



Floristic inventory and conservation of one of the most striking coastal mountains in the Brazilian Atlantic Forest

Rodrigo T. Valadares¹ , Valquíria F. Dutra¹ , Aline D. Firmino¹ , Diego T. Iglesias² , Lucas A. Silva¹ , Paulo Henrique D. Barros¹ , Vinícius C. Freitas¹ , Weverson C. Cardoso^{1,3} , André M. Assis¹ and José M. L. Gomes¹

Received: February 1, 2021

Accepted: August 31, 2021

ABSTRACT

The Atlantic Forest is made up of different vegetation types over extensive latitude. Most of its remnants are in mountain ranges, which are responsible for the maintenance of most endemic and threatened species in this domain. Here we present the floristic composition of the Área de Proteção Ambiental Mestre Álvaro (APAMA), a coastal massif at Espírito Santo State with expressive altitudinal amplitude (100-800 a.s.l.) containing remnants never floristically studied. Knowing the composition of this protected area is important because it includes an altitudinal range not yet evaluated in floristic comparisons involving highland and lowland forests between the latitudes 18-21° S. We found 493 species (in 292 genera and 91 families): ten are regional endemic species, nine are new records of occurrence for the state, and 52 are under some degree of threat of extinction. Our results indicate the presence of flora elements' typical of both highland and lowland forests, which makes the APAMA essential in a scenario extremely fragmented. Finally, our data provide an unprecedented floristic list for regional forest restoration projects, as well as an invaluable source of data for biogeographic studies that seek to understand the effect caused by neighboring vegetation types on the composition of lowland forests.

Keywords: APA Mestre Álvaro, Atlantic Forest, ravine forest, endangered species, protected areas

Introduction

“It will probably be many years before, with some exceptions, other Brazilian flora other than herbs and shrubs are known.”

Auguste de Saint-Hilaire,
when visiting the “Monte Mestre Alvo” (1818)

The Atlantic Forest plays multiple roles in climate regulation (Brasil 2018). Even recognizing the damage caused by its devastating history, this biome is still continuously shrinking (Dean 1996; Brasil 2012a; 2017; SOS Mata Atlântica & INPE 2020). Currently, it is represented by ca. 11% of its original coverage (Ribeiro *et al.* 2009) and most of its remnants are in mountain ranges (*e.g.*, Serra do Mar, Serra da Mantiqueira). These geomorphological sectors

¹ Laboratório de Taxonomia de Fanerógamas, Departamento de Ciências Biológicas, Centro de Ciências Humanas e Naturais, Universidade Federal do Espírito Santo, 29075-910 Vitória, ES, Brazil

² Universidade Federal de Minas Gerais, Instituto de Ciências Agrárias, 39404-547, Montes Claros, MG, Brazil

³ Programa de Pós-Graduação em Ciências Biológicas, Museu Nacional, Universidade Federal do Rio de Janeiro, 20940-040, Rio de Janeiro, RJ, Brazil

* Corresponding author: rodrigotheofilo@yahoo.com.br



are responsible for the maintenance of most endemic and threatened species in the Atlantic Forest domain (see Loyola *et al.* 2014; BFG 2018).

In the state of Espírito Santo, for example, the northern portion of Serra da Mantiqueira is home to numerous endemic taxa (Dutra *et al.* 2015) and new species from this region are continuously being described (Fraga *et al.* 2019). Further, there are still difficult access to contiguous forest remnants that guarantee the preservation of regional diversity (Assis 2007). However, most of the diversity in this region only began to be cataloged in the 1990s. Floristic inventories covering different life-forms are scarce for this state (*e.g.*, Assis *et al.* 2004; Lubner *et al.* 2016; Souza *et al.* 2016) and are greatly needed for the biome (see Menini-Neto *et al.* 2009).

The present study was carried out in an area of dense ombrophilous forest in the state (see Garbin *et al.* 2017). This type of vegetation was divided into different ecological formations according to altitudinal criteria (Veloso *et al.* 1991). In Espírito Santo, there have been some local studies restricted to a single ecological formation that only include research about the arboreal structure (Thomaz & Monteiro 1997; Saiter *et al.* 2011; Saiter & Thomaz 2014). However, floristic inventories in an altitudinal gradient that include more than one formation are non-existent for this region.

Considering these gaps, we aimed to perform a floristic inventory of angiosperms of the Área de Proteção Ambiental Mestre Álvaro (APAMA), a protected area within the scenario discussed. In addition, we classified the life-forms of the species recorded to the area, verify the conservation status of these and discuss the richness of the more representative families compared to other areas located at similar altitudinal ranges or under the distinct degree of regeneration and anthropic disturbances in the state.

Materials and methods

Study area

APAMA is a mountain area in Grande Vitória, in the south-central region of Espírito Santo State, in an extension of the Serra da Mantiqueira Setentrional (Gatto *et al.* 1983; Mendes *et al.* 1987). It is between 20°08'32"–20°11'28" S and 40°07'42"–40°19'44" W, with a total area of 2,389 ha, with an elevation gradient ranging from 50 to 833 m (Espírito Santo 2018) (Fig. 1). The climate is humid subtropical, with a dry winter and hot summer from 50–500 m a.s.l. and temperate summer from 500–800 m a.s.l. (Koppen classification), annual precipitation of 1300–1600 mm and a dry season from May to August, when the average precipitation is only 63 mm (Alvares *et al.* 2013). The vegetation type is submontane dense ombrophilous forest from 50–500 m a.s.l. and montane dense ombrophilous forest above 500 m a.s.l. (Veloso *et al.* 1991), where rise inselbergs interspersed

with forest ecosystems. The vegetation is currently under different degrees of regeneration, but still contains well-preserved areas (Fig. 2), such as ravine forest (*sensu* Menini-Neto *et al.* 2009) and inselberg vegetation (Porembski 1998). The area is of high conservation priority due to the presence of well-maintained fragments that house endemic and rare species (see Giulietti *et al.* 2009; Espírito Santo 2010a; Iglesias *et al.* 2016; Pereira-Silva *et al.* 2019).

Floristic survey

The angiosperms floristic survey was carried out through field trips conducted between 2012–2016 during the project Diversidade Florística da Área de Proteção Ambiental do Mestre Álvaro, using the walking method (Filgueiras *et al.* 1994). The specimens were processed using standard techniques (Fidalgo & Bononi 1989) and deposited in the herbarium VIES. A database was constructed based on the following: i) our field data and ii) herbarium records (CVRD, HUEFS, IPA, MBML, RB, SPE, SP, VIES – acronyms according to Thiers 2021), using only specimens identified by specialists.

The life-forms of each species were classified through direct field observations using the concepts proposed by Font Quer (2000). Additionally, we used data from herbarium labels to evaluate the morphological plasticity of the species. Venn diagrams were employed to identify unique and shared life-forms among species (Bardou *et al.* 2014).

We also used previously published lists for some angiosperm families in the area (Sarnaglia-Junior *et al.* 2014a; Iglesias & Dutra 2017). The final list obtained was compared to the Brazilian and Espírito Santo State Red Lists of Plants (Martinelli & Moraes 2013; Fraga *et al.* 2019) to verify the conservation status of the species of APAMA. We assume species not listed in Flora do Brasil 2020 (2020) and Dutra *et al.* (2015) as new occurrence records for the state of Espírito Santo.

Results

A total of 493 angiosperm species (Figs. S1-S3 in supplementary material) belonging to 292 genera and 91 families were recorded in APAMA (Tab. S1 in supplementary material). The richest families are Fabaceae (45 spp.), Malvaceae (28), Melastomataceae (27), Piperaceae (25), Rubiaceae (21), Orchidaceae (21), Araceae (19), Bromeliaceae (19), Asteraceae (15), Myrtaceae (15), Cactaceae (13) and Malpighiaceae (13). These accounted for 48 % of the species sampled. The most speciose genera are *Piper* (16 spp.), *Miconia* (10 spp.), *Peperomia* (9), *Anthurium* (8), *Begonia* (8), *Solanum* (8), *Philodendron* (7), *Psychotria* (7) and *Sida* (7).

Regarding the life-forms (Fig. 3), many species (79 spp.) exhibit more than one form (*e.g.*, *Randia armata*, *Davilla rugosa*). The proportion of herbs was 37 %, followed by trees (20 %), shrubs (16 %), subshrubs (15 %) and lianas or



climbers (12%). Within the herbs, the families Orchidaceae (20 spp.), Araceae (19), and Bromeliaceae (16) stand out. Among the trees, the richest family are Fabaceae (19 spp.), followed by Myrtaceae (15) and Melastomataceae (06). Among the shrub species, the families Melastomataceae (18 species), Myrtaceae (15), Fabaceae (13) and Rubiaceae (9) stand out for having the greatest richness. Subshrub species predominantly belong to Malvaceae (13 spp.), followed by Fabaceae (7 spp.) and Asteraceae (5 spp.). Among the lianas and climbers, the most representative family is Malpighiaceae (9 spp.), followed by Bignoniaceae (6). Lianas and climbers are concentrated in the most concave portions of the relief, where numerous trees up to 25 m house several species of epiphytes and hemiepiphytes, especially from the families Bromeliaceae, Orchidaceae and Araceae.

Our study recorded 10 regional endemic species (2.3%) from the state of Espírito Santo: *Aphelandra maximiliana*, *Begonia espiritosantensis*, *Clusia spiritu-sanctensis*, *Cryptanthus maritimus*, *Dalechampia margarethiae*, *Dichaea elianae*, *Huberia mestrealvarensis*, *Kuhlmanniodendron apterocarpum*, *Leandra triantha*, *Rudgea mucronata*, and *Tillandsia kautskyi*.

The inventory added seven new records of occurrence for the state of Espírito Santo: *Gurania pseudo-spinulosa* (Cucurbitaceae), *Mimosa debilis* (Fabaceae), *Peperomia*

martiana (Piperaceae), *Pavonia fruticosa*, *Sida spinosa*, *Triumfetta rhomboidei* (Malvaceae) and *Ziziphus undulata* (Rhamnaceae).

Among the species found in APAMA, 52 (10.5%) are under some degree of threat of extinction according to the Brazilian Red List and Espírito Santo Red List. Twenty-nine species were exclusive to the regional list, for example, *Erythroxylum nobile* (CR – critically endangered), *Bertolonia duasbocaensis* (CR), and *Huberia mestrealvarensis* (CR). Another seven species were only cited on the country's red list: *Aechmea depressa* (VU – vulnerable), *Aphelandra maximiliana* (VU), *Begonia itaguassuensis* (VU), *Begonia novalombardiensis* (VU), *Griffinia espiritensis* (VU), *Hippeastrum striatum* (VU), and *Zeyheria tuberculosa* (EN – endangered). Few species presented distinct categories in the two red lists: *Begonia kuhlmannii*, *Cariniana ianeirensis*, *Cryptanthus maritimus*, *Handroanthus riodocensis*, and *Sinningia aghensis*.

Other important species include taxa defined as the following: data deficient (DD), *Myrciaria tenella* and *Chondrodendron platyphyllum*; and near threatened (NT), *Philodendron hatschbachii*, *Pilosocereus brasiliensis* and *Mollinedia lamprophylla*.

Some naturalized species have been found associated with anthropized areas, such as *Menilis repens*, *Hedychium coronarium*, *Oeceoclades maculata* and *Impatiens walleriana*.



Figure 1. Location of Área de Preservação Ambiental do Mestre Álvaro (APAMA) and surrounding protected areas. 1: Área de Proteção Ambiental do Morro do Vigilante; 2: Área de Proteção Ambiental Costa das Algas; 3: Área de Proteção Ambiental do Mestre Álvaro; 4: Área de Proteção Ambiental Municipal da Lagoa Jacunem; 5: Área de Proteção Ambiental de Praia Mole; 6: Área de Proteção Ambiental Manguezal Sul da Serra; 7: Estação Ecológica do Lameirão; 8: Área de Proteção Ambiental do Maciço Central; 9: Parque Natural Municipal Von Schilgen; 10: Reserva de Desenvolvimento Sustentável Municipal do Manguezal de Cariacica; 11: Parque Natural Municipal do Manguezal de Itagua; 12: Área de Proteção Ambiental Municipal do Monte Mochuara; 13: Reserva Biológica Duas Bocas.

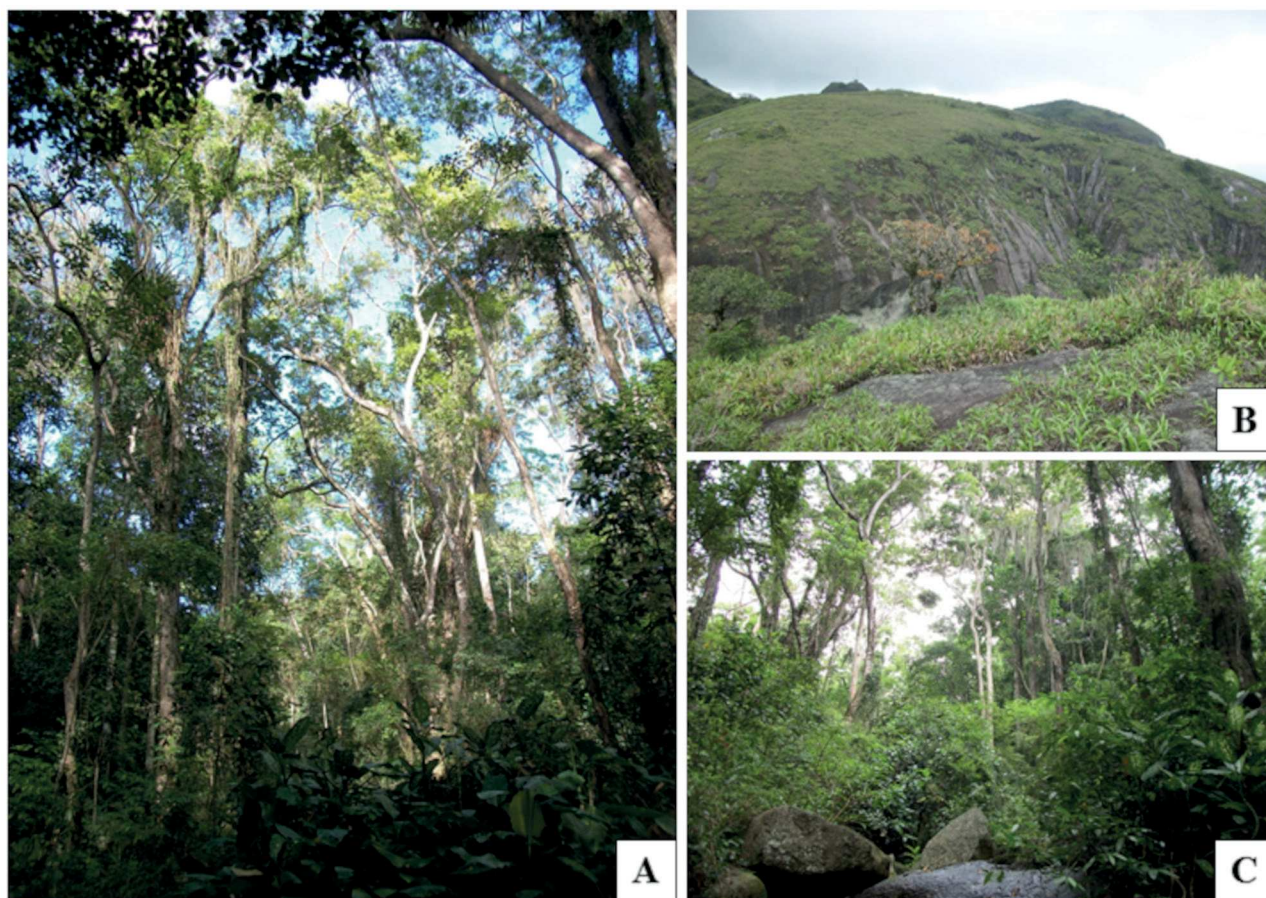


Figure 2. Conserved vegetation areas in Área de Proteção Ambiental do Mestre Álvaro. **A.** Forest in an advanced stage of regeneration on a convex portion of the relief; **B.** Rocky outcrop vegetation; **C.** Ravine forest.

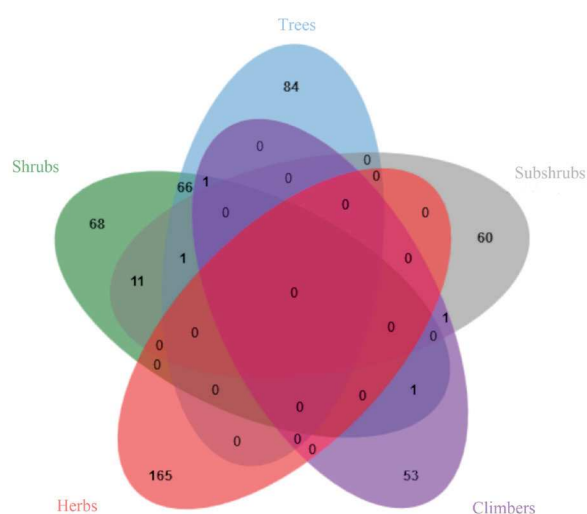


Figure 3. Venn diagram showing the number of life-forms expressed by species for Área de Proteção Ambiental do Mestre Álvaro.

Discussion

This study aimed to inventory the vegetation of APAMA, an important and poorly studied phytoecological region in

the state of Espírito Santo. Initial indicators, such as the description of new species (*e.g.*, Valadares & Sakuragui 2014; Iglesias *et al.* 2016; Valadares & Coelho 2017; Pereira-Silva *et al.* 2019), demonstrated the floristic importance of this area. Our results demonstrate a richness superior to initial estimates for similar altitudinal ranges in the state (see Luber *et al.* 2016). However, we agree with Menini-Neto *et al.* (2009) that we should not rule out the scarcity of studies focused on different life-forms in dense ombrophilous forest as a factor when making difficult comparisons.

Despite historical disturbances and current land use (IBC 1970), APAMA has well-preserved vegetation in regions with the most concave relief (ravine forest). Terrestrial and epiphytic herbaceous species are concentrated in ravines. The high humidity in these environments has been reported as an important factor for the maintenance of these life-forms (Benzing 1990; Menini-Neto 2009). APAMA is notable for the presence of perennial and seasonal streams that are often associated with ravines. The steepness of these ravine forests probably made it difficult to extract wood in the past, resulting in a much more expressive richness than in forests in convex areas. For example, some elements restricted to ravines include individuals of species with a diameter at breast height (DBH) greater than 79.5 cm that has recognized economic

value, such as *Pouteria venosa*, *Cariniana legalis*, *Lecythis pisonis*, *Actinostemon klotzschii*, *Handroanthus riodecensis*, and *Ocotea aniboides* (Lorenzi 2008; 2009; 2013).

It is interesting to note that the most representative families found in APAMA were also the focus of works within the project Diversidade Florística da Área de Proteção Ambiental do Mestre Álvaro: including unpublished data as Araceae, Cactaceae, Fabaceae, Malvaceae, Malpighiaceae and, Melastomataceae (Iglesias & Dutra 2017). This effect was also pointed out by Luber *et al.* (2016) as an important variable in a similar study. Even so, our data follow the expected trend for the families that are the most diverse lineages in the Atlantic Forest (BFG 2018): Asteraceae, Fabaceae, Melastomataceae, Myrtaceae, Bromeliaceae and Orchidaceae.

The family Fabaceae, for example, is also prominently reported in other studies involving the same phytoecological region (Luber *et al.* 2016), even when restricted to the arboreal component (Carvalho *et al.* 2007; Solórzano *et al.* 2007; Saiter *et al.* 2011). When comparing the species of this family in APAMA with other phytoecological regions of this state, we find more species shared with tabuleiro forest (e.g., *Abarema langsдорffii* and restinga (e.g., *Albizia polycephala*, *Chloroleucon extortum*) than with montane ombrophilous forest (*Inga marginata* and *Senna macranthera*). This result may be associated with a greater sampling effort made in the first two regionally well-studied vegetation types (Pereira *et al.* 1998; 2000; Pereira & Zambom 1998; Assis *et al.* 2004; Rolim *et al.* 2016), and also to the high amount of endemism found in forests above 800 m altitude (Thomaz & Monteiro 1997). Among the registered species, *Leucochloron incuriale* has a wide distribution, but within the state of Espírito Santo its occurrence is limited to APAMA, which is possibly associated with the scarcity of collections (Chagas *et al.* 2017).

In the case of Melastomataceae, species typical of dense montane ombrophilous forest accounted for ca. 70 % of the species collected in APAMA (Iglesias & Dutra 2017); the remainder are typically at altitudes below 500 m. Perhaps, this view is the best definition of APAMA's floristic identity, which has elements from both phytoecological regions. Although expected for the altitudinal range analyzed, the union between these elements is a relictual distribution in a sharply fragmented landscape.

Other significant families in APAMA have centers of diversity in the Atlantic Forest. This is the case for Araceae, which contains the conspicuous genera *Anthurium* and *Philodendron*. Their representativeness in APAMA supports Krömer *et al.* (2005) and Furtado & Menini-Neto (2018), who assume that up to 800 m of these genera are under optimal developmental conditions. Besides this, they are particularly remarkable for having dense populations along streams and on boulders in forests.

For Cactaceae, the center of diversity of the epiphytic tribe Rhipsalideae is in the Atlantic Forest, which contributes to it being one of the most representative vascular epiphyte families in this domain (Calvente *et al.* 2011; Freitas *et*

al. 2016). The diversity and abundance of these cacti in humid environments could be an indicator of the degree of regeneration of Atlantic Forest (Taylor & Zappi 2004). Some species, such as *Hatiora salicornioides*, *Lepismium cruciforme* and *Rhipsalis elliptica*, were recorded for the first time for the Grande Vitória Metropolitan Region, since they are associated with elevated areas in Espírito Santo, at submontane and montane forests (Cardoso *et al.* 2022).

The cases of Malpighiaceae and Malvaceae in APAMA are typical examples of representativeness as a reflection of the collection effort because both families generally do not appear prominent in floristic studies. Malpighiaceae, for example, only show significant representativeness in the state in a study by Pereira & Zambom (1998) conducted in restinga. Nevertheless, about 35 % of the Malpighiaceae genera recorded for Espírito Santo also occur in APAMA (see Almeida & Mamede 2014). The record of *Amorimia maritima* is the first for this species for ombrophilous forest in Espírito Santo.

For Malvaceae, there is a strong link of *Malvastrum*, *Sida*, *Sidastrum*, *Triumfetta* and *Waltheria* to altered environments (e.g., Bovini *et al.* 2001; Bovini & Baumgratz 2016), which occur in APAMA as pastures, roads, and landfills. These genera represent 73 % of the species sampled for the family. It is important to highlight that even though these species are ruderal (Moro *et al.* 2012), they contribute to APAMA's natural regeneration process and should be included in similar studies.

The representativity of Piperaceae in similar phytoecological regions in Espírito Santo was previously associated with disturbances of anthropic origin (Luber *et al.* 2016). However, in APAMA the richness of the family is well represented by *Peperomia*, which is a conspicuous element of dense ombrophilous forest (Carvalho-Silva & Guimarães 2008; Sarnaglia-Junior *et al.* 2014b). As previously noted by Sarnaglia-Junior *et al.* (2014a), *Piper* is common on the margins of well-preserved streams in ravines.

It is important to note the considerable lack of collections for some groups, such as Myrtaceae, Sapotaceae and Lauraceae, which are often representative components in Tertiary/Quaternary forests (Fabris & Cesar 1996; Fabris 2011; Fabris & Peixoto 2013; Giaretta & Peixoto 2015; Moraes & Vergne 2018; Moraes & Vergne 2019), as well as montane forests of Espírito Santo (Thomaz & Monteiro 1997; Barbosa *et al.* 2012; Giaretta *et al.* 2015; Monico & Alves-Araújo 2019). This makes clear the next gap to be filled regarding APAMA's flora, which will potentially result in additional information about the floristics of the area.

The richness found in APAMA is a positive example of what conservation units with different phytoecological regions contribute to the maintenance of ecological corridors. This study also provides a new source of data for biogeographic studies that seek to understand the effect caused by neighboring vegetation types on the composition of restinga vegetation (see Giaretta *et al.* 2013). In the state of Espírito Santo, the submontane dense ombrophilous



forest has never been studied in this scenario and APAMA's coastal location makes this possible.

Finally, it is important to note that, despite the significant number of species found in APAMA, floristic comparisons with other similar areas would be premature considering the current knowledge of their floras. This is because our results indicate a tendency for subsampling some representative families of the Atlantic Forest. However, this gap serves as a trigger to conduct new taxonomic studies involving these families.

We have shown the conservation of protected areas in large urban centers allows the maintenance of target species for conservation. This study can contribute to maintaining the conservation unit by providing information about the presence of endemic and endangered species. It is of paramount importance that decision-makers can obtain indicators as a metric for resource allocation. The presence of new records is indicative of the negligence this significant forest remnant has experienced until now and highlights the need to improve the research there.

Knowing the vegetation of APAMA is an important tool for restoration projects designed to meet the Brazilian Native Vegetation Protection Law (Brasil 2012b). We demonstrate that, despite the history of use, the study area guarantees the maintenance of a significant number of endemic and threatened species, as well as important ecosystem services. Our study presents an unprecedented documented floristic list for the altitudinal gradient (100–800 m) in the priority area for the conservation of Grande Vitória (Espírito Santo 2010b). This list will support forest restoration projects in line with the region's natural regeneration potential (Martins *et al.* 2014) and legally recognized ecological corridors (Espírito Santo 2010a).

Acknowledgements

We thank to Luana Calazans for providing valuable comments on this manuscript. This work was supported through a research grant from the Fundação de Amparo à Pesquisa do Espírito Santo (FAPES, Processo 57226334/12).

References

- Almeida RF, Mamede MCH. 2014. Checklist, conservation status, and sampling effort analysis of Malpighiaceae in Espírito Santo State, Brazil. *Brazilian Journal of Botany* 37: 329-337.
- Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM, Sparovek G. 2013. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* 22: 711-728.
- Assis AM. 2007. Diversidade e Conservação das Florestas de Encosta do Espírito Santo. In: Menezes LFT, Pires FR, Pereira OJ. (eds.) *Ecosistemas Costeiros do Espírito Santo*. Vitória, EDUFES. p 45-58.
- Assis AM, Thomaz LD, Pereira OJ. 2004. Florística de um trecho de floresta de restinga no município de Guarapari, Espírito Santo, Brasil. *Acta Botanica Brasiliica* 18: 191-201.
- Barbosa TDM, Baitello JB, Moraes PLR. 2012. A família Lauraceae Juss. no município de Santa Teresa, Espírito Santo. *Boletim do Museu de Biologia Mello Leitão (Nova Série)* 30: 5-178.
- Bardou P, Mariette J, Escudé F, Djemiel C, Klopp C. 2014. Jvenn: an interactive Venn diagram viewer. *BMC Bioinformatics* 15: 1-17.
- Benzing DH. 1990. *Vascular epiphytes: General biology and related biota*. Cambridge, Cambridge University Press.
- BFG. 2018. *Brazilian Flora 2020: Innovation and collaboration to meet Target 1 of the Global Strategy for Plant Conservation (GSPC)*. *Rodriguésia* 69: 1513-1527.
- Bovini MG, Baumgratz JFA. 2016. Taxonomic revision of *Wissadula* (Malvoideae, Malvaceae) in Brazil. *Phytotaxa* 243: 201-234.
- Bovini MG, Carvalho-Okano RM de, Vieira ME. 2001. *Malvaceae* A. Juss. no Parque Estadual do Rio Doce, Minas Gerais, Brasil. *Rodriguésia* 52: 17-47.
- Brasil. 2012a. Monitoramento do Desmatamento nos Biomas Brasileiros por Satélite: Monitoramento do Bioma Mata Atlântica 2008 a 2009. Brasília, Ministério do Meio Ambiente/Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis.
- Brasil. 2012b. Lei nº 12.651, de 25 de maio de 2012. *Diário Oficial da União* 149: 1-8.
- Brasil. 2017. *Estratégia e Plano de Ação Nacionais para a Biodiversidade*. EPANB: 2016-2020. Brasília, Ministério do Meio Ambiente, Secretaria de Biodiversidade, Departamento de Conservação de Ecossistemas.
- Brasil. 2018. *Impacts of climate change on the Atlantic Forest*. Brasília, Ministry of Environment.
- Calvente A, Zappi DC, Forest F, Lohmann LG. 2011. Molecular phylogeny, evolution, and biogeography of South American epiphytic cacti. *International Journal of Plant Sciences* 172: 902-914.
- Cardoso WC, Calvente A, Dutra VF, Sakuragui CM. 2022. Cactaceae in a priority area for conservation in Espírito Santo state. *Rodriguésia* 73: e00212021.
- Carvalho FA, Nascimento MT, Braga JMA. 2007. Estrutura e composição florística do estrato arbóreo de um remanescente de Mata Atlântica Submontana no município de Rio Bonito, RJ, Brasil (Mata Rio Vermelho). *Revista Árvore* 31: 717-730.
- Carvalho-Silva M, Guimarães EF. 2008. *Peperomia ciliatocaespitosa* M. Carvalho-Silva, E.F. Guim. (Piperaceae): uma nova espécie para o Brasil. *Acta Botanica Brasiliica* 22: 559-531.
- Chagas AP, Dutra VF, Garcia FCP. 2017. Flora do Espírito Santo: *Ingeae* (Leguminosae): parte 1. *Rodriguésia* 68: 1613-1631.
- Dean W. 1996. A ferro e fogo – a história e a devastação da Mata Atlântica brasileira. São Paulo, Companhia das Letras.
- Dutra VF, Alves-Araújo A, Carrijo TT. 2015. Angiosperm checklist of Espírito Santo: using electronic tools to improve the knowledge of an Atlantic Forest biodiversity hotspot. *Rodriguésia* 66: 1145-1152.
- Espírito Santo. 2010a. Decreto nº 2529-R. Institui Corredores Ecológicos Prioritários do Espírito Santo no âmbito do Corredor Central da Mata Atlântica. *Diário Oficial dos Poderes do Estado* 22589: 3-5.
- Espírito Santo. 2010b. Decreto nº 2530-R. Identifica Áreas Prioritárias para Conservação da Biodiversidade no Estado. *Diária Oficial dos Poderes do Estado* 22589: 5-6.
- Espírito Santo. 2018. Altera na Lei Estadual nº 4.507/1991. *Diário Oficial dos Poderes do Estado* 24759: 1-5.
- Fabris LC, Cesar O. 1996. Estudos florísticos em uma mata litorânea no sul do estado do Espírito Santo, Brasil. *Boletim do Museu de Biologia Mello Leitão (Nova Série)* 5: 15-46.
- Fabris LC, Peixoto AL. 2013. Sapotaceae das Restingas do Espírito Santo, Brasil. *Rodriguésia* 64: 263-283.
- Fabris LC. 2011. Sapotaceae ocorrentes na planície terciária e quaternária do Estado do Espírito Santo, Brasil. PhD Thesis, Escola Nacional de Botânica Tropical, Rio de Janeiro.
- Fraga CN, Peixoto AL, Leite YRL, et al. 2019. Lista da fauna e flora ameaçadas de extinção no estado do Espírito Santo. In: Fraga CN, Formigoni MH, Chaves FG. (eds.) *Fauna e Flora ameaçadas de extinção no estado do Espírito Santo*. Santa Teresa, Instituto Nacional da Mata Atlântica. p. 342-419.
- Fidalgo O, Bononi VLR. 1989. Técnicas de coleta, preservação e esterelização de material botânico. São Paulo, Instituto de Botânica, Secretaria do Meio Ambiente, Governo do Estado de São Paulo.
- Filgueiras TS, Nogueira PE, Brochado AL, Guala-II GF. 1994. Caminhamento: Um método expedito para levantamentos florísticos qualitativos. *Cadernos de Geociências* 12: 39-43.
- Flora do Brasil 2020. 2020. Jardim Botânico do Rio de Janeiro. <http://floradobrasil.jbrj.gov.br>. 05 Jan. 2020.
- Font Quer P. 2000. *Diccionario de Botánica*. Barcelona, Ediciones Península.
- Freitas L, Salino A, Menini-Neto L, et al. 2016. A comprehensive checklist of vascular epiphytes of the Atlantic Forest reveals outstanding endemic rates. *PhytoKeys* 58: 65-79.

- Furtado SG, Menini-Neto L. 2018. Elevational and phytophysiological gradients influence the epiphytic community in a cloud forest of the Atlantic phytogeographic domain. *Plant Ecology* 219: 677-690.
- Gatto LCS, Ramos VLS, Nunes BTA, *et al.* 1983. Geomorfologia. In: IBGE Folha SF. 23/24 (eds.) Rio de Janeiro/Vitória: geologia, geomorfologia, pedologia, vegetação e uso potencial da terra. Rio de Janeiro, Fundação Instituto Brasileiro de Geografia e Estatística. p. 305-384.
- Garbin ML, Saiter FZ, Carrijo TT, Peixoto AL. 2017. Breve histórico e classificação da vegetação capixaba. *Rodriguésia* 68: 1883-1894.
- Giaretta A, Peixoto AL. 2015. Myrtaceae da restinga no norte do Espírito Santo, Brasil. *Boletim do Museu de Biologia Mello Leitão (Nova Série)* 37: 45-126.
- Giaretta A, Menezes LFT, Pereira OJ. 2013. Structure and floristic pattern of a coastal dunes in southeastern Brazil. *Acta Botanica Brasílica* 27: 87-107.
- Giaretta A, Menezes LFT, Peixoto AL. 2015. Diversity of Myrtaceae in the southeastern Atlantic Forest of Brazil as a tool for conservation. *Brazilian Journal of Botany* 38: 175-185.
- Giulietti AM, Rapini A, Andrade MJG, Queiroz LP, Silva JMC. 2009. Plantas raras do Brasil. Belo Horizonte, Conservação Internacional/ Universidade Estadual de Feira de Santana.
- IBC - Instituto Brasileiro do Café. 1970. Aerolevanteamento do Estado do Espírito Santo. Grupo Executivo de Racionalização da Cafeicultura. <https://www2.geobases.es.gov.br/publico/AcessoNavegador.aspx?id=268&nome=FOTO%C3%8DNDICE%20IMAGENS%20ES%20IBC%20GERCA%201970>. 20 Apr. 2020.
- Iglesias DT, Dutra VF. 2017. Melastomataceae na Área de Proteção Ambiental Mestre Álvaro, Serra, Espírito Santo, Brasil. *Rodriguésia* 68: 1921-1937.
- Iglesias DT, Dutra VF, Goldenberg R. 2016. *Behuria mestrealvarens* (Melastomataceae): a new species on an inselberg in Espírito Santo, Brazil. *Phytotaxa* 255: 281-286.
- Krömer T, Kessler M, Gradstein R, Acebey A. 2005. Diversity patterns of vascular epiphytes along an elevational gradient in the Andes. *Journal of Biogeography* 32: 1799-1809.
- Lorenzi H. 2008. Árvores Brasileiras: Manual de identificação e cultivo de plantas arbóreas nativas do Brasil. Nova Odessa, Instituto Plantarum.
- Lorenzi H. 2009. Árvores Brasileiras: Manual de identificação e cultivo de plantas arbóreas nativas do Brasil. Nova Odessa, Instituto Plantarum.
- Lorenzi H. 2013. Árvores Brasileiras: Manual de identificação e cultivo de plantas arbóreas nativas do Brasil. Nova Odessa, Instituto Plantarum.
- Loyola R, Machado N, Vila-Nova D, Martins E, Martinelli G. 2014. Áreas prioritárias para conservação e uso sustentável da flora brasileira ameaçada de extinção. Rio de Janeiro, Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Andrea Jakobsson Estúdio.
- Luber J, Tuler AC, Torres F, Christ JA, Guidoni-Martins KG, Zanetti M, Hollunder RK, Manhães VC, Zorzanelli JPF, Mendonça ES, Garbin ML, Carrijo TT. 2016. List of angiosperm species in an Atlantic Forest fragment reveals collection gaps in Espírito Santo state, Brazil. *Check List* 12: 1835. doi: 10.15560/12.1.1835
- Martinelli G, Moraes MA. 2013. Livro Vermelho da Flora do Brasil. Rio de Janeiro, Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Andrea Jakobsson.
- Martins SV, Sartori M, Raposo-Filho FL, *et al.* 2014. Potencial de regeneração natural de florestas nativas nas diferentes regiões do estado do Espírito Santo. Vitória, Centro de Desenvolvimento do Agronegócio.
- Mendes IA, Dantas M, Bezerra LMM. 1987. Geomorfologia. In: IBGE Folha SE. 24. (eds.) Rio Doce: geologia, geomorfologia, pedologia, vegetação e uso potencial da terra. Rio de Janeiro, Fundação Instituto Brasileiro de Geografia e Estatística. p. 173-228.
- Menini-Neto L, Matozinhos CN, Abreu NL, *et al.* 2009. Flora vascular não-arbórea de uma floresta de grota na Serra da Mantiqueira, Zona da Mata de Minas Gerais, Brasil. *Biota Neotropica* 9: 149-161.
- Monico AZ, Alves-Araújo A. 2019. *Pouteria* (Sapotaceae) na Estação Biológica de Santa Lúcia, ES, Brasil. *Rodriguésia* 70: e02152017. doi: 10.1590/2175-7860201970024
- Moraes PLR, Vergne MC. 2018. A synopsis of Lauraceae (excluding *Ocotea*) from the Reserva Natural Vale, Linhares, Espírito Santo, Brazil. *Feddes Repertorium* 129: 247-303.
- Moraes PLR, Vergne MC. 2019. A synopsis of *Ocotea* (Lauraceae) from the Reserva Natural Vale, Linhares, Espírito Santo, Brazil. *Feddes Repertorium* 130: 117-217.
- Moro MF, Souza VC, Oliveira-Filho AT, *et al.* 2012. Alienígenas na sala: o que fazer com espécies exóticas em trabalhos de taxonomia, florística e fitossociologia? *Acta Botanica Brasílica* 26: 991-999.
- Pereira OJ, Zambom O. 1998. Composição florística da restinga de Interlagos, Vila Velha, ES. In: Anais do IV Simpósio de Ecossistemas Brasileiros. São Paulo, ACIESP. p. 129-139.
- Pereira OJ, Assis AM, Souza RLD. 1998. Vegetação da Restinga de Pontal do Ipiranga, Município de Linhares, ES. In: Anais do IV Simpósio de Ecossistemas Brasileiros. São Paulo, ACIESP. p. 117-128.
- Pereira OJ, Borgo JH, Rodrigues ID, Assis AM. 2000. Composição florística de uma floresta de Restinga no município da Serra, ES. In: Anais do V Simpósio de Ecossistemas Brasileiros: Conservação. São Paulo, ACIESP. p. 74-83.
- Pereira-Silva RA, Athiê-Souza SM, Melo AL, Ambruster WS. 2019. *Dalechampia margarethiae* (Euphorbiaceae), a new species from southeastern Brazil. *Systematic Botany* 44: 832-837.
- Porembski S, Martinelli G, Ohlemüller R, Barthlott W. 1998. Diversity and ecology of saxicolous vegetation mats on inselbergs in the Brazilian Atlantic rainforest. *Diversity and Distributions* 4: 107-119.
- Ribeiro MC, Metzger JP, Martensen AC, Ponzoni FJ, Hirota MM. 2009. The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation* 142: 1141-1153.
- Rolim SG, Peixoto AL, Pereira OJ, *et al.* 2016. Angiospermas da Reserva Natural Vale, na Floresta Atlântica do Norte do Espírito Santo. In: Rolim SG, Menezes LFT de, Srbek-Araújo AC. (eds.) Floresta Atlântica de Tabuleiro: diversidade e endemismos na Reserva Natural Vale. Belo Horizonte, Editora Rupestre. p. 167-230.
- Saiter FZ, Thomaz LD. 2014. Revisão da lista de espécies arbóreas do inventário de Thomaz & Monteiro (1997) na Estação Biológica de Santa Lúcia: o mais importante estudo fitossociológico em florestas montanas do Espírito Santo. *Boletim do Museu de Biologia Mello Leitão (Nova Série)* 34: 101-128.
- Saiter FZ, Dan ML, Thomaz LD. 2011. Floristic and structure of a secondary urban forest with a long history of man-made disturbances in Espírito Santo state, Brazil. *Brazilian Geographical Journal: Geosciences and Humanities research medium* 2: 69-85.
- Sarnaglia-Junior VB, Bermudez GMM, Guimarães EF. 2014a. Diversidade de Piperaceae em um remanescente de Floresta Atlântica na região serrana do Espírito Santo, Brasil. *Biotemas* 27: 49-57.
- Sarnaglia-Junior VB, Thomaz LD, Guimarães EF. 2014b. O gênero *Peperomia* Ruiz, Pav. na Área de Proteção Ambiental do Mestre Álvaro, Espírito Santo, Brasil. *Boletim do Museu de Biologia Mello Leitão (Nova Série)* 35:21-34.
- Solórzano A, Guedes-Bruni RR, Oliveira RR. 2007. Composição florística e estrutura de dois trechos de Floresta Ombrófila Densa submontana, no Parque Estadual da Pedra Branca, RJ. *Revista Brasileira de Biociências* 5: 609-611.
- SOS Mata Atlântica & Instituto Nacional de Pesquisas Espaciais. 2020. Atlas dos Remanescentes Florestais de Floresta Atlântica. Período: 2018/2019. Relatório Final. São Paulo, Fundação SOS Floresta Atlântica.
- Souza WO, Machado JO, Tognella MMP, Alves-Araújo A. 2016. Checklist de Angiospermas do Parque Estadual de Itaúnas, Espírito Santo, Brasil. *Rodriguésia* 67: 571-581.
- Taylor NP, Zappi D. 2004. Cacti of eastern Brazil. London, Royal Botanic Gardens.
- Thomaz LD, Monteiro R. 1997. Composição florística da Mata Atlântica de Encosta da Estação Biológica de Santa Lúcia, município de Santa Teresa - ES. *Boletim do Museu de Biologia Mello Leitão (Nova Série)* 7: 3-48.
- Thiers B. 2021, continuously updated. *Index Herbariorum*: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual herbarium. <http://sweetgum.nybg.org/ih/>. 03 Apr. 2021.
- Valadares RT, Coelho MAN. 2017. *Anthurium idimae* — a new species of Araceae from Southeastern Brazil. *Phytotaxa* 316: 73-78.
- Valadares RT, Sakuragui CM. 2014. A New Species of *Anthurium* (Araceae) sect. *Urospadix* subsect. *Obscureviridia* from Espírito Santo, Eastern Brazil. *Systematic Botany* 39: 31-35.
- Veloso EM, Rangel Filho ALR, Lima JCA. 1991. Classificação da vegetação brasileira, adaptada a um sistema universal. Rio de Janeiro, Instituto Brasileiro de Geografia e Estatística.

