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Vegetation and seed bank of an open-scrub bush *restinga* formation in the Southeastern coast of Brazil

Fernando Campanhã Bechara[1], Lívia Zocatelli Salvador[2], Raquel Almeida Ventura[3], Larissa Regina Topanotti[4*], Dionatan Gerber[5], Izaclaudia Santana da Cruz[6] & Marcelo Simonelli[7]

1. Universidade Tecnológica Federal do Paraná, Curso de Engenharia Florestal, Dois Vizinhos, Paraná, Brasil, University of Hawaii at Manoa; bechara@uftpr.edu.br
2. Faculdade de Saúde e Meio Ambiente (FAESA), Vitória, Espírito Santo, Brasil; lzsalvador@hotmail.com
3. Faculdade de Saúde e Meio Ambiente (FAESA), Vitória, Espírito Santo, Brasil; raquelventura@hotmail.com
4. Universidade Federal de Santa Catarina, Divisão de Atividades Agropecuárias, Curitibanos, Santa Catarina, Brasil; larissa.topanotti@ufsc.br
5. Instituto Politécnico de Bragança, Programa de Pós-Graduação em Gestão de Recursos Florestais, Bragança, Bragança, Portugal; dionatan_gerber@hotmail.com
6. Instituto Federal de Educação, Ciência e Tecnologia Baiano, Valença, Bahia, Brasil; izaclaudiasantana@yahoo.com.br
7. Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo, Vitória, Espírito Santo, Brasil; marcelosimonelli@hotmail.com

* Correspondence

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ABSTRACT. Introduction: *Restingas* are coastal plain ecosystems located along Eastern Brazil, corresponding to about 5 000 km. The *restinga* vegetation is associated with the Atlantic rainforest biome and comprises four distinct main formation zones: coastal grasslands, shrublands, open-forests and marsh zones. Especially due to coastal urbanization, this is a threatened ecosystem that, through its different shrub formations, exhibits a unique mosaic as a result of the vegetation distribution in nuclei of different covering, physiognomy and floristic composition. **Objective:** We aimed to characterize the above and belowground composition of a conserved, non-flooded, open-scrub, nuclei (patches of bushes) formation of *restinga* in Linhares, ES, southeastern Brazil. **Methods:** The vegetation survey was conducted using the line intercept method. Diameter and height of the first six nuclei were measured in five transects separated by 50 m, totaling 30 nuclei up to 350 m away from the shore line. The phytosociology and Shannon Index of the aboveground vegetation community were calculated. In the same 30 nuclei, leaf litter and topsoil layer (15 x 15 x 10 cm) samples were collected to survey the viable seed bank, which was later placed in a greenhouse for germination and seedling identification. The Sørensen Similarity index (SSi) was used to compare the floristic composition between the leaf litter and topsoil layer seed banks. Nuclei volume and number of species were calculated as well. **Results:** In the aboveground vegetation, 54 plant species belonging to 32 families were identified, totaling 1 098 individuals. The nuclei showed a diversity (H') of 3.08 nats, and an average diameter of 11.5 m (s = 9.1), area of 526.4 m^2 (s = 1 081.7), and height of 2.9 m (s = 1.1). *Davilla flexuosa*, followed by *Smilax rufescens*, presented the highest IVI (Importance Value Index). A total of 1 839 seedlings from 32 species and 19 families were identified in the seed bank. *Enydra sessilis* (Asteraceae) had the highest seed density (544), while the family with highest species richness was Cyperaceae. A low similarity between the vegetation surveyed and the seed bank composition was found (only

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5 species in common, SSi = 0.10). **Conclusions:** The results indicate that a post-disturbance early community, established from the seed bank, would have a substantially different species composition, but with other potential species to restore vegetation over the long-term succession.

Key words: shrublands, phytosociology, topsoil, nucleation, ecological restoration.

Restingas are coastal plain ecosystems located along Eastern Brazil, from latitude 4º N to 34º S, corresponding to about 5 000 km of the Atlantic coast. The largest *restinga* systems occur in the State of Rio Grande do Sul and deltas of the major rivers of the Brazilian Southeast and Northeast regions. The soil is composed by sediments classified as marine quartz sands deposited in the Quaternary period, so its origin is related to sedimentary geological phenomena and tidal regime of each location (Lacerda, Araujo, & Maciel, 1993).

The *restinga* vegetation is associated with the Atlantic rainforest biome and comprises four distinct main formation zones: coastal grasslands, shrublands, open-forests and marsh zones (Silva, Izeckson, & Silva, 2000). Since these shrublands patches are, generally, formed by dense bush islets of different sizes, widely spaced by open areas, we prefer to call them “nuclei open-scrub formation”, according to the nucleation theory by Yarranton and Morrison (1974).

Especially due to coastal urbanization, this is a threatened ecosystem that, through its different shrub formations, exhibits a unique mosaic, as a result of the distribution of vegetation in nuclei of different covering, physiognomy and floristic composition (Menezes, Souza, & Castro, 2007; Monteiro, Giaretta, Pereira, & Menezes, 2014). As an aggravating factor, the knowledge about the regeneration dynamics of this ecosystem is limited, and there is a lack of information about the *restinga* seed banks.

Seed banks, dormant, viable seeds that are present on the litter or into the soil of a given area, are related to four levels of the regeneration process: population settlement and colonization, species diversity maintenance, ecologic groups and the species richness (Uhl, Clark, Dezzeo, & Maquirino, 1988; Baker, 1989; Garwood, 1989; Grombone-Guaratini & Rodrigues, 2002). This paper aimed to characterize the environmental resilience of a non-flooded open-scrub bush *restinga* formation, through vegetation, leaf litter and seed bank characterization, to better understand its dynamics.

MATERIAL AND METHODS

Study area: The study site is in the municipality of Linhares, Espírito Santo, (19°39’26.125” S, 39°51’19.739” W), Brazil (Fig. 1). In this region, there are *restinga* strips of more than 30 km wide interspersed by extensive open areas (Colodete & Pereira, 2007). The climate is Aw type according to Köeppen: tropical hot, with moist summers (Oct-Jan; 166 mm on average) and dry winters (water deficit from Feb-Sep), reaching 1 200 mm per year. The average temperature is 20.7 to 26.2 °C, with the coldest temperatures (20.7 ºC) in June and the warmest (26.2 ºC) in January.

Vegetation survey: In March 2007, a perpendicular transect 150 m away from the shoreline towards the interior of the open-scrub was established. After this first transect, five transects were positioned, parallel to the shoreline and separated by 50 m from each other. The first six bush nuclei of each transect were sampled, totaling 30 nuclei, and they were mapped as well (Fig. 1). A bush nucleus was defined as one with a diameter equal or greater than 3 m and separated from others by a distance of at least 0.5 m of bare soil. The

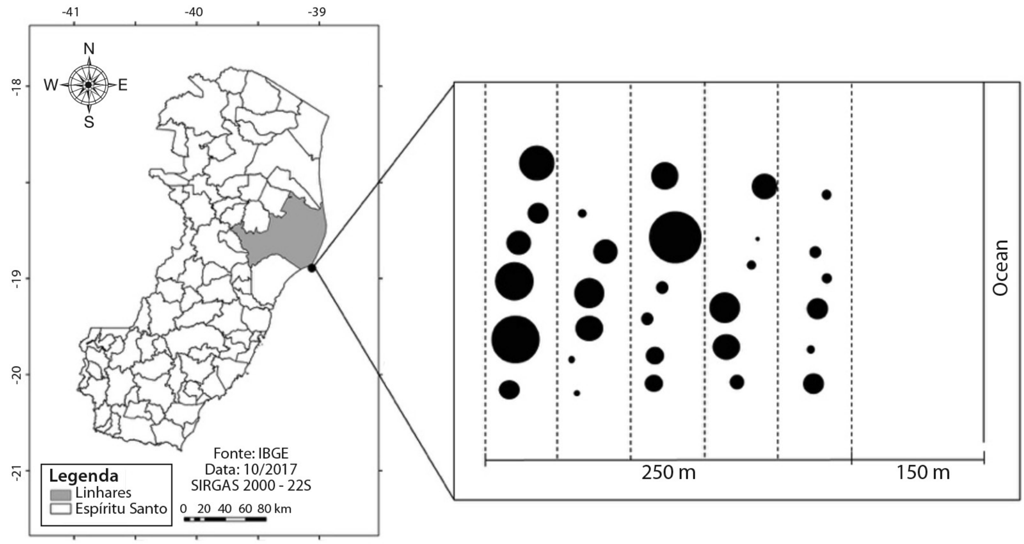

Fig. 1. Distribution of the bush nuclei sampled in an open-scrub *restinga* formation, non-flooded area, in Linhares (in gray), ES, Brazil.

height and the largest and smallest diameter extensions of all nuclei sampled were registered in order to obtain their volume. Nuclei diameters were measured at 1.0 m of height. The vegetation survey was conducted using the line intercept method (Müller-Dombois & Ellenberg, 1974), where all the intercepted plants were identified. The species were identified in the field or by comparison with the *herbaria* VIES and MBML.

Seed bank: The seed bank was sampled in the same 30 shrub nuclei defined in the vegetation survey (Fig. 1). The soil samples were obtained using a 15 x 15 x 10 cm depth frame. In each nucleus, four random units were sampled, two collected from the litter layer and two from the soil right below the litter. Litter samples (after filtering in a mesh size 6) and topsoil samples were placed into germination trays (0.61 x 0.43 x 0.10 m) with inert nursery substrate, and irrigation in a nursery (shade net covering) near the site. Additionally, control trays were assembled next to each sample tray to certify no contamination by surrounding anemochoric plant species. The composition of the seed bank was estimated using the seedling emergence method in incubated soil, which detects only the fraction of viable seeds (Brown, 1992). The observations were made every 15 days, identifying and quantifying all emergent seedlings. After emergence of the cotyledon leaves, the seedlings were removed from the trays and cultivated in plastic bags with soil, to identify them. Every 15 days, the substrate or topsoil remnant within the trays were mixed to ensure that as many viable seeds as possible would come to the surface and germinate. This procedure lasted for 12 months. Seedlings were identified and counted.

Data analysis: Phytosociology parameters –linear density, frequency and the Importance Value index of each species (Mueller-Dombois & Ellenberg, 1974)– and the Shannon-Weaver index of diversity for aboveground vegetation were calculated. The Sørensen Similarity index was used to compare the floristic composition between litter and topsoil seed bank, as well as between both and the aboveground vegetation survey. In addition, the regression between the nuclei volume and the number of species was calculated (α = 0.05) as well its determination coefficient (R^2) value.

RESULTS

Vegetation survey: The aboveground vegetation was composed by 54 species from 32 families. The families with higher species richness were Bromeliaceae (6 spp.), Orchidaceae (5), Myrtaceae (4), and Erythroxylaceae (3). We sampled a total of 1 098 individuals in 430 linear meters. Most of the species found in the aboveground were herbs (40.7 %), followed by shrubs and trees, representing 27.8 % each, and lianas (3.7 %). *Davilla flexuosa*, *Smilax rufescens*, *Guapira pernambucensis*, *Allagoptera arenaria* and *Paullinia weinmanniaefolia* presented the highest Importance Values (Table 1).

Three of the identified species are listed in the red book of species of Espírito Santo flora threatened by extinction (Simonelli & Fraga,

TABLE 1
Phytosociology in an open-scrub bush *restinga* formation in Linhares, ES, Brazil

Family	Species	N	COV	AD	RD	AF	RF	IV	LF
Dilleniaceae	*Davilla flexuosa*	177	183	0.412	69.191	0.426	0.119	69.310	S
Smilacaceae	*Smilax rufescens*	153	156	0.356	59.809	0.363	0.102	59.911	L
Nyctaginaceae	*Guapira pernambucensis*	63	79	0.147	24.627	0.184	0.052	24.679	T
Arecaceae	*Allagoptera arenaria*	62	143	0.144	24.236	0.333	0.093	24.330	H
Sapindaceae	*Paullinia weinmanniaefolia*	60	60	0.14	23.455	0.140	0.039	23.494	S
Araceae	*Anthurium raimundii*	59	61	0.137	23.064	0.142	0.040	23.103	H
Polygonaceae	*Coccoloba alnifolia*	50	129	0.116	19.545	0.300	0.084	19.630	S
Peraceae	*Pera glabrata*	50	127	0.116	19.545	0.295	0.083	19.628	S
Bromeliaceae	*Aechmea nudicaulis*	48	55	0.112	18.764	0.128	0.036	18.800	H
Poaceae	*Axonopus pressus*	47	47	0.109	18.373	0.109	0.031	18.403	H
Burseraceae	*Protium heptaphyllum*	41	92	0.095	16.027	0.214	0.06	16.087	T
Malpighiaceae	*Byrsonima sericea*	41	24	0.095	16.027	0.056	0.016	16.043	T
Bromeliaceae	*Vriesea procera*	25	26	0.058	9.773	0.060	0.017	9.790	H
Clusiaceae	*Clusia hilariana*	23	66	0.053	8.991	0.153	0.043	9.034	S
Chrysobalanaceae	*Chrysobalanus icaco*	22	42	0.051	8.600	0.098	0.027	8.627	S
Sapindaceae	*Cupania emarginata*	19	28	0.044	7.427	0.065	0.018	7.446	T
Primulaceae	*Myrsine umbellata*	14	22	0.033	5.473	0.051	0.014	5.487	T
Rubiaceae	*Salzmannia nitida*	14	18	0.033	5.473	0.042	0.012	5.484	S
Sapotaceae	*Manilkara subsericea*	12	18	0.028	4.691	0.042	0.012	4.703	S
Primulaceae	*Myrsine parvifolia*	11	12	0.026	4.300	0.028	0.008	4.308	T
Fabaceae	*Swartzia apetala*	10	11	0.023	3.909	0.026	0.007	3.916	T
Cactaceae	*Pilosocereus arrabidae*	9	12	0.021	3.518	0.028	0.008	3.526	H
Orchidaceae	*Vanilla bahiana*	9	10	0.021	3.518	0.023	0.007	3.525	H
Fabaceae	*Abarema jupunba*	7	15	0.016	2.736	0.035	0.010	2.746	T
Erythroxylaceae	*Erythroxylum* sp. (1)	7	9	0.016	2.736	0.021	0.006	2.742	S
Anacardiaceae	*Schinus terebinthifolius*	5	7	0.012	1.955	0.016	0.005	1.959	T
Bromeliaceae	*Bromeliaceae* sp.	5	5	0.012	1.955	0.012	0.003	1.958	H
Asteraceae	*Mikania glomerata*	5	5	0.012	1.955	0.012	0.003	1.958	H
Bromeliaceae	*Vriesea neoglutinosa*	5	5	0.012	1.955	0.012	0.003	1.958	H
Myrtaceae	*Eugenia rotundifolia*	4	7	0.009	1.564	0.016	0.005	1.568	T
Lauraceae	*Ocotea notata*	4	5	0.009	1.564	0.012	0.003	1.567	T
Cactaceae	*Cereus fernambucensis*	4	4	0.009	1.564	0.009	0.003	1.566	H
Apocynaceae	*Oxypetalum banksii*	4	4	0.009	1.564	0.009	0.003	1.566	H

Family	Species	N	COV	AD	RD	AF	RF	IV	LF
Calophyllaceae	*Kielmeyera albopunctata*	3	4	0.007	1.173	0.009	0.003	1.175	S
Orchidaceae	*Catasetum discolor*	2	3	0.005	0.782	0.007	0.002	0.784	H
Myrtaceae	*Eugenia* sp.	2	4	0.005	0.782	0.009	0.003	0.784	T
Euphorbiaceae	*Sebastiania glandulosa*	2	3	0.005	0.782	0.007	0.002	0.784	S
Orchidaceae	*Tillandsia stricta*	2	3	0.005	0.782	0.007	0.002	0.784	H
Erythroxylaceae	*Erythroxylum* sp. (3)	2	2	0.005	0.782	0.005	0.001	0.783	S
Bromeliaceae	*Quesnelia quesneliana*	2	2	0.005	0.782	0.005	0.001	0.783	H
Bromeliaceae	*Aechmea blanchetiana*	1	4	0.002	0.391	0.009	0.003	0.394	H
Polygonaceae	*Coccoloba arborescens*	1	3	0.002	0.391	0.007	0.002	0.393	S
Bignoniaceae	*Arrabidaea conjugata*	1	1	0.002	0.391	0.002	0.001	0.392	H
Rubiaceae	*Borreria verticillata*	1	1	0.002	0.391	0.002	0.001	0.392	H
Capparaceae	*Capparis flexuosa*	1	1	0.002	0.391	0.002	0.001	0.392	H
Fabaceae	*Chamaecrista flexuosa*	1	1	0.002	0.391	0.002	0.001	0.392	S
Orchidaceae	*Cyrtopodium polyphyllum*	1	2	0.002	0.391	0.005	0.001	0.392	H
Erythroxylaceae	*Erytthroxylum* sp. (2)	1	1	0.002	0.391	0.002	0.001	0.392	S
Orchidaceae	*Koellensteinia altissima*	1	2	0.002	0.391	0.005	0.001	0.392	H
Poaceae	*Melinis minutiflora*	1	1	0.002	0.391	0.002	0.001	0.392	H
Passifloraceae	*Passiflora* sp.	1	1	0.002	0.391	0.002	0.001	0.392	L
Schoepfiaceae	*Schoepfia brasiliensis*	1	2	0.002	0.391	0.005	0.001	0.392	T
Myrtaceae	*Myrciaria floribunda*	1	1	0.002	0.391	0.002	0.001	0.392	T
Myrtaceae	*Psidium macahense*	1	1	0.002	0.391	0.002	0.001	0.392	T
Total		1 098	1.53	2.55	429.22	3.56	1.00	430.22	
Mean		20.33	28.33	0.09	7 949	0.06	0.019	7 967	

N = number of individuals; COV = coverage (m); AD = absolute linear density; RD = relative linear density (%); AF = absolute frequency (%); RF = relative frequency (%); IV = importance value; LF = life form: H = herb, L = liana, S = shrub, T = tree.

2007): *Axonopus pressus*, restricted to the North of the state, is listed as critically endangered, as well as *Aechmea blanchetiana* and *Vriesea neoglutinosa*, classified as vulnerable. The most frequent species was *Allagoptera arenaria* (Arecaceae), which occurred in all lines. Other species, such as *Axonopus pressus*, *G. pernambucensis*, *S. rufescens*, *P. weinmanniaefolia*, *Pera glabrata* and *D. flexuosa*, were also highly frequent in more than 20 nuclei. The diversity index of Shannon-Weaver (H') was 3.08 nats for the whole experimentation site. The volumes of the studied nuclei varied from 29.3 m^3 to 22 562.5 m^3, with an average diameter of 11.5 m, mean area of 526.4 m^2 and mean height of 2.9 m. Most nuclei had a maximum volume of 1 000 m^3, with richness of 5-17 species each. The largest number of species was observed in the most voluminous nucleus (22 562.54 m^3), with 31 species sampled. The second richest nucleus, despite having a volume almost eight times smaller than the first, sheltered 30 different species. Therefore, a weak tendency of increasing richness with the increasing of the nucleus size was noted, with a coefficient of termination (R^2) of 0.487. The maximum nucleus height was 6 m, particularly represented by *Clusia hilariana* and *Coccoloba alnifolia*.

Seed bank: The highest proportion of germinated seeds occurred in the first four months of observation, showing a decrease in the following seven months followed by an increase in the last three months. A total of 1 839 seedlings were recorded in the seed bank (litter plus topsoil) distributed in 32 species and 19 families (Table 2). *Enydra sessilis* presented the highest density (544), followed by Poaceae sp. 2 (371). The most abundant family

TABLE 2
Seedlings germinated from the seed bank survey in an open-scrub bush *restinga* formation
in Linhares, ES, Southeastern Brazil

Family	Species	N	Ts	Li	LF
Asclepiadaceae	*Oxypetalum banksii*	2		X	liana
Asteraceae	*Enydra sessilis*	544	X	X	herb
	Pluchea sagittalis	139	X	X	herb
	Vernonia scorpioides	1	X		shrub
Blechnaceae	*Telmatoblechnum serrulatum*	5	X	X	herb
Bromeliaceae	*Quesnelia quesneliana*	1		X	herb
Cactaceae	*Pilosocereus arrabidae*	8	X	X	herb
Curcubitaceae	sp. 1	1	X		indet.
Cyperaceae	*Bulbostylis capillaris*	8	X	X	herb
	Cyperus haspan	1	X		herb
	Cyperus ligularis	138	X	X	herb
	Fimbristylis aspera	3	X		herb
Erythroxylaceae	*Erythroxylum* sp.	10	X	X	tree
Euphorbiaceae	*Euphorbia heterophylla*	1	X		herb
	Sebastiania glandulosa	34	X	X	herb
Fabaceae	*Chamaecrista ramosa*	3	X		herb
Melastomataceae	*Miconia albicans*	3	X		tree
Molluginaceae	*Mollugo verticillata*	358	X	X	herb
Poaceae	sp. 2	371	X	X	herb
Portulacaceae	sp. 3	28	X	X	herb
Primulaceae	*Myrsine umbellata*	4	X		tree
Pteridaceae	*Pityrogramma calomelanos*	76	X	X	herb
Rubiaceae	*Borreria verticillata*	2	X		herb
	Diodia sp.	3	X		herb
Smilacaceae	*Smilax rufescens*	1	X		liana
Solanaceae	*Solanum americanum*	4	X	X	shrub
	sp. 4	5	X	X	indet.
Indet.	sp. 1	54	X	X	indet.
	sp. 2	3	X		indet.
	sp. 3	16	X		indet.
	sp. 4	5	X		indet.
Urticaceae	*Cecropia hololeuca*	7	X		tree
Total		1 839			

N = total of seedlings; Ts = topsoil layer; Li = leaf litter; LF = life form; indet. = indeterminate species.

was Cyperaceae, represented by four species. Most species were herbs (56.25 %), but species of trees (12.5 %), shrubs (6.25 %) and lianas (6.25 %) were also observed.

Among the individuals listed, 64.6 % emerged from topsoil samples and 35.3 % emerged from litter. A number of 15 species were recorded exclusively in the topsoil samples, 2 exclusively in the litter and 15 species were common to both samples (Table 2). The Sørensen Similarity index (0.10) between the species sampled in the aboveground vegetation survey and those emerged from the seed bank (both litter and topsoil combined), showed low similarity (10 %), indicating that most of the species are not shared between both. Only five species were common to both aboveground and seed bank: the herbs *Borreria verticillata*, *Pilosocereus arrabidae*, *Quesnelia quesneliana*, *Sebastiania glandulosa* and the liana *S. rufescens*.

DISCUSSION

In the aboveground vegetation, *D. flexuosa* was classified as the most abundant species in our study, and it seems to be a common species in this type of ecosystem. The palm tree *A. arenaria* occurred in all the transects of the sampled area and was included among the three species with the highest Importance Value. *Allagoptera arenaria* has a wide occurrence in both open-scrub and "closed" *restinga* formations with the ability to be disseminated by seed or rhizomatous growth and sprouting after burning (Pereira, Cordeiro, & Araujo, 2004). *Protium heptaphyllum* was among the ten species with the highest IV, like studies conducted in other *restingas* (Pereira & Araujo, 2000). *G. pernambucensis* is widely distributed throughout tropical South America, according to Araujo, Oliveira, Vieira, Barros and Lima (2001). Both *B. sericea* and *S. terebinthifolius* are more common in disturbed areas. In *restinga* formations, Bromeliaceae is known to be common (as the ones found in our study *Aechmea blanchetiana*, *Aechmea nudicaulis*, *Q. quesneliana* and *Vriesea procera)* and are fundamental elements in this physiognomy composition, since they play an important ecological role, including the capacity to store water in their tanks and act as sites for germination and development of other plant species, which makes them "focal plants", important in maintaining the diversity of *restinga* habitats (Scarano, 2002). *Melinis minutiflora*, an invasive grass of African origin, reproduces both by seeds and vegetatively. It is sensitive to fire, but adapted to the condition of low soil fertility, being present in open and sunny environments. It has invaded large areas of tropical ecosystems, displacing native species due to its aggressiveness and superior competitive capacity. This species occurred in low abundance in our study, but still deserves special attention due to its biological invasive potential. *A. pressus* occurs in the open formation of Ericaceae *restinga* and was listed in the Espírito Santo red book as critically endangered, as well as *A. blanchetiana* and *V. neoglutinosa*, which are listed as vulnerable species (Simonelli & Fraga, 2007). About rare species, in our study they were represented only by 1.45 % of the total sampled, analogous to the rare species percentage of a *restinga* in Rio de Janeiro (2 %) (Pereira et al., 2004), but lower than the rate in another *restinga* in Espírito Santo (7.1 %) (Monteiro et al., 2014). Therefore, the Shannon-Weaner diversity index (H') obtained in our study (H = 3.08 nats) was higher than the H' = 2.84 nats found by Pereira & Araujo (2000) and H' = 1.89 nats registered in Pereira et al. (2004), both in open *restingas*, probably because it is a more conserved site than the other studies cited above.

Although the regression´s coefficient of determination was low, there was an increase in the number of species in relation to the nuclei volume, and the highest number of species was observed in the most voluminous nuclei. This might be related to the fact that some species might be more abundant under shrubs and others would prefer areas without coverage to develop (Shmida & Whittaker, 1981). Even though *restingas* are highly stressful ecosystems in terms of salinity, low fertilization, high radiation, low water availability on soil, wind exposure and sand burial, dense groups of plants facilitate the establishment of new species in these ecosystems due to their improvement in microclimate factors (Shumway, 2000). The nuclei found in this study may act in a nucleation process (Bechara et. al, 2014). These plants may play a key role in plants assemblages, especially in xerophytic environments, since they contribute to the improvement of conditions for germination, establishment and growth of other plant species (Zaluar & Scarano, 2000). For example, *Clusia hilariana*, which is often described as a nurse-plant, since it presents positive association between adults and juvenile density of other woody species and works as dispersers attractive in *restingas* (Dias, Zaluar, Ganade, & Scarano, 2005; Correia, Dias, & Scarano 2010).

The seedlings diversity from seed bank in our study is like other studies in *restingas*. Cyperaceae, the most abundant family, and *Cyperus* spp., are frequently found on *restingas* seed banks. Asteraceae, the second most abundant family, was also one of the most significant families in the floristic composition of Santa Catarina's *restingas* (Klein, Citadini-Zanette & Santos, 2007; Korte, de Gasper, Kruger, & Sevegnani, 2013). The most abundant species, *E. sessilis*, occurs in aquatic and terrestrial sites in *restingas*, so it can be considered an amphibian species. Poaceae, as the second family with more individuals, also occur in other *restingas* sites. The third most abundant species, *M. verticillata*, is one of the ten most abundant species as well in a *restinga* in Rio de Janeiro (Pereira et al., 2004). The predominance of herbs in the seed bank and in the aboveground vegetation is typical in *restingas*, and they are important especially in terms of soil coverage, interaction with other life form species and early ecological succession.

Regarding the germination over time, it is commonly reported that seed banks have rapid germination response in the first months of studies. Costa and Araújo (2003) reported the highest proportion of germinated seeds in the first month of observation. Caldato, Floss, Croce and Longhi (1996) also found that most of the seedlings emerged in the first four months, as in our study. Nonetheless, it is important to highlight that the soil seed bank of open areas such as *restingas* is mainly composed of species that germinate under constant sunlight. Most of the taxa emerged from seed bank in our study follow a pioneer species behavior, which is common in *restingas*, where the successional groups form mosaics defined by the diversity of different levels of soil-dependent climax. The richness of this seed bank (33 spp.) is like the results obtained by Bechara and Reis (2009), where the authors found a diversity of 35 species in a *restinga* site in Santa Catarina.

The low similarity between the aboveground vegetation floristic composition and the sampled seed bank indicates that early communities, after disturbances, could be significantly different in these delicate ecosystems. The higher diversity in the aboveground vegetation indicates a more mature community. The high abundance of seedlings found in seed banks indicates that they may be used as an important low-cost tool for open-scrub *restinga* restoration in nuclei (see Bechara et al., 2016).

Ethical statement: authors declare that they all agree with this publication and made significant contributions; that there is no conflict of interest of any kind; and that we followed all pertinent ethical and legal procedures and requirements. All financial sources are fully and clearly stated in the acknowledgements section. A signed document has been filed in the journal archives.

RESUMEN

Vegetación y banco de semillas en una formación de matorral abierto de *restinga* en el sureste de Brasil. Introducción: Las *restingas* son ecosistemas llanos costeros ubicados a lo largo del este de Brasil, que corresponden a unos 5 000 km de la costa atlántica brasileña. La vegetación de *restinga* está asociada con el bioma de la selva tropical atlántica y comprende cuatro zonas de formación principales: praderas costeras, matorrales, bosques abiertos y zonas pantanosas. Especialmente debido a la urbanización costera, este es un ecosistema amenazado, que, a través de sus formaciones arbustivas, exhibe un mosaico único, como resultado de la distribución de la vegetación en núcleos de diferentes coberturas, fisonomía y composición florística. **Objetivo:** Caracterizar la composición florística superficial y subterránea de una formación conservada, no inundada, de núcleos de matorral abierto de *restinga* en Linhares, ES, costa del sureste de Brasil. **Métodos:** La vegetación se muestreó utilizando el método de la línea de intercepción. El diámetro y la altura de los primeros seis núcleos se midieron en cinco transectos instalados cada 50 m, con un total de 30 núcleos distantes hasta 350 m de la línea de costa. Se muestreó la comunidad de vegetación y se calculó su fitosociología e índice de Shannon. En los mismos 30 núcleos, se recogió la hojarasca más la capa superior del suelo (15 x 15 x 10 cm) para examinar el banco de semillas viable, que luego se colocó en un invernadero para germinar e identificar las plántulas. El índice de similitud de Sørensen se usó para comparar la composición florística entre la hojarasca y el banco de semillas de la capa superficial del suelo y también se calculó la regresión entre el volumen del núcleo y el número de especies. **Resultados:** En la vegetación superficial se identificaron 54 especies de plantas pertenecientes a 32 familias, con un total de 1 098 plantas. Los núcleos registraron una diversidad (H') de 3.08 nats, y un diámetro promedio de 11.5 m (s = 9.1), área de 526.4 m² (s = 1 081.7) y altura de 2.9 m (s = 1.1). *Davilla flexuosa*, seguida de *Smilax rufescens*, presentó el VI (Valor de Importancia) más alto. Se identificaron un total de 1 839 plántulas de 32 especies y 19 familias en el banco de semillas. *Enydra sessilis* (Asteraceae) tuvo la mayor densidad de semillas viables (544), pero la familia con mayor riqueza de especies fue Cyperaceae. Se encontró una baja similitud entre la vegetación y la composición del banco de semillas (solo 5 especies en común, índice de Sørensen = 0.10). **Conclusiones:** Los resultados indican que una comunidad recién establecida después de una alteración podría tener una composición de especies sustancialmente diferente, pero con otras especies potenciales para restaurar la vegetación a largo plazo.

Palabras clave: matorrales, fitosociología, capa superficial del suelo, nucleación, restauración ecológica.

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