Biodiversity Data Journal 11: e109082
doi: 10.3897/BDJ.11.e109082

Data Paper

# Vascular plant taxa occurrences in exotic woodland and in natural and production forests on the Islands of São Miguel, Terceira and Pico (Azores)

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Academic editor: Paulo Borges

Received: 05 Jul 2023 | Accepted: 27 Jul 2023 | Published: 03 Aug 2023

Citation: Borges Silva L, Madeira P, Pavão D, Elias RB, Moura M, Silva L (2023) Vascular plant taxa occurrences in exotic woodland and in natural and production forests on the Islands of São Miguel, Terceira and Pico (Azores). Biodiversity Data Journal 11: e109082. https://doi.org/10.3897/BDJ.11.e109082

## Abstract

### Background

The data presented here originated from field expeditions carried out between 2017 and 2018, within the framework of Forest-Eco$^2$ project: "Towards an Ecological and Economic valorisation of the Azorean Forest". The project aimed to quantify the ecological value of the Azorean forests, including carbon accumulation and to design and propose measures that could further enhance forest sustainability. For that, 90 forest plots were sampled on three Azores islands - São Miguel, Terceira and Pico - equally distributed into natural

forest, exotic woodland and production forest. The aim of this report is to further expand knowledge on biodiversity trends enclosed in the different forest types present in the Azores, by providing a list of the occurrences of the 105 different vascular plant taxa together with a brief characterisation of their origin and life-form.

### New information

We provide an inventory of indigenous and non-indigenous vascular plant taxa from 90 forest stands. A total of 105 taxa were identified and registered, belonging to 60 families, 91 genera, 101 species and four subspecies. A total of 35% of the taxa were endemic, 27% native and 38% non-indigenous, including 19% of invasive taxa. Endangered and vulnerable taxa were registered, including *Elaphoglossum hirtum* (Sw.) C.Chr., *Lactuca watsoniana* Trel. and others which were considered by the authors a priority for conservation (e.g. *Arceuthobium azoricum* Wiens & Hawksw., *Bellis azorica* Hochst. ex Seub., *Sanicula azorica* Guthnick ex Seub., *Platanthera micrantha* (Hochst. ex Seub.) Schltr.). Our records provide detailed and updated knowledge of Azorean Forest flora and highlight the role of natural forests as indigenous plant diversity hotspots and exotic woodland as a source of invasive taxa within the Archipelago.

## Keywords

Azores, islands, Plantae, endemic, native, exotic woodland, natural forest, production forest, Magnoliophyta, Magnoliopsida, Liliopsida, Lycopodiophyta, Pinophyta, Pteridophyta, occurrences

## Introduction

Studies on ecology and the distribution of organisms in a gradient of forest types, particularly with an emphasis on flora and species attributes, have been the focal point in many projects on forests ecosystems across the world (Rahbek 1995, Kessler 2000, Pavón et al. 2000, Grytnes 2003, Olthoff et al. 2016, Vinod et al. 2022) and also in the Azores Islands (Marcelino et al. 2013, Marcelino et al. 2014, Elias et al. 2016, Borges Silva L et al. 2022b).

Forests and woodlands constitute a striking and structuring element of the Azorean landscape. Occupying about 30% of the insular terrestrial territory (DRRF 2014), they harbour enormous terrestrial biodiversity, making them, in essence, critical habitats for plant species and for providing a wide range of ecosystem services (Matos et al. 2019, Borges Silva L et al. 2022b).

The flora of the Azores comprises about 4000 vascular plant taxa (Tracheobionta) (Silva et al. 2008, Silva et al. 2022, Borges Silva L et al. 2022a), including cultivated taxa; but excluding another 1397 taxa without a confirmed presence in the Azores. Distributed within

several groups, namely Magnoliophyta, Pinophyta, Pteridophyta and Lycopodiophyta (Silva et al. 2008, Silva et al. 2010), approximately 133 species are considered as native and 101 endemic, distributed over 60 families, the vast majority of which only contain a single endemic taxon (Silva et al. 2008, Silva et al. 2022, Borges Silva L et al. 2022a). The families with the highest numbers of endemic taxa correspond to Asteraceae (13), Dryopteridaceae (8), Poaceae (12) and Apiaceae (7) (Silva et al. 2009, Silva et al. 2010, Moura et al. 2013, Borges Silva et al. 2016, Moura et al. 2018, Moura et al. 2019, Vieira et al. 2020, Elias et al. 2022). The remaining taxa consist of exotic plants, distributed over 200 families, 2901 considered as cultivated or at least imported, 322 as casual escapes and 578 as naturalized, of which 140 are invasive, occupying large extensions (Silva et al. 2008, Silva et al. 2022, Borges Silva L et al. 2022a).

As in many archipelagos, the Azorean primary forest was largely cleared and replaced by secondary forest and grassland (Matos et al. 2019, Pavão et al. 2021). Currently, land use in the Azores is dominated by pastures and agriculture (60%), planted or alien dominated forests (22%), with natural forests and vegetation representing 10% of the territory (DRRF 2014).

The Azorean production forest is dominated by a reduced number of species, including *Cryptomeria japonica* D. Don (12,856 ha), *Eucalyptus globulus* Labill. (3786 ha), *Pinus pinaster* Aiton (874 ha) and by non-productive exotic woodland occupying more than 30% of the forest areas, where *Pittosporum undulatum* Vent. is the dominant woody species, occupying 23,939 ha (Lourenço et al. 2011, DRRF 2014, Borges Silva et al. 2014, Borges Silva et al. 2017, Borges Silva et al. 2018).

Non-indigenous invasive species, such as *P. undulatum*, *Hedychium gardnerianum* Sheppard ex Ker-Gawl., *Leycesteria formosa* Wall., *Clethra arborea* Aiton, *Gunnera tinctoria* (Molina) Mirb. and tree ferns, such as *Sphaeropteris cooperi* (F.Muell.) R.M.Tryon, *Sphaeropteris medullaris* Bernh and *Dicksonia antarctica* Labill., currently threaten the conservation of endemic Azorean species and natural forests (Silva and Smith 2006, Silva et al. 2009, Costa et al. 2013, Borges Silva et al. 2014, Borges Silva et al. 2017, Silva and Beech 2017, Borges Silva et al. 2018).

The publication of updated species lists and suitable floristic data, makes available relevant information for the evaluation of the conservation *status* of species and ecosystems (Simões et al. 2021, Büttner et al. 2022).

This paper aims to publish a dataset of vascular plant occurrences in 90 Azorean forests, highlighting the importance of natural forests as indigenous plant diversity hotspots and of exotic woodland as a source of invasive taxa.

## General description

**Purpose:** The purpose of this paper was to publish a dataset of vascular plant occurrences in three forest types (NF-Natural Forest, EW-Exotic Woodland and PF-Production Forest)

on three islands of the Azores Archipelago (São Miguel, Terceira and Pico), already published in GBIF as a Darwin Core Archive.

## Project description

**Title:** Vascular plant taxa occurrences in exotic woodland and in natural and production forests on the islands of São Miguel, Terceira, and Pico (Azores).

**Personnel:** Lurdes Borges Silva, Patrícia Madeira, Diogo Pavão, Rui Bento Elias, Mónica Moura and Luís Silva.

**Study area description:** The Azores Archipelago is situated in the North Atlantic Ocean, between North America and Europe, about 1500 km west of mainland Portugal, roughly at 38°44'52"N, 31°32'16"W and 38°55'27"N, 25°0'36"W (Fig. 1). The Archipelago is formed by nine main islands and some small islets, all of them of volcanic origin. The islands are divided into three main groups: the western group (Corvo and Flores), the central group (Faial, Pico, Graciosa, São Jorge and Terceira) and the eastern group (São Miguel and Santa Maria). The climate in the Azores is temperate oceanic, with regular and abundant rainfall, high levels of relative humidity and persistent winds, mainly during winter and autumn (Azevedo et al. 2004).

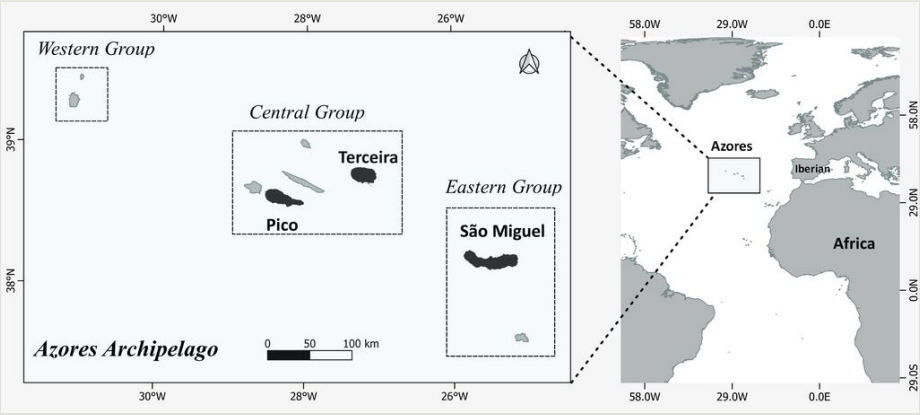


Figure 1. doi

The Azores Archipelago with its location in the middle Atlantic (right panel) and Azorean Islands namely São Miguel, Terceira and Pico islands (left panel).

The landscape of the islands is composed by a mosaic of habitats, ranging from herbaceous to arboreal and from natural to anthropogenic (Silva et al. 2008, Soares et al. 2021). The original landscape was strongly altered by replacing pristine and native forest areas with exotic tree plantations, crops, pastures and urban areas (Silva et al. 2008). During the last decades of the 20$^{th}$ century, the reduction of native forest area was significant, with the clearing of large fragments, at mid- and high altitude, for pasture ( Gaspar et al. 2008). *Pittosporum undulatum*, *Acacia melanoxylon* R.Br. or *Eucalyptus*

*globulus* dominate most forest patches located in low- to mid-elevation areas. At higher altitudes, *Cryptomeria japonica* dominates, along with the remaining stands of natural forests, particularly above 600 m a.s.l. (Elias et al. 2016, Borges Silva et al. 2017, Borges Silva et al. 2018, Dutra Silva et al. 2019). The natural vegetation includes diverse communities, namely coastal vegetation, coastal and inland wetlands, meadows, peat bogs and several types of native forests and scrubs. However, forests are the dominant natural vegetation type. In fact, before human settlement, laurel forests could have covered around 75% of Azorean islands (Elias et al. 2016). Currently, the native laurel forest comprises about 5% of the total surface of the Archipelago and has remained only at higher elevations and in inaccessible areas of the islands (Elias et al. 2016).

This research comprised three islands contributing with the largest forest areas: São Miguel Island with 745 $km^2$, the highest elevation being 1105 m a.s.l. with an estimated age of 0.79 MY (millions of years) (Sibrant et al. 2015), Terceira Island with 400 $km^2$, a maximum elevation of 1023 m a.s.l. and 0.39 MY (Hildenbrand et al. 2014) and Pico Island with an area of 447 $km^2$, mostly occupied by a volcanoes reaching an altitude of 2351 m a.s.l. and an approximate age of 0.27 MY (Demand et al. 1982) (Fig. 1).

**Design description:** A total of 90 forests patches were randomly sampled, with 30 quadrats plots (100 $m^2$, divided into four subplots), per island. Surveys took place in spring and summer of 2017 (São Miguel and Terceira Islands) and 2018 (São Miguel and Pico Islands), for a period of 8 months (4 months per year), corresponding to a total of 240 days. Study areas were delimited using a geographic information system (GIS; QGis 3.28) to map and select forest stands, based on the data provided by the Azorean Forest Inventory (DRRF 2007) (see Borges Silva L et al. (2022b) , Figure 2).

**Funding:** This work was funded by: i) Project FOREST-ECO2-Towards an Ecological and economic valorization of the Azorean Forest ACORES-01-0145-FEDER-000014-Azores 2020 PO, 2016–2019; ii) FEDER funds through the Operational Programme for Competitiveness Factors-COMPETE; iii) by PO Azores Project “Portal da Biodiversidade dos Açores” - M1.1.A/INFRAEST CIENT/001/2022; and iv) by National Funds through FCT-Foundation for Science and Technology under the UID/BIA/50027/2019 and POCI-01-0145-FEDER-006821.

## Sampling methods

**Description:** Three types of vegetation were included (Borges Silva L et al. 2022):

- Natural forest, corresponding to submontane and montane cloud forests (Elias et al. 2016). Its distribution in the Azores evolved in unique conditions, due to a pronounced isolation, relatively homogeneous climatic conditions and a limited number of native woody species, but high plant biodiversity and a high number of endemic species, which are dominated by *Ilex azorica* Gand., *Juniperus brevifolia* (Hochst. ex Seub.) Antoine, *Laurus azorica* (Seub.) Franco, *Morella faya* (Aiton)

Wilbur and *Picconia azorica* (Tutin) Knobl (Dias et al. 2007, Elias and Dias 2008, Silva et al. 2010, Pavão et al. 2022, Pavão et al. 2023a, Pavão et al. 2023b).

- Exotic woodland, located at lower to mid-elevations and dominated by *P. undulatum* covering more than 30% of the forest area, which expanded from sea level up to 600 m (Borges Silva et al. 2017, Dutra Silva L et al. 2017a, Dutra Silva et al. 2017b, Borges Silva et al. 2018, Dutra Silva et al. 2019).
- Production forest, dominated by *C. japonica*, occupying 60% of the area dedicated to this type of forest, the most economically important forestry species in the Azores and with an important impact on the landscape (DRRF 2007, Lourenço et al. 2011, DRRF 2014).

**Sampling description:** A total of 90 forest stands were randomly sampled, 30 in each of the three selected islands São Miguel, Terceira and Pico (10 NF, 10 EW and 10 PF) (Table 1). At each forest, we delimited a 10 × 10 m (100 $m^2$) plot and recorded the vascular plant taxa. To quantify the cover-abundance of each taxon, we used the Braun Blanquet scale modified by Van der Maarel E (1979).

Table 1.

List of the 90 sampled forests in São Miguel (SMG, n = 30), Terceira (TER, n = 30) and Pico (PIC, n = 30) Islands. Information about Forest Type (Natural - Natural Forest, Exotic-*Pitt* - Exotic Woodland dominated by *Pittosporum undulatum*, Production-*Cryp* - Production Forest dominated by *Cryptomeria japonica*), Location ID (Code), Locality, decimal geographical coordinates (datum WGS84) and elevation in metres is provided.

| Island | Forest type | Location ID | Locality | Latitude | Longitude | Elevation (m) |
|---|---|---|---|---|---|---|
| SMG | Natural | SMLO-NF01 | Lombadas | 37.78824 | -25.46862 | 654 |
| SMG | Natural | SMTR-NF02 | Tronqueira | 37.79914 | -25.18354 | 646 |
| SMG | Natural | SMVO-NF03 | Lomba do Carro | 37.78122 | -25.27603 | 568 |
| SMG | Natural | SMER-NF04 | Sete Cidades (Estrada-Sul Vista do Rei) | 37.83654 | -25.78826 | 640 |
| SMG | Natural | SMLF-NF05 | Lagoa do Fogo | 37.76259 | -25.46632 | 653 |
| SMG | Natural | SMVA-NF06 | Pico da Vela | 37.76174 | -25.46140 | 855 |
| SMG | Natural | SMMT-NF07 | Tronqueira | 37.79804 | -25.18430 | 677 |
| SMG | Natural | SMME-NF08 | Monte Escuro | 37.77866 | -25.43709 | 753 |
| SMG | Natural | SMTR-NF09 | Tronqueira | 37.79701 | -25.18442 | 754 |

| Island | Forest type | Location ID | Locality | Latitude | Longitude | Elevation (m) |
|---|---|---|---|---|---|---|
| SMG | Natural | SMLM-NF10 | Lomba do Botão | 37.77383 | -25.27546 | 455 |
| SMG | Exotic-*Pitt*. | SMCM-EW01 | Ferraria (Pico das Camarinhas) | 37.85843 | -25.84877 | 205 |
| SMG | Exotic-*Pitt*. | SMCB-EW02 | Lagoa (Chã do Rego d`Água) | 37.77367 | -25.56959 | 240 |
| SMG | Exotic-*Pitt*. | SMMF-EW03 | Mosteiros (Pico de Mafra) | 37.89435 | -25.80720 | 200 |
| SMG | Exotic-*Pitt*. | SMLS-EW04 | Lagoa Santiago | 37.85266 | -25.77467 | 502 |
| SMG | Exotic-*Pitt*. | SMPP-EW05 | Pinhal da Paz | 37.79015 | -25.63265 | 394 |
| SMG | Exotic-*Pitt*. | SMFA-EW06 | Fenais da Ajuda (Lomba de Cima) | 37.82921 | -25.31140 | 405 |
| SMG | Exotic-*Pitt*. | SMFT-EW07 | Faial da Terra | 37.75355 | -25.21646 | 508 |
| SMG | Exotic-*Pitt*. | SMPB-EW08 | Pico Bartolomeu | 37.80110 | -25.15830 | 607 |
| SMG | Exotic-*Pitt*. | SMFN-EW09 | Furnas Norte (Caminho Norte/Sul) | 37.78404 | -25.29760 | 315 |
| SMG | Exotic-*Pitt*. | SMNG-EW10 | Lagoa do Congro | 37.75813 | -25.40702 | 607 |
| SMG | Production-*Cryp*. | SMAL-PF01 | Caldeira do Alferes | 37.87024 | -25.80575 | 483 |
| SMG | Production-*Cryp*. | SMEM-PF02 | Lagoa das Empadadas | 37.82668 | -25.74983 | 845 |
| SMG | Production-*Cryp*. | SMCT-PF03 | Castelo Branco | 37.74732 | -25.35377 | 638 |
| SMG | Production-*Cryp*. | SMFN-PF04 | Furnas Norte (Caminho Norte/Sul) | 37.77344 | -25.36415 | 654 |
| SMG | Production-*Cryp*. | SMAG-PF05 | Água de Pau | 37.73415 | -25.49549 | 432 |
| SMG | Production-*Cryp*. | SMPG-PF06 | Planalto dos Graminhais | 37.80362 | -25.26304 | 850 |
| SMG | Production-*Cryp*. | SMTR-PF07 | Tronqueira | 37.79797 | -25.17647 | 683 |
| SMG | Production-*Cryp*. | SMSB-PF08 | Lagoa São Brás | 37.79404 | -25.41236 | 716 |
| SMG | Production-*Cryp*. | SMFT-PF09 | Faial da Terra | 37.77265 | -25.18795 | 470 |

| Island | Forest type | Location ID | Locality | Latitude | Longitude | Elevation (m) |
|---|---|---|---|---|---|---|
| SMG | Production-*Cryp*. | SMGI-PF10 | Ginetes | 37.87205 | -25.82743 | 289 |
| TER | Natural | TETB-NF01 | Reserva Natural da Terra Brava | 38.73293 | -27.20936 | 692 |
| TER | Natural | TEBL-NF02 | Reserva Natural da Terra Brava | 38.73942 | -27.21194 | 710 |
| TER | Natural | TETR-NF03 | Reserva Natural da Terra Brava | 38.73086 | -27.19350 | 679 |
| TER | Natural | TETA-NF04 | Reserva Natural da Terra Brava | 38.73008 | -27.19260 | 692 |
| TER | Natural | TEIN-NF05 | Caldeira de Santa Bárbara | 38.73461 | -27.30828 | 889 |
| TER | Natural | TEIS-NF06 | Caldeira de Santa Bárbara | 38.73390 | -27.30933 | 904 |
| TER | Natural | TEMO-NF07 | Morro Assombrado | 38.75619 | -27.22497 | 591 |
| TER | Natural | TEMA-NF08 | Morro Assombrado | 38.75763 | -27.22706 | 550 |
| TER | Natural | TELM-NF09 | Lomba | 38.73911 | -27.29289 | 725 |
| TER | Natural | TELO-NF10 | Lomba | 38.73844 | -27.29036 | 700 |
| TER | Exotic-*Pitt*. | TEMD-EW01 | Monte Brasil (Ponta de São Diogo) | 38.64105 | -27.22841 | 212 |
| TER | Exotic-*Pitt*. | TESE-EW02 | Serreta (Pico do Carneiro) | 38.76431 | -27.35234 | 492 |
| TER | Exotic-*Pitt*. | TESC-EW03 | Biscoitos | 38.79195 | -27.24367 | 139 |
| TER | Exotic-*Pitt*. | TEPT-EW04 | Pico do Teles | 38.73238 | -27.36180 | 443 |
| TER | Exotic-*Pitt*. | TEFE-EW05 | Feteira | 38.66165 | -27.15121 | 279 |
| TER | Exotic-*Pitt*. | TEMG-EW06 | Caparica (Caminho dos Caneleiros) | 38.77158 | -27.26219 | 386 |
| TER | Exotic-*Pitt*. | TELJ-EW07 | Vila das Lajes | 38.75774 | -27.10938 | 129 |
| TER | Exotic-*Pitt*. | TECU-EW08 | Serra do Cume | 38.72935 | -27.09827 | 264 |
| TER | Exotic-*Pitt*. | TELC-EW09 | São Brás (Ladeira do Cardoso) | 38.74693 | -27.13439 | 265 |
| TER | Exotic-*Pitt*. | TEAG-EW10 | Agualva | 38.79077 | -27.19684 | 197 |

| Island | Forest type | Location ID | Locality | Latitude | Longitude | Elevation (m) |
|---|---|---|---|---|---|---|
| TER | Production-*Cryp*. | TETE-PF01 | Terra Chã | 38.69952 | -27.23730 | 517 |
| TER | Production-*Cryp*. | TESS-PF02 | Serra de Santa Bárbara | 38.71403 | -27.32952 | 600 |
| TER | Production-*Cryp*. | TEGN-PF03 | Gruta de Natal | 38.73102 | -27.28399 | 661 |
| TER | Production-*Cryp*. | TEGR-PF04 | Gruta de Natal | 38.73999 | -27.26335 | 593 |
| TER | Production-*Cryp*. | TEBI-PF05 | Biscoitos | 38.76861 | -27.25169 | 443 |
| TER | Production-*Cryp*. | TECB-PF06 | São Bento (Caminho do Cabrito) | 38.70378 | -27.17663 | 468 |
| TER | Production-*Cryp*. | TEEC-PF07 | Algar do Carvão (Caminho) | 38.72588 | -27.24099 | 579 |
| TER | Production-*Cryp*. | TEMH-PF08 | Malha Grande | 38.75945 | -27.26404 | 498 |
| TER | Production-*Cryp*. | TERF-PF09 | Reserva Florestal Parcial (Serreta e Serra de Santa Bárbara) | 38.76519 | -27.32107 | 555 |
| TER | Production-*Cryp*. | TEMS-PF10 | Mato da Serreta | 38.74679 | -27.33689 | 800 |
| PIC | Natural | PISG-NF01 | Saída das Lages | 38.43333 | -28.30689 | 419 |
| PIC | Natural | PIPR-NF02 | Mistério da Prainha | 38.48544 | -28.27356 | 516 |
| PIC | Natural | PIBU-NF03 | Trilho dos Burros | 38.47972 | -28.27231 | 621 |
| PIC | Natural | PIAC-NF04 | Planalto da Achada | 38.46914 | -28.31014 | 682 |
| PIC | Natural | PICD-NF05 | Caiado | 38.45589 | -28.25708 | 808 |
| PIC | Natural | PICA-NF06 | Caveiro | 38.43753 | -28.20108 | 905 |
| PIC | Natural | PICT-NF07 | Caveiro | 38.43606 | -28.20761 | 940 |
| PIC | Natural | PIAF-NF08 | Caminho do Arrife | 38.45067 | -28.30986 | 580 |
| PIC | Natural | PICS-NF09 | Cabeçinhos | 38.44350 | -28.31883 | 530 |
| PIC | Natural | PICX-NF10 | Cabeço do Teixo | 38.48775 | -28.34708 | 850 |
| PIC | Exotic-*Pitt*. | PIPH-EW01 | Prainha | 38.46781 | -28.21922 | 296 |
| PIC | Exotic-*Pitt*. | PISR-EW02 | São Roque | 38.51144 | -28.33072 | 282 |
| PIC | Exotic-*Pitt*. | PISL-EW03 | Santa Luzia | 38.52550 | -28.39169 | 344 |

| Island | Forest type | Location ID | Locality | Latitude | Longitude | Elevation (m) |
|---|---|---|---|---|---|---|
| PIC | Exotic-*Pitt*. | PIAM-EW04 | Santo Amaro | 38.45053 | -28.18022 | 229 |
| PIC | Exotic-*Pitt*. | PIPE-EW05 | Piedade | 38.43203 | -28.07394 | 200 |
| PIC | Exotic-*Pitt*. | PIRI-EW06 | Ribeiras | 38.41289 | -28.14211 | 358 |
| PIC | Exotic-*Pitt*. | PILG-EW07 | Lajes do Pico | 38.42542 | -28.27253 | 288 |
| PIC | Exotic-*Pitt*. | PICB-EW08 | Candelária | 38.47233 | -28.50047 | 124 |
| PIC | Exotic-*Pitt*. | PIBD-EW09 | Bandeiras | 38.52964 | -28.46250 | 202 |
| PIC | Exotic-*Pitt*. | PIJO-EW10 | São João | 38.42733 | -28.33086 | 320 |
| PIC | Production-*Cryp*. | PIFR-PF01 | Farrobo | 38.51358 | -28.43758 | 534 |
| PIC | Production-*Cryp*. | PIBU-PF02 | Trilho dos Burros | 38.47986 | -28.27272 | 627 |
| PIC | Production-*Cryp*. | PIAR-PF003 | São Miguel Arcanjo | 38.49628 | -28.29019 | 377 |
| PIC | Production-*Cryp*. | PIAF-PF004 | Caminho do Arrife | 38.45461 | -28.30689 | 604 |
| PIC | Production-*Cryp*. | PIJO-PF005 | São João | 38.44089 | -28.32081 | 514 |
| PIC | Production-*Cryp*. | PICE-PF006 | São Caetano | 38.43192 | -28.36583 | 434 |
| PIC | Production-*Cryp*. | PIIR-PF007 | Ribeirinhas | 38.43044 | -28.09308 | 362 |
| PIC | Production-*Cryp*. | PIAM-PF008 | Santo Amaro | 38.44797 | -28.15064 | 292 |
| PIC | Production-*Cryp*. | PIPH-PF009 | Prainha | 38.46158 | -28.21608 | 374 |
| PIC | Production-*Cryp*. | PICI-PF010 | Caminho do Caveiro (Lagoa do Caiado) | 38.45689 | -28.25922 | 804 |

## Analysis

*Colonisation status*. We determined the indigenous and non-indigenous plants globally and specifically for the groups Magnoliopsida, Liliopsida, Pinophyta, Pteridophyta and Lycopodiophyta. The contribution of each family was evaluated by calculating the number of genera for indigenous and non-indigenous taxa within each family and the number of infrageneric taxa per genus.

*Biogeography of non-indigenous plants.* The distribution of non-indigenous taxa was classified by region, according to Pielou (1992). Taxa present in more than two biogeographic regions were considered as subcosmopolitan.

*Life forms.* The classification of life forms followed Franco (1971), Franco (1984), Franco and Afonso (1994) and Franco and Afonso (1998) and the frequency of each life form was then calculated. Life forms were based on the Raunkjaer (1936) main criterion (height of perennating buds): phanerophytes-perennating buds on aerial shoots (nanophanerophytes < 2 m in height, microphanerophytes 2-8 m, mesophanerophytes 8-30 m, megaphanerophytes > 30 m); chamaephytes - perennating buds very close to the ground; hemicryptophytes - perennating buds at ground level; cryptophytes - perennating buds below ground level (geophytes) and therophytes - annual species (Silva and Smith 2004).

*Useful species*. The number of taxa in the following categories was calculated: ornamental, forestry, cultivated (aromatic, animal fodder, hedge-plants), crops (human food) and ruderal. The percentages of taxa considered as plant invaders and as ecological threats by Portuguese legislation were also calculated DLR 15 from 2 April 2012 (DLR15 2012) and DL 92 from 10 July 2019 (DL92 2019).

**Quality control:** Specimens representing most of the inventoried species, were collected in the field, following standard herbarium techniques and then deposited in the Herbarium Ruy Telles Palhinha, University of the Azores (AZB). All sampled individuals were sorted by trained taxonomists.

Taxonomic nomenclature obtained from:Seubert and Hochstetter (1843), Seubert (1844), Dröuet (1866), Trelease (1897), Cedercreutz (1941), Tutin et al. (1964), Palhinha (1966), Tutin et al. (1968), Franco (1971), Tutin et al. (1972), Sjögren (1973), Tutin et al. (1976), Tutin et al. (1980), Fernandes and Fernandes (1980), Fernandes and Fernandes (1983), Franco (1984), Fernandes and Fernandes (1987), Valdés et al. (1987), Franco and Afonso (1994), Press and Short (1994), Franco and Afonso (1998), Schaefer (2002), Schaefer (2003), Schaefer (2005), Schaefer (2005a), Silva et al. (2010), Vieira et al. (2020)

In terms of species colonisation *status*, we followed Silva et al. (2010) categories: Azorean endemic species, i.e. species (or subspecies) occurring only in the Azores, as a result of either speciation events (neo-endemics) or extinct of the mainland populations (paleo-endemics); Macaronesian endemic species, i.e. species only known from the Macaronesian archipelagos (the Azores, Madeira, Canaries and Cape Verde); Native species, i.e. species which arrived by long-distance dispersal to the Azores and which also occur naturally elsewhere. Regarding Introduced species, that occur in the archipelago as a result of human activities, we distinguished two groups, Naturalised, with self-supporting populations and Casual, occasionally escaped from cultivation.

The biogeographic and historic criteria used to classify taxa as non-indigenous were adapted from Silva et al. (2000): (i) classified as such by several authors from the 19$^{th}$ century; (ii) first record in the last 100 years; (iii) distribution restricted to a reduced number of islands; (iv) record of a recent (last 100 years) extension of the distribution in the Azores;

(v) absence in other Macaronesian islands; (vi) disjunct distribution; (vii) anthropochoric taxa - only casual in the native vegetation. These criteria were applied after exclusion of endemic taxa. Database queries allowed the determination of the taxa number in each category, globally and specifically for the Magnoliopsida, Liliopsida, Pinophyta, Pteridophyta and Lycopodiophyta groups (Silva and Smith 2004).

## Geographic coverage

**Description:** São Miguel, Terceira and Pico Islands, in the Azores Archipelago (Portugal).

**Coordinates**: São Miguel: 37°55'45.6"N and 37°42'22.8"N Latitude; 25°53'28.2"W and 25°0'27.6"W Longitude Terceira: 38°38'16.8"N and 38°48'50.4"N Latitude; 27°23'38.4"W and 27°0'54"W Longitude Pico: 38°34'53"N and 38°21'48"N Latitude; 28°33'40"W and 28°0'14.9"W Longitude.

## Taxonomic coverage

**Description:** For the three forest types and for the three Islands, the dataset includes 105 vascular plant taxa, represented by 101 species and four subspecies, mostly including indigenous plants (35% endemic and 27% native) and 38% of non-indigenous plants (Fig. 2 and Fig. 3). Magnoliopsida were the highest proportion and Pinophyta the lowest (Fig. 2 and Fig. 3). The 105 taxa were distributed by 60 families belonging to 91 genera (Fig. 2). In general, each family and genus contributed only with a small number of indigenous (1-6) or non-indigenous taxa (1-3) (Fig. 2).

Regarding Magnoliopsida, NF showed the highest numbers of endemic and native taxa, while EW and PF showed the highest values of invasive taxa, EW also showing a high number of naturalised and casual species (Fig. 2). For Liliopsida, again NF showed the highest values of endemism, despite also including naturalised and invasive taxa (Fig. 2). For Pteridophyta, all three forests showed similar values of endemic, native and invasive taxa (Fig. 2).

In the Pteridophyta, for the three forest types, 10 families included one or two genera, one family included three genera and only two families participated with more than two species, namely the Dryopteridaceae and Hymenophyllaceae (Table 2). We found two Lycophytes, one a Macaronesian endemism, *Huperzia suberecta* (Lowe) Tardieu. The Pinophyta only included two Cupressaceae, with one endemic taxon, *Juniperus brevifolia* (Hochst. ex Seub.) Antoine subsp. *brevifolia* (Table 2). For the three forest types, the Liliopsida included 11 families and 27 genera, most contributing with only one taxon. The Cyperaceae and Poaceae included the highest numbers of indigenous taxa (Table 2). For the Magnoliopsida, we found 35 families and 83 genera. In general, the families including more indigenous taxa were the Asteraceae, Ericaceae, Lauraceae and Rosaceae (Table 2).

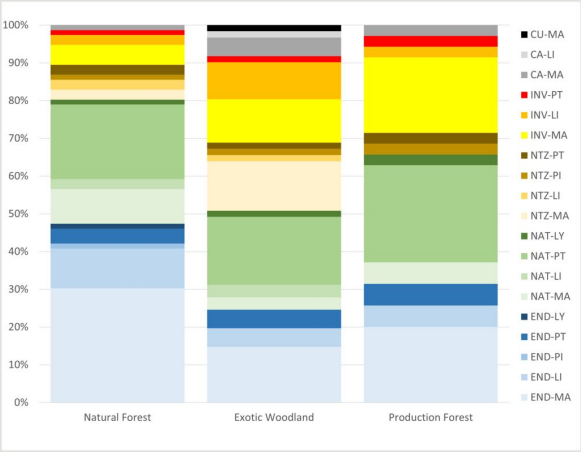


Figure 2. doi

Categorisation of 105 Azorean vascular plant taxa, observed at 90 forests in the Azores, per forest type (Natural Forest, Exotic Woodland and Production Forest) and according to the five major groups of vascular plants (MA-Magnoliopsida, LI-Liliopsida, PI-Pinophyta, PT-Pteridophyta and LY-Lycopodiophyta,). Number of taxa in each category: END-Endemic (taxa only occurring in the Azores); NAT-Native (colonised the Azores without human intervention, also occurring in other regions); INV-Invasive; NTZ-Naturalised (with self-supporting populations); CA-casual (occasionally escaped from cultivation) and CU-Cultivated (Silva et al. 2010).

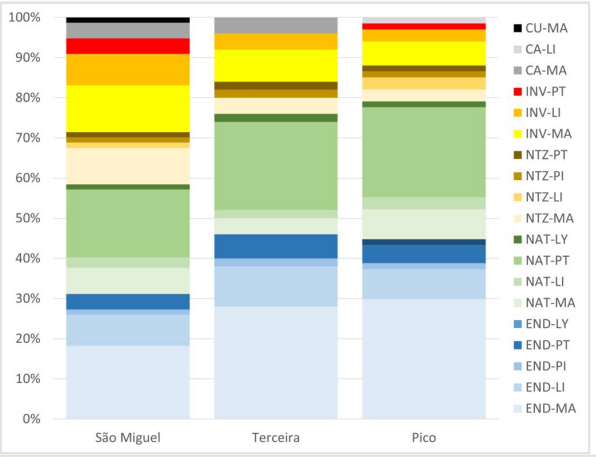


Figure 3. doi

Categorisation of 105 Azorean vascular plant taxa, observed at 90 forests in the Azores, per Island (São Miguel, Terceira and Pico) and according to the five major groups of vascular plants (MA-Magnoliopsida; LI-Liliopsida; PI-Pinophyta; PT- Pteridophyta; and LY-Lycopodiophyta). Number of taxa in each category: END-Endemic (taxa only occurring in the Azores); NAT-Native (colonised Azores without human intervention, also occurring in other regions); INV-Invasive; NTZ-Naturalised (with self-supporting populations); CA-casual (occasionally escaped from cultivation) and CU-Cultivated (Silva et al. 2010).

Table 2.

Number of genera and of infrageneric taxa per family, for indigenous and non-indigenous vascular plants, in three forest types (Natural Forest, Exotic Woodland and Production Forest), on three Azores Islands (São Miguel, Terceira and Pico). Numbers within brackets represent number of genera shared between indigenous and non-indigenous taxa.

| Family | Indigenous | | Non-indigenous | | Family | Indigenous | | Non-indigenous | |
|---|---|---|---|---|---|---|---|---|---|
| | Genera | Taxa | Genera | Taxa | | Genera | Taxa | Genera | Taxa |
| **Magnoliopsida** | | | | | **Liliopsida** | | | | |
| Adoxaceae | 1 | 1 | | | Amaryllidaceae | | | 1 | 1 |
| Apiaceae | 1 | 1 | | | Araceae | | | 2 | 2 |
| Apocynaceae | | | 1 | 1 | Asparagaceae | | | 1 | 1 |
| Aquifoliaceae | 1 | 1 | | | Commelinaceae | | | 1 | 1 |
| Araliaceae | 1 | 1 | | | Cyperaceae | 1 | 4 | | |
| Asteraceae | 4 | 5 | 3 | 3 | Iridaceae | | | 1 | 1 |
| Brassicaceae | 1 | 1 | | | Juncaceae | 2(1) | 2 | 1(1) | 1 |
| Caprifoliaceae | | | 1 | 1 | Orchidaceae | 1 | 2 | | |
| Clethraceae | | | 1 | 1 | Poaceae | 3(1) | 3 | 2(1) | 2 |
| Ericaceae | 3 | 3 | | | Smilacaceae | 1 | 1 | | |
| Euphorbiaceae | 1 | 1 | | | Zingiberaceae | | | 1 | 1 |
| Fabaceae | | | 1 | 1 | **Pinophyta** | | | | |
| Geraniaceae | | | 1 | 1 | Cupressaceae | 1 | 1 | 1 | 1 |
| Hydrangeaceae | | | 1 | 1 | **Pteridophyta** | | | | |
| Hypericaceae | 1 | 1 | | | Aspleniaceae | 1 | 2 | | |
| Lamiaceae | | | 1 | 1 | Athyriaceae | 2 | 2 | 1 | 1 |
| Lauraceae | 1(1) | 1 | 3(1) | 3 | Blechnaceae | 2 | 2 | 1 | 1 |
| Myricaceae | 1 | 1 | | | Culcitataceae | 1 | 1 | | |
| Myrsinaceae | 1 | 1 | | | Cyatheaceae | | | 1 | 1 |
| Myrtaceae | | | 2 | 2 | Dennstaedtiaceae | 1 | 1 | | |
| Oleaceae | 1 | 1 | | | Dryopteridaceae | 3 | 6 | 1 | 1 |
| Onagraceae | | | 1 | 1 | Hymenophyllaceae | 2 | 3 | | |
| Pittosporaceae | | | 1 | 1 | Osmundaceae | 1 | 1 | | |
| Plantaginaceae | 1 | 1 | | | Polypodiaceae | 1 | 1 | | |
| Platanaceae | | | 1 | 1 | Pteridaceae | 1 | 1 | 1 | 1 |
| Primulaceae | 1 | 1 | | | **Lycopodiophyta** | | | | |

| Family | Indigenous | | Non-indigenous | | Family | Indigenous | | Non-indigenous | |
|---|---|---|---|---|---|---|---|---|---|
| | Genera | Taxa | Genera | Taxa | | Genera | Taxa | Genera | Taxa |
| Rhamnaceae | 1 | 1 | | | Lycopodiaceae | 1 | 1 | | |
| Rosaceae | 4 (1) | 4 | 1(1) | 1 | Selaginellaceae | 1 | 1 | | |
| Rubiaceae | 1 | 1 | | | | | | | |
| Santalaceae | 1 | 1 | | | | | | | |
| Scrophulariaceae | 1 | 1 | | | | | | | |
| Solanaceae | | | 2 | 2 | | | | | |
| Thymelaeaceae | 1 | 1 | | | | | | | |
| Ulmaceae | | | 1 | 1 | | | | | |
| Urticaceae | | | 2 | 2 | | | | | |

The frequency of indigenous vascular plant taxa showed the highest values for NF (55% endemic and 38% native) and the lowest for EW (23% endemic and 25% native) and PF (17% endemic and 18% native) (Table 3). Pico Island displayed the highest number of indigenous taxa in the NF and the lowest number in PF (Table 3).

Table 3.

Conservation *status* and occurrence of indigenous vascular plant taxa per forest type (NF-Natural Forest, EW-Exotic Woodland and PF-Production Forest), in each Island (SMG-São Miguel; TER-Terceira and PIC-Pico). Based on 90 forests sampled in the Azores. *Colonisation status* (CS) follows Silva et al. (2010): NAT-Native and END-Endemic. Conservation *status* according to IUCN (threatened species: VU = Vulnerable, EN = Endangered; LC = Least Concern, NT = Near Threatened) and DLR no. 15/2012/A (Legal regime for nature conservation and protection of the Azores Autonomous Region biodiversity): H (Habitats Directive - Natura 2000 Network); B (Berne Convention); T100 (100 priority threatened species for management in the European biogeographical region of Macaronesia); CITES; R4 (protected by regional interest); P (priority for conservation) and *(priority European species).

| Scientific Name | CS | Forest type | | | Island | | | Conservation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NF | EW | PF | SMG | TER | PIC | DLR15 | H | B | UICN | Others |
| *Arceuthobium azoricum* Wiens & Hawksw. | END | X | | | | X | X | X | X | | | T100\|P |
| *Asplenium adiantum-nigrum* L. | NAT | | X | | X | | | | | | | |
| *Asplenium scolopendrium* L. | NAT | | X | | | X | | | | | | |
| *Athyrium filix-femina* (L.) Roth | NAT | X | X | X | X | X | X | | | | LC | |
| *Bellis azorica* Hochst. ex Seub. | END | X | | | | | X | X | | X | | T100\|P |
| *Callitriche stagnalis* Scop. | NAT | X | | | | | X | | | | LC | |
| *Calluna vulgaris* (L.) Hull | NAT | X | | | X | | | | | | LC | |

| Scientific Name | CS | Forest type | | | Island | | | Conservation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NF | EW | PF | SMG | TER | PIC | DLR15 | H | B | UICN | Others |
| *Cardamine caldeirarum* Guthnick ex Seub. | END | X | | | X | | | | | | | |
| *Carex divulsa* Stokes | NAT | X | X | | X | X | X | | | | | |
| *Carex hochstetteriana* J.Gay ex Seub. | END | | X | X | X | X | | | | | | |
| *Carex pendula* Huds. | NAT | | X | | X | | | | | | | |
| *Carex vulcani* Hochst. ex Seub. | END | X | X | | | X | X | | | | | |
| *Culcita macrocarpa* C.Presl | NAT | X | X | X | X | X | X | X | X | X | NT | T100 |
| *Daphne laureola* L. | NAT | X | | | | | X | | | | | |
| *Deschampsia foliosa* Hack. | END | X | | | X | | | | | | | |
| *Diplazium caudatum* (Cav.) Jermy | NAT | X | X | X | X | X | X | | | | LC | |
| *Dryopteris aemula* (Aiton) Kuntze | NAT | X | X | X | X | X | X | | | | LC | |
| *Dryopteris affinis* (Lowe) Fraser-Jenk. | NAT | X | | | | | X | | | | | |
| *Dryopteris azorica* (Christ) Alston | END | X | X | X | X | X | X | | | | | |
| *Dryopteris crispifolia* Rasbach, Reichst. & Vida | END | X | X | X | X | X | X | | | | LC | |
| *Elaphoglossum hirtum* (Sw.) C.Chr. | NAT | X | | | X | X | X | | | | EN | |
| *Erica azorica* Hochst. ex Seub. | END | X | X | | X | X | X | X | X | X | | |
| *Euphorbia stygiana* H.C.Watson subsp. *stygiana* | END | X | | | | | X | X | X | X | | T100\|P |
| *Festuca francoi* Fern.Prieto, C.Aguiar, E.Días & M.I.Gut | END | X | | | X | | | | | | | |
| *Fragaria vesca* L. | NAT | X | | | X | | | | | | | |
| *Frangula azorica* Grubov | END | X | | | X | X | X | X | X | X | LC | T100\|P |
| *Hedera azorica* Carrière | END | X | X | X | X | X | X | | | | | |
| *Holcus rigidus* Hochst. ex Seub. | END | X | | | X | X | | | | | | |
| *Huperzia suberecta* (Lowe) Tardieu | END | X | | | | | X | X | X | | LC | R4 |
| *Hymenophyllum tunbrigense* (L.) Sm. | NAT | X | | X | X | X | X | | | | LC | |
| *Hymenophyllum wilsonii* Hook. | NAT | X | | | | X | X | | | | LC | |
| *Hypericum foliosum* Aiton | END | X | | | X | X | X | | | | LC | |
| *Ilex azorica* Gand. | END | X | X | X | X | X | X | X | | | LC | T100 |
| *Juncus effusus* L. | NAT | X | | | | | X | | | | | |

| Scientific Name | CS | Forest type | | | Island | | | Conservation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NF | EW | PF | SMG | TER | PIC | DLR15 | H | B | UICN | Others |
| *Juniperus brevifolia* (Hochst. ex Seub.) Antoine subsp. *brevifolia* | END | X | | | X | X | X | X | | X | VU | T100\|P |
| *Lactuca watsoniana* Trel. | END | X | | | | | X | X | X | X | EN | T100\|* |
| *Laurus azorica* (Seub.) Franco | END | X | X | X | X | X | X | X | | | LC | T100\|P |
| *Leontodon filii* (Hochst. ex Seub.) Paiva & Ormonde | END | X | | | X | | | X | | X | | T100\|P |
| *Leontodon rigens* (Aiton) Paiva & Ormonde | END | X | | | | | X | | | | | |
| *Luzula purpureosplendens* Seub. | END | X | | X | X | X | X | | | | | |
| *Lysimachia azorica* Hornem. ex Hook. | END | X | X | X | X | X | X | | | | | |
| *Morella faya* (Aiton) Wilbur | NAT | X | X | X | X | X | X | | | | LC | |
| *Myrsine retusa* Aiton | END | X | X | X | X | X | X | | | | | |
| *Osmunda regalis* L. | NAT | X | | | X | | X | | | | LC | |
| *Picconia azorica* (Tutin) Knobl. | END | X | X | | | X | X | X | X | X | LC | T100\|P |
| *Platanthera micrantha* (Hochst. ex Seub.) Schltr. | END | X | | | | | X | X | | | | CITES\|P |
| *Platanthera pollostantha* R.M.Bateman & M.Moura | END | X | | | | | X | | | | | |
| *Polypodium macaronesicum* subsp. *azoricum* (Vasc.) Rumsey, Carine & Robba | END | X | X | | X | X | X | | | | | |
| *Polystichum setiferum* (Forssk.) T.Moore ex Woynar | NAT | X | X | | X | | X | | | | | |
| *Potentilla erecta* (L.) Raeusch. | NAT | X | | | X | | X | | | | | |
| *Prunus lusitanica* subsp. *azorica* (Mouill.) Franco | END | X | | | X | | | X | X | X | | T100\|P |
| *Pteridium aquilinum* (L.) Kuhn | NAT | X | X | X | X | X | X | | | | LC | |
| *Pteris incompleta* Cav. | NAT | X | X | X | X | | X | | | | NT | |
| *Rubia agostinhoi* Dansereau & P.Silva | END | X | X | X | X | X | X | | | | | |
| *Rubus hochstetterorum* Seub. | END | X | | | | | X | X | | | LC | P |
| *Sanicula azorica* Guthnick ex Seub. | END | X | | | | | X | X | X | X | | T100\|P |
| *Selaginella kraussiana* (Kunze) A.Braun | NAT | X | X | X | X | X | X | | | | LC | |
| *Sibthorpia europaea* L. | NAT | X | X | X | X | X | X | | | | | |

| Scientific Name | CS | Forest type | | | Island | | | Conservation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NF | EW | PF | SMG | TER | PIC | DLR15 | H | B | UICN | Others |
| *Smilax azorica* H.Schaef. & P.Schönfelder | END | X | X | | X | X | X | X | | X | | |
| *Struthiopteris spicant* (L.) Weis | NAT | X | X | X | X | X | X | | | | LC | |
| *Tolpis azorica* (Nutt.) P.Silva | END | X | | | | X | X | X | | | | R4 |
| *Vaccinium cylindraceum* Sm. | END | X | X | X | X | X | X | X | | | LC | T100\|P |
| *Vandenboschia speciosa* (Willd.) G.Kunkel | NAT | X | | | | X | X | x | X | X | LC | |
| *Viburnum treleasei* Gand. | END | X | | | X | X | X | X | | | LC | T100\|P |
| *Woodwardia radicans* (L.) Sm. | NAT | X | X | X | X | | X | X | X | X | VU | |

Regarding the conservation *status* of indigenous vascular plant taxa, we found 23 considered as Least Concern (LC) and two as Endangered (EN) in NF and in the three forest types, two as Vulnerable (VU) and two as Near Threatened (NT) (Table 3). We also found particularly rare species such as *Lactuca watsoniana* Trel. In total, 36 indigenous species (55%) had not been evaluated by IUCN criteria (Table 3).

Although, based on DLR no. 15/2012/A (DLR15 2012), 35% of the indigenous species in the current study are covered by measures for conservation and protection (Table 3), of these 60% are proprietary for conversion (P) and all taxa present in NF, 13% EW and 9% PF (Table 3).

## Traits coverage

### Life forms

The majority of indigenous and non-indigenous Pteridophyta were hemicryptophytes, 60% and 75%, respectively, while Pinophyta only included one megaphanerophyte and one microphanerophyte.

Non-indigenous and indigenous Magnoliopsida included a larger proportion of phanerophytes than Liliopsida (Fig. 4), while geophytes and hemicryptophytes were of some importance in the Liliopsida (Fig. 4).

### Biogeography of non-indigenous plants

Most non-indigenous taxa had a wide geographic distribution. About 75% were Subcosmopolitan and a considerable percentage had a Palaearctic distribution (Fig. 5).

## Useful species

Almost all non-indigenous Pteridophyta were ornamental plants, while the Pinophyta were forest species (Fig. 6). The Magnoliopsida included a large proportion of ornamental and

ruderal plants. The Liliopsida included a large percentage of ornamental and a small proportion of ruderal taxa (Fig. 6).

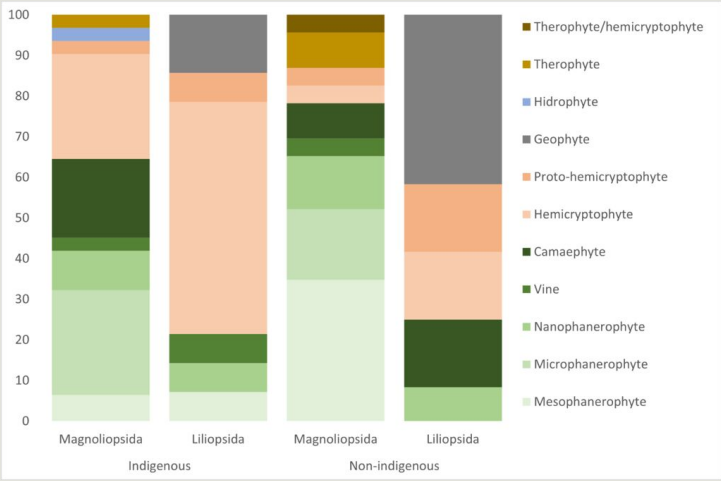


Figure 4. doi

Frequency (%) of life forms for indigenous and non-indigenous Magnoliopsida and Liliopsida, for the three forest types and the three Islands (90 forests in the Azores).

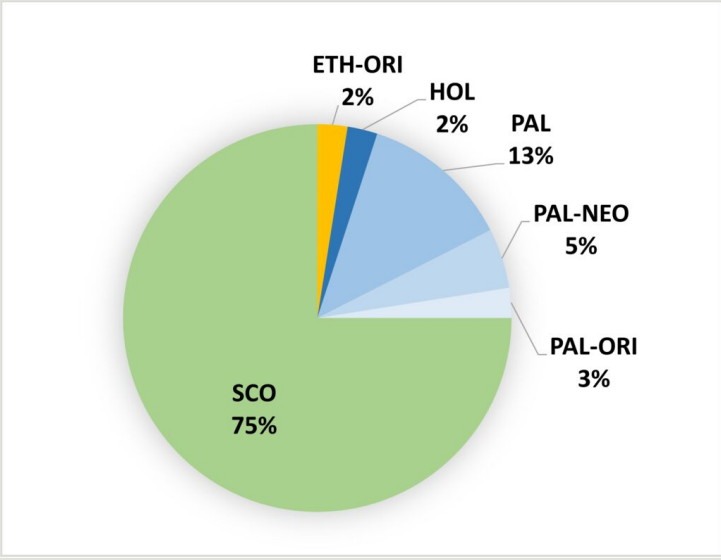


Figure 5. doi

Biogeography of 40 non-indigenous vascular plant taxa sampled at 90 forests in São Miguel, Terceira and Pico Islands, Azores. SCO - Subcosmopolitan, NEO - Neotropical, PAL - Palaearctic, ORI - Oriental, ETH - Ethiopian, HOL – Holarctic. (Example: PALNEO - Palaearctic and Neotropical).


Figure 6. doi

Percentage of non-indigenous vascular plants (naturalised or casual) with human utilisation (ornamental, forest species and food crops) or ruderal, for the three forest types in São Miguel, Terceira and Pico Islands, Azores. The data labels correspond to the number of taxa.

## Temporal coverage

**Notes:** 2017-4-09 - 2018-7-27

## Usage licence

**Usage licence:** Creative Commons Public Domain Waiver (CC-Zero)

## Data resources

**Data package title:** Vascular plant taxa occurrences in exotic woodland and in natural and production forests on the Islands of São Miguel, Terceira and Pico (Azores).

**Resource link:** https://www.gbif.org/dataset/158e0f0d-26e3-4883-bf5e-6040c1bb1ff4

**Alternative identifiers:** http://ipt.gbif.pt/ipt/resource?r=plants-azo-foresteco2&v=1.2

**Number of data sets:** 2

**Data set name:** Event Table

**Character set:** UTF-8

**Download URL:** http://ipt.gbif.pt/ipt/resource?r=plants-azo-foresteco2&v=1.2

**Data format:** Darwin Core Archive format

**Data format version:** Version 1.2

**Description:** The dataset was published in Global Biodiversity Information Facility platform, GBIF (Borges Silva et al. 2023).The following data table includes all the records for which a taxonomic identification of the species was possible. The dataset submitted to GBIF is structured as a sample event dataset that has been published as a Darwin Core Archive (DwCA), which is a standardised format for sharing biodiversity data as a set of one or more data tables. The core data file contains 90 records (eventID). This IPT (integrated publishing toolkit) archives the data and thus serves as the data repository. The data and resource metadata are availabe for download from Borges Silva et al. (2023).

| Column label | Column description |
|---|---|
| eventID | Identifier of the events, unique for the dataset. https://dwc.tdwg.org/terms/#dwc:eventID |
| datasetName | The name identifying the data set from which the record was derived. https://dwc.tdwg.org/terms/#dwc:datasetName |
| habitat | The habitat for an Event. https://dwc.tdwg.org/terms/#dwc:habitat |
| samplingProtocol | The sampling protocol used to capture the species. https://dwc.tdwg.org/terms/#dwc:samplingProtocol |
| sampleSizeValue | The numeric amount of time spent in each sampling. https://dwc.tdwg.org/terms/#dwc:sampleSizeValue |
| sampleSizeUnit | The unit of the sample size value. https://dwc.tdwg.org/terms/#dwc:sampleSizeUnit |
| samplingEffort | The amount of time of each sampling. https://dwc.tdwg.org/terms/#dwc:samplingEffort |
| eventDate | Date of the sampling. https://dwc.tdwg.org/terms/#dwc:eventDate |
| locationID | Identifier of the location. https://dwc.tdwg.org/terms/#dwc:locationID |
| islandGroup | Name of the archipelago. https://dwc.tdwg.org/terms/#dwc:islandGroup |
| island | Name of the island. https://dwc.tdwg.org/terms/#dwc:island |
| country | Country of the sampling site. https://dwc.tdwg.org/terms/#dwc:county |
| countryCode | The standard code for the country of the sampling site. https://dwc.tdwg.org/terms/#dwc:countryCode |
| stateProvince | Name of the region of the sampling site. https://dwc.tdwg.org/terms/#dwc:stateProvince |
| municipality | Municipality of the sampling site. https://dwc.tdwg.org/terms/#dwc:municipality |
| locality | Name of the locality. https://dwc.tdwg.org/terms/#dwc:locality |
| locationRemarks | Comments or notes about the Location. https://dwc.tdwg.org/terms/#dwc:locationRemarks |

| | |
|---|---|
| minimumElevationInMetres | The lower limit of the range of elevation (altitude, usually above sea level), in metres. https://dwc.tdwg.org/terms/#dwc:minimumElevationInMeters |
| maximumElevationInMetres | The upper limit of the range of elevation (altitude, usually above sea level), in metres. https://dwc.tdwg.org/terms/#dwc:maximumElevationInMeters |
| verbatimCoordinates | Original coordinates recorded. https://dwc.tdwg.org/terms/#dwc:verbatimCoordinates |
| decimalLatitude | Approximate centre point decimal latitude of the field site in GPS coordinates. https://dwc.tdwg.org/terms/#dwc:decimalLatitude |
| decimalLongitude | Approximate centre point decimal longitude of the field site in GPS coordinates. https://dwc.tdwg.org/terms/#dwc:decimalLongitude |
| geodeticDatum | The ellipsoid, geodetic datum or spatial reference system (SRS) upon which the geographic coordinates given in decimalLatitude and decimalLongitude are based. https://dwc.tdwg.org/terms/#dwc:geodeticDatum |
| coordinateUncertaintyInMetres | Uncertainty of the coordinates of the centre of the sampling plot in metres. https://dwc.tdwg.org/terms/#dwc:coordinateUncertaintyInMeters |
| georeferenceSources | Method used to obtain coordinates. https://dwc.tdwg.org/terms/#dwc:georeferenceSources |

**Data set name:** Occurrence Table

**Character set:** UTF-8

**Download URL:** http://ipt.gbif.pt/ipt/resource?r=plants-azo-foresteco2&v=1.2

**Data format:** Darwin Core

**Data format version:** Version 1.2

**Description:** The dataset was published in Global Biodiversity Information Facility platform, GBIF (Borges Silva et al. 2023). The following data table includes all the records for which a taxonomic identification of the species was possible. The dataset submitted to GBIF is structured as a occurrence table that has been published as a Darwin Core Archive (DwCA), which is a standardised format for sharing biodiversity data as a set of one or more data tables. The core data file contains 1150 records (occurrenceID). This IPT (integrated publishing toolkit) archives the data and thus serves as the data repository. The data and resource metadata are available for download from Borges Silva et al. (2023).

| Column label | Column description |
|---|---|
| licence | Reference to the licence under which the record is published. https://dwc.tdwg.org/terms/#dcterms:license |
| institutionID | The identity of the institution publishing the data. https://dwc.tdwg.org/terms/#dwc:institutionID |
| institutionCode | The code of the institution publishing the data. https://dwc.tdwg.org/terms/#dwc:institutionCode |
| basisOfRecord | The nature of the data record. https://dwc.tdwg.org/terms/#dwc:basisOfRecord |
| occurrenceID | Identifier of the record, coded as a global unique identifier. https://dwc.tdwg.org/terms/#dwc:occurrenceID |
| recordedBy | A list of names of the people who performed the sampling of the specimens. https://dwc.tdwg.org/terms/#dwc:recordedBy |
| organismQuantity | A number or enumeration value for the quantity of organisms. https://dwc.tdwg.org/terms/#dwc:organismQuantity |
| organismQuantityType | The type of quantification system used for the quantity of organisms. https://dwc.tdwg.org/terms/#dwc:organismQuantityType |
| establishmentMeans | The process of establishment of the species in the location, using a controlled vocabulary: 'native', 'introduced'. https://dwc.tdwg.org/terms/#dwc:establishmentMeans |
| eventID | Identifier of the events, unique for the dataset. https://dwc.tdwg.org/terms/#dwc:eventID |
| identifiedBy | A list of names of people who assigned the Taxon to the subject. https://dwc.tdwg.org/terms/#dwc:identifiedBy |
| dateIdentified | Date on which the record was identified. https://dwc.tdwg.org/terms/#dwc:dateIdentified |
| scientificName | Complete scientific name including author. https://dwc.tdwg.org/terms/#dwc:scientificName |
| kingdom | Kingdom name. https://dwc.tdwg.org/terms/#dwc:kingdom |
| phylum | Phylum name. https://dwc.tdwg.org/terms/#dwc:phylum |
| class | Class name. https://dwc.tdwg.org/terms/#dwc:class |
| order | Order name. https://dwc.tdwg.org/terms/#dwc:order |
| family | Family name. https://dwc.tdwg.org/terms/#dwc:family |
| genus | Genus name. https://dwc.tdwg.org/terms/#dwc:genus |
| specificEpithet | Specific epithet. https://dwc.tdwg.org/terms/#dwc:specificEpithet |
| infraspecificEpithet | Infraspecific epithet, when available. https://dwc.tdwg.org/terms/#dwc:infraspecificEpithet |
| taxonRank | Lowest taxonomic rank of the record. https://dwc.tdwg.org/terms/#dwc:taxonRank |

| | |
|---|---|
| scientificNameAuthorship | Name of the author of the lowest taxon rank included in the record.https://dwc.tdwg.org/terms/#dwc:scientificNameAuthorship |
| taxonRemarks | Comments or notes about the taxon or name. https://dwc.tdwg.org/terms/#dwc:taxonRemarks |
| dynamicProperties | A list of additional measurements, facts, characteristics or assertions about the record. Meant to provide a mechanism for structured content. https://dwc.tdwg.org/terms/#dwc:dynamicProperties |

## Additional information

### Conclusions and prospects

For the three forest types and for all Islands, the dataset included 105 vascular plant taxa, 62% indigenous and 38% non-indigenous, distributed by 60 families belonging to 91 genera, each family and genus contributing only with a small number of taxa.

Regarding Magnoliopsida, NF showed the highest number of endemic and native taxa, while EW and PF showed the highest values of invasive taxa, with EW also showing a high number of naturalised and casual taxa. For Liliopsida, again NF showed the highest values of endemism, despite also including naturalised and invasive taxa. For Pteridophyta, all three forest types showed similar values of endemic, native and invasive taxa.

The frequency of indigenous vascular plant taxa was highest for NF (55% endemic and 38% native) and lowest for EW (23% endemic and 25% native) and PF (17% endemic and 18% native). Pico Island displayed the highest number of indigenous species in NF and the lowest number in PF. The results of this study agree with data from previous investigations (Borges Silva L et al. 2022b). As expected, natural forests correspond to indigenous plant diversity hotspots and exotic woodland works as a source of invasive taxa.

According to our results, 35% of the indigenous plant taxa in the current study are covered by conservation regulations.

The list of the vascular plants found in our study devoted to natural and production forests and to exotic woodland in three Azores Islands, clarifies the type of flora to be expected in the forested areas in the Azores, emphasising the relevant role of the former as hotspots of native biodiversity, which agrees with previous studies for the Azores (Silva et al. 2010, Marcelino et al. 2013, Mendonça 2013, Marcelino et al. 2014, Elias et al. 2016, Borges 2018, Borges Silva et al. 2018, Borges Silva L et al. 2022b).

As stated by Borges Silva L et al. (2022b), natural forests mainly corresponded to montane forests which occur in the thermotemperate-hyperhumid and ultrahyperhumid belts, from 600 to 1000 m a.s.l., in areas with high rainfall (3000 to 5000 mm year$^{-1}$) and occult precipitation (cloud forests) (Gabriel and Bates 2005, Elias et al. 2016). These forests have small stature and are frequently subjected to natural disturbances (Elias et al. 2011). This favours plant diversity by allowing the existence of both light-demanding and shade

tolerant species. They are characterised by a high percentage of endemic species, trees covered by epiphytes and a complex vertical structure with several layers (Elias et al. 2016).

Meanwhile, the role of exotic woodland and, to a lesser extent, of production forest, as reservoirs of invasive species is also confirmed (Borges Silva L et al. 2022b). The low plant diversity noted in EW and PF could be explained by the dominance of a single species (*Pittospotum undulatum* and *Cryptomeria japonica*, respectively), contributing with nearly 90% of the total number of trees per plot and dominating the canopy where only ferns and a few invasive species that tolerate low levels of light intensities below 1% full sunlight at ground level (e.g. *Hedychium gardnerianum*) are found (Gleadow and Ashton 1981, Gleadow et al. 1983, Cordeiro and Silva 2003, Borges Silva L et al. 2022b).

Regarding anthropogenic action, NF have less human influence and are hard to access (Ramos 1996). Disturbances are limited to minor harvesting of non-timber forest products (Borges Silva L et al. 2022b). Nevertheless, active and persistent conservation measures are needed to ensure the preservation of the natural forests in the Azores. In the case of PF and the spread of invasive species in EW, an intensive management regime resulted in a decrease in plant diversity levels (Silva et al. 2008, Castro et al. 2010, Kueffer et al. 2010 , Gil et al. 2013, DRRF 2017). While plantations are known for high timber productivity, their potential to harbour plant diversity is low (Borges et al. 2019). In the Azores, the new production forests already include a buffer zone with native elements (DRRF 2017). However, management plans should be developed for exotic woodland, following the guidelines already established for the renovation of *Cryptomeria japonica* production forests in the Azores.

Finally, we consider that our dataset and the derived conclusions will be useful for future conservation and research activities, as well as for forest managers, in the development of more comprehensive action plans, particularly on islands.

## Acknowledgements

This research was funded by Project FOREST-ECO2-Towards an Ecological and economic valorization of the Azorean Forest ACORES-01-0145-FEDER-000014-Azores 2020 PO, 2016–2019; FEDER funds through the Operational Programme for Competitiveness Factors-COMPETE and by National Funds through FCT-Foundationfor Science and Technology under the UID/BIA/50027/2019 and POCI-01-0145-FEDER-006821. Additionally, by the Portal da Biodiversidade dos Açores - PO Azores Project - M1.1.A/ INFRAEST CIENT/001/2022. We thank students Angela Vieira, Celia Canizares, Mireia Mari, Ruben Rego, Gonçalo Almeida and Bruno Alves for support in field and lab work. We are grateful to Paulo Borges and Rui Figueira for helping with the Darwin Core Archive. We are grateful to Roberto Resendes, technician of AZB Herbarium in the University of the Azores. We would also like to thank Natural Parks of Terceira and Pico Islands and Direcção Regional dos Recursos Florestais for providing GIS data on the distribution of each forest type.

## Author contributions

LBS with conceptualisation and writing original draft, carried out field and lab work, data collection and analysis, writing-review and editing. LS conceived the project, carried out fieldwork, data collection, writing-review and editing. DP carried out field, lab work, data collection. RBE carried out field, lab work, data collection, review. MM carried out fieldwork, data collection. PM review. All authors have read and agreed to the published version of the manuscript.

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