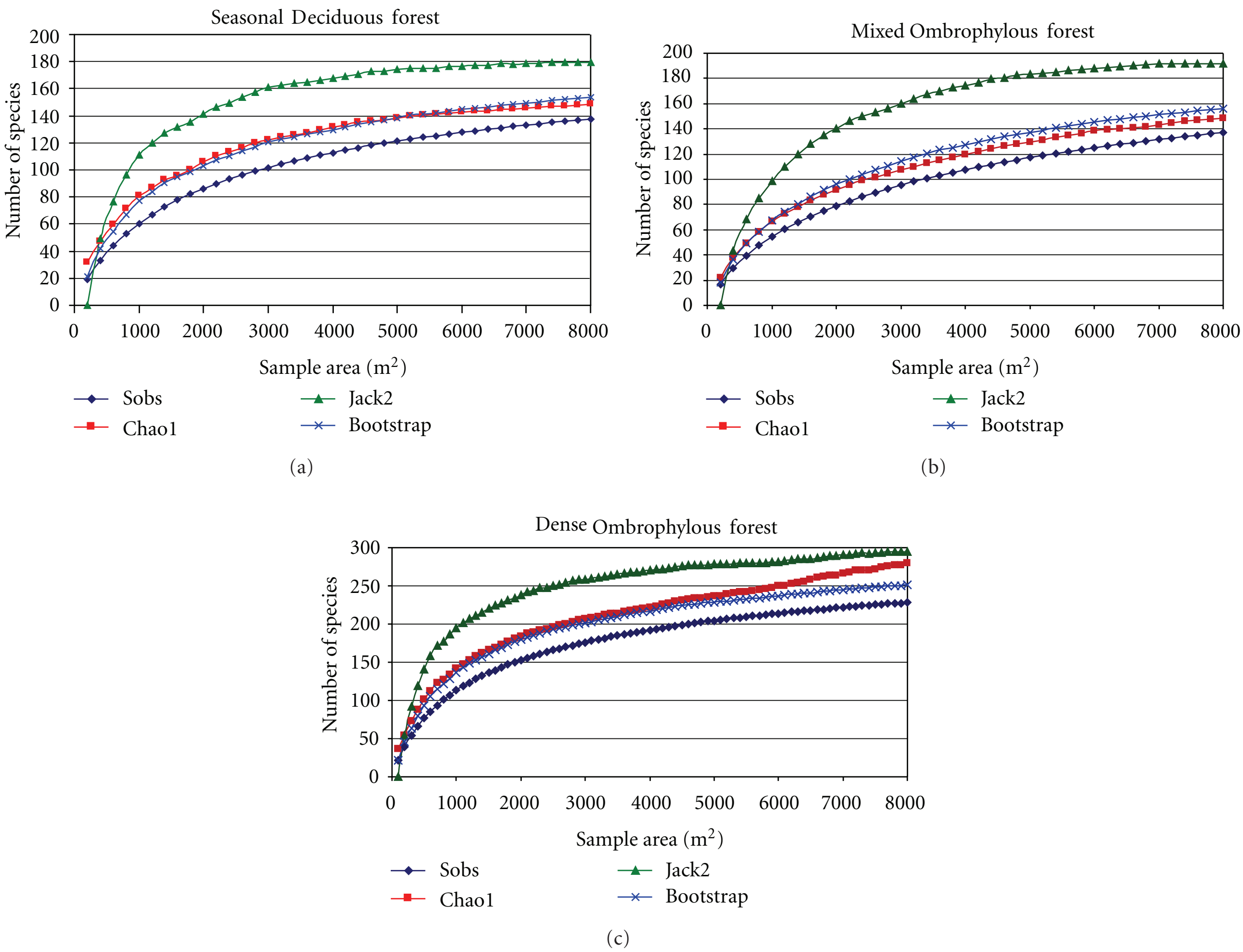

FIGURE 2: Sample-based rarefaction curves (Sobs) and species richness estimators (Chao1, Jack2 and Bootstrap) for three forest types in the Mata Atlântica.

Diversity and especially species richness increased over time since abandonment, similar to what has been found in other studies of swidden fields, abandoned plantations and pasture [13, 31–34].

The peak in the numbers of species found in Arboreal Stages of all forest types is consistent with the "intermediate disturbance hypothesis" [35], that during the early stages of secondary forest succession a few pioneer species dominate but are replaced over time by species better adapted to the increasingly competitive environments that develop. Species diversity is often greatest during mid-successional stages that contain both early and late successional species. In all three forest types studied here, the Arboreal Stage (15–30 years) had a richness that was greater than for any other stage in the SDF and MOF types and equal in richness to the advanced arboreal stage of the DOF type.

Species richness is only one component of diversity but because it gives the same weight to all species irrespective of their relative abundance it is strongly influenced by the number of rare species. Evenness, another component of diversity, is strongly influenced by the relative frequencies of dominant species [36, 37]. We use different measures of diversity to emphasize different diversity patterns that reflect different ecological processes.

Our Shannon-Wiener diversity estimates were similar to, or slightly higher than, those of other studies of comparably aged Mata Atlântica forests. For example, Oliveira [34] and Torezan [38] estimated $H' = 2.51$ nats/ind in five-year-old early successional stands; Pessoa et al. [39] estimated $H' = 3.66$ nats/ind in a thirty-year-old pole stand; and Oliveira [34] estimated $H' = 3.33$ nats/ind in a twenty-five-year-old stand and $H' = 3.10$ nats/ind in a fifty-year-old area stand. All these studies were conducted on sites with land use histories characterized by shifting cultivation.

The Shannon index is a common diversity estimate reported in the literature ranging from 3.26 to 4.36 for the mature forests of these types [40–46]. The higher values reported here for all stages of our study in relation to values reported in the literature may be due to the sampling method and criteria used for plant inclusion. Also our use of more plots, especially noncontiguous plots, likely raised the levels of beta diversity.

Values of the Shannon index can be influenced by the number of species with intermediate values of relative

Table 2: Phytosociological indices estimated for four successional stages in three Mata Atlântica forest formations; SDF: seasonal deciduous forest, MOF: mixed ombrophylous forest, DOF: dense ombrophylous forest; H' is Shannon-Wiener's index of diversity, J' is evenness, D is Simpson's index.

Forest Type	Successional stage	Plots (no.)	Sampling area (m^2)	Species richness (no.)	Family richness (no.)	H' [a] (nats/ind)	J'	D
SDF	Shrubby (0–8 y)	10	2000	45	24	2.08	0.400	0.335
	Small trees (8–15 y)	10	2000	72	32	3.25	0.760	0.076
	Arboreal (15–30 y)	10	2000	94	40	3.98	0.870	0.026
	Advanced arboreal (30–60 y)	10	2000	84	33	3.70	0.840	0.036
	All stages		8000	135	46	4.00	0.817	0.034
MOF	Shrubby (0–8 y)	10	2000	46	19	2.74	0.719	0.122
	Small trees (8–15 y)	10	2000	51	22	3.16	0.797	0.069
	Arboreal (15–30 y)	10	2000	95	41	3.76	0.822	0.036
	Advanced arboreal (30–60 y)	10	2000	81	34	3.57	0.809	0.052
	All stages		8000	135	45	3.92	0.799	0.035
DOF	Shrubby (0–8 y)	20	2000	80	30	3.09	0.705	0.073
	Small trees (8–15 y)	20	2000	116	43	3.35	0.700	0.058
	Arboreal (15–30 y)	20	2000	163	51	4.24	0.829	0.025
	Advanced arboreal (30–60 y)	20	2000	161	48	4.42	0.867	0.019
	All stages		8000	230	55	4.28	0.787	0.031
DOF2	Shrubby (0–8 y)	10	1000	75	29	3.03	0.701	0.081
	Small trees (8–15y)	10	1000	92	35	3.32	0.755	0.076
	Arboreal (15–30 y)	10	1000	132	46	4.16	0.852	0.026
	Advanced arboreal (30–60 y)	10	1000	134	43	4.42	0.902	0.016
	All stages		4000	204	53	4.22	0.794	0.031

[a] Estimated using the natural logarithm (base e).

abundance [47], and may introduce some variation in the estimates of species richness of communities [48]. As the value of Simpson's D has an inverse relationship with the indices of Shannon and evenness [49], the value of D decreases along successional stages.

The floristic composition of secondary forest formations described in this study was very similar with respect to genera reported for other studies in the Mata Atlântica of southeastern Brazil (Table 4).

5. Conclusion

The floristic diversity observed for the forests we surveyed largely agree with patterns of post-agricultural secondary forest succession observed for many other neotropical forests. The chronosequence covers a relatively large range of successional ages (0–60 years) that results in large changes in species diversity and composition despite a limited geographical sampling. This result suggests that the patchy mosaic of secondary forests in Santa Catarina has a high potential for biodiversity conservation. Whether it can also provide for economic development in the way of nontimber forest products would depend upon the life histories of individual species and any rules instituted to guide their sustainable management.

The results of this study demonstrate that the patterns of secondary succession appear very similar among the three forest types with respect to changes in species richness and other measures. However, the species composition among the types, while quite similar in the earliest shrubby stage, diverges during succession, with the largest differences noted between the DOF and the other two types. As expected, and despite high species richness, a small set of "pioneer species" dominates the shrubby and small tree stages until about age 15. After that time, more shade-tolerant species increase during the Arboreal and advanced arboreal stages of forest succession, but only a small number become structurally important after 25–30 years.

Table 3: Woody species most characteristic of four secondary forest successional stages in the Mata Atlântica of Santa Catarina.

Successional stage	Dominan species[a]	Five most important species	IV value[b]	Successional position[c]
Seasonal deciduous forest (SDF)				
Shrubby	6	*Baccharis calvensces, B. dracunculifolia, B. elaeagnoides, Anonna silvatica, Schinus terebinthifolius.*	137	E
Small trees	9	*Baccharis dracunculifolia, Dalbergia frutescens, Schinus terebinthifolius, Solanum mauritianum, Trema micrantha*	108	E
Arboreal	16	*Alchornea triplinervia, Aloysia virgata, Apuleia leiocarpa, Dahlstedtia pinnata, Nectandra lanceolata*	64	M
Advanced arboreal	12	*Alchornea triplinervia, Cupania vernalis, Nectandra lanceolata, N. megapotamica, Parapiptadenia rigida.*	100	M-L
Mixed ombrophylous forest (MOF)				
Shrubby	6	*Baccharis dracunculifolia, B. semiserrata, Eupatorium vauthierianum, Piptocarpha angustifolia, Solanum mauritianum.*	137	E
Small trees	9	*Baccharis dracunculifolia, Matayba elaeagnoides, Mimosa scabrella, Myrsine coriaceae, Sapium glandulatum.*	100	E
Arboreal	11	*Clethra scabra, Matayba elaeagnoides, Mimosa scabrella, Ocotea puberula, O. pulchella.*	97	M
Advanced arboreal	11	*Clethra scabra, Cupania vernalis, Matayba elaeagnoides, Ocotea porosa, O. puberula.*	108	M-L/U
Dense ombrophylous forest (DOF)				
Shrubby	6	*Baccharis dracunculifolia, Dodonaea viscosa, Leandra dasytricha, Myrsine coriaceae, Tibouchina trichotona.*	115	E
Small trees	8	*Miconia cabucu, M. cinnamomifolia, M. rigidiuscula, Myrsine coriaceae, Tibouchina pulchra.*	133	E-M
Arboreal	17	*Hyeronima alchorneoides, Miconia cabucu, M. cinnamomifolia, Myrsine coriaceae, Tibouchina pulchra*	83	M
Advanced arboreal	20	*Euterpe edulis, Marlieria eugeniopsioides, Miconia cinnamomifolia, Psychotria longipes, Tibouchina pulchra.*	44	M-L/U

[a]Dominant species are defined as those species whose summed importance values, when ranked from the highest to lowest, contained 50% of the total for a given stand, after Finegan [14].
[b]IV: Importance Value, here we include the proportion (from a base of 300) accounted for by the five most important species.
[c]Successional position (E: early successional, M: mid successional, L: late successional, U: understory) of the five most important species.

Table 4: Plant genera with a high frequency of occurrence in secondary forests of the Mata Atlântica in Southern and Southeastern Brazil.

Forest Formation	Frequent botanic genus	Authors
Seasonal deciduous forest	*Baccharis*, *Alchornea*, *Casearia*, *Inga*, *Solanum*, *Nectandra*, *Ocotea*, *Ilex*, *Allophylus*, *Apuleia*, *Cedrela*, *Cupania*, *Lonchocarpus*, *Luehea*, *Machaerium*, *Sorocea* and *Trema.*	Vaccaro and Longhi [50]; Rondon-Neto et al. [51]; Andreis et al. [52]; Hack et al. [53].
Mixed ombrophylous forest	*Baccharis*, *Casearia*, *Chethra*, *Ilex*, *Solanum*, *Nectandra*, *Ocotea*, *Myrsine*, *Matayba*, *Piptocarpha*, *Sapium*, *Vernonia*, *Allophylus*, *Zanthoxylum* and *Capsicodendron.*	Rondon-Neto et al. [54]; Pezzatto et al. [55]; Narvaes et al. [56]; Ramos and Boldo [57].
Dense ombrophylous forest	*Baccharis*, *Tibouchina*, *Myrsine*, *Cecropia*, *Alchornea*, *Solanum*, *Miconia*, *Nectandra*, *Ocotea*, *Jacaranda*, *Chethra*, *Ilex*, *Cedrela*, *Cupania*, *Psychotria*, *Euterpe*, *Guarea* and *Matayba.*	Klein [18]; Tabarelli and Mantovani [33]; Oliveira [34]; Oliveira-Filho et al. [58]; Mantovani et al. [59]; Schorn and Galvão [60]; Liebsh et al. [61].

A chronosequence approach only allows us to infer successional changes because we do not analyze the underlying processes mediating these changes on our sites (growth, mortality, and recruitment). Thus, we suggest that long-term permanent plots be established in this region, to improve our understanding of secondary forest dynamics, while also creating a framework for future comparative studies of the role of ecological processes and mechanisms in different successional stages.

Appendix

See Table 5.

Table 5: List of families, species and number of individuals in four successional stages (SR: shrubby, ST: small trees, AR: arboreal and AA: advanced arboreal) in the Mata Atlântica forest formations, Brazil; SDF: seasonal deciduous forest, MOF: mixed ombrophylous forest, DOF: dense ombrophylous forest.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Adoxaceae (Caprifoliaceae)												
Sambucus australis Cham. & Schltdl.			1									
Anacardiaceae												
Lithraea brasiliensis March.					1	1	38					
Schinus molle L.					3	5	3					
Schinus terebinthifolius Raddi	21	51	8		22	40	41	1			1	
Tapirira guianensis Aubl.										4		
Annonaceae												
Annona glabra L.											3	4
Duguetia lanceolata A.St.-Hil.									1		2	5
Guatteria australis A.St.-Hil.									1	1	1	3
Annona rugulosa Schl.			6	3	3	11	21	10				
Annona sericea R.E.Fries			1							6	9	20
Annona sylvatica A.St.-Hil.	23	2	9	4						7	9	6
Annona sp.											1	2
Xylopia brasiliensis Spreng.											34	27
Apocynaceae												
Aspidosperma parvifolium A.DC.	5	2	4	1							2	6
Rauvolfia sellowii Müll.Arg.		1	3	7								
Tabernaemontana catharinensis A. DC.										2	3	5
Aquifoliaceae												
Ilex brevicuspis Reissek							1	1			1	4
Ilex dumosa Reissek											6	1
Ilex microdonta Reissek							2				3	1
Ilex paraguariensis A.St.-Hil.	2	2	43			5	73	27				
Ilex theezans Mart. ex Reissek						2	7	1	1		9	7
Araliaceae												
Schefflera angustissima (Marchal) Frodin				1				1		1	14	3
Schefflera morototoni (Aubl.) Maguire, Stey. & Frod					3	5	3					
Araucariaceae												
Araucaria angustifolia (Bertol.) Kuntze						2	2	3				
Arecaceae												
Bactris setosa Mart.										5	28	19
Euterpe edulis Mart.											18	131
Geonoma gamiova Barb.										1	6	41
Geonoma schottiana Mart.										2	2	2
Syagrus romanzoffiana (Cham.) Glassman						2						
Asteraceae												
Asteracea sp1									1			
Asteracea sp2		1										
Baccharis calvensces A.P. Candole	16	10			14	2	1		79	23	2	
Baccharis dentata (Vell.) G.M.Barroso					1							

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Baccharis dracunculifolia DC.	307	72	1		203	114	11		81	22	1	
Baccharis elaeagnoides Steud.	14	11			23	2			81	24		
Baccharis erioclada DC.					31							
Baccharis semiserrata DC.	3				8							5
Baccharis sp1	16	10				1						
Baccharis sp2						1			81	32		
Baccharis sp3					11							
Baccharis trimera (Less.) DC.					4							
Baccharis uncinella DC.					5							
Eupatorium serratum Spreng.					3					9		
Eupatorium sp2					32	7	2					
Eupatorium sp3									5			
Eupatorium sp1	2	1										
Eupatorium vauthierianum DC.					132	51		13				
Gochnatia polymorpha (Less.) Cabrera.						2						
Piptocarpha angustifolia Dusén ex Malme				1	44	1	5		11	20	13	
Piptocarpha tomentosa Baker.		1					6	1		2	1	
Vernonia discolor (Spreng.) Less.				6	1	5	25	2	5	46	37	3
Vernonia petiolaris DC.					27							
Vernonia puberula Less.									13			1
Vernonia sp1					14	2	2					
Vernonia sp2						7						
Vernonia sp3											1	
Bignoneaceae												
Jacaranda micrantha Cham**.**			1	5	2	6	4	2	21	53	47	3
Jacaranda puberula Cham**.**					1	1	3	1	3	37	12	
Tabebuia sp.											6	2
Tabebuia umbellata (Sond.) Sandw.	1	4	8	2						3		
Boraginaceae												
Cordia ecalyculata Vell	1	13	9	12								
Cordia americana (L.) Gottschling & J.S. Mill.	3	2	3	5								
Burseraceae												
Protium kleinii Cuatrec.											3	1
Cannabaceae (Ulmaceae)												
Celtis triflora (Klotzsch.)Miq.						4						
Trema micrantha (L.) Blume	8	186	4	1		1			7	7	1	
Canellaceae												
Capsicodendron dinisii (Schwacke) Occhioni						2	32	31				
Cardiopteridaceae (Icacinaceae)												
Citronella paniculata (Mart.) R.A.Howard			2	14								

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Caricaceae												
Carica quercifolia (A.St.-Hil.) Hieron		2										
Celastraceae												
Maytenus muelleri Scheacke			3	1			4	1				
Maytenus robusta Reiss.									1		2	2
Chloranthaceae												
Hedyosmum brasiliensis Mart.									1	9	17	
Chrysobalanaceae												
Hirtella hebeclada Moric. ex DC.									1	2	3	8
Clethraceae												
Clethra scabra Pers.		1	2		14	24	29	22	2	10	60	7
Clusiaceae												
Calophyllum brasiliense Cambess.											4	1
Clusia parviflora (Saldanha) Enfler										9	24	7
Garcinia gardneriana (Planch. & Triana) Zappi									1		5	8
Combretaceae												
Terminalia cf. *australis* Cambess.										2	1	
Cunoniaceae												
Lamanonia speciosa (Camb.) L.B. Smith.			3			3	5	7				
Lamanonia ternata Vell.												2
Weinmania humilis Engl.											1	2
Weinmannia paulliniifolia Pohl ex Ser.							3			4	1	
Cyatheaceae												
Alsophila sp.										1	2	1
Cyathea schanschin Mart.											22	33
Cyathea vestita Mart.										8	24	35
Dicksoniaceae												
Dicksonia sellowiana Hook							3	2				
Ebenaceae												
Diospyros inconstans Jacq.										10	3	1
Elaeocarpaceae												
Sloanea guianensis (Aubl.) Benth.		1		1								
Erythroxylaceae												
Erythroxyllum deciduum A.St.-Hil.							2					
Erythroxylum cf. *cuneifolium* (Mart.) O.E. Schulz		3										
Erythroxylum myrsinites Mart.										4	2	
Euphorbiaceae												
Alchornea iricurana Casar.										1	1	
Alchornea sidifolia Müll.Arg.	3		2	2					2	2	4	
Alchornea triplinervia (Spreng.) Müll. Arg.	1	5	23	28	1		1	5	7	12	7	6
Gymnanthes concolor Spreng.		1	20	24			6	2			11	4

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Manihot grahami Hook.	6	11	4	1		10	2	1			5	
Pausandra morisiana (Casar.) Radlk.											3	3
Pera glabrata (Schott) Baill									1	4	53	25
Ricinus communis L. (exótica)	2											
Sapium glandulosum (L.) Morong	1	1	1		6	20	18	11	1	7	1	1
Sebastiania commersoniana (Baill.) L.B. Smith & R.J.Downs	1	3	4	3								
Tetrorchidium rubrivenium Poepp. & Endl.									120	21	27	
Phylanthaceae												
Hyeronima alchorneoides Fr. Allem.									32	58	78	39
Richeria australis Mull.Arg.											1	
Fabaceae												
Abarema langsdorfii (Benth.) Barneby & J.W. Grimes										2	5	
Albizia polycephala (Benth.) Killip		5										
Andira anthelmintica Benth.			1							5		1
Andira fraxinifolia Benth.											1	
Apuleia leiocarpa (Vog.) Macbr.	2		25	11								
Bauhinia forficata Link.	2	11	5	19								
Calliandra selloi (Spreng.) Macbr.		3	6	1								
Copaifera trapezifolia Hayne												3
Dahlstedtia pinnata (Benth.) Malme		7	36									
Dalbergia frutescens Britton	17	73	19	36								2
Enterolobium contortisiliquum (Vell.) Morong.				1								
Holocalyx balansae Micheli				2								
Inga marginata Willd.		26	20	7					7	3	6	2
Inga sessilis (Vell.) Mart.									4	2	2	1
Inga vera Willd.		11	7									1
Inga virescens Benth.					1	1	3	18			1	
Lonchocarpus campestris Mart. ex Benth	5	4	39	10		29	17		11	12		
Lonchocarpus guilleminianus (Tul.) Malme		3	12	7			10	12	1			
Lonchocarpus sp.			9	1							1	
Machaerium hirtum (Vell.) Stell Feld												2
Machaerium paraguariensis Hassler	6	22	2		1	2		2	1			
Machaerium sp.1		49										
Machaerium stipitatum (DC.) Vog.		34	3	3		24	13	1	3		2	2
Mimosa bimucronata (DC.) O. Ktze.									6	16	2	3
Mimosa scabrella Benth					8	13	75	2				
Myrocarpus frondosus Allem.		2		3								
Ormosia arborea (Vell.) Harms.									1	1		
Papilionaceae sp.												1

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Parapiptadenia rigida (Benth.) Brenan	5	11	15	37								
Peltophorum dubium (Spreng.) Taub.			1									
Piptadenia gonoacantha (Mart.) Macbr.									6			3
Schizolobium parahyba (Vell.) Blake							3					
Zollernia ilicifolia Vog.									1		9	4
Lamiaceae												
Aegiphila sellowiana Cham.							5	2			3	5
Vitex megapotamica (Spreng.) Moldenke			2	3								1
Lauraceae												
Cinnamomum amoenum (Nees) Kosterm.							1	1				
Cryptocarya aschersoniana Mez								3				
Cryptocarya cf. *moschata* Nees et Mart. ex Nees												10
Endlicheria paniculata (Spreng.) Macbride			3	3								8
Lauraceae sp1		1	1									
Lauraceae sp2												1
Nectandra lanceolata Nees et Mart. ex Nees	2	28	67	73		1	6	39		6	12	11
Nectandra leucothyrsus Meissn.										1	2	3
Nectandra megapotamica Mez.		14	18	90		6		4	1	11	2	20
Nectandra membranacea (Sw.) Griseb.											6	10
Nectandra oppositifolia Nees									1	2	10	13
Nectandra rigida (Kunth) Nees			1									2
Nectandra sp1												1
Nectandra sp2		1										
Nectandra sp3								6				
Ocotea catharinensis Mez												1
Ocotea diospyrifolia (Meisn.) Mez	1	4	13	29			2	2				1
Ocotea odorifera (Vell.) Rohwer			5	5								
Ocotea porosa (Nees & C. Mart.) Barroso						14	1	19				
Ocotea puberula (Rich.) Nees		2	4		7	16	53	38		1		2
Ocotea pulchella Mart.			2	10	1	7	33	18			10	
Ocotea sp1												3
Ocotea sp2							3					
Ocotea teleiandra (Meissn.) Mez												1
Persea americana Mill.				4								
Persea major (Nees) L. E. Kopp								1				
Persea sp.				2			1					
Loganiaceae												
Strychnos brasiliensis (Spreng.) Mart.							1	3			6	5

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Lythraceae												
Lafoensia pacari A.St.-Hil.							1					
Magnoliaceae												
Magnolia ovata (A.St.-Hil.) Spreng.										2		1
Malpighiaceae												
Bunchosia maritima (Vell.) J. F. Macbr.			2									
Byrsonima ligustrifolia A.Juss.										3	6	
Malvaceae												
Bastardiopsis densiflora (Hook. & Arn.) Hassler											5	31
Luehea divaricata Mart.		11	4	8	2	1	1	7	1			
Sida rhombifolia L.			2									
Melastomataceae												
Huberia semiserrata DC.										10	29	
Leandra australis (Cham.) Cogn.					3							
Leandra cf. *dasytricha* (A. Gray) Cogn.									217	3	13	
Leandra sp1									6	31	16	6
Leandra sp2									41	39	41	1
Miconia cabucu Hoehme									2	76	109	31
Miconia cf. *latecrenata* (DC.) Naudin										4	8	
Miconia cinnamomifolia (DC.) Naudin									7	444	197	23
Miconia cubatanensis Hoehne									2		4	5
Miconia flammea Cesar.										5		
Miconia ligustroides (DC.) Naudin									1	7		
Miconia rigidiuscula Cogn.									11	63	97	3
Miconia sp1										3	7	1
Mouriri chamissoniana Cogn.											3	2
Tibouchina cf. *trichopoda* Baill.									120	21	27	
Tibouchina pulchra Cogn.									44	211	126	43
Tibouchina sellowiana (Cham.) Cogn.									6	35	10	
Meliaceae												
Cabralea canjerana (Vell.) Mart.		2	6	13			4	1			14	24
Cedrela fissilis Vell.	1	2	19	19	1	5	5	4		3	2	1
Guarea macrophylla Vahl			1	1					1	4	20	26
Trichilia catigua A.Juss.			4	2								
Trichilia elegans A.Juss.			7	13			2	5		1	7	5
Trichilia lepidota Mart.										4	6	
Monimiaceae												
Mollinedia sp.								1			3	15
Mollinedia triflora (Spreng.) Tul									2	3	13	26
Moraceae												
Brosimum lactescens (S. Moore) C.C. Berg									1	1	4	8
Ficus cf. *insipida* Willd.			2									
Ficus organensis (Miq.) Miquel										1	2	
Ficus sp.							1					

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Maclura tinctoria (L.) D.Don ex Steud.			1								4	4
Sorocea bonplandii (Bail.) Burg., Lanj & Boer			4	22			9					4
Myristicaceae												
Virola bicuhyba Schott									1		9	24
Myrsinaceae												
Myrsine cf. *lancifolia* Mart.							1					
Myrsine coriacea (Swartz) R. Brown ex Roemer & Schultz	1	3		3	21	35	52	12	116	277	71	7
Myrsine parviflora A. DC.									1	1	6	5
Myrsine umbellata Mart ex. DC.	2	2	11	7	6		22	7	2	19	12	8
Myrtaceae												
Blepharocalyx salicifolius (Kunth) O. Berg							1	2				
Calyptrantes sp.								2	1			
Calyptranthes cf. *grandifolia* O. Berg.												9
Campomanesia guaviroba (DC.) Kaiaerskou										1		2
Campomanesia guazumifolia (Cambess.) O. Berg			3	2								
Campomanesia reitziana Legr.							1	1		1		3
Campomanesia sp.												4
Campomanesia xanthocarpa O. Berg				14			3	7		2		4
Eugenia burkartiana (Legr.) Legr.										1		
Eugenia chlorophylla O. Berg								2				
Eugenia involucrata DC.							2	2			1	2
Eugenia neoaustralis Sobral											1	
Eugenia playtsema O.Berg											1	2
Eugenia pyriformis Camb.	1		3	5								
Eugenia uniflora L.				1				2	1			
Gomidesia palustris (DC.) D.Legrand												11
Gomidesia schaueriana O.Berg												1
Gomidesia spectabilis (DC.) O. Berg									2	5	13	19
Gomidesia tijucensis (Kiaerskov) Legr.											1	1
Marlieria cf. *eugeniopsioides* (Kaus. & Legr.) Legr.										3	25	38
Marlierea parviflora O. Berg.												4
Marlierea tomentosa Cambess.				1					1		20	23
Mosiera prismatica (D. Legrand) Landrum							3	17				
Myrceugenia sp.												1
Myrcia gracilis O.Berg										2	2	
Myrcia guianensis (Aubl.) DC.					1			2				
Myrcia multiflora (Lam.) DC.							1				2	
Myrcia palustris DC.								1				
Myrcia rostrata DC.							17	3	3	3	22	10
Myrcia splendens (Sw.) DC.											1	
Myrcia tenuivenosa Kiaersk.											3	

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Myrcianthes pungens (O. Berg) Legr.								1				
Myrciaria tenella (DC.) O. Berg.				1			2	2				2
Myrtaceae sp1							2	20				
Myrtaceae sp2								21				1
Myrtaceae sp3		2										
Myrtaceae sp4											2	10
Psidium cattleyanum Sabine								1	9	32	10	4
Nyctaginaceae												
Guapira hirsuta (Choisy) Lundell											14	
Guapira opposita (Vell.) Reitz										3	24	30
Pisonia ambigua Heimerl			1	4						1	4	5
Ochnaceae												
Ouratea parviflora (DC.) Baill.										1	9	16
Oleaceae												
Chionanthus filiformis (Vell.) P.S. Green									1			
Olacaceae												
Heisteria silvianii Schwacke										1	1	2
Phytolaccaceae												
Phytolacca dioica L.		6		2								
Seguieria glaziovii Briq.		1										
Picramniaceae (Simaroubaceae)												
Picramnia parvifolia Engl.							2					
Picramnia sp.				3								
Piperaceae												
Piper arboreum Aubl										5		5
Piper cernuum Vell.										5	3	3
Piper gaudichaudianum Kuntze									4	24	112	28
Podocarpaceae												
Podocarpus lambertii Klotzsch							18					
Polygonaceae												
Coccoloba warmingii Meisn.										1	3	1
Ruprechtia laxiflora Meisn.	15	1					2	2				
Proteaceae												
Roupala asplenioides Sleumer								9				
Roupala cataractarum Sleumer			7									
Roupala cf. *brasiliensis* Klotzsch												1
Quiinaceae												
Quiina glaziovii Engl.										1	2	11
Rhamnaceae												
Hovenia dulcis Thumb. (exótica)			30	16			1					
Rhamnaceae sp1		3	1									
Scutia buxifolia Reissek.		1					5	7				

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Rosaceae												
Prunus brasiliensis (Cham. & Schlechtd) D. Dietr.									1		4	1
Prunus myrtifolia (l.) Urb.							5					
Prunus sellowii Koehne			12	1							1	3
Prunus sp.			1								1	
Rubiaceae												
Alibertia concolor (Cham.) K. Schum.										1	2	2
Amaioua guianensis Aubl.										9	9	4
Bathysa australis (A.St.-Hil.) Benth. & Hook.F.									4	3	24	15
Chomelia pedunculosa Bentham											1	5
Posoqueria latifolia (Rudge) Roem. & Schult.									1	2	5	6
Psychotria carthagenensis Jacq.											2	4
Psychotria leiocarpa Cham.										1	9	7
Psychotria longipes Muell.Arg.		1		1						8	62	43
Psychotria nuda (Cham. and Schltdl.) Wawra			2								8	10
Psychotria officinalis (Aubl.) Raeusch. ex Sandwith				1							5	14
Psychotria sp1							3	12				
Psychotria sp2		1	3	6								
Psychotria sp3											2	3
Psychotria sp4										1	34	45
Psychotria stenocalyx Müll.Arg.										2	9	21
Psychotria suterella Müll. Arg.							2	2	1		15	22
Randia armata (Sw.) DC.		5	1				2	2				
Rubiaceae sp1			3	12								
Rubiaceae sp2												5
Rudgea jasminioides (Cham.) Müll.Arg.									1	3	21	25
Ruscaceae (Agavaceae)												
Cordyline dracaenoides Kunth					3		1	7				
Rutaceae												
Balfourodendron riedelianum (Engl.) Engl.			4	5								
Esenbeckia grandiflora Mart.											5	5
Helietta apiculata Benth.	2											
Pilocarpus pennatifolius Lem.			1	2								
Zanthoxylum cf. *astrigera* Cowan												1
Zanthoxylum hiemalis A.St.-Hil.						1	3	1				
Zanthoxylum petiolare A.St.-Hil. & Tul.				3								
Zanthoxylum rhoifolia (Lam.) Engl.	1	3	7	8	1	11	26	9	1	2	17	3
Sabiaceae												
Meliosma cf. *sellowii* Urban.											3	2
Salicaceae (Flacourtiaceae)												
Banara parviflora (A. Gray) Benth.								2		5	7	
Banara tomentosa Clos.			1				5					

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Casearia decandra Jacq.		6	5	4	2	7	21	22	2		33	31
Casearia sylvestris Sw.	2	1	19	29			4	8	8	5	67	23
Xylosma pseudosalzmannii Sleumer.							1	1				
Sapindaceae												
Allophylus edulis (A.St.-Hil. & et al.) Radlk	1	4	9	39			19	23			20	15
Allophylus guaraniticus (A.St.-Hil.) Radlk						3	36	26				
Cupania oblongifolia Mart.										2	2	
Cupania vernalis Camb.	2	13	34	65	4	9	24	75	22	10	51	7
Diatenopteryx sorbifolia Radlk.			5									
Dodonaea viscosa (L.) Jacq.									127	18	1	
Matayba elaeagnoides Radlk.		6	15	25	28	30	93	140				
Matayba guianensis Aubl.									4	3	21	8
Sapotaceae												
Chrysophyllum gonocarpum (Mart. & Eichl.)Engl.	1		6	8								
Chrysophyllum marginatum (Hook. & Eichler) Engl.	1	3	10	11								1
Pouteria venosa (Mart.) Baehni										2	8	3
Solanaceae												
Capsicum cf. *flexuosum* Sendtn							2					
Cestrum strigilatum Ruiz & Pav.	1		4									
Solanaceae sp1							4					
Solanum diflorum Vell.	9	29	2	1	11	34	1		6	9	2	
Solanum mauritianum Scopoli		1	3	6	4	2						
Solanum pseudoquina A.St.-Hil.			2	7			1		1			
Solanum sanctae-catharinae Dunal					30		1					
Solanum sp2									2			
Solanum sp3	1		33	6	1				1	1	24	8
Styracaceae												
Styrax leprosus Hook. & Arn.		1		1			2	2				
Symplocaceae												
Symplocos celastrina Mart.							2					
Symplocos lanceolata (Mart.) A.DC.											1	
Symplocos sp1							5				4	3
Symplocos tenuifolia Brand			3				2	5				
Symplocos uniflora (Pohl) Benth.										1	2	
Theaceae												
Laplacea fruticosa (Schrad.) Kobuski.										4	8	
Urticaceae												
Boehmeria caudata Sw	13	30	7									
Cecropia glaziovii Snethl.									33	28	10	2
Urera baccifera (L.) Gaudich. ex Wedd		3										
Verbenaceae												
Aloysia virgata (Ruiz & Pav.) Juss.	1	2	31	1								
Citharexylum myrianthum Cham.										3		1
Lantana camara L.											2	1

Table 5: Continued.

Botanic family/species	SDF				MOF				DOF			
	SR	ST	AR	AA	SR	ST	AR	AA	SR	ST	AR	AA
Winteraceae												
Drimys brasiliensis Miers							8	9				
Undetermined												
Nonidentified		3	6	1			10	23		7	6	15
Dead												
Dead	6	5	12	15			9	7		13	6	1

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