

Plantas Invasoras na Ilha Terceira (Açores): diversidade, distribuição e perspetivas da população local

Invasive plants on Terceira Island (Azores): Biodiversity, distribution and locals' perspectives

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Plantas Invasoras na Ilha Terceira (Açores): diversidade, distribuição e perspetivas da população local

**Invasive plants on Terceira Island (Azores): Biodiversity, distribution and
locals' perspectives**

Tese de Mestrado

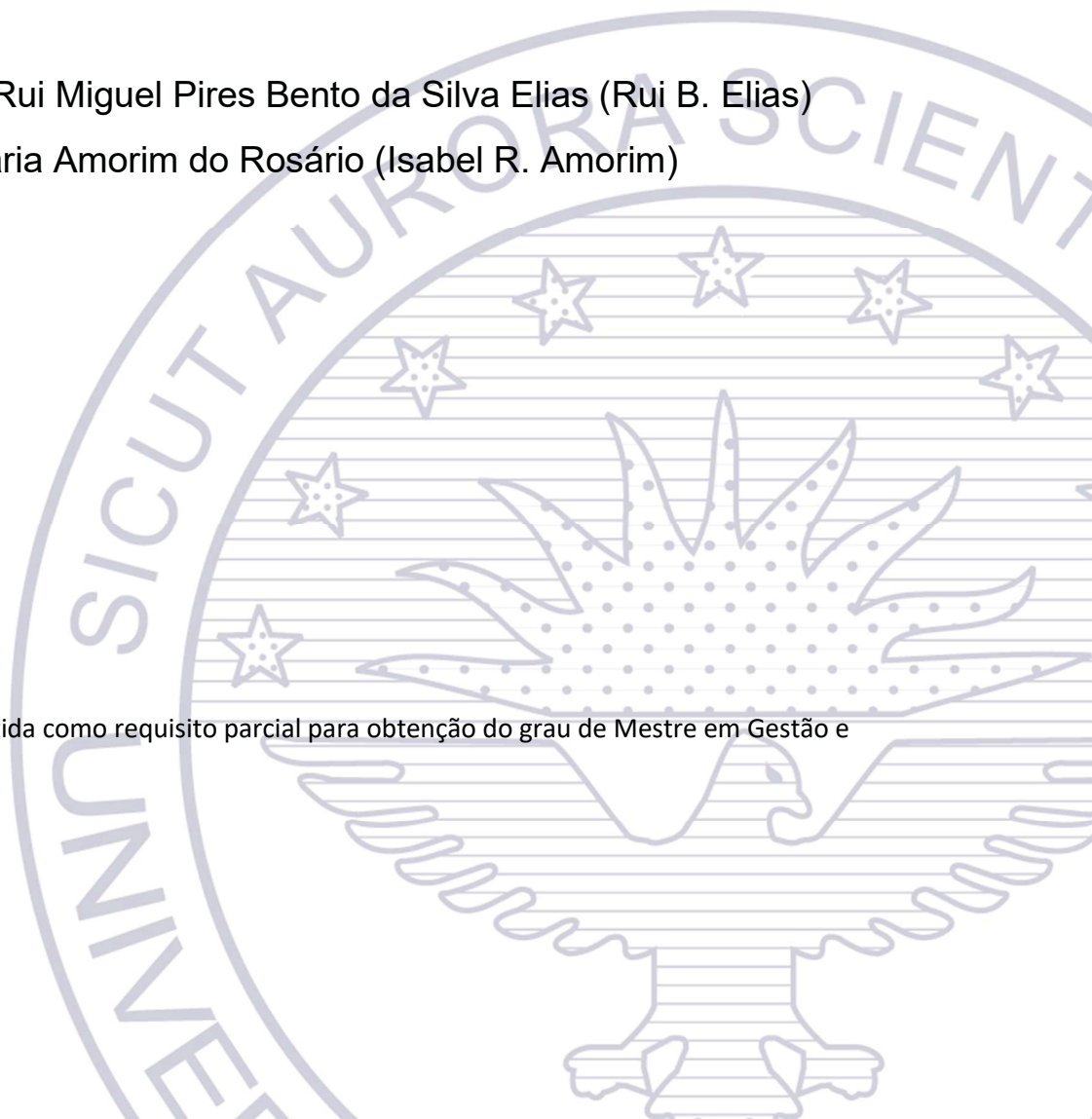
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“People are like plants: they grow towards the light. I chose science because science gave me what I needed – a home as defined in the most literal sense: a safe place to be.”

Hope Jahren (Lab Girl)

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SUMÁRIO

Historicamente, as ilhas oceânicas têm sido suscetíveis às invasões biológicas devido à falta de harmonia taxonômica e intensa alteração dos habitats mediada pelas atividades humanas, entre outras razões. No entanto, o conhecimento fornecido através de diferentes fontes (e.g. acadêmica, amadora –não tendo como objectivo final a produção de ciência-, ciência cidadã) constitui uma valiosa contribuição para a detecção, monitorização e controle de espécies exóticas invasoras. Na Ilha Terceira (Açores), a presença, abundância e distribuição de espécies de plantas exóticas invasoras são influenciadas por fatores ecológicos e sociais. A atualização periódica dos dados disponíveis sobre essas espécies permitirá detectar diferenças com outras ilhas do arquipélago e possíveis mudanças ao longo do tempo que, junto com as perspectivas das populações locais, devem ser tidas em conta para a gestão deste assunto. Neste contexto, esta tese de mestrado pretende fornecer uma atualização do conhecimento sobre as espécies de plantas exóticas invasoras da Ilha Terceira, bem como fornecer uma abordagem exploratória das perspectivas dos habitantes locais sobre esta questão. Os dados foram recolhidos através de métodos qualitativos e quantitativos: um estudo ecológico sobre a distribuição e abundância de 30 espécies de plantas exóticas invasoras da Ilha Terceira e através de um inquérito online (questionário) para estudar as percepções, conhecimentos e atitudes dos habitantes locais sobre plantas invasoras. Os resultados deste estudo mostram que atividades humanas como o uso da terra ou a proteção dos habitats nativos, juntamente com fatores ecológicos (ex. altitude e tipo de habitats) determinam a presença de espécies de plantas invasoras, e que o nível de consciência dos habitantes locais sobre esse problema é principalmente influenciado pela sua área de formação académica, nível académico e duração da sua residência nos Açores. Estes resultados mostram que a compressão das invasões de plantas na Ilha Terceira não deve ser abordada apenas do ponto de vista ecológico, mas que variáveis sociais e ambientais devem ser tidas em conta na concepção de futuras campanhas de sensibilização sobre as espécies de plantas exóticas invasoras e utilizada para apoiar as políticas ambientais na Ilha Terceira.

Palavras-chave: ilhas oceânicas, espécies exóticas invasoras, uso do solo, tipo de habitat, atitudes, percepções, consciência, conhecimento.

ABSTRACT

Historically, oceanic islands have been susceptible to biological invasions due to the lack of taxonomic harmony and intense habitat alteration mediated by human activities, among other reasons. However, increased knowledge provided through different sources (e.g. academic, amateur –without the primary goal of producing scientific data-, citizen science) is a valuable contribution to support the detection, monitoring and control of invasive alien species. On Terceira Island (Azores), the presence, abundance and distribution of invasive alien plant species is driven by ecological and social factors. Thus, periodic update of the data on invasive alien plant species is necessary in order to detect differences from the rest of the archipelago and possible changes over the time which, together with the local populations' perspectives, should be taken into account for the management of this issue. In this context, this master's thesis aims to provide an update of the current knowledge with regards to invasive alien plant species of Terceira Island as well as to provide an exploratory approach to locals' perspectives about this topic. The data were collected both through qualitative and quantitative methods: an ecology study on the distribution and abundance of 30 invasive alien plant species of Terceira Island, and through an online survey (questionnaire) aiming to study locals' perceptions, knowledge and attitudes. The results of this study show that anthropogenic activities such as land use or the protection of native habitats, together with ecological factors (altitude, type of habitats), determine the presence of invasive alien plant species; and that locals' level of awareness about this issue is influenced by their academic background, educational level and the length of their residence in the Azores. These results show that plant invasions on Terceira Island cannot be understood only from an ecological approach. Social and environmental variables should be taken together into account for the development of campaigns to raise people awareness about invasive alien plant species and their support to the environmental policies on Terceira Island.

Keywords: oceanic islands, invasive alien species, land use, type of habitat, attitudes, perceptions, awareness, knowledge.

CHAPTER I. INTRODUCTION TO THE STUDY OF INVASIVE ALIEN PLANTS SPECIES ON TERCEIRA ISLAND AND POPULATION PERSPECTIVES

I.1 INTRODUCTION

The introduction of new plant species on oceanic islands, as well as the species exchanges between different bio-geographical regions as a consequence of historical human activity has serious environmental, social and economic consequences (Silva 2000, Silva *et al* 2008, Tellería 2012).

According to the European Alien Species Information Network of the European Commission (EASIN), alien species – non-native organisms that become established in a new environment due to human action –, including alien plant species, are on the increase worldwide. While most of them do not present significant risks for their new environment, some of them adapt successfully and become invasive – from being biological curiosities they become threats to local ecosystems, crops and livestock, threatening the environmental and social wellbeing. Invasive alien species are the second leading cause of biodiversity loss, after habitat alteration, and have an economic impact estimated at around € 12 billion per year.

Globalization and the homogenization of the flora can make indigenous vegetation more vulnerable to environmental changes, whilst fostering the propagation of certain plant diseases and affecting local plantations (Vilà 2011, Simberloff *et al* 2013). This is even more accentuated in small islands, due to the decreased level of native biodiversity, the taxonomic disharmony between different groups of plants, the large proportion of altered habitats and the high number of alien species introduced (Schaefer 2003, Silva 2006). In this sense, insular territories are still global *hotspots* for the process of naturalization of introduced plants (Blackburn *et al* 2014).

With regard to the defining characteristics of the alien vascular plants that, with time, become invasive, these plants are R-strategy species, with effective spread mechanisms, increased reproductive capacity (including vegetative reproduction), rapid growth, increased tolerance to environmental changes, with the capacity to produce secondary, repellent substances against herbivores and associated with altered habitats (Richardson *et al* 2000, Silva *et al* 2008, Blackburn *et al* 2014). The introduction and propagation of these plants is a potential threat to local biodiversity and ecosystem services, which may cause changes in ecological succession and ecosystem function. (Richardson *et al* 2000, Vilà 2011). Some of the most important invasions are common to different archipelagos of the world. (Pysek *et al* 2017)

Currently, introduced plants, including those that may become invasive plants, represent a large proportion of the Azorean vascular flora (Silva *et al* 2008). Within this archipelago, the landscape has been severely altered by the replacement of the native forests with pastures, crops (corn, forage etc.) or production forest, with the subsequent reduction of native species and expansion of invasive ones. Thus, changes in land use and in the original vegetation cover, together with the regional economic development, led to the development of the existing vegetation (Silva *et al* 2000, Borges *et al* 2009). In order to be able to set conservation priorities, it is therefore important to investigate the composition of the current local flora (Silva *et al* 2009).

The spread of invasive alien plant species depends on several factors, such as: invasiveness potential, type of habitat in which they occur and the overall conservation state of the infested area. Human activities also have an influence on these species' capacity of arrival, colonization and propagation (Kueffer *et al* 2010). Detailed data regarding past and current distribution of invasive plants in the Azores, and in particular on the Terceira Island (Silva 2001), will allow to monitor the species with invasive potential on the island and to provide new information to support management decisions on how to tackle this threat.

When producing this new information, it is also necessary to take into account the differences between past and present perspectives on biological invasions, since the focus, which was traditionally on the biological aspect, is nowadays multidisciplinary (Simberloff *et al* 2013).

The challenge to understand the current impact of biological invasions, on different scales, requires a new theoretical framework for invasive plants. This new framework also includes the reasons behind the role of different social actors, an increased knowledge and perception, compiled and updated information can raise social awareness and conflict resolution (Pejchar, & Mooney 2009, Cajuapé-Castells *et al* 2010). Thus, nature conservation policies should also include public participation as one of the essential pillars for the control and regulation of invasive alien species, in the endeavor to support territorial management and promote prevention in those areas in which citizens have a great decision power (Reis *et al* 2013, Roy *et al* 2015). Taking as an example ornamental plants, it is a known fact that these species are one of the main reasons of biological invasions, being derived from direct human use (Dehnen-Schmutz 2007).

It is through this multi-scale approximation that it is possible to generate data that will enable decision making regarding conservation of native or endemic species. This can be more effective considering the active participation of the local population and by understanding its perspectives on this matter (García-Llorente 2009, 2011) as well as its general attitudes regarding natural conservation

of indigenous nature (Milfont *et al* 2010). Once these perceptions are defined, this will enable a more efficient planning for awareness-raising campaigns, aiming to promote behavioral changes within the local population concerning their active involvement in the conservation of native and endemic species (Pocock *et al* 2014).

Biological invasions occur mediated by human activities that affect ecosystems at environmental, economic and social levels (Marchante *et al* 2008a, Pejchar & Mooney 2010, Pyšek & Richardson 2010, Vilà *et al* 2010). Humans are the main mean of introduction and spread of invasive alien species, and at the same time, they can play an essential role in the reporting and monitoring of such occurrences. In many cases, citizens contribute with new findings, monitoring and controlling of invasive alien species on islands. For instance, in the context of LIFE and local volunteering projects, some good examples of citizens' engagement are found in Canary Islands, Spain, where different actions have been taken place to remove *Pennisetum setaceum* involving volunteers and technicians ("Campaña de Voluntariado en La Gomera: control del Rabo de gato", Matorrisco Association 2018), and in Menorca (Balearic Islands, Spain), where more than 25 tons of this species and *Carpobrotus edulis* have been removed from Natura 2000 sites in 2018 (Flora Menorca - Conservation of areas with threatened species of the flora in the island Minorca LIFE00 NAT/E/007355 Project). Also, in Berlengas Islands (Portugal), more native bird species are nesting after the tackling of invasive species (LIFE Berlengas - Conserving threatened habitats and species in Berlengas SPA through sustainable management LIFE13 NAT/PT/000458).

In contrast, it has been also debated that, in many cases, it is not possible to revert the negative effects of invasive species, especially in more sensitive habitats such as coastal areas on islands. Scientific literature has documented how non-native species homogenize ecosystems and can cause local extinction of native populations (Simberloff 2018). In addition, Target 15.8 of the Sustainable Development Goals calls for preventing the introduction of alien species, reduction of their impact and control of key species by 2020 (UNGA 2015). To attain this goal, the approach for a better understanding of alien species risks and management has to consider both ecological and social aspects, including people' attitudes towards native biodiversity and perceptions on alien species ecosystem services.

This being the case, this work has the purpose of achieving a better understanding and updating the available knowledge of the current problem of invasive alien plants species on the Terceira Island, through complementary methodologies. Thus, the specific objectives of this thesis are presented in the following paragraphs:

1. To characterize the invasive alien plant species of Terceira Island in terms of diversity, distribution and abundance;
2. To compare the occurrence of the invasive alien plants species, according to the types of habitat and the different types of land use existing on Terceira Island;
3. To determine the factors that best explain the occurrence of invasive alien plant species on Terceira Island;
4. To update the available data on invasive alien plant species on Terceira Island and the Azores and contribute to the existing database Azores Biodiversity Portal;
5. To investigate the level of knowledge of the local population on the topic of invasive species and their ability to identify them in order to determine possible knowledge-gaps regarding the current state of the local natural environment;
6. To investigate to what extent the local population is concerned with invasive species as a threat to the original (native) biodiversity and to the environment quality;
7. To investigate the willingness of the population to get involved in actions meant to control invasive species as well as in the conservation of local biodiversity;
8. To identify what type of plants (natives, endemics, alien, invasive) are preferred by the local population as representatives of Terceira Island and the reasons behind it; and
9. To identify what key aspects should be taken into account for the development of a communication strategy on invasive alien plant species to support management actions on Terceira Island.

To summarize, the purpose of this work is to contribute to the general knowledge on the problematic of invasive species on Terceira, and it includes: literature review, field and office work to characterize the invasive alien plant species and the habitats where these species occur, as well as a study of the perspectives of the local population on this matter.

The main goal is to produce up-to-date information that could be used for a better management of invasive species on Terceira Island, and therefore to contribute to a better conservation of the native biodiversity on the island.

I.2 CONTEXT

The Azorean archipelago, discovered in the 15th century, consists of nine islands of volcanic origin, located in the northern part of the Atlantic Ocean, in the microplate of the Azores. This archipelago is part of the bio-geographical region of Macaronesia (Fernández-Palacios *et al* 2011, Connor *et al* 2012).

The climate, determined by its oceanic localization, characterized by high levels of humidity and precipitation and influenced by the high pressures of the Azorean anticyclone, is defined as semi-humid, mesothermal, having an average annual temperature of 17 degrees °C. Terceira Island is in the central group of the Azorean islands, between 27°10'W and 38°40'N along a E-W axis. Its total area is of 400 km², having a length of 30 km and a width of 19 km. The landform is generally characterized by low altitudes, the highest peak being in the geodesic point of Santa Barbara (1,021 m). The highest temperatures are recorded during the month of August, with maximums of 26 degrees C, whilst the lowest temperatures are recorded during the month of February, 11.8 degrees C. The most intense precipitation is recorded during the months of September and March, and varies from low to high elevation, reaching 4,000 mm/year in highest elevation areas (Forjaz 2004, Azevedo 2014).

Even though the Azorean archipelago and particularly Terceira Island are relatively young from a geological perspective, its territories have been intensively altered ever since the first human settlements in the 15th century. The landscape has been strongly shaped by human activity, intensive agriculture and other types of soil occupations (Borges *et al* 2009, Connor *et al* 2012).

In general, about 50% of the total land use is agricultural (crops and pastures). Below 300 m of altitude, different types of crops (such as corn) exist, while above this height production forests are normally found (*Cryptomeria japonica* L.fil. e *Eucalyptus globulus* Labill.) and cattle pastures (Silva, A. 2006). Terceira is an island with a relevant urban development, 8% of the territory being urbanized while 28% is occupied by forests and natural vegetation and, more than 60% is used for agriculture and pasturing (Cruz *et al* 2007). (Figures 1 & 2).



Figure 1. Percentage of land use type on Terceira Island. Extracted from figure 4 of the Land Occupation Map of the Autonomous Region of the Azores. Source: Cruz *et al* 2007. Regional Secretariat for the Environment and the Sea Regional Directorate for Spatial Planning and Water Resources

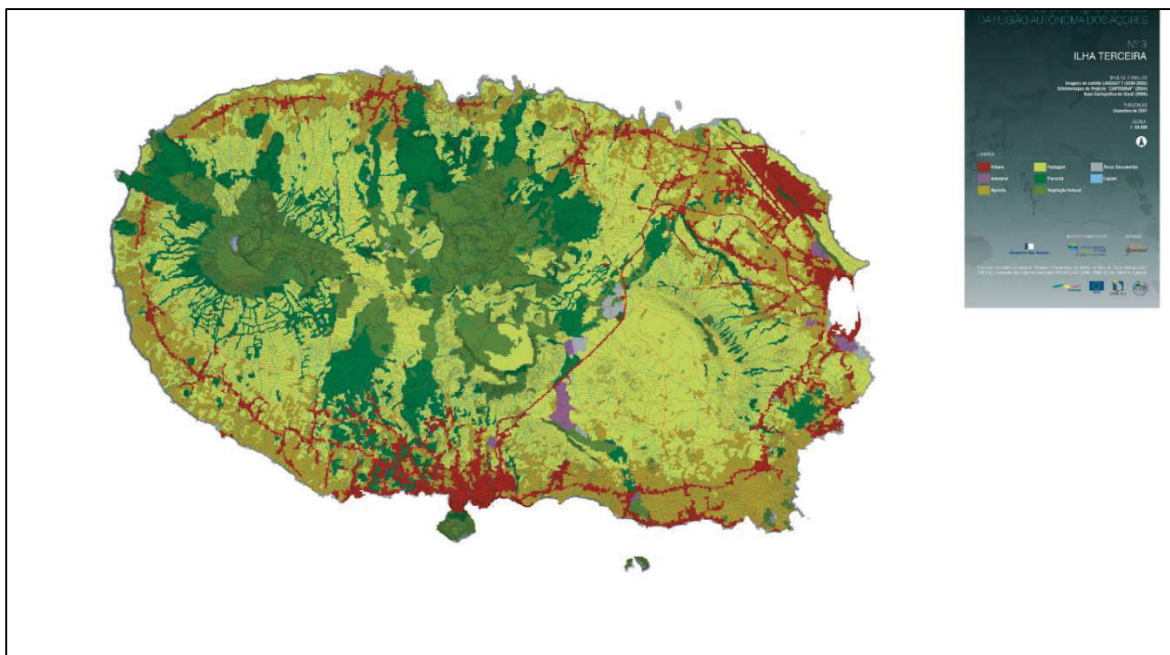


Figure 2. Map of land use on Terceira Island. Source: Cruz *et al* 2007. Regional Secretariat for the Environment and the Sea Regional Directorate for Spatial Planning and Water Resources

Regarding current vegetation on the Terceira Island, 674 species of vascular plants have been described, out of the overall of 1,110 species which are currently listed on the inventory of terrestrial and marine organisms of the Azores (Borges *et al* 2010).

The potential vegetation on the island, below 600 m of altitude, would have been dominated by forests of *Laurus* and *Picconia-Morella* (laurissilva) (Elias *et al* 2016). Currently, the dominant native forest in the Azores and on Terceira Island, are the mountainous rain forest of *Juniperus* and *Ilex* and the mountainous rain woodlands of *Juniperus* (the so called “cloud forests”) which grow above 600 m (Elias *et al* 2016).

Apart from the native and production forests, in the Azores, there are also forests composed by exotic plants, mainly dominated by extended spots of *Pittosporum undulatum* Vent. (Silva 2008). Therefore, over time, the insular native vegetation has suffered an important change in composition and structure, and has been impacted by the introduction of alien species as a result of human activity and economic growth.

Nowadays, about 70% of the 1,000 vascular plant species which compose the Azorean flora are plants that were introduced in the ecosystem, whereas endemic species only amounts to about 7% of the archipelago’s terrestrial flora (Silva 2006).

When it comes to manage the conservation of the unique and native biodiversity of the islands, there is a network of natural parks, aimed to protect native biodiversity and habitats, classified according to the IUCN criteria regarding species and landscape conservation, which take into account human, ecological and economical interests. Terceira Island stands out as being the island which has the largest area covered by a Natural Park, having nearly 22% of its territory declared as protected (Regional Secretariat for the Environment and the Agriculture 2011).

Next is the map of the Natural Park of Terceira Island, with its main protective figures (Figure 3):

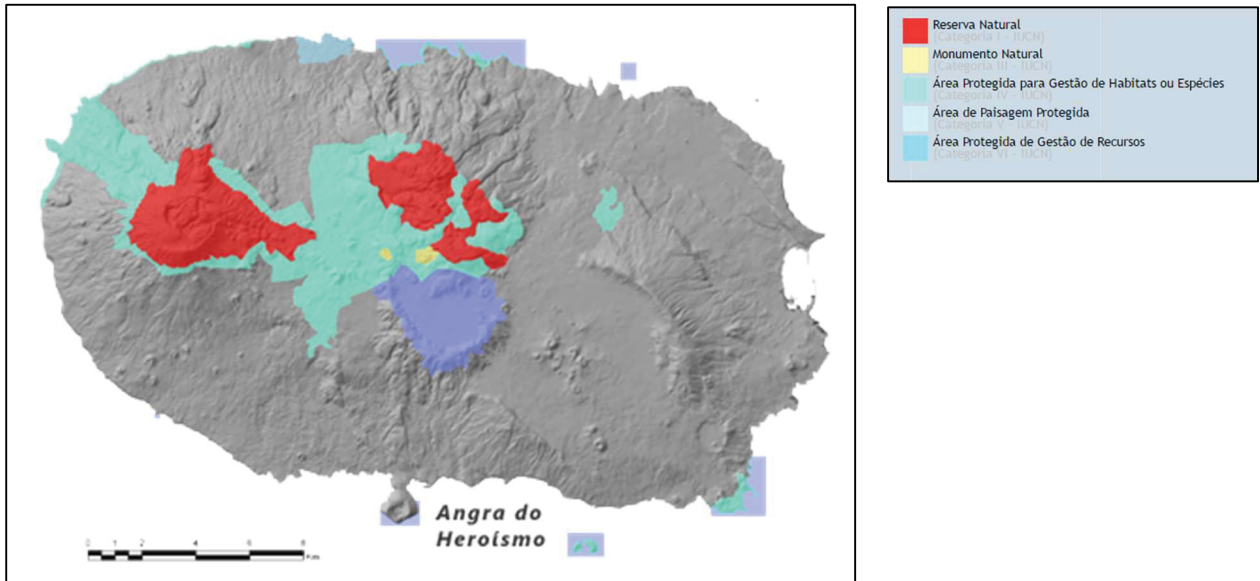


Figure 3. Terceira Island Natural Park. Source: Regional Network of Protected Areas of the Autonomous Region of the Azores. 2011.

With the aim to preserve these areas and having into account that invasive species are a threat for biodiversity conservation in these unique sites, several actions were developed in the Azores, in the frame of the “Regional Plan for the Eradication and Control of Invasive alien plant species in Sensitive Areas” (PRECEFIAS 2003-2008), focusing on the removal of invasive alien plant species from various areas, especially from iconic sites. On the island of Terceira, these actions were implemented in the areas of "Algar do Carvão", "Lagoinha da Serreta" and "Pico Alto", involving, among others, the species *Hedychium gardneriaum*, *Hydrangea macrophylla*, *Pittosporum undulatum* and *Rubus ulmifolius* (Costa et al 2013). The following map (Figure 4) shows the mentioned locations where these measures have been implemented within the Natural Park of Terceira Island:

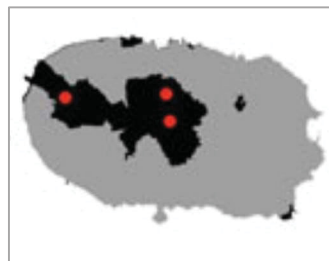


Figure 4. Locations of the main actions aiming to control invasive alien plant species within the framework of PRECEFIAS (2003-2008) on Terceira Island. Protected areas of Terceira Island (highlighted in black) and actions in the framework (red dots).

In terms of its territorial administration, the Terceira Island is divided in two municipalities: "Angra do Heroísmo" and "Praia da Vitória" which are sub-divided into 30 parishes. According to the populational census of 2011, the total population of the island amounts to 56 062 inhabitants, having a density of 139.4 inhabitants per km² (Azorean Regional Statistics Service, 2011).

In the Azores and implicitly on the Terceira Island, livestock activity is the main economic activity, while in the last years, the Tertiary sector and its related activities especially tourism and in particular nature-tourism, has been increasingly expanding, including activities such as whale watching, pedestrian hikes, rural and geological tourism (Calado *et al* 2011, Bentz *et al* 2013, Lima *et al* 2014).

At the same time, these anthropogenic activities can also question the conservation of the native biodiversity of the islands, for example through the impact on the native flora that occurs on hiking trails (Queiroz *et al* 2014). This fact underlines the importance of a coordinated collaboration between various stakeholders such as: scientists, Natural Parks managers, members of the local community, members of the Municipalities etc., in order to, adopting an integrative approach, efficiently manage those topics which may raise conflict of interests (Guimarães *et al* 2013).

The strategic program Azores 2020 (Action Plan 2014-2020) is focused on the necessity to preserve biodiversity and the natural patrimony of the Azores, through increased citizen awareness. Emphasis is put on the development of a network of infrastructures that promotes communication and environmental education such as: environmental centers or science centers, as well as on the need to further develop programs aiming to reintroduce endemic species.

In this sense, on Terceira Island, several actions have been implemented through the use of associations and infrastructures which promote environmental awareness and natural conservation, such as, activities organized by the Natural Park of the island (Portal "Educar para o Ambiente e a Sustentabilidade", 2017); the environmental center of "Pauis da Praia" in the context of the LIFE CWR project - *Ecological Restoration and Conservation of Praia da Vitória Coastal Wet Green Infrastructure* (LIFE12 BIO/PT/000110); or the management of the geological patrimony and outdoors sports activities organized by the Association "Os Montanheiros", founded in 1963. Specific interventions promoting endemic species of Terceira Island, and the Azores in general, targeting the general public have also been developed by researchers at the University of the Azores (Amorim *et al* 2016, Arroz *et al* 2016).

I.3 RESEARCH QUESTIONS AND MODEL OF ANALYSIS

The present study is founded on and aims to answer to the following research questions:

1) What is the current distribution of the invasive alien plant species on Terceira Island in terms of diversity, abundance and distribution in relation to habitat types and types of soil occupation (land use)?

and

2) What is the current perception of the local population of the island of Terceira regarding invasive plants, considering general knowledge, attitudes and degree of awareness, and is there any relationship among a person's perception and its sociodemographic profile?

In what follows, it is presented the specifications table (Table 1) based on analysis model for the study of the invasive alien plant species on Terceira Island, as the framework of the most relevant concepts, dimensions and indicators to be used to characterize this research context.

Table 1. Specifications table based on the analysis model for the study of invasive alien plant species on Terceira Island. Green color refers to the vegetation study, light-orange refers to the population's perspectives study and blue refers to the characterization of the participants in the online questionnaire.

SPECIFICATIONS TABLE FOR THE STUDY OF INVASIVE ALIEN PLANT SPECIES ON TERCEIRA ISLAND					
Construct	Dimensions	Definition	Components	Indicators	Anticipated positions
Invasive alien plants on Terceira Island	Study of the invasive alien plant species on Terceira Island	Study of the current distribution of 30 invasive alien plant species on 1x1 km quadrats through a vegetation study	Importance	Occurrence on Terceira Island (present or not), and relationship of (frequency x abundance)	Rank (1-30)
			Diversity	Richness	Number of species per quadrat, type of habitat and type of land use
			Abundance	Ordinal qualitative scale of abundance	1- isolated plants; 2- dispersed plants ; 3- plants in groups; 4- plants in layers; 5- plants as pure extense layers
			Distribution	Type of habitat	General (coastal area, crops, protected area, uncultivated area, mixed forest, buildings, water related, road network), and specific (slopes, stonewalls, hedgerows, garden, hiking trail, secondary road, main road, roadside, stream water, pond)
				Type of land use	Urban, industrial, agricultural, pastures, production forest, native vegetation, exploited area
Frequency	% of occurrence of every species per quadrat	Values in %			

Table 1 (Continuation). Specifications table based on the model of analysis for the study of the invasive alien plant species on Terceira Island. Green color refers to the vegetation study, clear-orange color refers to the population perspectives study, blue color refers to the characterization of the participants in the online questionnaire. Source: Own elaboration. 2017.

Construct	Dimensions	Definition	Components	Indicators	Anticipated positions (multi-choice questions indicated in Portuguese, as expressed in the questionnaire)
Invasive alien plants on Terceira Island	Study of local population's perceptions	Study of the knowledge, attitudes and level of awareness of the local population that can have an influence on their perception about the invasive alien plants on Terceira Island, through an online survey through questionnaire	Knowledge	Answers given for the stimulus expression "plantas introduzidas nos Açores"	Number of words, position of evocation and meaning of the words
				Name of the plant	Open answer
				Habitat of the plant	Open answer
				colonization status of the plant	Native / Introduced / no answer
			Attitudes	willingness to plant native species in different areas of the island	(Likert scale 1-5): 1= "Nada disposto" to 5="Muito disposto"
				willingness to plant native species in different areas of the island	(Likert scale 1-5): 1= "Nada disposto" to 5="Muito disposto"
			Awareness	Selection of the main environmental problems in the Azores Islands (Related to invasive species / not related to invasive species)	a) A poluição do ar causada pela utilização de carros e outros veículos
					b) A introdução de espécies (plantas ou animais) que não pertencem aos ecossistemas naturais Açorianos
					c) As atividades humanas que põem em causa a biodiversidade marinha
					d) A gestão de resíduos urbanos
					e) A perda de biodiversidade nativa (Birth placeal) e única (endémica) das ilhas.
					f) A fragmentação da paisagem pelas atividades humanas
					g) A falta de programas e atividades de sensibilização sobre o meio natural dirigidas para o público em geral.
h) Os efeitos das alterações ambientais que pousam pôr em risco o ambiente					
i) A falta de mais espaços verdes nas áreas urbanas					
j) O número crescente de turistas, que ameaçam a conservação da natureza					
k) A falta de áreas protegidas					
l) Outro					
Selection of the stakeholders responsible for the mentioned problems	a) Do Governo Regional dos Açores				
	b) Das Câmaras Municipais				
Level of preoccupation about the invasive plants on Terceira Island	c) Das associações ambientalistas				
	d) Dos cidadãos				
Colaboration with environmental entities	e) Dos cientistas da Universidade dos Açores				
	f) Outro				
Previous experience in conservation/environmental activities	(Likert scale 1-5): 1= "Nada preocupado" to 5="Muito preocupado"				
	Yes / No / No answer				
Plant chosen to represent Terceira Island (native/ endemic/ alien/invasive)	Yes / No / No answer				
	Open answer				
Sociodemographic profile	Collection of sociodemographic data of the participants	Characteristics of the participants that can have an influence on the answers that they give on the questionnaire	Personal	Sex	Man/Woman
				Age	Open answer (years)
			Professional and academic	Educational level	Básico (1º,2º,3º) / Secundário/ Licenciatura/Mestrado/Doutoramento /Outro
				Academic background	Nature related/other
				Professional area	Setor primário/ secundário/terciário /outro
			Living characteristics related to Terceira Island and the Azores	Ownership of land/area to plant	Yes / No / No answer
				Place of birth	Portugal / other country
					Azores / other area in Portugal
					Terceira / other island
					Área urbana / área peri-urbana/ área rural / Outro
				Place of residence	Portugal / other country
					Azores / other area in Portugal
			Terceira / other island		
Área urbana / área peri-urbana/ área rural / Outro					
Time of residence in the Azores Islands	Open answer (years)				

CHAPTER II. METHODOLOGY

II.1 Methodology for the study of biodiversity, distribution and abundance of invasive alien plant species on Terceira Island.

The following methodology was adopted in the first part of this master's thesis to perform the study on biodiversity, distribution and abundance of invasive alien plant species on Terceira Island:

- 1) Bibliographic review and databases query: compilation of the available information about invasive alien plant species on Terceira Island, Azores and Portugal. This information was collected from occurrence lists, databases, articles, field work guides, and national legislation. The PhD thesis of Silva 2001 and the derived articles (Silva & Smith 2006; Silva *et al* 2008) were taken as the baseline and complemented with the data from Marchante *et al* 2014; Borges *et al* 2010, DL 565/99; DLR 15/2012/A; Pyšek *et al* 2017, and the Database of the Azorean Biodiversity Group in collaboration with the INVASORAS.pt Project). The available information came from different sources with various levels of expertise: academic research and citizen science data provided by volunteers and validated by experts.

The information contained in the sources mentioned above was object of scrutiny and comparison (ANNEX 1), resulting in a list of 30 invasive alien plant species to be studied within this master's thesis for Terceira Island presented in Table 2. The information contained in ANNEX 1 reports the presence of the species in the bibliographic and databases sources used to create the mentioned list. The species that appeared only in one of the previously mentioned sources or, that appear only in references that did not include Terceira Island were excluded. For instance, one species cited in Pyšek *et al* 2017 and in "Decreto de Lei 565/99" with no reference to the Azores or Terceira Island was not included in this list. The advantage of using this methodology (presence/absence of the species in the mentioned references) is the crossing of data from very different data sources and recorded through different methodologies, which can allow spotting differences between data recorded almost 20 years ago (Silva L. 2001) and the present moment.

Table 2. List of the invasive alien plant species on Terceira Island to be studied. The color scale was set related to the number of times (1 to 6) that the species appear in the bibliographic references and databases used to produce this list:

List of proposed species to be studied:	
1	<i>Arundo donax</i> L.
2	<i>Conyza</i> sp (<i>Conyza bonariensis</i> (L.) Cronq. e <i>Conyza canadensis</i> (L.) Cronq.)*
3	<i>Lantana camara</i> L.
4	<i>Phytolacca americana</i> L.
5	<i>Pittosporum undulatum</i> Vent.
6	<i>Tradescantia fluminensis</i> Vell.
7	<i>Acacia melanoxylon</i> R. Br.
8	<i>Agave americana</i> L.
9	<i>Aptenia cordifolia</i> (L. fil.) Schwantes
10	<i>Carpobrotus edulis</i> (L.) N. E. Br.
11	<i>Erigeron karwinskianus</i> DC.
12	<i>Hedychium gardnerianum</i> Sheppard ex Ker Gawl.
13	<i>Oxalis pes-caprae</i> L.
14	<i>Ricinus communis</i> L.
15	<i>Salpichroa organifolia</i> (Lam.) Baillon.
16	<i>Araujia sericifera</i> Brot.
17	<i>Argemone adenophora</i> (Spreng.) R. M. King & H. Rob.
18	<i>Drosanthemum floribundum</i> (Haw.)
19	<i>Hydrangea macrophylla</i> (Thumb.) Ser.
20	<i>Ipomoea indica</i> (Burm.) Merr.
21	<i>Mentha suaveolens</i> Ehrh.
22	<i>Polygonum capitatum</i> Buch.-Ham.Ex D.Don.

List of proposed species to be studied within this master's thesis:	
23	<i>Rubus ulmifolius</i> Schott
24	<i>Solanum mauritianum</i> Scop.
25	<i>Ulex europaeus</i> L.
26	<i>Cynodon dactylon</i> L. (Pers.)
27	<i>Ulex minor</i> Roth.
28	<i>Opuntia ficus-indica</i> (L.) Mill.
29	<i>Cyathea cooperii</i> (Hook. Ex F. Muell) Domin
30	<i>Cyrtomium falcatum</i> (L. f) C. Presl.



*Species of *Conyza* sp. were gathered under genus category, due to the potential difficulty to identify them because of hybridization processes (Marchante *et al* 2014).

2) Fieldwork:

Fieldwork related to the presence and abundance of the 30 invasive alien plants species on Terceira Island to be studied was conducted during the autumn of 2017 (September-November 2017). The study areas were defined according to 1 km² UTM quadrats. To determine the number of quadrats to be studied, the work of Silva (2001) was taken into account. In that work, approximately 20% of Terceira Island was studied, with a total of 80 UTM quadrats. Since Terceira Island territory covers 400 UTM quadrats (400 km²), a total of 320 were not studied. Our objective was to study 10% of quadrats that were not studied in the mentioned PhD thesis of Silva 2001.

The specific location of the quadrats was randomly set through an Excel command. In order to make geographical balance when choosing the UTM quadrats to be studied, this 10% was calculated separately for each military chart that contained the maps of reference (Military Maps of Portugal,

Figure 5). One quadrat related to Natural Vegetation land use was relocated during fieldwork to a more accessible area with similar characteristics of altitude and land use, due to the lack of accessibility. In addition, one additional quadrat was made in Raminho coastal area since the first selected quadrat was partially located on the ocean and it was not possible to make the minimum transect. In total, 35 quadrats were selected for the vegetation study.

The table below (Table 3) shows the UTM coordinates of the selected quadrats:

Table 3. UTM coordinates of the randomly selected quadrats for fieldwork, based on the Military Maps (22 - 25) of Figure 5.

Military map 22		Military map 23		Military map 24		Military map 25	
x	y	x	y	x	y	x	y
4292	468	4290	482	4282	472	4282	483
4288	467	4292	483	4281	472	4280	486
4288	470	4292	484	4279	475	4280	493
4289	469	4285	484	4281	477	4281	492
4286	473	4286	486	4283	480	4281	491
4290	474	4289	486	4283	481	4282	490
4290	478	4288	492			4283	495
4290	479	4287	493			4278	491
4288	479	4285	493			4285	483
4286	480						
4285	481						

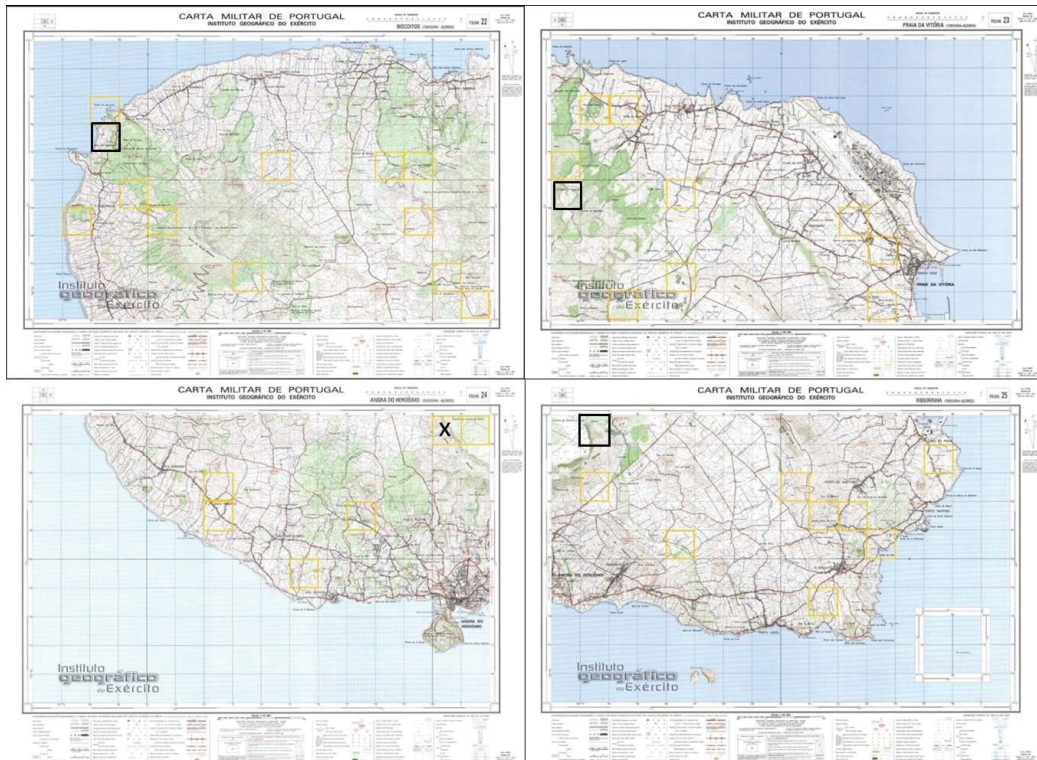


Figure 4. Location of the quadrats for fieldwork based on the Military Maps of Portugal 22, 23, 24 and 25. Terceira Island (Azores). The yellow quadrats indicate the random selection for fieldwork. The black quadrats were studied in addition to complement fieldwork because of the unaccessibility of some areas. The black quadrat with "X" was eliminated due to the lack of access to the area and relocated as mentioned.

For each selected UTM quadrat, the presence of the invasive alien plants species contained in the reference list was registered. The time spent in each quadrat varied between 1 and 1.5 hours depending on the accessibility of the quadrat and type of habitat. For instance, quadrats located in low altitude next to main roads were more easily accessible than those located at higher altitude with natural vegetation. In terms of distance, minimum transect of 1 km was done in each quadrat (equivalent to the quadrat's length). In all cases, the transect was made along a combination of main, secondary, and forestry roads and hiking trails in order to cover different types of land uses and habitats contained in the quadrats.

In each quadrat, the following variables were recorded (adapted from Silva 2001):

- Average altitude: taken from Google Earth;
- Land use: classified as urban, industrial, agricultural, pasture, production forest, natural vegetation and uncovered area according to the land use classification of the Regional Secretariat for the Environment and the Sea - Regional Directorate for Spatial Planning and Water Resources (Figures 1 and 2). To attribute a specific type of land use to a quadrat the rule of covering at least 50% of the area of the quadrat had to be met. For the rest of the quadrats, those with a mix of land use and with non-specific type of dominant land use within its area, four different types were found and classified as follows:

Mixed land use	Types of land use present
Mix1	Agricultural_Pastures_ProductionForest_Urban
Mix2	Agricultural_Pastures_Urban
Mix3	NaturalVegetation_Pastures_ProductionForest
Mix4	NaturalVegetation_ProductionForest

Table 4. Classification used for the types of mixed land use.

And,

- Invasive species: according to the reference list (Table 2).

For each species found the following variables were recorded (adapted from Silva 2001):

- Habitat: general (road network, coastal area, cultivated, building, native shrub, woods, water bodies and uncultivated) and specific (cliff, explored area, forest edge, garden edgerow, house,

marsh, pond, water stream sides, main road, hiking trail, secondary road, pasture edge, road slope, stone wall) (Adaptated from Silva 2001);

- Abundance: for every species record, a qualitative value of abundance was given according to Braun-Blanquet ordinal scale (Kershaw & Looney, 1985) adapted in line with Silva & Smith (2006):

1. Isolated plants
2. Dispersed plants
3. Plants in groups
4. Plants in patches
5. Plantas forming pure patches

and

- Culture associated: presence of planted *Criptomeria japonica*, *Zea mays*, *Vitis vinifera*, *Eucaliptus globulus*, or others, in the quadrat.

These data were recorded by hand during fieldwork, and occasionally by voice recording. In addition, the use of binoculars supported the observations in areas where the landscape allowed spotting more distanced plants (e.g. big trees such as *Acacia*). Also, any information considered of interest (e.g. presence of human elements, other frequent alien species not present in the list) was recorded.

Data analysis:

In this part of the study, Excel 2016 and IBM SPSS Statistics 22.0 and 24.0. were used to perform the descriptive and statistic analysis. The following analysis were performed to study the abundance, biodiversity and distribution of the invasive alien plants on Terceira Island (species of the produced list on Table 2). Descriptive statistic was used to analyse species diversity, frequency, abundance and importance. Kolmogorov-Smirnov test was used to test the Normality of the data. Principal Component Analysis for Categorical Data (CATPCA) was performed to identify the variables (gathering together qualitative and quantitative variables) that better explain the presence of invasive alien species and the variance of the data; Correlation analysis was performed to study the association between the variables altitude and number of species. Regression analysis was performed to study the relationship between variables when correlated.

II.2 Methodology for the study of locals' perspectives on invasive alien plant species

The online questionnaire was open for 3 months (February 13 - May 17, 2018). The link to access the survey was sent to different entities on Terceira Island such as NGOs, students associations, Municipalities authorities, sport clubs, schools, tourism businesses and agricultural societies in order to cover a wide range of citizens. It was also sent to a few entities of general interest in the Azores (for example, Environmental and Tourism Government services and nature related associations). (See ANNEX 6). The online questionnaire was approved by the Ethics Committee of the University of the Azores.

Survey collection through questionnaires is a methodology that allows the gathering of large quantity of data in a limited time on the knowledge, opinions, perspectives and attitudes of people about a certain topic. The main limitations of this tool include defining the target audience, reaching the minimum number of participants needed to obtain relevant information, and losing information during the data processing (Hill & Hill 2005). In this sense, the right design of the questionnaire is essential to reach the objectives of the research. For this case of study, the following methodology was followed:

- Structure: three parts consisting of an informed consent (part 1), questionnaire (part 2) and debriefing (part 3, confirmation message and explanation of the investigation). The full questionnaire (parts 1, 2 and 3) can be found in ANNEX 5.
- Target audience: citizens of Terceira Island in first place, and secondarily the general population of the Azorean Islands;
- Time it takes to complete: 10-15 minutes;
- Format: online and autonomous.
- Type of questions:
 - part I: word association test, multichoice questions, likert scale questions, open answer questions, questions about photographs of plant species of Terceira Island.
 - part II: participants characterization data.
- Plant species used for the photography questions: *Hedychium gardnerianum*, *Pittosporum undulatum*, *Cyathea cooperii*, *Vaccinium cylindraceum*, *Arundo donax*, *Juniperus brevifolia*, *Erica azorica* and *Polypodium azoricum*.
- These species were chosen according the following criteria:

- alien invasive and endemic plant species that occur on Terceira Island;
- the invasive species chosen are part of the produced list for this study (Table 2);
- invasive species well known as threats for conservation and/or targets for control actions;
- diversity of taxonomic groups;
- species used in other previous similar study (Gabriel & Silva 2007);
- species with diverse uses (wood, ornamental, soil stabilization etc) so that can be recognized by people with different backgrounds;
- species that occur in different island habitats; and
- species with particular characteristics to facilitate identification (color, shape of the leaves etc.).

The participants on the survey indicated/characterized their place of birth and their professional sector considering the descriptions and examples given in the questionnaire (ANNEX 5).

Data analysis:

The following tests were performed for the statistic analysis of the data generated: Word association analysis was used to obtain the number, frequency and type of words mentioned by the participants in order to have an overview of the collective memory of the population about the topic of introduced plants in the Azores; Kolmogorov-Smirnov test was used to test the Normality of the data; Mann-Whitney U test was used to compare differences between groups (between educational levels, academic backgrounds and birth places); and Chi-squared test to determine differences between the observed and expected frequencies of the categories (groups) for the variables that can have an influence on the willingness of participation in engagement volunteering activities. To perform the Mann-Whitney U test and Chi-squared analysis, the variable "educational level" was organized in two categories, "Under-Bachelor" ("Ensino não superior"), and "Bachelor or above" ("Ensino Superior"), due to the fact that two of the categories ("Ensino Secundário" and "Ensino pós-secundário CET") had less than 30 participants and some of the groups presented less than five valid cases. For the same reason, a categorization was done for the academic background area of the participants, where two categories were created, "Nature-related" and "Non-related to nature" background, as it will be shown in the results. Correlation and regression analyses were used to study differences between participants in relation to the time of residence in the Azores; and Principal Component Analysis (PCA) to study to what type of volunteering activities and areas the participants were more willing to get engaged. To perform

the Principal Component Analysis, all items were summed and recodified in order to obtain two new variables with the overall value for willingness to participate in the activities. The Alpha 's Cronbach coefficient was calculated to investigate the likert scale (1 to 5, not willing to very willing to participate in the proposed activities) internal consistency.

The softwares used to performed the mentioned descriptive and statistic tests included Excel 2016, IBM SPSS Statistics 22.0 and 24.0, Evocation 2003, and the wordcloud free online tool available at <https://wordart.com/create> for the graphic representation of the Word Association analysis.

CHAPTER III. RESULTS

III.1. Results of the study of the biodiversity, distribution and abundance of invasive alien plant species on Terceira Island.

3.1 General characterization

A total of 1,089 records of invasive plants species were registered in 35 quadrats of 1km², with an average of 27 records/quadrat and a statistic mode value of 24. Related to the number of species, 29 out of the 30 species of the list were found during fieldwork. The species *Drosanthemum floribundum* (Haw.) was not found in any of the quadrats, maybe due to the low number of quadrats located on coastal areas. According to the Azores Bioportal Database, this species occurs on Terceira Island in a different (coastal) area than those studied in this work. In contrast, other alien species not present in the list were often found such as *Leycesteria formosa* Wall, *Ailanthus altissima* (Mill.) Swingle, *Deparia petersenii* (Kunze) M. Kato or *Tropaeolum majus* L.

The table below (Table 5) shows a general characterization of the quadrats with the average altitude, number of species, abundance (mode), land use and status of protection (protected/unprotected):

Table 5. General characterization of the quadrats of the vegetation study including the location, average altitude, number of species, abundance (mode), land use and status of protection (protected/unprotected).

General characterization of the quadrats of this study on Terceira Island						
No. quadrat	Location (as a reference on Terceira Island)	Altitude (m.a.s.l.)	Land use	No. species (out of 30)	Abundance (mode)	Status quadrat
1	Cinco Ribeiras 1	122	Agricultural	15	2	Unprotected
2	Cinco Ribeiras 2	187	Pastures	16	3	Unprotected
3	Terra Chã	204	Mix 1	20	2	Unprotected
4	Serreta-orla costeira	182	Production Forest	15	3	Unprotected
5	Agualva mato	173	Pastures	18	3	Unprotected
6	Agualva estrada	127	Mix 2	17	3	Unprotected
7	Rocha do Chambre	601	Pastures	8	3	Protected
8	GM- trilho Montanheiros	506	Natural Vegetation	7	3	Protected

General characterization of the quadrats of this study on Terceira Island						
9	Gilherme Moniz-1	472	Natural Vegetation	10	2	Protected
10	Gilherme Moniz-2	527	Natural Vegetation	8	3	Protected
11	Caminho Furnas	545	Mix 3	10	2	Protected
12	Serreta1	727	Natural Vegetation	8	2	Protected
13	Serreta2	440	Production Forest	11	3	Protected
14	São Mateus	60	Mix 1	15	2	Unprotected
15	Raminho	63	Natural Vegetation	13	3	Protected
16	Raminho2	121	Mix 3	16	2	Protected
17	Golf	331	Mix 3	15	3	Unprotected
18	Cruze Agualva/Vila Nova	195	Pastures	16	3	Unprotected
19	Praia_StaLuzia	69	Mix 2	11	3	Unprotected
20	Praia_perto cidade	50	Mix 2	7	3	Unprotected
21	Cabo da Praia-Paul	48	Pastures	19	3	Unprotected
22	Praia-BeloJardim	29	Mix 2	14	3	Unprotected
23	São Sebastião-Salga	93	Agricultural	13	3	Unprotected
24	Serra do Cume	323	Pastures	11	3	Unprotected
25	Ribeira Seca da Cima	226	Pastures	10	3	Unprotected
26	Ribeira Seca- urbana	145	Mix 1	11	3	Unprotected
27	Baía da Vila	41	Agricultural	9	3	Unprotected
28	Via Rápida	325	Pastures	12	3	Unprotected
29	ReservaBiscoitos1	436	Production Forest	10	3	Protected
30	ReservaBiscoitos2	436	Mix 4	7	3	Protected
31	Altares	429	Pastures	8	3	Unprotected
32	Caminho Algar do Carvão	404	Production Forest	6	3	Unprotected
33	RN Biscoitos-Agualva	566	Natural Vegetation	8	2	Unprotected
34	Lagoa Patas	667	Mix 3	6	3	Protected
35	Plantação Pinheiros	284	Mix 3	16	3	Unprotected

The quadrat with highest number of invasive species (20 out of 29) corresponds to Terra Chã area (Quadrat 3). This quadrat presents Mixed land use classified as Mix1: agricultural, pastures, urban and

production forest. The two quadrats with lowest number of species (6), correspond to the Quadrat 34 (located on protected area), which also presents Mixed land use classified as Mix3: pastures, natural vegetation and production forest; and the quadrat located on the Quadrat 32 (main road nearby Algar do Carvão area) which presents Production Forest land use type and it is an unprotected area.

Most of the quadrats present an average value of abundance among species of 3, although in several quadrats this abundance present similar representativeness for 2 and 3, or 3 and 4 values of abundance.

3.2 Altitude

For each quadrat, it was recorded the average altitude. The fieldwork was developed within a minimum altitude of 29 m a.s.l. and maximum altitude of 727 m a.s.l., with an average altitude of 203.9 m a.s.l. The graphic below (Figure 6) shows the relationship between the average altitude of every quadrat and the number of species (dependent variable) registered:

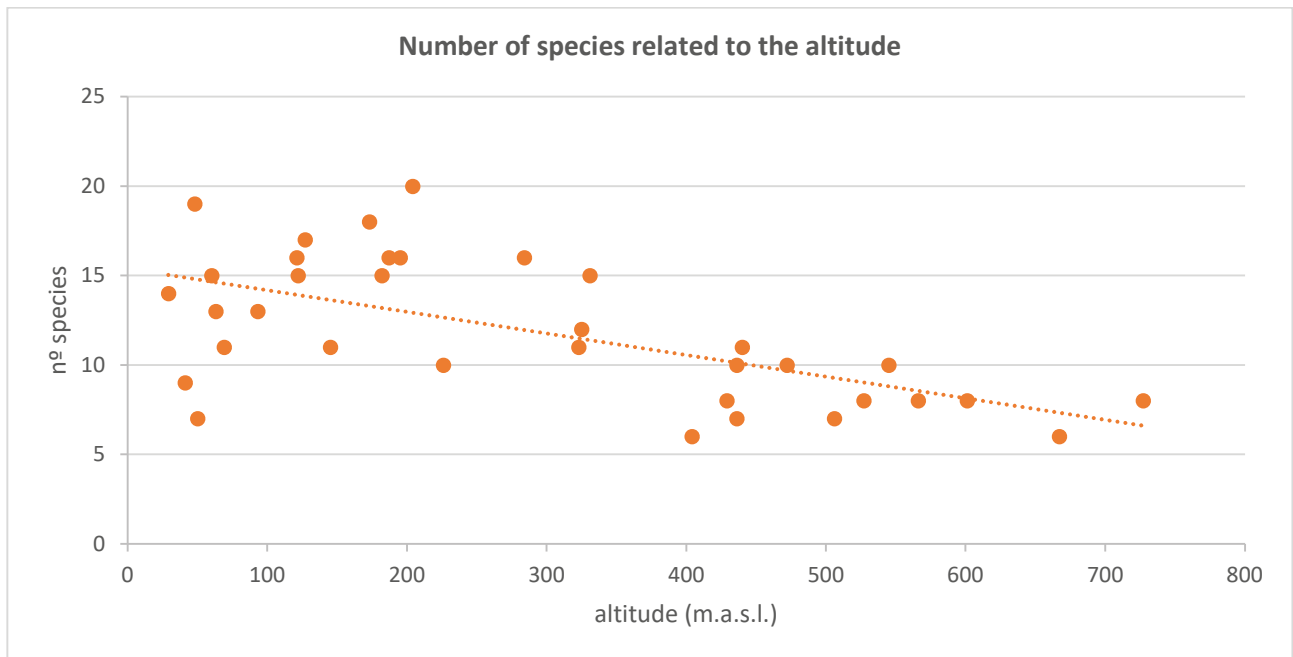


Figure 5. Number of species in relation to the altitude.

Although the graphic shows variations in the number of species, it exists a decreasing tendency for this variable related to the altitude. A higher altitude corresponds, in general, to a lower number of invasive

species. A faster decreasing rate for the number of species appears at 200 m.a.s.l. The number of invasive species remains below 11 (out of 29) for this and higher altitudes

The Spearman correlation test (Kolmogorov-Smirnov test, $p < 0.05$), performed in SPSS in order to know if there is a statistic relationship between the altitude and the number of species, to test the hypothesis:

H0: the number of species is unrelated to the altitude

H1: the number of species is not unrelated to the altitude;

Shows that the number of species is negatively correlated to the altitude (coefficient correlation = -0.553; p -value = 0.001). In addition, a regression test was performed. This test shows a negative relationship between the variable altitude and the number of species ($R = -0.619$; p -value < 0.05), which means a statically significant decrease in the number of species in higher altitudes.

3.3 Land use and habitat

Since the selection of the study areas for Terceira Island was randomized, the number of quadrats varies in relation to each type of land use. None of the quadrats was fully located on urban areas. A higher proportion of the quadrats (more than one third) were located on Mixed land use, which was subdivided in 4 types for the analysis (as mentioned in the Methodology).

The following chart graph (Figure 7) shows the proportion of types of land use related to the total number of quadrats in this study:

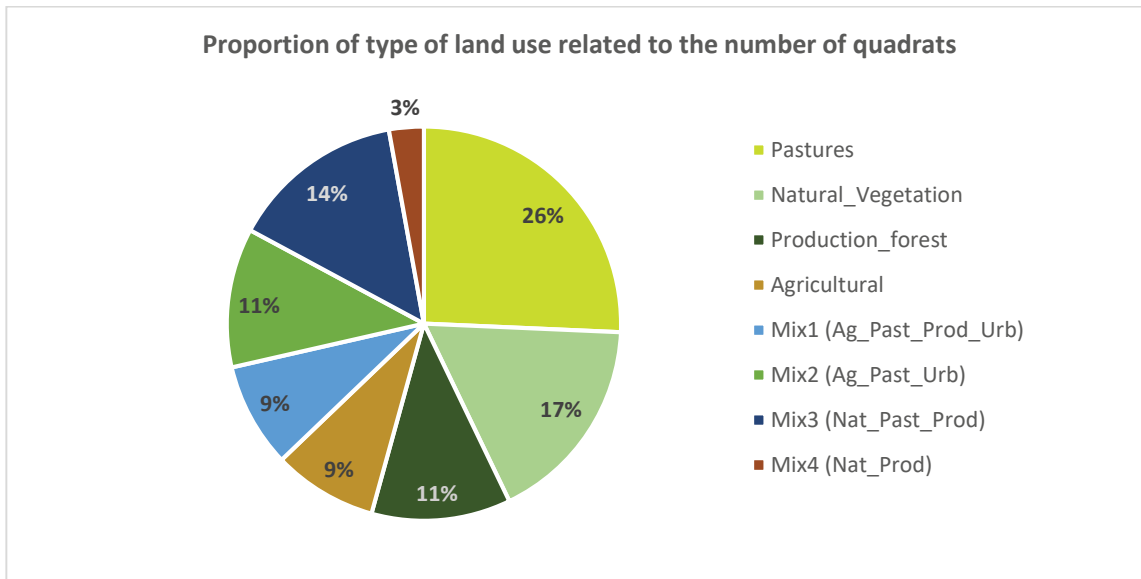


Figure 6. Proportion of type of land use related to the number of quadrats.

The higher value in the number of species (26) was found in Pastures land, which also present the higher number of quadrats (9) and represents one quarter of the studied areas. However, in proportion to the number of quadrats, the higher values for the number of species appear in Agricultural, Mix Land Use 1 and Mix Land Use 2 with 23 species and an average between 5.8 and 7.7 species per quadrat. Both types, Mix land 1 and Mix land use 2, have in common Agricultural, Urban and Pastures land uses. For the 3 quadrats fully located in Agricultural land use, 23 out of 29 species were found. These 3 quadrats were located at 41, 93 and 122 m a.s.l. respectively. Also, in proportion to the number of quadrats, the lowest values for the number of species are found in Natural Vegetation, Production Forest, Pastures and the Mix of these three types of land use. For Mix 4 land use (Natural and Production forest), 7 species per quadrat were found, however, this only represents one quadrat in the whole of the study. Here this number does not represent a high value as in Mix 1 or Mix 2 since this is expressed in proportion to the number of quadrats for every type of land use.

The table below (Table 6) shows a summary of the values mentioned for the number of species related to the type of land use:

Table 6. Number of species related to the type of land use and in proportion to the number of quadrats located in each type of land use.

Type of land use	no. quadrats	% land use type	no. invasive species (out of 29)	no. invasive species/ quadrats
Pastures	9	25,7	26	2,9
Natural_Vegetation	6	17,1	23	3,8
Production_forest	4	11,4	17	4,3
Agricultural	3	8,6	23	7,7
Mix1 (Ag_Past_Prod_Urb)	3	8,6	23	7,7
Mix2 (Ag_Past_Urb)	4	11,4	23	5,8
Mix3 (Nat_Past_Prod)	5	14,3	22	4,4
Mix4 (Nat_Prod)	1	2,9	7	7,0

In addition to the land use, the type of habitats and the status of the quadrats related to Terceira Natural Park (protected area/unprotected area) were registered. During fieldwork, a large amount of the records were registered within the Road Network of Terceira Island. Most of them were spotted on the sides and slopes of secondary roads and between the sides of these roads and the forest edge, but also on the main road, hiking trails and elements present on the roads such as stonewalls and hedgerows. However, it is in Uncultivated habitats where a higher number of species appears (27 out of the 29 found in the study). Also, a high number of species are found in Water related habitats (23, same number of species than in the Road Network habitats, but almost in half the number of quadrats). In most of the cases, these species appear in water streams (“ribeiras”). These three types of habitats, Road network, Uncultivated and Water related, present the higher values for the number of species. There is a very little amount of species in coastal areas due to the low number of quadrats located over the coastal line (only three quadrats were fully located in coastal areas, and in all cases, part of the quadrat was occupied by the ocean).

Table 7. Number of species, quadrats and proportion of records in every type of habitat

Habitat	No. of species*	No. of quadrats in which the type of habitat appears *	Proportion of records of invasive plants in each habitat (No. of records habitat / no. quadrats)
Road_network	23	30	9.63
Cultivated	21	28	6.50
Woods	22	24	8.33
Uncultivated	27	20	5.55
Water	23	17	9.00
Building	19	15	4.73
Native	13	12	5.50
Coastal	9	3	5.67

*The number of quadrats and number of species are not cumulative in this table. Same species and habitats were recorded several times in every quadrat of the study.

The following graph chart (Figure 8) shows the proportion of every type of habitat out of the total recorded in this study:

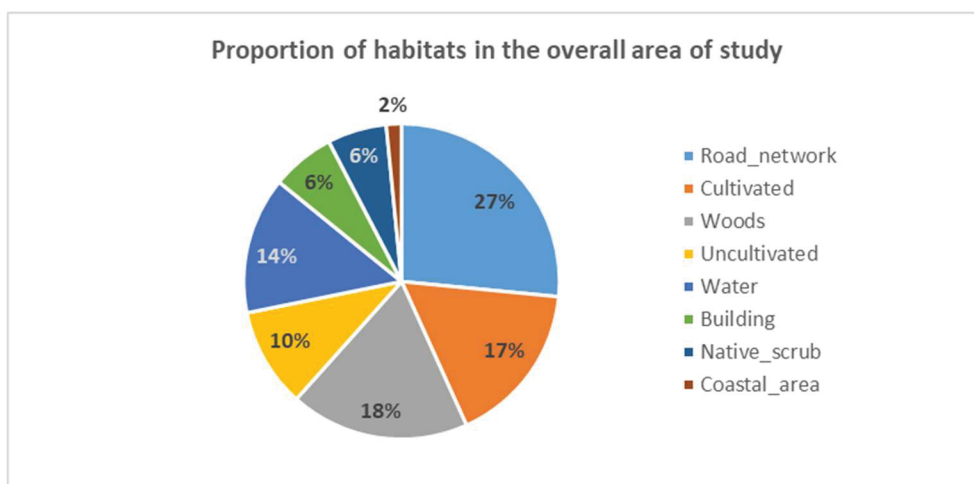


Figure 7. Proportion of type of habitats in the overall area of study

Related to the area of study that belongs to the Natural Park of Terceira Island, almost two thirds of the quadrats (22 quadrats, 63%) were located in unprotected areas. However, a high proportion of the species (24 out of 29 found) were registered in protected areas, also considering the proportion to the number of quadrats. The 5 species that were found in unprotected areas but not in protected areas were: *Agave americana*, *Lantana camara*, *Araujia sericifera*, *Ricinus comunis* and *Ulex europaeus*. All the records related to these species were collected below 400 m.a.s.l, while all the protected areas in this study are located above at 400 m.a.s.l. In this sense, the variable altitude can make the difference in the number of species. A summary of these values is shown in the table below (Table 8):

Table 8. Proportion of quadrats studied and species foun in protected and unprotected areas

	No. quadrats	%area studied	No. species	No. species / No. quadrats
Protected areas	13	37%	24	2
Unprotected areas	22	63%	29	1

Finally, the culture (agricultural or forestry holding) associated, if any, was also recorded during fieldwork. In those quadrats in which a planted culture is present, *Criptomeria japonica*, *Eucaliptus globulus* or a mix of both were the cultures found more often during fieldwork. These two species were also frequent as part of the Production Forest land use (11% of the land use in this study). In the presence of these two cultures, 15 out of 29 species were found.

3.4 Invasive alien plant species ranking

A summary of the number of records per species, frequency, abundance (qualitative scale), importance, most frequent land use and main type habitat is presented in the following table (Table 9):

Table 9. Species characterization and ranking according to the importance. Number of records, frequency, abundance, importance, and most frequent type land use and habitat.

	Species	no. records* (Absolute frequency)	Relative frequency (no. records/ total)	Abundance (statistic mode)	Importance ** %(frequency x abundance)	Land use ***	Type of habitat***
1	<i>Rubus ulmifolius</i>	126	0.12	3	13.90	Pastures	Cultivated. roads
2	<i>Hedychium gardnerianum</i>	112	0.1	3	11.58	Pastures	Woods
3	<i>Pittosporum undulatum</i>	104	0.1	3	11.58	Pastures	Woods
4	<i>Arundo donax</i>	91	0.08	3	9.27	Mix2	Cultivated
5	<i>Conyza sp</i>	68	0.06	2	4.63	Pastures	Uncultivated. Roads
6	<i>Phytolacca americana</i>	66	0.06	2	4.63	Pastures	Road_network
7	<i>Solanum mauritianum</i>	66	0.06	2	4.63	Pastures	Woods. roads
8	<i>Hydrangea macrophylla</i>	47	0.04	3	4.63	Pastures	Building. roads
9	<i>Mentha suaveolens</i>	40	0.04	3	4.63	Pastures	Road_network
10	<i>Persicaria capitata</i>	41	0.04	3	4.63	Mix3, Production forest	Road_network
11	<i>Ipomoea indica</i>	30	0.03	4	4.63	Mix2, Pastures	Roads. Water
12	<i>Acacia melanoxylon</i>	49	0.04	2	3.09	Pastures	Woods
13	<i>Cyrtomium falcatum</i>	22	0.02	3	2.32	Mix2, Mix3	Road_network
14	<i>Oxalis pes-caprae</i>	27	0.02	3	2.32	Pastures	Road_network
15	<i>Cyathea cooperii</i>	48	0.04	1	1.54	Pastures, Natural Vegetation	Road_network
16	<i>Araujia sericifera</i>	18	0.02	2	1.54	Mix1	Uncultivated
17	<i>Cynodon dactylon</i>	23	0.02	2	1.54	Agricultural, Pastures	Road_network
18	<i>Erigeron karvinskianus</i>	24	0.02	2	1.54	Mix3, Pastures	Road_network
19	<i>Tradescantia fluminensis</i>	16	0.01	4	1.54	Pastures	Woods. Water
20	<i>Salpichroa organifolia</i>	15	0.01	3	1.16	Pastures	Road_network
21	<i>Ulex europaeus</i>	11	0.01	3	1.16	Mix3	Woods
22	<i>Ulex minor</i>	10	0.01	3	1.16	Mix3, Natural vegetation	Uncultivated
23	<i>Agave Americana</i>	7	0.01	2	0.77	Agricultural	Coastal area
24	<i>Ageratina adenophora</i>	6	0.01	2	0.77	Mix1, Mix2	Water

Species	no. records* (Absolute frequency)	Relative frequency (no. records/ total)	Abundance (statistic mode)	Importance ** %(frequency x abundance)	Land use ***	Type of habitat***	Species
25	<i>Lantana camara</i>	7	0.01	2	0.77	Mix2	Building
26	<i>Aptenia cordiflora</i>	3	0	3	0.00	Agricultural. Pastures	Coastal area
27	<i>Carpobrotus edulis</i>	3	0	2	0.00	Agricultural	Coastal area
28	<i>Opuntia ficus-indica</i>	5	0	3	0.00	Agricultural, Pastures	Coastal area
29	<i>Ricinus comunis</i>	5	0	2	0.00	Mix1, Mix2, Pastures	Uncultivated. Water

*Number of records is not equal to the number of individuals. It indicates the number of times that the species was found during fieldwork. Every record was made according to a qualitative scale of abundance but not by counting. This value is shown to support the characterization of the data but not to be analysed separately.

** The importance was calculated according Silva & Smith 2006 as a percentage expression of the product of the abundance and the relative frequency. This data gives relevant information about the “weight” of every specie on the overall of the study. The value of importance per every species was calculated as follows:

Value of importance = ((abundance x relative frequency)/ average abundance¹) x 100

¹Average abundance = 2.59.

***Two types of land uses are indicated when the specie appears with the same frequency in both of them. Two types of habitats are indicated when the specie appears with the same recurrence in both of them.

The species on the Table 9 have been organize according to the importance. The colour scale has been set according to this value (red=higher importance, green=lower importance). Data related to *Conyza* sp (*Conyza bonariensis* and *Conyza canadensis*) species were gathered as *Conyza* sp. In general, there is a coincidence for some species with higher representativeness in the table defined in the Methodology based on number of citations (Table 2) and the species with higher values of importance in this table, such as *Hedychium gardnerianum* and *Pittosporum undulatum* (11.58 for both of them), *Arundo donax*

(9.27), *Conyza* sp (4.63) and *Phytolacca americana* (4.63). In addition, some species with lower representativeness in Table 2 of the Methodology have lower values of importance in Table 9 such as *Opuntia ficus-indica* and the two species of *Ulex*.

On the other hand, species such as *Lantana camara*, *Argeratina adenophora*, *Agave americana* and *Ricinus comunis* were expected to have higher values of importance according to their position in Table 2; while *Solanum mauritianum*, *Mentha suaveolens*, *Persicaria capitata*, *Cyrtomium falcatum* and *Cyathea cooperii* show high values of importance here (Table 9) but were not so cited in the bibliography of reference (these species occupied medium or low positions in Table 2).

Regarding the abundance, land use and habitat Table 9 shows the most frequent option found for every species. Most of the species present a qualitative abundance of 2 or 3 which means that they usually appear in little disperse quantities or in groups. In contrast, *Rubus ulmifolius* and *Pittosporum undulatum* often presented values of abundance of 4 during fieldwork. Also, only five species were recorded once with a value of abundance of 5: *Acacia melanoxylon*, *Hedychium gardnerianum*, *Ipomoea indica*, *Persicaria capitata* and *Pittosporum undulatum*.

The Spearman correlation test performed in SPSS to check if there it exists any relationship between the altitude and the abundance, to test the hypothesis:

H0: the species abundance is not related to the altitude

H1: the species abundance is not unrelated to the altitude;

shows a $R= 0.042$ and $p\text{-value}=0.161$, meaning that the variables altitude and abundance of the species are not related. This could be explained because this relationship was calculated considering the mean value of abundance only, which being a quantilative value (3 in most of the cases), can also gather the cases in which the main values of abundance were 2 or 3, and 3 or 4; not being so representative at species level but maybe more relevant at record level.

In Table 9, Pastures and Mix2 (Agricultural, Pastures and Urban) types of land uses are the most common type of land use when looking at every single species. Agricultural land use was the non-Mix type of land use with the highest number of species (Table 6). When looking at every single species in

Table 9, the species that occur preferably in Agricultural land use grow in low altitudes areas, less represented in this study, as already mentioned. Finally, most of the species preferably appear in Uncultivated areas, Road Network and Water streams habitats (coinciding with the results showed in above in the text).

Altogether, a mix of variables influence the occurrence, frequency and abundance of the invasive alien plant species on Terceira Island.

The Principal Component Analyses for Categorical Data (CATPCA) performed in SPSS in order to determine what variable(s) have a higher weight on the results and how much of the variance of the data they explain (Table 10), shows a Cronbach's alpha of 0.82; suggesting a high internal consistency of the data. The CATPCA analysis shows that the variables land use, habitat, altitude and status of the quadrat (protected/unprotected) explain 88,15% of the variance of the data in this study. Table 10 shows the SPSS outputs of the Principal Component Analysis for Categorical data (CATPCA) and Cronbach's alpha:

Table 10. SPSS output of the CATPCA analysis

Summary of the model

Dimension	Cronbach's alpha	Variance calculated for	
		Total (autovalor)	% variance
1	,826	2,633	65,820
2	-,155	,893	22,336
Total	,955 ^a	3,526	88,156

a. Cronbach's alpha is used for total autovalor

Variance contabilized for

	Coordinated centroid			Total (coordinates vector)		
	Dimension		Average	Dimension		Total
	1	2		1	2	
Altitude	,980	,251	,615	,855	,013	,869
Land_use	,748	,076	,412	,748	,004	,752
Habitat	,357	,860	,609	,176	,822	,997
Status_quadrat	,854	,054	,454	,854	,054	,909
Total active	2,939	1,242	2,090	2,633	,893	3,526
% variance	73,485	31,038	52,261	65,820	22,336	88,156

(Table 10 Cont.) **Transformed correlation variables**

	Altitude	Land_use	Habitat	Status_quadrat
Altitude	1,000	,678	,288	-,869
Land_use	,678	1,000	,282	-,722
Habitat	,288	,282	1,000	-,190
Status_quadrat	-,869	-,722	-,190	1,000
Dimension	1	2	3	4
Autovalor	2,633	,894	,354	,120

Altitude is the variable that better explains the variance in the first reduction of dimensions (0.98, explaining 61.5 % of the variance), followed by the status of the quadrat (0.85) and land use (0.74). In the average of reduction of dimensions 1 and 2, the altitude is followed by the variable habitat, explaining 60.9% of the variance. In the totals, the four variables, altitude, land use, habitat and status of the quadrat have a value ≥ 0.7 , meaning that all of them are relevant to explain the 88.15% of the variance of the data.

The correlation matrix shows that the variable land use is more strongly related to the altitude ($R=0.67$), and strongly negatively correlated to the status of the quadrat (protected/unprotected) ($R=-0.86$). Land use and status of the quadrat are also strongly negatively correlated ($R=-0.72$). These results are in line with the location of Terceira Natural Park, in general high altitudes, plus more variety of types of land use are found in lower altitudes.

Overall, the four variables mentioned (altitude, land use -also correlated to each other-, habitat and status of the quadrat) have an important weight on the results obtained, explaining a high the variance of the data. In this sense, these variables need to be taking into account when taking decisions in the management and communication strategies about the invasive alien species studied here for Terceira Island.

III.2 Results of the survey through questionnaire on local's perspectives on invasive alien plant species.

III.2.1 Participants' characterization

During the period the online questionnaire was available, the answers of 276 participants were collected.

Sex

From the 276 participants, 181 were women who represent 66% of the participants, and 94 were men who represent 34% of the total amount of participants.

Age

The age range of the participants was from 15 to 65 years old, the average being 37 years old. The modes are found in the age range between 26 and 31 years old, with 10-13 participants per age within this group.

Birthplace and type of birthplace

Survey participants are from 11 different countries: 237 (87%) are from Portugal and 36 (13%) are from 10 other countries including Germany, Italy, Spain, Slovakia, Angola, France, United Kingdom, United States of America, Canada and Brazil.

Among the Portuguese participants 81% (192 participants) are from the Azores. All islands, except Corvo and Graciosa, are represented in this study. Most of the Azorean participants are from Terceira Island (133 participants, 69%), followed by São Miguel Island (37 participants, 19%) as shown in Figure 9.

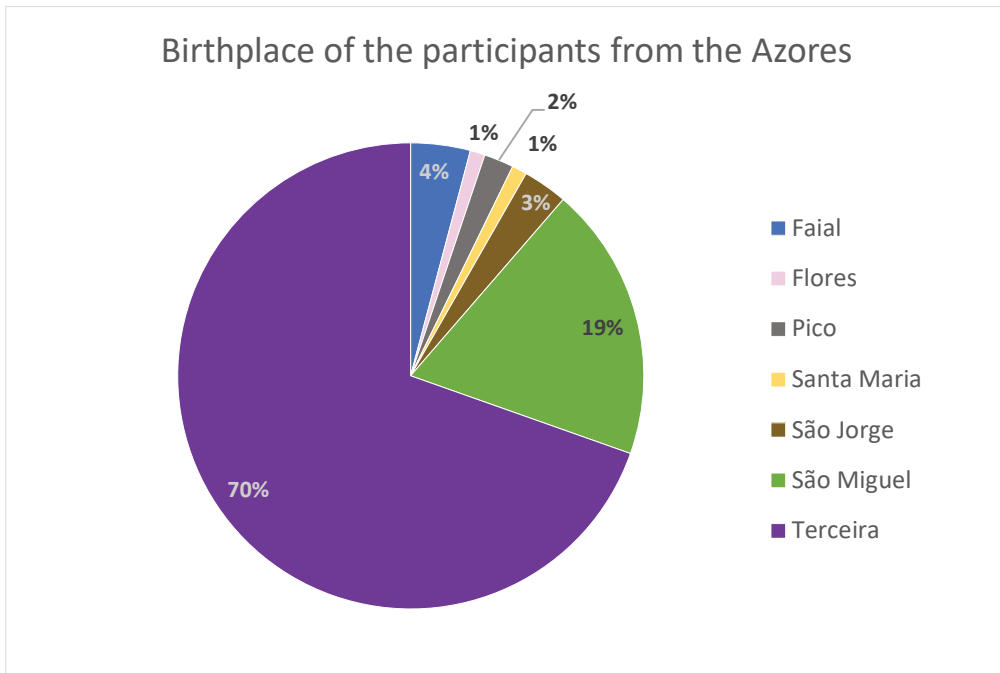


Figure 8. Proportion of participants per Azorean Island

Almost half of the participants (132, 48%) are from urban areas, while 62 participants (23%) are from peri-urban areas, and 79 participants (29%) were born in rural areas (Figure 10).

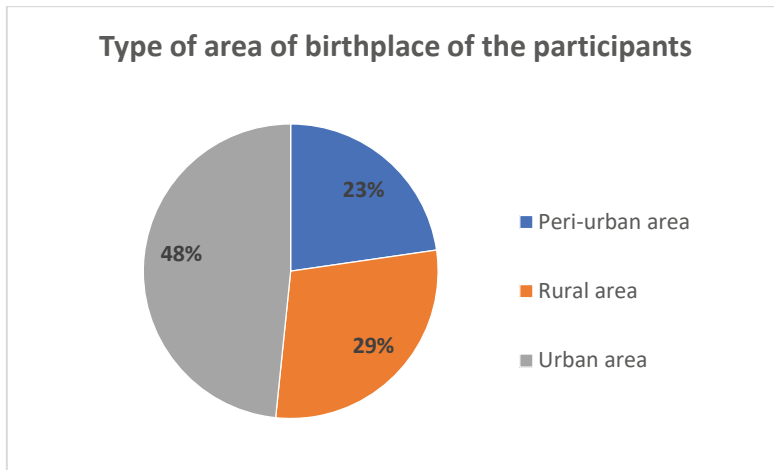


Figure 9. Type of area of birthplace of the participants

Place, type and time of residence

Regarding the current place of residence, almost all participants in this survey (258 participants, 97%) live in Portugal, and 248 out of these 258 participants are residents in the Azores. All the islands of the archipelago, except Flores, are represented here. Most of the participants residents in the Azores live on Terceira Island (187 participants, 76%) followed by São Miguel (39 participants, 16%) (Figure 11).

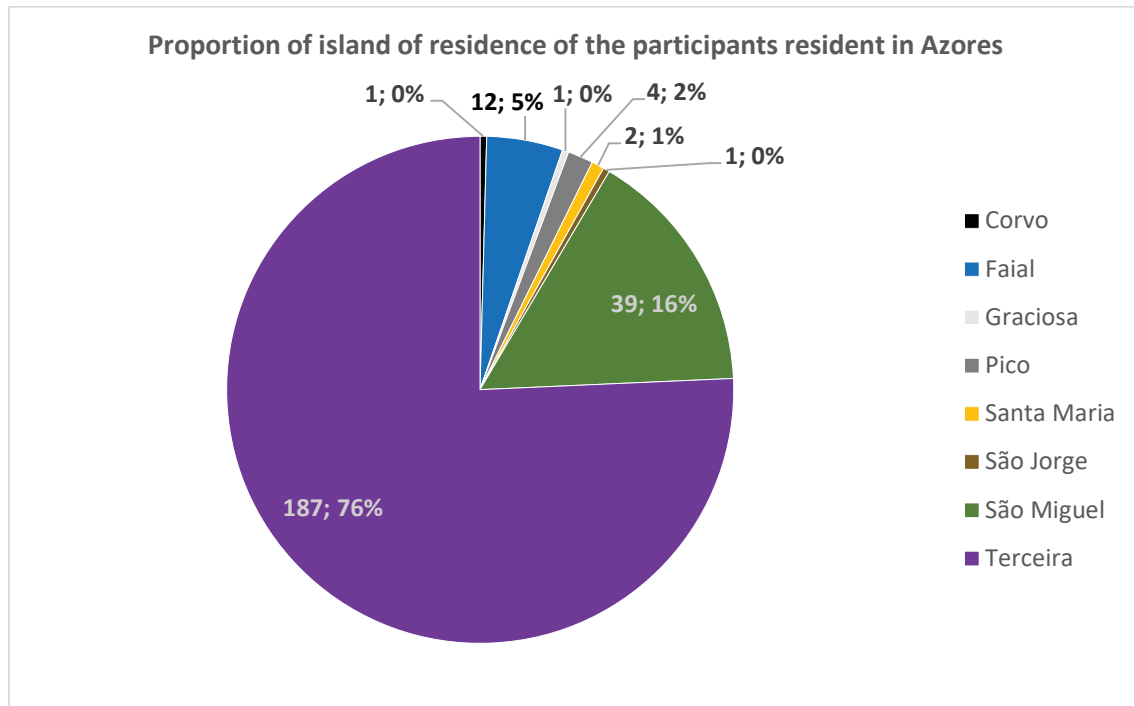


Figure 10. Proportion of participants residents in the Azores per island

Concerning the type of place of residence, 98 participants (36%) live in urban areas, 75 (28%) live in peri-urban areas and 95 (35%) in rural areas (Figure 12).

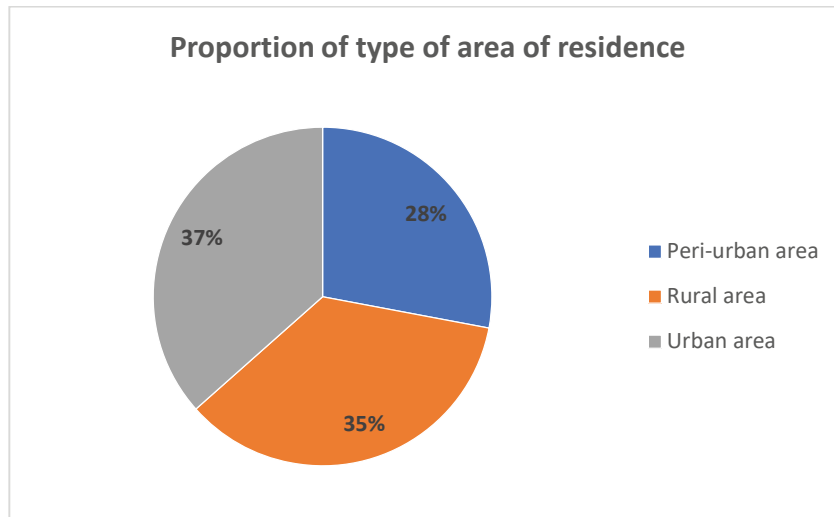


Figure 11. Proportion of participants per type of area of residence

Considering only the participants residents on Terceira Island, the focus island of this study, these values have a higher representation for rural areas: 54 participants (29%) live in urban areas, 58 (31%) live in peri-urban areas and 73 participants (39%) live in rural areas (Figure 13).

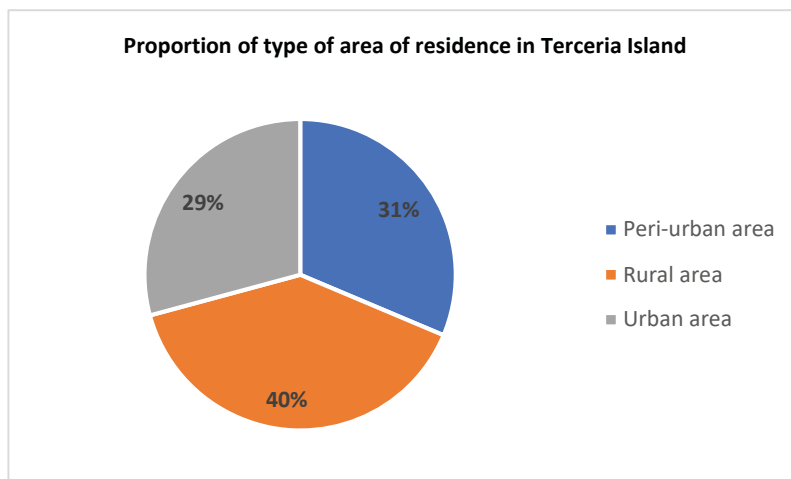


Figure 12. Proportion of participants residents on Terceira Island per type of area of residence

Time of residence in the Azores varies between less than one year and 65 years, being the average time of residence 19.4 years for Terceira Island and 12.6 years for São Miguel Island.

In addition, 201 out of the 248 participants residents in the Azores have access to cultivation or gardening areas. Most of those (145, 72%) live on Terceira Island, followed by São Miguel Island with 27 (13%) participants with access to these kind of areas. Most of the participants in this study were born and are resident in these two islands.

Occupation

Concerning the economic area or sector of professional activity, a high percentage of participants work in the Tertiary Sector (198, 74%), followed by those working in the Primary Sector (22, 8%) and the Secondary Sector (16, 6%). The rest of the participants, “other”, were either students (11%) or unemployed (1%) (Figure 14).

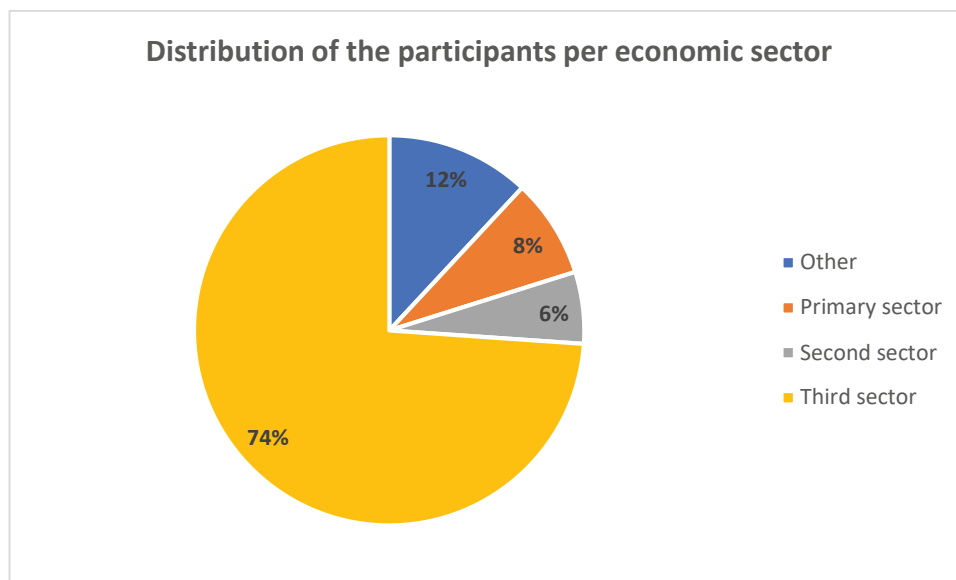


Figure 13. Proportion of participants per economic sector

For those participants residents on Terceira Island these values are similar, 76% for the Tertiary Sector (138 participants), 6% (11 participants) for the Secondary Sector and 8% (14 participants) for the Primary Sector (Figure 15).

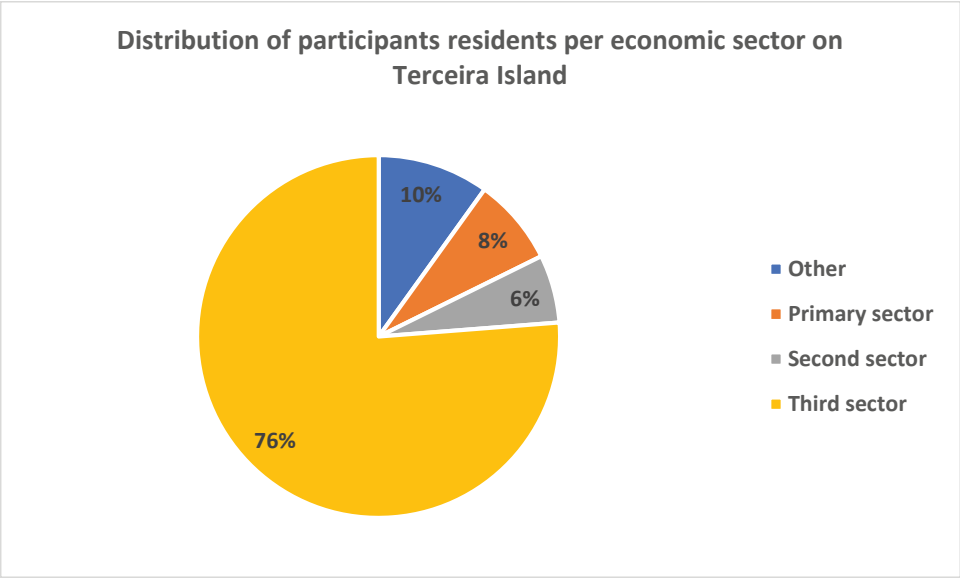


Figure 14. Proportion of participants residents on Terceira Island per economic sector

Education

The distribution of the level of education of the participants is showed in the graphic below, where three thirds of the participants have attended university (124 participants (46%) Bachelor, and 78 participants (29%) Master or PhD degrees) (Figures 16 and 17).

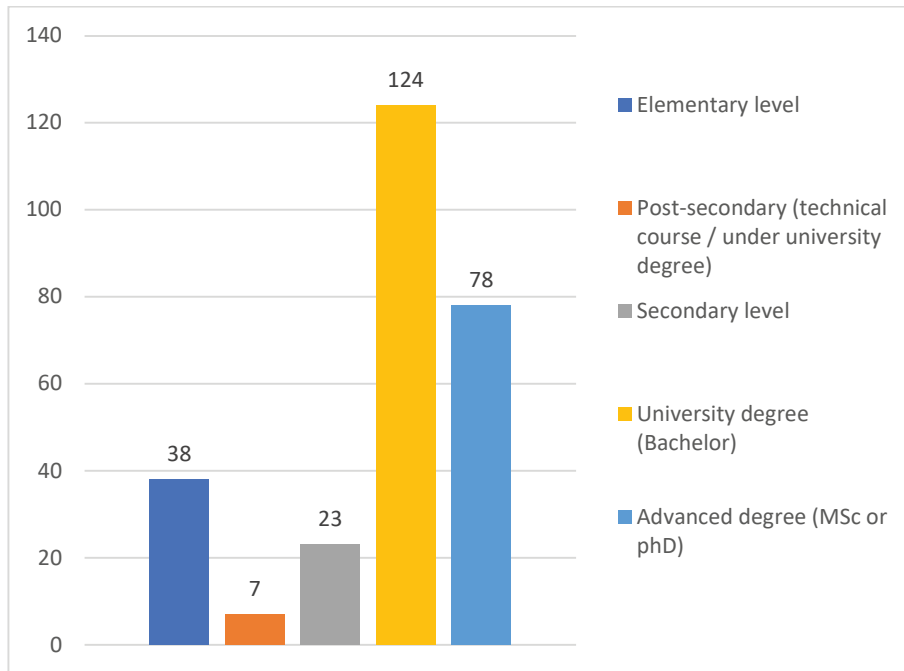


Figure 15. Number of participants per educational level

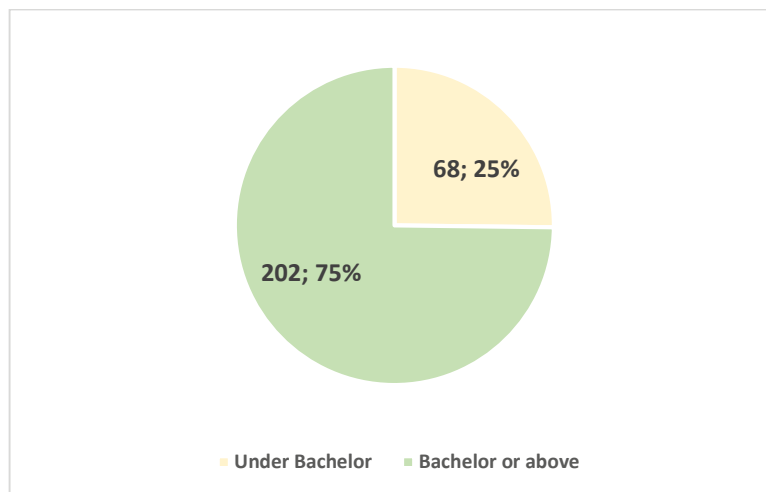


Figure 16. Distribution of the educational level of the participants grouped by two categories: under bachelor and bachelor or above

Related to the area of education (excluding Elementary and Secondary Educational levels) the survey shows 28 different academic areas. The areas better represented in this survey (with more than 10 participants/academic area) are presented in Table 11.

Table 11. Number of participants per academic area

Academic area	No. of participants
Environmental Sciences	26
Biology	35
Science and Technology	17
Education	26
Humanities	24
Health	20
Tourism	11

A second classification of the previous 28 academic areas was made in order to identify those more related to nature versus those that are not. In result, 106 (38%) participants have an academic background related to nature and 170 (62%) have other types of academic backgrounds. The subjects considerate as potentially nature related were: Environmental Sciences, Biology, Agricultural Sciences, Landscape architecture, Forestry engineering, Agricultural engineering and Tourism. Tourism was included as a nature-related area since there is a specific university degree at the University of the Azores in Wildlife and Heritage and, most of the tourism companies working in the Tertiary Sector in the Azores Islands include nature related activities in their services

III.2.2 Answers to the questionnaire questions

For every question the number (according to the numeration on the survey) and the topic are indicated.

PI.1 Word Association Test

The stimulus sentence in this item was “Plantas introduzidas nos Açores”. Participants contributed with a total of 958 words (258 words in first position, 234 in second position, 190 in third position, 153 in fourth position and 123 in fifth position). The number of different words was 195 with an average of 3.17 words cited per participant.

The most cited word was “Hortênsia” (109 times), followed by “Invasoras” (75 times) and “Conteira” (71 times). However, the lowest average evocation order corresponds to “Trazidas” (1.33), followed by “Exóticas” (1.72). The word “Hortênsia” occupies the fifth position in the lowest average evocation order (1.88), i.e. although it was the most mentioned word, “Hortênsia” was not the most frequent word mentioned in the first position. The word “Trazidas”, by contrast was mentioned only six times but in all cases was the first word mentioned (lowest evocation order).

In this case, the EVOCATION 2003 programme shows that 70.9% of the words used by respondents in this item include the words that are named at least six times. The minimum frequency of evocation value is six and the average of 3.17 words cited per participant was taken into account in the following step of the word analysis.

The output of the software EVOCATION 2003 of the Word Association Test is presented in figure 18. Here we can see the words that were mentioned at least six times, which include 70.9% of the total number words cited. The words are divided into four quadrats according to absolute frequency and average evocation order. Thus, Quadrat 1 or Central Quadrat (Figure 18), includes the most repeated words and those with the lowest average evocation order. Here words such as “Invasoras”, “Estrangeiras”, “Exóticas” and names of alien plants (“Conteira”, “Hortensia”) are present. “Diversidade” and “Endémicas” are also part of this group. Quadrats 2 and 3 (Figure 18), include words that can have either lower frequency or higher average evocation order in comparison to the Central Quadrat of words. Here, several names of invasive alien plant species (“Acacia”, “Cana”, “Incenso”), two words with negative connotations (“Infestantes” and “Praga”) and, “Homem” and “Trazidas”, both with low frequency (6) and evocation order (2.16 and 1.33 respectively), appear. The peripheral region (Quadrat 4) includes the combination of words with low frequency and high average evocation order. Words with a variety of meanings appear here, such as “Adaptação”, “Competição”, “Economia” or “Beleza”.

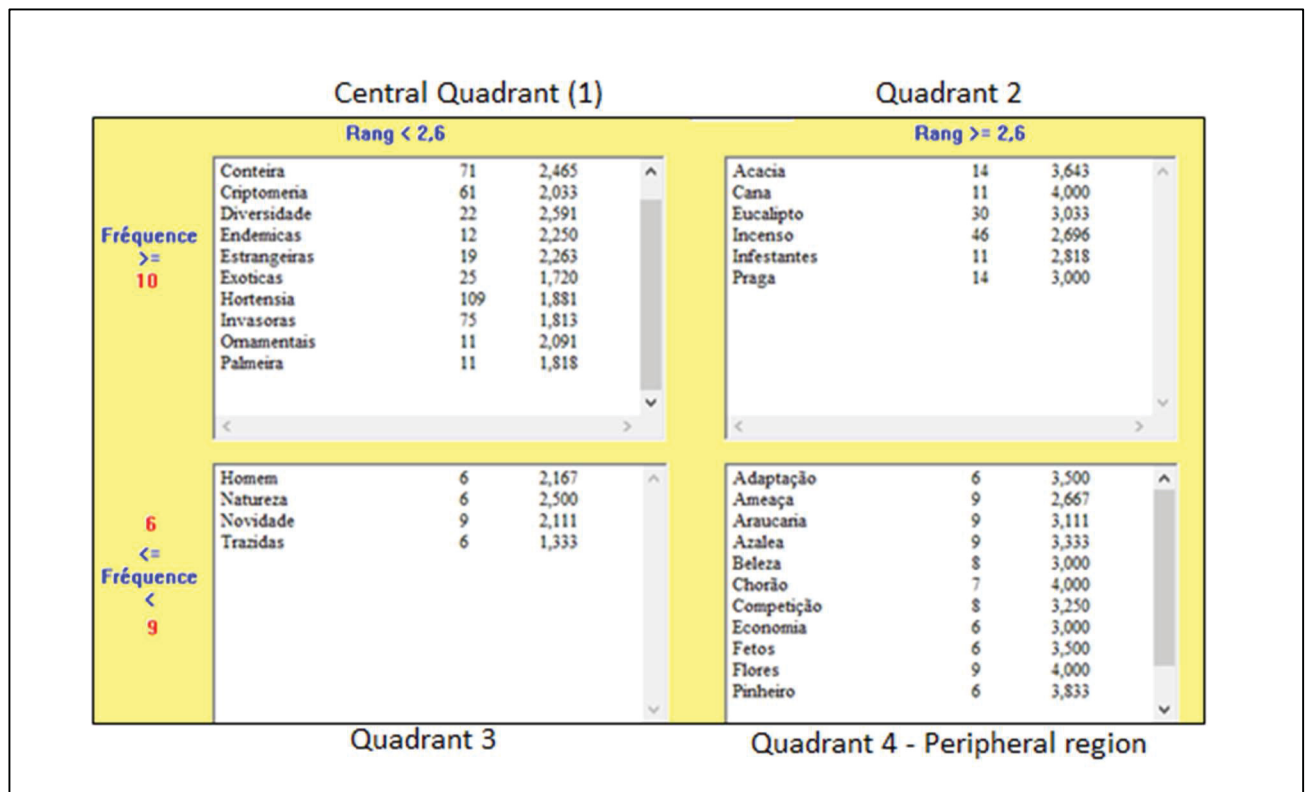


Figure 17. Output of the EVOCATION 2003 software for the words mentioned at least 6 times. The Central Quadrant represents the collective memory of the group, more resistant to the context. Quadrant 2 and 3 gather words that may become part of the Central Quadrant. Quadrant 4 represent the group of words more sensitive to the context, words with lowest frequency of evocation and highest average evocation order.

The diversity and frequency of words used by the participants can also be visually represented by a word cloud (Figure 19). This picture, generated by an online free tool (<https://wordart.com/>), does not take into account the word evocation order (Figure 19).



Figure 18. Wordcloud for the free word evocation, survey question PI.1. Bigger font size and stronger colour intensity means a higher frequency of evocation.

The complete list of words is available in ANNEX 3. The results also show that 10 out of the 30 invasive alien plant species of the vegetation study (Table 9) were mentioned by the participants. Namely, "Hortênsia" and "Conteira" are part of the collective memory of the participants (Quadrat 1), while "Incenso", "Acacia" and "Cana" may potentially become part of it (Quadrants 2 and 3). In Quadrat 4, "Chorão" (mentioned seven times) and "Fetos" (mentioned six times, considering reference to *Cyathea cooperii*) are found. "Lantana" (mentioned five times), "Silva" (mentioned five times) and "Agave" (mentioned 1 time) were mentioned less than six times and are not included in Figures 18 and 19. (see ANNEX 3).

Finally, it was investigated if the differences in the number of words cited are related to the participants' "educational level", "academic background" and "birthplace" (from the Azores/other).

Since the variable "number of words cited" did not follow a Normal distribution ($p\text{-value} \leq 0.05$), a Mann-Whitney U test for independent samples was used to test the hypothesis:

H0: having a nature-related or non-nature related academic background does not affect the average number of words cited by the participants

H1: having a nature-related or non-nature related academic background affects the average number of words cited by the participants;

H0: having an educational level under bachelor, or, bachelor or above does not affect the average number of words cited by the participants

H1: having an educational level under bachelor, or, bachelor or above affects the average number of words cited by the participants;

And,

H0: the birthplace does not affect the average number of words cited by the participants

H1: the birthplace affects the average number of words cited by the participants

Results provided by the SPSS programme show, for the "educational level", a Z-value= -1.064; p-value= 0.287; meaning that having a different "educational level" has no effect on the number of words cited by participants. For "academic background", the SPSS programme shows a Z-value= -3.252 and a p-value= 0.01; meaning that having an academic background related to or non-related to nature has an

effect on the number of words cited by participants. Participants with an academic background related to nature cited a higher number of words. This could be explained because this question is a call for the “immediate memory” of the participant, which is itself reflected in the collective memory of the population of the study. In other words, the stimulus sentence had a stronger effect on the participants with academic background to nature when answering the question, reflected in a higher number of words. For “birthplace”, the SPSS programme shows a Z-value= -0.333 and a p-value=0.739; meaning that the place where the participants were born (Azores/other) has no effect on the number of words cited.

All outputs of the SPSS programme for the statistic analysis performed for the online questionnaire, for this and the following questions, are available in ANNEX 4.

PI.2 Environmental problems in the Azores

Half of the items, six out of 12 options (11 given items plus open answer) were chosen at least once by more than 25% of the participants. The four most voted items (chosen for more than one third of the participants) were "introduction of foreign species" (140 participants, 50.7%), "loss of native and endemic biodiversity" (133 participants, 48.2%), "human activities that might endanger marine biodiversity" (123 participants, 44.6 %) and "habitat fragmentation due to human activities" (94 participants, 34.1 %). These numbers are not cumulative as participants were able to choose up to three options in this question, being the final number of answers higher than the number of participants.

To analyse the answers given in this question, the items were classified in two groups: four items were considered related to the introduction of invasive species (directly or indirectly): options B - Introduction of alien species, E - Loss of local biodiversity, F - Habitat fragmentation due to human activities, and H - Climate Change; the rest of the items were labelled as “Other”. The test was performed to test the hypothesis:

H0: choosing items related to invasive species is independent of the participant’s academic background area

H1: choosing items related to invasive species depends on the participant’s academic background area

The results of the Chi-squared test show a Chi-squared value of 40.427 and a p-value ≤ 0.05 , i.e., there is an association between having an academic background related to nature sciences and the choice of options related to invasive species.

PI.3 Responsibilities of environmental problems in the Azores

In this question, the participants chose one of their given answers in the previous question (environmental problems), in order to assign responsibilities for that problem in the Azores. Three stakeholders out of the six options given (Regional Government, City Town Halls, environmental associations, citizens, scientists of the University of the Azores or Other), were pointed out as the main responsible for the environmental problems in the Azores. The “Regional Government” was chosen by 198 participants as the main responsible, followed by the option “Citizens” (164 times), and the “City Town Halls”, chosen by 127 participants. These numbers are not cumulative since participants were able to choose up to six options in this question, therefore the total of answers is higher than the number of participants.

The options given in this question include different stakeholders. Since two out of the three most voted items are related to institutional authorities (Regional Government and City Town Halls), a Chi-squared test was performed to check if academic background (nature related/unrelated) had an impact on assigning responsibilities to these institutional authorities or other stakeholders; Academic background was the only variable with the minimum number of valid cases (five), to test the hypothesis:

H0: A participant “pointing responsibilities” to institutional authorities (Regional Government and City Town Halls) is independent of its “academic background” area

H1: A participant “pointing responsibilities” to institutional authorities (Regional Government and City Town Halls) depends on its “academic background” area

The SPSS programme showed a Pearson Chi-squared value = 1336.996 and a p-value = 0.000, meaning that there is an association between the academic background area of a participant and having the participant assigning responsibilities to institutional authorities (Regional Government and City Town Halls). People with an academic background non-related to nature were more likely to identify

institutional authorities (Regional Government and City Town Halls) as the responsible for the environmental problems in the Azores.

PI.4 Identification of Azorean plants based on photographs

Table 12. Summary of the answers to Question 4 – Identification of plants on photographs.

Plant picture	Name (common or scientific) (no. of correct answers and percentage)*	Status (native or introduced) (no. of correct answers and percentage)*	Habitat (open answer, most cited) **
Picture 1. <i>Hedychium gardeniarum</i>	208; 75.3%	191; 69.2%	Roads and trails, woods, pasture, stream water
Picture 2. <i>Cyathea cooperii</i>	168; 60.8%	145; 52.5%	Garden, woods, water, high altitude, island's interior
Picture 3. <i>Vaccinium cylindraceum</i>	131; 47.4%	140; 50.7%	Protected areas, natural areas, high altitude
Picture 4. <i>Arundo donax</i>	210; 76%	173; 62.7%	Everywhere, coastal areas, uncultivated areas, agricultural areas
Picture 5. <i>Erica azorica</i>	182; 65.9%	236; 85.5%	Everywhere, trails, coastal areas, high altitude, natural areas
Picture 6. <i>Polypodium azoricum</i>	176; 63.7%	159; 57.6%	Water, stonewalls, walls, forest
Picture 7. <i>Pittosporum undulatum</i>	178; 64,5%	145; 52.5%	Shrub, mixed forest, coastal areas, natural areas, water, uncultivated, hedgerows
Picture 8. <i>Juniperus brevifolia</i>	130; 47.1%	157; 55.9%	Natural forest, protected areas, island's interior

*The remaining answers related to the name and status of the plant were either wrong, non-applicable or participants have not answered the question.

**Most cited general type of habitats excluding specific locations.

Name of the plant: either the proper scientific or common name were considered correct answers, with an average number of 5.1 out of 8 possible correct answers per participant.

Arundo donax was the specie with the highest number of correct answers, followed by *Hedychium gardnerianum*, with 210 and 208 correct answers respectively. However, these values are not so high, meaning that the species was correctly identified in both cases by less than 80% of the participants answering this question. *Juniperus brevifolia* was the specie with the least number of correct answers, only 130 participants were able to correctly identify this species based on the pictures presented. This species was often confused with *Erica azorica*, while *Cyathea cooperii* was often confused with palm trees.

Since the variable “number of correct answers for the name of the plant” does not follow a Normal distribution ($p\text{-value} \leq 0.05$), a Mann-Whitney U test for independent samples was performed using the SPSS programme in order to investigate if there is a relationship between the number of correct answers and the educational level of the participants (“above bachelor” or “bachelor or higher”) and their “academic background” (“related to nature” or “non-related to nature”), under the following hypotheses:

H0: having an educational level “above bachelor” or “bachelor or higher” does not affect to the number of correct answers for the name of the plant

H1: having an educational level “above bachelor” or “bachelor or higher” affects to the number of correct answers for the name of the plant

And,

H0: having an academic background “related to nature” or “non-related to nature” does not affect to the number of correct answers for the name of the plant,

H1: having an academic background “related to nature” or “non-related to nature” affects to the average number of correct answers for the name of the plant.

For both variables, “educational level” and “academic background” the SPSS programme shows a $p\text{-value} \leq 0.05$, which means that the ability to correctly name a plant species is not independent of the educational level nor the academic background of the participants.

In addition, a Spearman correlation test was performed in the SPSS programme in order to investigate if the “number of correct answers for the name of the plant” is related to the amount of time participants have lived in the Azores, to test the hypothesis:

H0: the amount of time a participant has lived in the Azores does not affect the “number of correct answers for the name of the plant”,

H1: the amount of time a participant has lived in the Azores affects the “number of correct answers for the name of the plant”.

In this case, the Spearman correlation test shows a value of $R = 0.008$ and $p\text{-value} = 0.892$, meaning that the variables “number of correct answers for the name of the plant” and the “amount of time a participant has lived in the Azores” are not related.

Colonization status of the plant (native or introduced): the average number of correct answers per participants was 4.8 out of 8, slightly below than the average for the correct name of the plants. In this case, the highest number of correct answers corresponds to a native plant, *Erica azorica* with 237 participants who answered correctly. On the opposite end of the spectrum, *Vaccinium cylindraceum* was the specie with the least number of correct answers, only 140, followed by two introduced species: *Cyathea cooperii* and *Pittosporum undulatum*, both with 145 correct answers, and often mentioned as native species.

Here, the hypothesis to be tested were:

H0: having an educational level “above bachelor” or “bachelor or higher” does not affect to the number of correct answers for the status of the plant

H1: having an educational level “above bachelor” or “bachelor or higher” affects to the number of correct answers for the status of the plant

And,

H0: having an academic background “related to nature” or “non-related to nature” does not affect to the number of correct answers for the status of the plant,

H1: having an academic background “related to nature” or “non-related to nature” affects to the average number of correct answers for the status of the plant.

Also here, the Chi-squared test shows a p-value ≤ 0.05 , meaning that the number of correct answers about the colonization status of the plant is not independent of the variables “educational level” and “academic background” of the participants.

Here, the Spearman correlation test was also performed to test the hypothesis:

H0: the amount of time a participant has lived in the Azores does not affect the “number of correct answers for the colonization status of the plant”

H1: the amount of time a participant has lived in the Azores affects the “number of correct answers for the colonization status of the plant”

The results show a $R = -0.095$ and p-value $= 0.125$, i.e., the variables “amount of time a participant has lived in the Azores” and “number of correct answers for the colonization status of the plant” are not related.

Finally, the Spearman correlation test performed in order to investigate if there is a relationship between the “number of correct answers for the name of the plant” and the “number of correct answers for the colonization status of the plant” shows a $R = 0.756$ and a p-value ≤ 0.05 , meaning that there is a strong correlation between knowing the name of a plant species and its colonization status. The two variables are correlated in more than 75% of the cases.

The regression test was performed in order to investigate the type of relationship between both variables, “number of correct answers for the name of the plant” and “number of correct answers for the colonization status of the plant”. The variable “number of correct answers for the name of the plant” was set as the independent variable. The results show a positive relation between both variables ($R = 0.722$; p-value ≤ 0.05), meaning that if a participant gets the name of a plant species right, chances are that he/she will get the colonization status of that plant right as well (higher knowledge of plant species names followed by higher knowledge on that species colonization status).

Habitat: since answering this question relied on the memory of the participants, no right or wrong answers were considered here. However, many of the answers (see column 4 of Table 11), excluding very specific locations, coincided with land uses (e.g.- Mixed, Agricultural, Natural Vegetation) and

habitat classification (e.g.- water, coastal areas, roads) used during the first part of this thesis concerning the distribution of invasive plants on Terceira Island.

PI.5 Related to the introduction of foreign plant species to Terceira Island

Most participants, 220 out of 276 (80.3%) considered that the introduction of plant species might turn them into invasive species, and that this will become a health problem, an economic problem and a threat to local biodiversity of Terceira Island. In the 1-5 scale (1 - not concerned to 5 - very concerned) used to indicate their level of concern, most participants chose 4 (92 participants, 35%) or 3 (89 participants, 33.8%). Only 31 participants indicated that they did not consider this fact to be a problem, and from those who considered it to be a problem, only 7 described themselves as not concerned (1 within the 1-5 scale).

PI.6. Possibility of engagement in volunteer activities to promote nature conservation

A series of questions related to the possibility of the participants engaging in conservation activities to plant endemic species and/or to remove invasive alien plant species in different areas were presented. The participants answered according to a 1-5 scale (1- not willing to participate, 5- very willing to participate). The answers to these questions are presented in Table 13.

Table 13. Number of participants willing to participate in each type of activity according to the area where the activity will take place.

PI. 6 Willingness of engagement in conservation activities	In a protected area of Terceira Island (no. of participants within the 1-5 scale)	On the roadsides of your parish (no. of participants within the 1-5 scale)	In public gardens of your parish (no. of participants within the 1-5 scale)	At your own property (garden, others) (no. of participants within the 1-5 scale)
PI.6.1. Willingness to plant native species	1) 10 2) 15 3) 58 4) 87 5) 105	1) 22 2) 24 3) 64 4) 83 5) 80	1) 13 2) 20 3) 56 4) 88 5) 98	1) 12 2) 12 3) 35 4) 75 5) 140

Table 13 (Continuation)	In a protected area of Terceira Island (no. of participants within the 1-5 scale)	On the roadsides of your parish (no. of participants within the 1-5 scale)	In public gardens of your parish (no. of participants within the 1-5 scale)	At your own property (garden, others) (no. of participants within the 1-5 scale)
Pl.6.2. Willingness to remove invasive species	1) 20 2) 25 3) 73 4) 64 5) 92	1) 24 2) 26 3) 86 4) 59 5) 78	1) 23 2) 27 3) 84 4) 61 5) 78	1) 10 2) 13 3) 57 4) 64 5) 129

The following graphics (Figure 20 and 21) show the proportion of answers given for the proposed activities for the different areas:

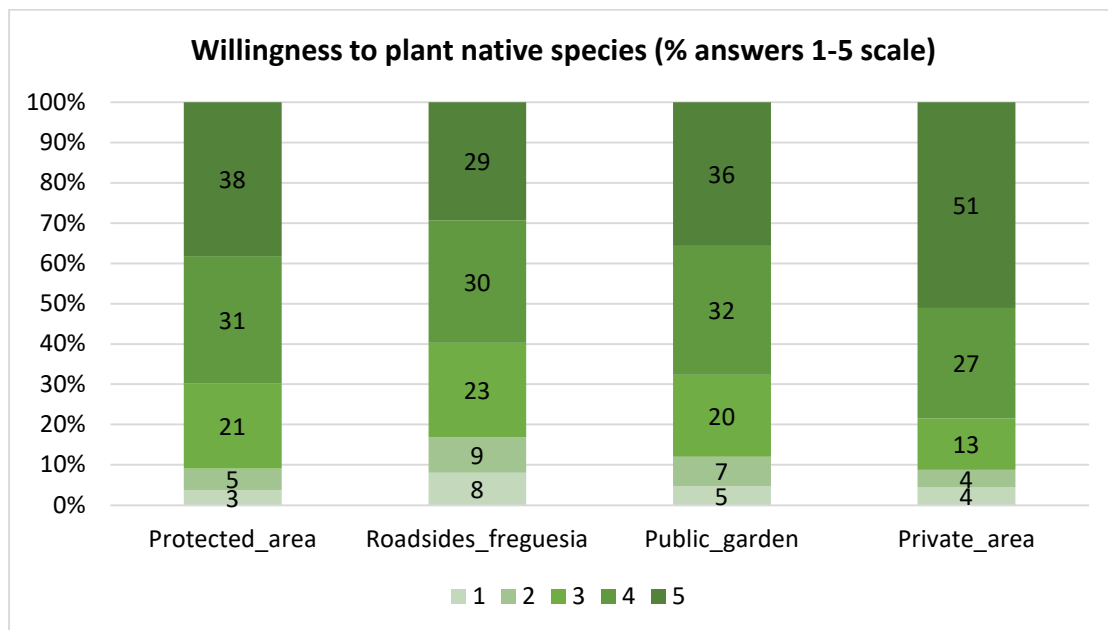


Figure 19. Proportion of participants willing to plant native species per area type

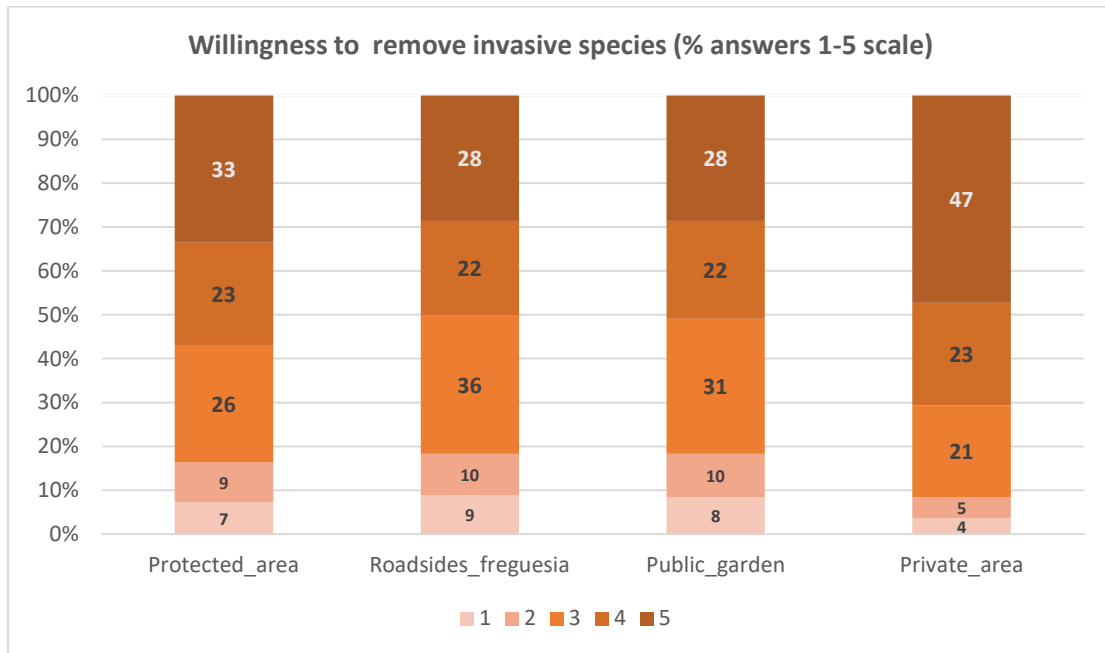


Figure 20. Proportion of participants willing to remove invasive species per area type

In both cases, participants were more willing to participate in activities in their own properties (a higher proportion chose 4 or 5), followed by activities in protected areas. For both activities, participants were less willing to act on the roadsides of their parishes (*parishes*). Participants were more willing to plant native species (more than 50% chose 4 or 5 for the four given areas) than to remove alien species, (a higher proportion chose 3 for roadsides and public gardens). For both activities, for all area types, a low proportion of participants (less than 20%) chose 1 or 2 on the scale.

In addition, the alpha's Cronbach calculated for the 1-5 scale showed a value of 0,815, indicating that the items (type of activity and type of area) have relatively high internal consistency and high reliability in the scale used.

The Principal Component Analysis (PCA) performed to investigate associations among the answers shows that two out of eight components explain more than 70% of the data variance.

The correlation matrix shows that there is a strong association ($R > 0.7$) between the willingness to “remove invasive alien plant species” and to “plant native species” in protected areas ($R = 0.725$); the willingness to “remove invasive alien plant species” and to “plant native species” in public gardens

($R=0.722$); and the willingness to “remove invasive alien plant species” in public gardens and roadsides ($R=0,889$).

The full outputs of the SPSS programme for the Principal Component Analysis (PCA) are presented in ANNEX 4.

The Chi-squared analysis performed in order to test the influence of the variables “sex”, “birthplace” (from the Azores/other), “educational level” (below bachelor/ bachelor or above), “academic background” (nature related/other), “type of birthplace” (rural/peri-urban/urban), “type of residence place” (rural/peri-urban/urban), and “belonging to an association” in the overall willingness to participate in the proposed activities showed a $p\text{-value} \geq 0.05$ for tests, meaning that there is no significant association between any of these variables and the overall willingness to plant native plants or to remove invasive plants.

The correlation test performed to check the influence of the “time of residence in the Azores” in the overall willingness to participate in the proposed activities showed that there is no association between the variables “time of residence” and the “willingness” to participate in any of the activities ($p\text{-value} \geq 0.05$).

The Chi-squared analysis performed to test the influence of the same variables mentioned above (“sex”, “birthplace”, “academic background”, “type of birthplace”, “type of residence place” and “being a member of an association”) and the willingness to participate according to area type, showed significant relationships between "academic background area" and "willingness to remove invasive plants" in Natural Parks ($p\text{-value}=0.09$). Participants with an academic background non-related to nature showed more willingness to remove invasive plants on protected areas. In addition, the Chi-squared test showed differences concerning the participants birthplace (Azores/other) and the willingness to remove invasive plants in Natural Parks ($p\text{-value}=0.006$), on roadsides ($p\text{-value}=0.023$), and in public gardens ($p\text{-value} =0.043$). Participants from the Azores are more willing to remove invasive plants in these habitats.

The full outputs of the SPSS programme for these analyses are presented in ANNEX 4.

PI.7-7.1 Previous experience in nature conservation/environmental activities

From the 138 participants who have had previous experience in this type of activities, 16 mentioned invasive species, 35 planting activities and 85 other activities, such as, litter removal, special campaigns or divulgation activities.

The Spearman correlation test was performed in order to investigate if there is a relationship between having previous experience in nature conservation activities and the willingness to participate in the proposed activities and showed a $R = -0.183$ and $p\text{-value} = 0.003$ for “plant native species”; and $R = -0.277$ and $p\text{-value} = 0.000$ for “remove invasive species”. There is a negative relationship between having previous experience in nature conservation activities and the willingness to participate in the proposed activities.

PI.8 Supporting environmental associations

Only 35 (13%) of the 272 participants who answered this question support environmental associations and most of them (24) support local entities. Among those 35 participants, 29 have previously participated in nature related activities (information collected in the previous question).

A Spearman correlation test was performed in order to investigate if there is a relationship between supporting environmental associations and the willingness to participate in the proposed activities (plant native plant species and remove invasive alien plant species). The test showed a $p\text{-value} > 0.05$ for both activities, meaning that supporting environmental associations and the willingness to participate in the proposed activities are not related.

PI.9. Favourite plant to represent Terceira Island

This question was answered by 202 participants that mentioned 33 different species. From those, *Juniperus brevifolia* was the favourite for 45 participants, followed by *Hydrangea macrophylla* (28 participants) and *Erica azorica* (26 participants). Most of the favourite plants mentioned are endemic species (139 participants mentioned 17 endemic species), followed by invasive plants (41 participants mentioned 4 alien invasive species).

The four invasive alien plant species mentioned (*Hydrangea macrophylla*, *Pittosporum undulatum*, *Cyathea cooperii* and *Hedychium gardnerianum*) are included in the list of invasive alien plant species of Terceira Island studied in the vegetation study of this work (Table 9). These species also presented high values of importance in Table 9. The proportion of plants voted by the participants according to their colonization status - endemic, native and alien (introduced not invasive, or introduced invasive) - are presented in Figure 22.

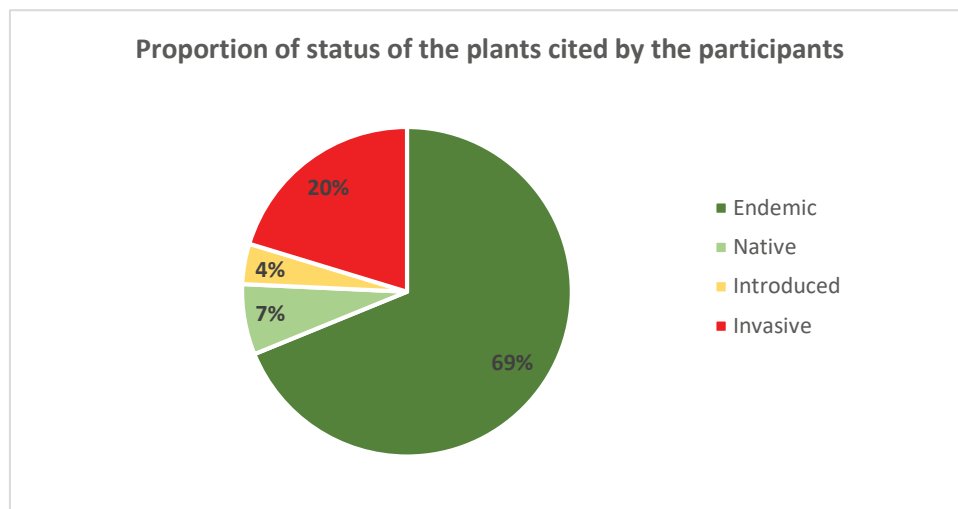


Figure 21. Proportion of participants favourite plants according to their colonization status

Different reasons to choose a particular plant were presented by 194 participants, mainly related to the beauty, rarity, endemism, importance, personal memories and symbolism regarding Terceira Island (Table 14).

Table 14. Number of participants per every type of reason behind their choice of a favourite plant to represent Terceira Island

Main reason	No. of participants
personal memories	5
rarity/unique	11
importance	14
symbolism	32
native/endemic	37
aspect/beauty	44
Other reasons (including a mix of the previous ones)	51

A Chi-squared test was performed to investigate if the fact of choosing a native or endemic plant species versus alien (invasive or introduced) species is related to some of the participants' characteristic, to test the hypothesis:

H0: having an educational level “above bachelor” or “bachelor or higher” does not affect to the fact of choosing native/endemic plants *versus* invasive/introduced plants

H1: having an educational level “above bachelor” or “bachelor or higher” affects to the fact of choosing native/endemic plants *versus* invasive/introduced plants;

H0: having an academic background “related to nature” or “non-related to nature” does not affect to the fact of choosing native/endemic plants *versus* invasive/introduced plants,

H1: having an academic background “related to nature” or “non-related to nature” affects to the fact of choosing native/endemic plants *versus* invasive/introduced plants;

And

H0: the “birthplace” of the participants does not affect to the fact of choosing native/endemic plants *versus* invasive/introduced plants,

H1: the “birthplace” of the participants affects to the fact of choosing native/endemic plants *versus* invasive/introduced plants.

The test shows statistically significant differences ($p\text{-value}\leq 0.05$) for the “academic background”, “educational level” and “birthplace” of the participants. Participants with an educational level of bachelor or higher chose more often endemic/native plants as their favourite to represent Terceira Island ($p\text{-value}=0.000$). Participants with non-nature related academic background were more likely to choose invasive/introduced plants as their favourite to represent Terceira Island ($p\text{-value}=0.001$). Participants from the Azores were more likely to choose native/endemic plants than those who are not ($p\text{-value}=0.000$). All SPSS outputs for these analyses are available in ANNEX 4.

Finally, the Mann-Whitney U test was performed to check if there is a relationship between knowing the colonization status of the plants (PI.4), and being more likely to choose native or endemic plants to represent Terceira island (PI.9.), to test the hypothesis:

H0: knowing a plant “colonization status” do not affect to the fact of choosing endemic/native plant

H1: knowing a plant “colonization status” affects to the fact of choosing endemic/native plant.

The test supports that the number of correct answers for the plant colonization status and choosing a favourite native/endemic plant are related ($p\text{-value}=0.000$). Participants with a higher number of correct answers in Question 4 (PI.4) for the plant colonization status were more likely to choose native/endemics plants as their favourites.

Overall, the statistical test performed support a relationship between different participants’ characteristics and the knowledge (acquired information), perception (based on personal experience) and attitudes (willingness to perform a specific action) towards invasive plants on Terceira Island and the Azores. Namely, the educational level, type of academic background and the birthplace of the Azorean participants are the main variables driving the results.

CHAPTER IV. DISCUSSION

This work, based on the data from the PhD work of Silva L. 2001, on citizen science data on invasive alien plant species of Terceira Island, and on the new data produced in this master's thesis, results in an update of the knowledge on the distribution and abundance of 30 invasive alien plants species of Terceira Island and represents an approach to locals' perspectives on the subject.

Concerning the different data sources used to produce the list of plants to be studied (Table 2) and the final list of the invasive alien plant species of Terceira Island (Table 9), it has to be highlighted the importance of the data quality coming from citizen science contributions for scientific and knowledge production purposes (Conrad & Hilchey 2011). The citizen science data considered in this study (Azorean Biodiversity Group database in contribution to Invasoras.pt) were gathered by volunteers with different types of background and knowledge level (visiting students and citizens from Terceira Island) and were validated by experts from the Azorean Biodiversity Group and the Invasoras.pt project. Therefore, these data were reliable and have been a major contribution to the species list used in this study (Table 2). These data were also the most recent available source of information for Terceira Island (Azorean Biodiversity Group database). This is an example on how citizens can contribute to different stages of science production for biodiversity conservation and invasive alien species monitoring purposes. Other studies, have also look at the reliability of data coming from citizens' contribution, concluding that volunteers and professionals can perform similarly in the monitoring of the most common and easily identifiable invasive species (Crall *et al* 2011, Cronje *et al* 2011).

Overall and accordingly to this thesis results, several variables, namely area protection status, altitude, roads network, type of habitats and land use, have been identified, both in insular and continental contexts, as important drivers of invasive species diversity (McKinney 2002, Silva & Smith 2006, Hejda & Pyšek 2009). In this case of study, this thesis results support that both, environmental and human components, determine the abundance and distribution of invasive alien plant species on Terceira Island. The identification of the most important variables in determining invasive alien plant species richness is crucial to define management measures to reduce invasive species establishment; as

it was done for the land use, the type of habitat, the altitude and the area conservation status in the present work.

Focusing on the environmental variables determining the presence of invasive alien plant species on Terceira Island, altitude plays a determinant role. The results of this study show that higher altitudes mean in general less presence of invasive alien species (Figure 6) both in terms of the number of species and their frequency (number of records per species). Also, higher altitudes mean better conservation status (most of the Natural Park sites of Terceira Island are found above 200 m.a.s.l.), less density or lack of human populations and human activities (e.g. farming activities), less land use dedicated to human-related activities, and less territory fragmentation due to the road network. Higher altitudes also imply fewer introduced vascular plants, as other studies in the Azores also indicate (Silva & Smith 2000, Moreira *et al* 2018).

In the cases where in high altitude a high frequency of invasive alien plant species was found, other environmental components, such as, habitat diversity and type, and land use, may play a dominant role. This is the case for quadrat number 7, located on the surroundings of Rocha do Chambre area. In this quadrat, only 8 out of 30 species were founded but very frequently. In this area, 5 out of the 8 types of habitats were found, including water-related habitats (*Ribeiras*) where the presence of these species was usually higher. Other studies also identified water presence as an important driver for invasive alien plant species (Marais *et al* 2004, Cavaleri & Sack 2010, Zehnsdorf *et al* 2015), which can be better water-use efficient and have a higher growth rate than native species under certain environmental conditions (e.g.- warm temperatures). The management of these invasive species in water-related habitats can be also more demanding (e.g. need for a higher level of stakeholders' engagement, such as landowners, and for more economical efforts to remove invasive alien plant species) (Bruno *et al* 2014). Nevertheless, although demanding in sources and methodologies, positive experiences can be also found in water-related habitats in the management of invasive alien plant species, such as, the eradication of *Arundo donax* (rank 4 in the list of Table 9) in riparian habitats of the Mediterranean context (Bruno *et al* 2014). The success of removing actions also requires the effective involvement, in the middle and long term, of local and regional stakeholders in land use management (Aguiar & Ferreira 2013, Flávio *et al* 2017).

"Altitude" was a variable also mentioned (explicitly or implicitly) by the participants in the online questionnaire. In relation to people's perspectives about habitat driving the presence of species, when participants were asked about the places where they usually see the native species shown in Question 4 (Table 11), they often mentioned "high altitudes", "interior of the island" (which is at high altitude) and "natural park" (which is mostly located at high altitude). This indicates that better conservation status related to altitude, and a higher presence of native species and lower presence of invasive species was also perceived by the inquired population.

In conclusion, altitude alone but also combined with other environmental and anthropogenic features drive the presence of invasive alien plant species on Terceira Island. This is reinforced by the Principal Component Analysis for Categorical Data where altitude is the variable that best explains data variance, but also land use, type of habitat and quadrat conservation status (protected/unprotected) are relevant to explain the variance of the results.

The dominant type of land use in the mentioned area of this study (Quadrat 7) is Pastures, which is also the overall dominant type in this study. Pastures present the higher total number of invasive alien plant species in the sites where they are dominant or where they appear combined with other types of land use (Mix land use). In addition to land use, differences in the number of species and frequency can also be explained by other factors, such as, temperature (lower temperatures in higher altitudes can difficult the spread of invasive species), or quadrat accessibility. In general, quadrats located at lower altitudes are more fragmented by the road network of Terceira Island and can be more susceptible to biological invasions as is further discussed in the text.

Concerning land use, as mentioned above, a high number of invasive species (out of 30) are found in Pastures. However, it is in Agricultural land use and Mix 1 and 2 (both with presence of Agriculture, Urban and Pastures) were the highest number of invasive alien plant species are found, taking into account the number of species found in relation to the number of quadrats located on each type of land use. In all cases, most of the species have an abundance value of 3 (forming groups). This can be explained by the relationship that seems to exist between areas with more human activities and with a higher presence of invasive alien species (Silva & Smith 2004). The mentioned value of abundance can

be also explained because of the qualitative nature of the scale of abundance used (1 to 5), which advantage is the reliability and consistency of the values of abundance attributed when used by different researchers, but could also gather values of abundance close to 2 and 4. In Barney *et al* 2013, it is discussed however, the difficulty to evaluate the impact of invasive species taking into account variables such as groundcover and geographical context because of general lack of mathematical framework that integrates combined metrics. For every land use type, the higher number of invasive species and records were strongly related to water presence (water streams or “ribeiras”) and habitat fragmentation (road network).

When studying the species ranking, no big differences were found for some of the species in comparison to the first list produced in the Methodology (Table 2) and to the study of Silva & Smith (2006) for the Azores. Also, some of these species found within the first half of the ranking in Table 2, occupied some of the first positions in this study namely, *Hedychium gardnerianum*, *Pittosporum undulatum*, and *Arundo donax*. However, the results of this thesis show that some of the species that had not a great representativeness in Table 2 present high values of importance in the results (Table 9). *Rubus ulmifolius* is the specie with the highest importance value in this study (rank 1, value of importance 13.9). This is very different from this species position in Table 2, where it only occupies position number 23 out of 30. However, this first raking position coincides with the rank in Silva & Smith 2006, where the species is also the first on the list. The differences found for this species between the rank in the Methodology table (Table 2) and this study results, could be explained by the variety of sources used to produce the first table, being that in some of studies the invasiveness of the species *Rubus ulmifolius* was studied in depth but in other studies it was not mentioned as relevant. In any case, comparing this study results to Silva L. 2006, this species seems to have the same importance for the Azores and for Terceira Island.

In addition, relevant differences were found for coastal species, such as, *Agave americana*, *Opuntia ficus-indica* and *Aptenia cordiflora*. These species occupy the last positions in the list produced in the results, with low importance values. The differences in the values of importance obtained could be explained, among other reasons, by the low number of quadrats located on coastal areas. In addition, it has to be taken into account the fact that Methodology (Table 2) was built according to the data

available for the most represented invasive species on Terceira Island and the Azores, while this study focuses only on Terceira Island. Some of the species, (e.g. *Agave americana*) might have a higher representativeness on the archipelago but not have such representativeness and importance on Terceira Island (although the species is present in some areas of the island which were not within the quadrats of the study, for instance, in Porto Martins area).

Related to habitat types, looking at the species shared by Silva L. 2006 and the list of the results of this study for Terceira Island (Table 9), *Rubus ulmifolius* had a higher importance on road networks in Silva L. 2006, coinciding with this study for Terceira Island. In Terceira, it was also frequently found on cultivated areas and crops. *Pittosporum undulatum* appeared mainly in the woods for both studies and also in hedgerows in Silva L. 2006. The species *Hedychium gardnerianum* had higher importance on the road networks and water streams in Silva L. 2006 study, but it appears mainly in the woods in the current study for Terceira Island. *Mentha suaveolens* appears mainly on the road network in both studies, and it also has a high importance in pastures in Silva L.2006. *Conyza* sp appears mainly on the road network for both studies but it is also very frequent in uncultivated areas in the current study for Terceira Island. *Tradescantia fluminensis* appears mainly on the road network in both studies and in water streams in this study for Terceira Island. *Arundo donax* has the best representativeness on the coast (low altitudes) and hedges of cultivated areas in both studies. *Acacia melonxylon* appears mainly in the woods for both studies. *Persicaria capitata*, *Phytolacca americana* and *Erigeron karvinskianus* appear occur mainly on the road network for both studies; and finally, *Cynodon dactylon* also appears on road network in both studies and also on the coastal area when comparing to Silva L. 2006. Similarities were expected for the best documented plants for Teceira Island and the Azores (ANNEX 1) and the differences can be explained by quadrat randomization in both studies, and by the number of quadrats on coastal areas for this study on Terceira Island.

In most cases, those shared species were found in this study on Terceira Island in quadrats dominated by Pastures or Mix land uses including pastures, agricultural and urban type of land uses. These land use types were fostering a high number of invasive species (out of 30) in the vegetation study. Species were dispersed or formed groups, being the most common abundance value for these shared species 2 or 3. There is an exception, *Tradescantia fluminensis*, which was only found 16 times in

this study on Terceira Island, but frequently with an abundance value of 4. In these cases, species appeared covering a large extension of the woods ground or the slopes of water streams. Overall, habitats that better determine the presence of these species for Terceira Island are road network and the presence of Pastures, which is in line with Silva L. 2006 study, but also habitats related to water streams. In general, land uses related to human activities (Agriculture, Pastures) and the presence of human infrastructures in water stream habitats, such as, walls and hedgerows favour the presence of invasive alien species because it is in these areas where the species were first and more likely to be introduced (Silva L. 2006, Exposito *et al* 2018).

Other studies (Harrison *et al* 2002, Barton *et al* 2004, Mortensen 2009) also point to the differences in invasive alien plant species richness and abundance in some of the habitat types studied in this master's thesis (roadsides and road network, water-related habitats, native forest). The distribution and abundance of invasive alien plant species is influenced by landscaped features and habitat suitability. However, they point out that habitats that act as corridors (e.g. roads, *ribeiras*) drive diversity and abundance of invasive alien plant species, but not necessarily the spread to other areas (e.g. crops and pastures surrounding water streams). In further studies for Terceira Island it would be necessary to establish additional level of categorizations at habitat and species level, in order to determine how the habitat influences invasiveness, in order to design effective prevention and management practices aimed at limiting abundance and spread of invasive plants. In addition, those studies indicate that for woody invasive alien plant species, abundance increases gradually in proximity to urban areas, suggesting a close association between local horticulture and the spread of those invasives.

In general, small remote oceanic island have a low rate of colonization by new species; however, the anthropogenic introduction of alien species has inverted this trend over time (Moser *et al* 2018). One of the main biases in decision-making towards invasive alien species is that even though research supports a better understanding of the ecology and distribution of invasive alien species, the negative effects on ecosystems takes time to be understood by the population, and in many cases, it is too late to counter the environmental impacts (Simberloff *et al* 2018). Nevertheless, places like Terceira Island, with small population size and geographically isolated, can have a leader role in the management and prevention of invasive species introduction, involving the local population in taking action (Champion

2017 2018). The results of the vegetation study in this master's thesis show that the variables that best determine the presence, abundance and distribution of the 30 invasive alien plant species on Terceira Island studied are related to human activities, land use and habitat type (more or less altered by humans), together with environmental variables (altitude). Therefore, this should be taken into account when promoting activities that involve citizens' participation on Terceira Island. In this sense, the online survey through questionnaire, provides an overview about locals' perceptions about invasive alien plant species on Terceira Island and in the Azores.

The opening question of the online questionnaire gave a first insight about participants' memory of "introduced plants in the Azores" (quote used as stimulus). The results show different type of words, including adjectives and names of plants. Namely, *Conteira* and *Hortênsia* are part of the collective memory of the inquired group being also cited among the favourite plants that represent Terceira Island (Question 9). It seems that these two species can represent opposite thoughts among the participants, either in terms of invasiveness, or as nature symbols of the island, even though some participants were also aware of the invasiveness of these plants (as the number of correct answers for the conservation status of the plant in Question 4). One possible reason behind this ambiguity is that is more difficult to perceive the risks associated to ornamental plants, being citizens more familiar with these plants perceived benefits (e.g. beauty), as suggested in Humair *et al* 2014. In these cases, scientific evidence can be in conflict with population' perceptions. Therefore, risk communication strategies should focus on stakeholders (e.g. horticulturist) to promote the mandatory trade regulation related to invasive plants species and focus on the negative impacts of harmful species that can be best perceived by the local population.

The stimulus given mainly brought alien plant species to the minds of the participants, including invasive species, along with some more specific connotations, either negative among the words less sensitive to the context (*invasoras, infestantes, praga*), or positive but more sensitive to the context since they do not belong to the central quadrant (*economia, beleza, novidade*). Different types of words (name of plants, adjectives, etc) and meanings were expected, given the diversity of entities to which the link containing the online questionnaire was sent. However, it has to be highlighted that 10 out of the 30 invasive alien plant species of Terceira Island studied here (Tables 2 and 9) were mentioned by

the participants. This reveals a certain level of knowledge about the topic among the participants, including the perception of species introduction. In this case, this level of knowledge seems to be explained by the academic background, which had influence in the number of words cited, being higher for the participants with academic background related to nature. On the opposite of what was expected, no influence was found for the educational level and the place of birth of the participants, i.e., having a higher educational level or being born in Terceira/Azores did not translate into more words being cited. Also, the average number of words per participant was low (given the possibility of cite a maximum of 5, the average was below 4). This can indicate that the perception of the topic of introduced species is not settled homogeneously among the participants, however, in the contrast zone of the word analysis is where more information about these differences was found.

In addition, the type of academic background also influences the choice of environmental problems in the Azores directly or indirectly related to biological invasions, namely the introduction of foreign species, the loss of native and endemic biodiversity, and habitat fragmentation due to human activities. Related to the last environmental problem, the vegetation study of this master's thesis also showed that a higher number of invasive species were found in habitats and land use with higher level of fragmentation due to human activities (road network, presence of pastures, agriculture). The type of academic background was also the main variable influencing assigning responsibilities of these environmental problems to the Government of the Azores and the Municipalities of Terceira Island.

In contrast, educational level, together with academic background, drove the results in Question 4 (photographies of Azorean plants). Participants with higher educational level and/or academic background related to nature were more likely to choose the correct options for this question, meaning that greater specific knowledge related to invasive species (in this case name of the plant and colonization status) resulted in a better chance to correctly identify the plant species on the pictures. This is opposite to the already mentioned study of Cronje and colleagues (Cronje *et al* 2011), that concluded that knowledge acquired through previous training did not influence participants performance when evaluating instruments to assess the effect of training in invasive species monitoring, but their self confident in the development of the task. However, for the participants in this study, the

academic background and educational level did have an influence in the ability to correctly identify plants.

Arundo donax and *Hedychium gardnerianum* were the invasive species whose name is best known and *Cyathea cooperii* and *Pittosporum undulatum* are the plant species for which the colonization status is best known, although *Cyathea cooperii* was often confused with palm trees. *Arundo donax*, *Hedychium gardnerianum* and *Pittosporum undulatum* have a high level of importance in the vegetation study (Table 9). In contrast, related to the colonization status of the plant, participants had a higher number of correct answers for native species. This could be explained by the lack of knowledge on the birthplace of plant species to which the participants are familiar with in urban and semi-urban environments (common ornamental plants as the mentioned species), in line with other studies (Humair *et al* 2014). A positive correlation between the correct name and colonization status of a plant means that when people know the plant, they also usually know if it is a native or introduced species. In addition, other studies (Gardiner *et al* 2012), show that for activities that involve the identification of species, people with a certain level of expertise and people with non-nature related background perform similarly for common well know species. However, misidentifications are common for less common species when identified by non-experts. This can be the case for *Cyathea cooperii* in Question 4, often confused with palm trees by people with a lower educational level (under bachelor). This species also ranked low in importance in the vegetation study (Table 9), being less representative on Terceira Island than other invasive species of the list. This species was found both in low altitudes (in private gardens) and in high altitudes on hiking trails and mixed with natural vegetation. This could explain the dichotomy of answers given for this species.

Many of the habitats mentioned in Question 4 by the participants (Table 11), excluding very specific locations, coincided with types of land use (e.g.- Mixed, Agricultural, Natural Vegetation) and the habitat classification (e.g.- water, coastal areas, roads) used during the vegetation study. This fact means that participants are able to associate the invasive plants presented in the photographs to their habitats. This general knowledge about the location of the most invasive plants can be very useful for surveillance campaigns and collection of scientific data, even when provided by non-expert collectors given that they should have an academic background related to nature and/or a high educational level. The study above

mentioned of Gardiner and colleagues (Gardiner *et al* 2012), showed that concerning the participation of citizens in the identification of invasive species, after basic training in the topic, amateur participants were able to perform similarly to experts, which can be useful not only for identifying the plant but also its habitat.

As expected, participants with a nature-related academic background (i.e., having a greater knowledge and/or being more familiar to the topic of biological invasions) also showed a higher awareness about invasive alien plant species in the Azores and the environmental problems they may cause. However, participants with academic background non-related to nature were more likely to point responsibilities in the management of these problems to the regional and local authorities, while those with higher awareness and nature-related academic background pointed also to scientists and citizens. However, these results should be interpreted with caution, since a higher awareness does not mean necessarily a higher willingness of engagement. The results of this thesis also showed that participants with previous experience in environmental activities were not more willing to get involved in the proposed activities (planting native plants and removing invasive species). So, not only previous knowledge, but also willingness and motivations of citizens to participate should be taken into account when promoting these types of activities.

In general, participants were more willing to plant native species than to remove alien species. For both activities, participants were less willing to act on the roadsides of their parish. However, this type of habitat (related to the road network) is one of the most affected by the presence of alien species according to the vegetation study (see Table 6). One reason that could stand behind these preferences is that planting activities can be more rewarding for younger participants (most of the participants in the online questionnaire were between 26 and 31 years old) since, according to other studies (Bremner 2007) their perceptions about nature conservation differ from older people who usually can be more aware of the need of active management of biodiversity (e.g. tackling or removing invasive species). In addition, for both activities, participants were more willing to participate in the activities in their own properties, followed by activities in protected areas. This should be taken into account when promoting this type of activities on Terceira Island, since is in their private properties where participants can have the highest engagement level and decision capacity.

Participants with an academic background non-related to nature showed more willingness to remove invasive plants on protected areas, and therefore these could be a good starting point to engage people in these activities. People seem to value the need to keep habitat conservation status and to protect the natural park, but it should also be taken into account that this result may reflect the fact that in well protected areas less effort is needed to "fix" this problem since there are less invasives to be removed. Also, the natural park can be a more attractive context to develop this type of activity than other places (e.g. roadsides) so that can be considered as the starting point, as mentioned, but not to be limited to, since the need of management of the issue goes beyond the natural areas.

Related to the birth place of participants, Azoreans showed more overall willingness to participate in these activities than those birthplaceally from elsewhere, namely on protected areas, private areas, public gardens and roadsides. This result could be explained by the place identity factor. Different studies (Niemiec *et al* 2016, Hausmann *et al* 2016) explain how locals' emotional connections to the place of residence or birthplace, that can link ecological and social issues, are important for understanding their level and willingness of engagement in invasive species control efforts. This result is indeed important for the effective design of engagement campaigns, and because it is nearby or in the urban environment where many species (more or less appreciated) are usually introduced for some specific reason (ornamental, soils stabilization, etc) and end up causing negative effects. Thus, it is important to understand the perceptions of inhabitants of these areas about these plant species in order to determine the need of management in urban or semi urban environments and to provide citizens with suitable options of engagement. As in other studies via online questionnaires (Potgiete 2019), urban residents in the Azores with higher education level and awareness about invasive alien species were more likely to support control actions in urban environments than those with lower educational level, or lower level of general awareness. Overall, the type of activity and the type of habitat where the activity takes place matters and can drive the willingness to participate in such activities, being this willingness driven by different participants' factors.

Having previous experience in conservation activities had no influence in the overall willingness to participate in planting and removing plant activities in the Azores. However, other studies show that people who participate in these types of activities show more pro-environmental attitudes after

participating (Bonney *et al* 2009a, Crall *et al* 2013). The overall willingness can be driven by people's motivations and role in the activity development rather than by knowledge. In any case, positive attitudes are found in this study for Terceira Island and the Azores, which are necessary to further stimulate behavioural change after the participation in conservation activities. However, further studies with combined methodologies are necessary to report and monitor the behaviour change trends in the long term.

When choosing a plant that represents Terceira Island, participants with an educational level of bachelor or higher chose more often endemic/native plants; and participants with non-nature related academic background were more likely to choose invasive/introduced plants, namely *Hydrangea macrophylla*, *Pittosporum undulatum*, *Cyathea cooperii* (which was often confused with palms in Question 4) and *Hedychium gardnerianum*. Participants from the Azores were more likely to choose native/endemic plants, meaning that belonging to a place has an influence in how well people know local nature. However, in this question place identity can play a double role, driving the choice of native/endemic species among participants with a higher level of awareness on one hand, and the choice of invasive/introduced by those with less knowledge who appreciate ornamental plants (*Hortensia*, *Conteira*, *Feto arboreo*) and are oblivious to the risk some these species pose.

Other studies (Sharp *et al* 2011) support the results of this thesis in the importance of education level to perceive the threat that invasive species pose, as well as that attitudes are good indicators of the willingness of engagement in management activities. The results of this thesis can help deciding what steps should be followed to overcome biases in population's perceptions, including developing targeted education and communication campaigns and may provide a better understanding of the motivations that drive people's behaviour in the medium and long term.

Few participants were totally unwilling to get involved in the proposed activities in the online questionnaire. The reasons behind this could either be due to a lack of recognition of the negative impacts of invasive species, or because they do not consider the introduction of exotic species to be an important process on islands, as other similar studies developed in Mediterranean Islands suggest (Bardsley & Edwards-Jones 2006). There is a need to better understand the particular impacts of

invasive species in order to raise awareness among the population, so that they will be better equipped to make effective decisions about where and how invasive exotic species should be managed. If a raise of awareness occurs, it is expected to result in greater support among the local populations for control programs.

Raising awareness is also essential to ensure the right key stakeholders engagement in the management and control of invasive alien species. In many cases a low level of engagement and awareness comes from the lack of perception of the importance of a person's own role, i.e, people often fail to recognize themselves as relevant stakeholders (Reaser 2018). In this sense, the combination of exploratory methodologies, such as the online survey of this study to get a general insight on the population's perceptions about the topic on Terceira Island, with others (e.g.- Q method, surveys through questionnaire face-to-face) can not only help to identify stakeholders, but more importantly, make them aware of their potential role (Vass *et al* 2019). In addition, qualitative analyses, such as the ones used in this thesis, can be an advantage in the analysis of people perspectives and attitudes but these are in general less used to detect trends driving people perceptions about invasive species (Kapitza *et al* 2019). Furthermore, the aforementioned study (Kapitza *et al* 2019) corroborates common bias (e.g. the perception of how species can be dangerous or how they can have a negative effect in the long term) on those perceptions not only among the general public, like in this thesis study, but also among specific types of stakeholders.

In many cases, traditional environmental educational programmes focus on influencing people's capabilities as driver of behaviour (Reaser 2018). However, other strategies such as communication outreach awareness campaigns should put the focus in people's identity as stakeholders (e.g. gardeners, educators, nature sport professionals, airport workers, politicians) to raise their willingness to take action in the situations that are familiar to them.

Other study (Prinbeck *et al* 2011) identified some of these biases in local stakeholders' perception (e.g. gardeners, farmers) pointing that people can be more concerned about other environmental

problems (e.g. pesticides) than invasive alien species, at the preoccupation for the economical effort needed for the management of the invasive species, at preventive behaviors that seem to be too difficult to perform, and at the lack of prioritization by local or regional institutions for this problem. This is important not only to support local actions, but also actions at a national level, since national authorities are legally obliged to report, monitor and manage specific invasive species (e.g. in the case of the invasive alien species of European Union concern through the Regulation (EU) No. 1143/2014), even though key stakeholders, and citizens in general, seem not to be aware enough of these legal obligations.

Shackelton *et al* 2019, also pointed at land use transition from urban to rural landscapes in the perception of problematic areas where invasive species should be managed. This change in perception along an urban-rural gradient is linked to the level of impact of invasive species in certain landscapes and type of habitats, the level of altered territory that can be more or less perceived as natural or not, and the level of appreciation of landscape aesthetics by the population. Invasive alien plant species change along an urban-rural gradient on Terceira Island should be taken into account for decision-making in the management of those species, since changes in land use also influence different stakeholders' perceptions, although further research is needed on this topic.

Overall, this master's thesis support the idea that the management of plant invasions, namely invasive alien plant species on Terceira Island, should not only be addressed from an ecological perspective, but from a human component as well. A holistic approach should be taken when promoting eradication programmes, which should include not only assessment and removal, but if possible, also restoration to safeguard native diversity and ecosystems of Terceira Island, always making sure to engage and involve the local population in these actions in the long term.

Recent developed guidelines for invasive species planning and management on Islands (IUCN 2018), corroborate that in many cases, people on islands (citizens and relevant stakeholders) are not aware of which common species are introduced or native in their surroundings, gardens and cities. Therefore, that they do not give the necessary importance to the management and rapid eradication of new

population of invasive species. For governments to take responsibility, they need to have access to the most updated scientific information on the topic and understand public perceptions. Ideally, all stakeholders (governments, NGOs, the private sector and the general public) should get involved in preventing and managing invasive species. The above mentioned report (IUCN 2018) also points that governments on island usually do not have enough technical capacity and resources to handle the problem, and often are not fully aware of the damage caused by invasive species in their environment. Thus, it is necessary to increase public and political awareness of the problematic, focusing in the realization of the damage caused by invasives species and what they can do to prevent it. Communication strategies aiming at promoting behaviour changes should focus on decision-makers, local communities, NGOs and businesses, and children (building future social consciousness), and must be specifically tailored for each target group.

Overall, locals with university educational level seem to be aware and have knowledge about invasive plants species on Terceira Island. However, the interpretation of the results of this master's thesis should take into account the bias in the methodology used to study population perceptions: online questionnaire only available to internet users. In general, this awareness seems to be increasing in general among the Portuguese population as well (Marchante & Marchante 2016). In both national and local levels there are some biases in the type of public that this topic reaches. Since citizens' engagement is needed to support policies to improve the monitoring, control and prevention of invasive alien species, more work has to be done in order to expand the audience of this topic through the already mentioned dedicated activities and communication strategies.

In support of these communication strategies, currently more tools are being developed to facilitate citizens' engagement in the reporting and monitoring of invasive alien species, namely smartphone apps and participatory online platforms at different geographical levels, such as the ones developed by the Invasoras Project in Portugal, and European Alien Species Information Network (European Commission) with the apps "Plantas Invasoras" and "Invasive Alien Species in Europe", respectively. In addition, relevant online resources of biodiversity information combine data from expert and non-expert participants, such as the Global Biodiversity Information Facility (GBIF), where it is estimated that around 50% of the records and 10% of the datasets come from citizens contributions.

These citizens' contributions are important since they can support the monitoring of invasive alien species and the development of new research studies that allow improving the knowledge about invasive alien species.

Minimizing the impact of invasive alien species on islands requires intensive researcher to provide reliable information on the environmental and socioeconomic consequences of invasive alien species to be made available to locals and policy makers (Reaser *et al* 2007), and to facilitate their engagement in the management of the problem. In this sense, more efforts in transdisciplinary research (e.g. biology and social sciences) are needed to identify information gaps in order to define the bases for the development of policies to minimize the impact of invasive species on islands contexts. Policies promoting invasive plants removal should include population's perspectives, to ensure the positive perception of the action and local support. (Van Wilgen 2012, Williams *et al* 2019). Conservation successful stories managing invasive species on islands exist, and owe much to people engagement (e.g. through job creation), political support and scientific evidence.

CHAPTER V. CONCLUSIONS

The following conclusions can be drawn from the results of this master's thesis:

- periodical update of information on invasive alien plant species on Terceira Island based on past and present data is necessary to provide state-of-the-art knowledge to support policy-making for the management of invasive alien plant species, and to spot differences with the rest of the arquipelago;
- diversity, distribution and abundance of the invasive alien plant species on Terceira Island are influenced by anthropogenic variables (land use, protection of areas), together with environmental factors. Pastures, Mixed land uses, gradients between land uses, and habitats that can act as corridors drive the occurrence of those species and should be further studied to act at invasive species, land use and stakeholder levels altogether;
- the population of Terceira Island (and the Azores) is familiar and has general knowledge about the problematic of invasive alien plant species. However, this knowledge does not lead necessarily to a higher level of engagement in the long term; and place identity plays a double and opposite role in the appreciation of the local flora. Knowledge gaps between the different types of publics should be further defined to increase their awareness about the local flora;
- New approaches through effective communication strategies should be developed focusing on people's motivations and their role as stakeholders to complement traditional environmental education, based on formal education programs, and experience in conservation activities are useful to raise awareness among locals but not to keep their level of engagement in environmental activities over time.; and
- transdisciplinary studies are useful and should be further developed to continue counteracting the biases between ecological and social approaches in the study of invasive alien plant species, namely on Terceira Island. Special focus should be put on the engagement of local authorities and citizens, on key stakeholders' perceptions, and on the land use gradients (e.g., between urban and rural environments) to define management priorities, taking into account that all of these items can change over time.

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ANNEXES

Note: Due to the versions of the softwares used during the statistic analysis performed for this master's thesis, they were originally pre-configured in languages different than English. Thus, the outputs of the Word Analysis in Evocation 2003 are in French with the answers provided by the participants in Portuguese. The SPSS outputs are in English and Spanish (with the name of the variables in English). When it comes to values that include decimals, values in English express decimals as (.) and in Spanish as (,).

ANNEX 1. BIBLIOGRAPHIC REVIEW OF THE INVASIVE PLANTS ON TERCEIRA ISLAND AND THE AZORES

Species	Silva & Smith 2006 Article (from PhD of reference)	Book TOP 100 IAS in Macaronesia (Citation considered only for Terceira Island)	Database of the Azorean Biodiversity Group in contribution to Invasoras.pt project	Dec. Lei 565/99 Portugal	DLR 15/12 Açores	Pysek <i>et al</i> 2017 article	No. of times that the species is cited (sum)
<i>Arundo donax</i> L.	1	1	1	1	1	1	6
<i>Conyza bonariensis</i> (L.) Cronq.	1	1	1	1	1		5
<i>Lantana camara</i> L.		1	1	1	1	1	5
<i>Phytolacca americana</i> L.	1	1	1	1	1		5
<i>Pittosporum undulatum</i> Vent.	1	1	1	1	1		5
<i>Tradescantia fluminensis</i> Vell.	1	1	1	1	1		5
<i>Acacia melanoxylon</i> R. Br.	1	1	1	1			4
<i>Agave americana</i> L.	1, including Terceira Island	1	1	1	1		4
<i>Aptenia cordifolia</i> (L. fil.) Schwantes		1	1	1	1		4
<i>Carpobrotus edulis</i> (L.) N. E. Br.		1	1	1	1		4
<i>Conyza canadensis</i> (L.) Cronq.		1	1	1	1		4
<i>Erigeron karwinskianus</i> DC.	1	1	1	1			4
<i>Hedychium gardnerianum</i> Sheppard ex Ker Gawl.	1	1	1		1		4

Species	Silva & Smith 2006 Article (from PhD of reference)	Book TOP 100 IAS in Macaronesia (Citation considered only for Terceira Island)	Database of the Azorean Biodiversity Group in contribution to Invasoras.pt project	Dec. Lei 565/99 Portugal	DLR 15/12 Açores	Pysek <i>et al</i> 2017 article	No. of times that the species is cited (sum)
<i>Oxalis pes-caprae</i> L.		1	1	1	1		4
<i>Ricinus communis</i> L.		1	1	1		1	4
<i>Salpichroa organifolia</i> (Lam.) Baillon.	1, including Terceira Island	1	1	1	1		4
<i>Araujia sericifera</i> Brot.		1	1	1			3
<i>Argeratina adenophora</i> (Spreng.) R. M. King & H. Rob.		1	1		1		3
<i>Drosanthemum floribundum</i> (Haw.)		1		1	1		3
<i>Hydrangea macrophylla</i> (Thumb.) Ser.		1	1	1			3
<i>Ipomoea indica</i> (Burm.) Merr.		1	1		1		3
<i>Mentha suaveolens</i> Ehrh.	1		1		1		3
<i>Polygonum capitatum</i> Buch.-Ham.Ex D.Don.	1		1		1		3
<i>Rubus ulmifolius</i> Schott	1		1		1		3
<i>Solanum mauritianum</i> Scop.	1, including Terceira Island	1	1		1		3
<i>Ulex europaeus</i> L.		1	1		1		3
<i>Cynodon dactylon</i>	1				1	1	3
<i>Opuntia ficus-indica</i> (L.) Mill.	1, including Terceira Island			1		1	2
<i>Ulex minor</i> Roth.		1	1		1		3
<i>Cyathea cooperii</i> (Hook. Ex F. Muell) Domin		1	1				2
<i>Cyrtomium falcatum</i> (L. f) C. Presl		1	1				2

1=cited in the bibliographic reference

Blank=not cited in the bibliographic reference

ANNEX 2. SPSS OUTPUTS FOR THE STATISTIC ANALYSIS OF THE VEGETATION STUDY - ALTITUDE

Kolmogorov- smirnov test for the Normality of the values of the altitude:

Resumen de contrastes de hipótesis

	Hipótesis nula	Prueba	Sig.	Decisión
1	La distribución de Altitude_ average es normal con la media 290,114 y la desviación estándar 203,48.	Prueba de Kolmogorov-Smirnov para una muestra	,046 ¹	Rechace la hipótesis nula.
2	La distribución de Number_ sightings es normal con la media 37,114 y la desviación estándar 15,80.	Prueba de Kolmogorov-Smirnov para una muestra	,058 ¹	Conserve la hipótesis nula.
3	La distribución de Number_ species es normal con la media 11,886 y la desviación estándar 3,97.	Prueba de Kolmogorov-Smirnov para una muestra	,134 ¹	Conserve la hipótesis nula.

Se muestran significaciones asintóticas. El nivel de significancia es ,05.

¹Lilliefors corregido

Spearman correlation test for the number of species related to the altitude:

Rho Spearman Correlations		
		Number_species
Altitude_ average	Correlation coefficient	-,553**
	Sig. (bilateral)	,001
	N	35

Resume of the Model				
Model	R	R square adjusted		Standard error
1	,619 ^a	,364		3,164

a. Predictors: (Constant), Altitude_ average

Spearman correlation test for the abundance related to the altitude:

Coefficients ^a				
Model		Standard error	Coefficients standardized	Sig.
			Beta	
1	(Constant)	,941		,000
	Altitude_average	,003	-,619	,000

a. Dependent variable: Number_species

			Altitude	Abundance
Rho	Altitude	Correlation coefficient	1,000	,042
		Sig. (bilateral)	.	,161
		N	1089	1089
Spearman	Abundance	Correlation coefficient	,042	1,000
		Sig. (bilateral)	,161	.
		N	1089	1089

ANNEX 3. WORD ANALYSIS – EVOCATION SOFTWARE OUTPUTS (PI Questionnaire):

Les 3 colonnes correspondent respectivement:

au Mot

à sa Fréquence

à son Rang Moyen

Le Fréquence minimale des mots est 6

Cas ou la Fréquence ≥ 10

et

le Rang Moyen $< 2,6$

Camelias	21	2,476
Conteira	71	2,465
Criptomeria	61	2,033
Diversidade	22	2,591
Endemicas	12	2,250
Estrangeiras	19	2,263
Exoticas	25	1,720
Hortensia	109	1,881
Invasoras	75	1,813
Ornamentais	11	2,091
Palmeira	11	1,818

Cas ou la Fréquence ≥ 10

et

le Rang Moyen $\geq 2,6$

Acacia	14	3,643
Cana	11	4,000
Eucalipto	30	3,033
Incenso	46	2,696
Infestantes	11	2,818
Praga	14	3,000

Cas ou la Fréquence < 10

et

le Rang Moyen < 2,6

Homem	6	2,167
Natureza	6	2,500
Novidade	9	2,111
Trazidas	6	1,333

Cas ou la Fréquence < 10

et

le Rang Moyen >= 2,6

Adaptação	6	3,500
Ameaça	9	2,667
Araucaria	9	3,111
Azalea	9	3,333
Beleza	8	3,000
Chorão	7	4,000
Competição	8	3,250
Economia	6	3,000

Fetos	6	3,500
Flores	9	4,000
Pinheiro	6	3,833
Utilidade	6	3,500

OUTPUT EVOCATION. WORD ANALYSIS (PI Questionnaire)

ENSEMBLE DES MOTS	RANGS						
	:FREQ.:	1 *	2 *	3 *	4 *	5 *	
Abandono	:	1:	0*	0*	0*	1*	
Abrigos	:	1:	0*	0*	0*	1*	
Acacia	:	14:	2*	1*	1*	6*	4*
		moyenne : 3.64					
Adaptação	:	6:	0*	2*	1*	1*	2*
		moyenne : 3.50					
Agave	:	2:	1*	0*	0*	1*	
Agricultura	:	5:	0*	0*	3*	1*	1*
Alegria	:	1:	0*	0*	0*	1*	
Alfazema	:	1:	0*	0*	0*	1*	
Alimentação	:	1:	0*	0*	0*	1*	
Alterações	:	4:	1*	0*	1*	1*	1*
Ambiente	:	3:	0*	1*	0*	2*	

Ameaça : 9: 1* 3* 3* 2*
moyenne : 2.67

Americanos : 1: 0* 1*

Ananas : 1: 1*

Araucaria : 9: 1* 2* 3* 1* 2*
moyenne : 3.11

Araçazeiros : 1: 0* 1*

Arbustos : 1: 0* 0* 0* 0* 1*

Artificial : 2: 0* 1* 1*

Arvore : 2: 0* 0* 1* 0* 1*

Aves : 2: 0* 0* 1* 0* 1*

Azalea : 9: 0* 3* 1* 4* 1*
moyenne : 3.33

Azeda : 2: 0* 0* 1* 0* 1*

Bananeira : 2: 1* 0* 0* 1*

Banksia : 1: 0* 0* 0* 1*

Batata : 5: 1* 2* 0* 1* 1*

Baterraba : 1: 0* 0* 1*

Beladona : 1: 0* 1*

Beleza : 8 : 1* 1* 4* 1* 1*
 moyenne : 3.00
 Benefico : 1 : 0* 0* 0* 0* 1*
 Bom : 2 : 1* 0* 1*
 Brçcolos : 1 : 0* 0* 0* 1*
 Burocracia : 1 : 0* 0* 1*
 Cactos : 3 : 0* 1* 0* 2*
 Cafe : 2 : 2*
 Camelias : 21 : 3* 7* 9* 2*
 moyenne : 2.48
 Cana : 11 : 0* 1* 3* 2* 5*
 moyenne : 4.00
 Caracteristicas : 1 : 1*
 Caravelas : 1 : 0* 1*
 Cedro : 2 : 0* 1* 0* 1*
 Cenoura : 1 : 0* 0* 0* 0* 1*
 Cereais : 1 : 0* 0* 0* 1*
 Chazeiro : 1 : 1*
 Cheiro : 1 : 0* 0* 0* 0* 1*

Chorão : 7: 0* 1* 1* 2* 3*
moyenne : 4.00

Ciencia : 1: 0* 0* 0* 0* 1*

Clima : 1: 0* 1*

Clonagem : 1: 1*

Combate : 1: 0* 0* 0* 1*

Comercio : 1: 0* 1*

Competição : 8: 0* 2* 3* 2* 1*
moyenne : 3.25

Conteira : 71: 20* 21* 14* 9* 7*
moyenne : 2.46

Coquilho : 1: 1*

Cor : 2: 0* 0* 1* 1*

Cravo : 2: 1* 0* 1*

Criptomeria : 61: 23* 20* 13* 3* 2*
moyenne : 2.03

Cuidado : 1: 1*

Cultivares : 1: 0* 1*

Cultura : 1: 0* 1*

Curiosidade : 1: 0* 0* 1*

Descobrimentos : 2 : 1* 0* 1*

Desconhecimento : 3 : 0* 0* 2* 1*

Descontrole : 4 : 0* 0* 0* 1* 3*

Desequilíbrio : 2 : 0* 1* 1*

Desnecessario : 1 : 1*

Desrespeito : 1 : 0* 0* 1*

Destruição : 4 : 0* 3* 0* 0* 1*

Diferente : 3 : 0* 1* 1* 1*

Diversidade : 22 : 5* 8* 4* 1* 4*
 moyenne : 2.59

Dragoeiro : 1 : 0* 1*

Ecologia : 1 : 0* 0* 0* 0* 1*

Economia : 6 : 1* 1* 2* 1* 1*
 moyenne : 3.00

Ecossistema : 2 : 0* 0* 1* 1*

Endemicas : 12 : 5* 3* 1* 2* 1*
 moyenne : 2.25

Enriquecedor : 1 : 0* 1*

Estrangeiras : 19 : 7* 5* 3* 3* 1*

moyenne : 2.26

Estrelcias : 3 : 0* 0* 1* 1* 1*

Eucalipto : 30 : 2* 7* 11* 8* 2*

moyenne : 3.03

Evolução : 1 : 1*

Exóticas : 25 : 15* 6* 1* 2* 1*

moyenne : 1.72

Exportadas : 1 : 0* 1*

Externas : 4 : 1* 1* 1* 1*

Extinção : 4 : 0* 2* 2*

Fetos : 6 : 1* 0* 2* 1* 2*

moyenne : 3.50

Figueira : 1 : 0* 0* 0* 0* 1*

Fiscalização : 1 : 0* 0* 0* 1*

Flores : 9 : 0* 0* 3* 3* 3*

moyenne : 4.00

Frescura : 2 : 1* 0* 0* 1*

Fruta : 2 : 0* 1* 0* 1*

Futuro : 1 : 0* 0* 0* 0* 1*

Gestão : 2 : 0* 0* 1* 1*

Gigante : 2 : 0* 0* 0* 1* 1*

Globalização : 1: 0* 0* 1*

Graminha : 1: 0* 1*

Habitat : 2: 0* 0* 2*

Homem : 6: 3* 0* 2* 1*
 moyenne : 2.17

Hortelã : 1: 0* 0* 0* 1*

Hortensia : 109: 57* 27* 12* 7* 6*
 moyenne : 1.88

Hospedeiro : 1: 0* 0* 1*

Ibisco : 2: 0* 1* 0* 0* 1*

Identidade : 1: 0* 0* 1*

Importação : 1: 1*

Incenso : 46: 11* 8* 14* 10* 3*
 moyenne : 2.70

Infestantes : 11: 2* 2* 4* 2* 1*
 moyenne : 2.82

Informação : 1: 0* 0* 0* 0* 1*

Inhame : 1: 0* 0* 1*

Invasoras : 75: 40* 21* 5* 6* 3*
 moyenne : 1.81

Jardim : 1: 0* 0* 0* 1*

Jasmim : 1: 0* 0* 1*

Junça : 1: 0* 0* 1*

Lantana : 5: 0* 1* 0* 2* 2*

Laranjeira : 4: 0* 1* 1* 2*

Laurisilva : 1: 0* 0* 0* 0* 1*

Legislação : 2: 0* 1* 0* 1*

Madeira : 1: 0* 0* 1*

Malmequeres : 3: 0* 1* 0* 0* 2*

Mar : 1: 0* 0* 0* 1*

Margaridas : 2: 0* 0* 0* 1* 1*

Mau : 3: 0* 1* 0* 1* 1*

Metrosideros : 4: 0* 1* 1* 1* 1*

Milho : 2: 0* 0* 2*

Morte : 1: 0* 1*

Mudança : 2: 0* 0* 0* 1* 1*

Nativas : 4: 1* 2* 0* 0* 1*

Naturalizadas : 3 : 0* 1* 2*

Natureza : 6 : 2* 1* 1* 2*
moyenne : 2.50

Necessidade : 1 : 0* 0* 1*

Nespereira : 1 : 0* 0* 0* 0* 1*

Nogueira : 1 : 0* 0* 1*

Normalidade : 1 : 0* 1*

Novidade : 9 : 4* 3* 0* 1* 1*
moyenne : 2.11

Oliveiras : 1 : 0* 0* 0* 0* 1*

Oportunidade : 3 : 0* 2* 0* 0* 1*

Origem : 1 : 0* 0* 1*

Ornamentais : 11 : 5* 2* 3* 0* 1*
moyenne : 2.09

Orquideas : 2 : 0* 2*

Oxigenação : 2 : 0* 1* 0* 0* 1*

Paisagismo : 1 : 0* 1*

Palmeira : 11 : 6* 2* 2* 1*
moyenne : 1.82

Papoilas : 1 : 0* 0* 1*

Parasita : 1: 0* 0* 0* 0* 1*

Paraíso : 1: 0* 0* 1*

Pastel : 1: 0* 1*

Patrimonio : 1: 1*

Perda : 4: 0* 2* 0* 2*

Perigro : 5: 3* 1* 0* 0* 1*

Pimentão : 1: 0* 0* 0* 1*

Pinheiro : 6: 0* 2* 0* 1* 3*

moyenne : 3.83

Planeamento : 1: 0* 0* 0* 1*

Plantado : 1: 1*

Platano : 3: 0* 0* 1* 1* 1*

Poder : 1: 0* 0* 1*

Povoamento : 3: 1* 2*

Praga : 14: 1* 5* 3* 3* 2*

moyenne : 3.00

Problema : 5: 1* 2* 0* 0* 2*

Produção : 1: 0* 0* 0* 1*

Propagação : 5 : 1* 2* 0* 1* 1*

Proteas : 1 : 1*

Qualidade : 1 : 0* 1*

Raras : 2 : 0* 1* 1*

Recursos : 1 : 0* 0* 0* 0* 1*

Resistentes : 1 : 0* 1*

Riqueza : 2 : 1* 0* 0* 1*

Risco : 3 : 1* 1* 1*

Rosa : 5 : 0* 1* 1* 2* 1*

Roxo : 1 : 0* 1*

Sabor : 1 : 0* 0* 0* 0* 1*

Salgueiro : 1 : 0* 1*

Saude : 1 : 0* 0* 1*

Silva : 5 : 0* 1* 3* 1*

Sobrevivencia : 2 : 0* 0* 0* 2*

Sociedade : 1 : 0* 0* 0* 0* 1*

Sustentabilidade : 2: 0* 0* 0* 1* 1*

Tabaco : 1: 0* 1*

Tabaqueira : 2: 0* 1* 0* 0* 1*

Tempo : 1: 0* 0* 0* 0* 1*

Tomarilho : 1: 0* 0* 0* 1*

Trazidas : 6: 5* 0* 1*

moyenne : 1.33

Trepadeiras : 1: 0* 0* 1*

Trevobranco : 1: 0* 0* 1*

Trigo : 1: 0* 0* 0* 1*

Tropical : 1: 0* 0* 1*

Turismo : 2: 1* 0* 0* 1*

Utilidade : 6: 1* 0* 2* 1* 2*

moyenne : 3.50

Vento : 2: 0* 0* 0* 1* 1*

Verde : 2: 1* 0* 0* 1*

Vergonha : 1: 0* 0* 0* 0* 1*

Videira : 1: 0* 1*

ambiente : 1: 0* 0* 0* 1*

cedro : 1: 0* 1*

gigante : 1: 0* 0* 0* 1*

madeira : 1: 0* 0* 0* 1*

pastagem : 1: 0* 0* 0* 0* 1*

simbiose : 1: 0* 0* 0* 1*

teste : 1: 0* 0* 0* 0* 1*

trabalho : 1: 0* 0* 0* 1*

DISTRIBUTION TOTALE : 958 : 258* 234* 190* 153* 123*

RANGS 6 ... 15 0* 0* 0* 0* 0* 0* 0* 0* 0* 0*

RANGS 16 ... 25 0* 0* 0* 0* 0* 0* 0* 0* 0* 0*

RANGS 26 ... 30 0* 0* 0* 0* 0*

Nombre total de mots differents : 195

Nombre total de mots cites : 958

moyenne generale : 2.63

DISTRIBUTION DES FREQUENCES

freq. * nb. mots * Cumul evocations et cumul inverse

1 *	99	99	10.3 %	958	100.0 %
2 *	34	167	17.4 %	859	89.7 %
3 *	12	203	21.2 %	791	82.6 %
4 *	9	239	24.9 %	755	78.8 %
5 *	8	279	29.1 %	719	75.1 %
6 *	8	327	34.1 %	679	70.9 %
7 *	1	334	34.9 %	631	65.9 %
8 *	2	350	36.5 %	624	65.1 %
9 *	5	395	41.2 %	608	63.5 %
11 *	4	439	45.8 %	563	58.8 %
12 *	1	451	47.1 %	519	54.2 %
14 *	2	479	50.0 %	507	52.9 %
19 *	1	498	52.0 %	479	50.0 %
21 *	1	519	54.2 %	460	48.0 %
22 *	1	541	56.5 %	439	45.8 %
25 *	1	566	59.1 %	417	43.5 %
30 *	1	596	62.2 %	392	40.9 %
46 *	1	642	67.0 %	362	37.8 %
61 *	1	703	73.4 %	316	33.0 %
71 *	1	774	80.8 %	255	26.6 %
75 *	1	849	88.6 %	184	19.2 %
109 *	1	958	100.0 %	109	11.4 %

ANNEX 4. SPSS OUTPUTS FOR THE ANALYSIS OF THE ONLINE QUESTIONNAIRE

P1. Mann Whitney test for the number of words cited related to the participant's education (educational level)

Descriptive statistics

	N	Average	Standard dev.	Minimum	Maximum
num_words	276	3,54	1,610	0	5
Educational level	270	1,75	,435	1	2

Ranges

	Educational_level	N	Average range	Sum of ranges
num_words	Under_bachelor	68	127,27	8654,50
	Bachelor or above	202	138,27	27930,50
	Total	270		

Estadísticos de prueba^a

	num_words
U Mann-Whitney	6308,500
W Wilcoxon	8654,500
Z	-1,064
Sig. asintotic (bilateral)	,287

a. Variable de agrupación:

Educational_level

P1. Mann Whitney test for the number of words cited related to the participant's academic background subject

Estadísticos descriptivos

	N	Media	Desviación estándar	Mínimo	Máximo
num_words	276	3,54	1,610	0	5
Academic_background_category	276	1,62	,487	1	2

Rangos				
	Academic_background_category	N	Rango promedio	Suma de rangos
num_words	Nature_related	106	157,20	16663,00
	Nature_unrelated	170	126,84	21563,00
	Total	276		

Estadísticos de prueba^a

	num_words
U de Mann-Whitney	7028,000
W de Wilcoxon	21563,000
Z	-3,252
Sig. asintótica (bilateral)	,001

a. Variable de agrupación:
Academic_background_category

P1. Mann Whitney test for the number of words cited related to birthplace

Estadísticos descriptivos

	N	Media	Desviación estándar	Mínimo	Máximo
num_words	276	3,54	1,610	0	5
Origin_cat	276	,71	,455	0	1

Rangos

	Origin_cat	N	Rango promedio	Suma de rangos
num_words	0	80	136,13	10890,50
	1	196	139,47	27335,50
	Total	276		

Estadísticos de prueba^a

	num_words
U Mann-Whitney	7650,500
W Wilcoxon	10890,500
Z	-,333
Sig. asintótica (bilateral)	,739

a. Variable de agrupación: Origin_cat

PI.2 Chi-squared test (Question 2):

Ac_background*Problem_group c

Recuento

	Problem_group		Total
	Other	Problem_IAS	
Ac_background Nature_related	100	198	298
Non-related to nature	273	206	479
Total	373	404	777

Pruebas de chi-cuadrado

	Valor	gl	Sig. asintótica (2 caras)	Significación exacta (2 caras)	Significación exacta (1 cara)
Chi-cuadrado de Pearson	40,427 ^a	1	,000		
Corrección de continuidad ^b	39,494	1	,000		
Razón de verosimilitud	41,001	1	,000		
Prueba exacta de Fisher				,000	,000
N de casos válidos	777				

a. 0 casillas (0,0%) han esperado un recuento menor que 5. El recuento mínimo esperado es 143,06.

b. Sólo se ha calculado para una tabla 2x2

Chi-squared test PI.3 (Question 3)

Academic_background * Stakeholder

Tabla cruzada

Recuento

	Stakeholder			Total
		Institutional authorities	Ohters	
Academic_background	1104	0	0	1104
Nature_related	3	87	16	106
Non-related to nature	5	130	35	170
Total	1112	217	51	1380

Pruebas de chi-cuadrado

	Valor	gl	Sig. asintótica (2 caras)
Chi-cuadrado de Pearson	1336,996 ^a	4	,000
Razón de verosimilitud	1287,575	4	,000
N de casos válidos	1380		

a. 1 casillas (11,1%) han esperado un recuento menor que 5. El recuento mínimo esperado es 3,92.

PI.4 (Question 4) Man Whitney U test. Number of correct species names and status based on pictures

Rangos

	Educational_level	N	Rango promedio	Suma de rangos
Correct name	Under bachelor	68	105,91	7202,00
	Bachelor or above	202	145,46	29383,00
	Total	270		

Estadísticos de prueba^a

	right_name
U Mann-Whitney	4856,000
W Wilcoxon	7202,000
Z	-3,655
Sig. asintótica (bilateral)	,000

a. Variable de agrupación: Academic_level

Rangos

	Academic_background_c ategory	N	Rango promedio	Suma de rangos
Correct name	Nature_related	106	181,08	19194,50
	Non-related to nature	170	111,95	19031,50
	Total	276		

Estadísticos de prueba^a

	right_name
U Mann-Whitney	4496,500
W Wilcoxon	19031,500
Z	-7,077
Sig. asintótica (bilateral)	,000

a. Variable de agrupación: Academic_background_category

PI.4 (Question 4) Correlation test – number of correct answers to the names and colonization status with the time of residence in the Azores

Correlaciones

			correct_name	Time_residence
Rho de Spearman	correct_name	Coeficiente de correlación	1,000	,008
		Sig. (bilateral)	.	,892
		N	276	263
	Time_residence	Coeficiente de correlación	,008	1,000
		Sig. (bilateral)	,892	.
		N	263	263

Correlaciones

			Time_residence	correct_status
Rho de Spearman	Time_residence	Coeficiente de correlación	1,000	-,095
		Sig. (bilateral)	.	,125
		N	263	263
	correct_status	Coeficiente de correlación	-,095	1,000
		Sig. (bilateral)	,125	.
		N	263	276

PI.4 (Question 4) U Man Whitney tests for name and status of the plant related to the educational level and academic background:

Rangos

	Educational_level	N	Rango promedio	Suma de rangos
Correct status	Under_bachelor	68	99,71	6780,50
	Bachelor or above	202	147,55	29804,50
	Total	270		

Estadísticos de prueba^a

	Correct status
U Mann-Whitney	4434,500
W Wilcoxon	6780,500
Z	-4,409
Sig. asintótica (bilateral)	,000

a. Variable de agrupación:
Academic_level

Rangos

	Academic_background_category	N	Rango promedio	Suma de rangos
Correct status	Nature_related	106	177,83	18850,50
	Non-related to nature	170	113,97	19375,50
	Total	276		

Estadísticos de prueba^a

	Correct status
U Mann-Whitney	4840,500
W Wilcoxon	19375,500
Z	-6,524
Sig. asintótica (bilateral)	,000

a. Variable de agrupación:
Academic_background_category

PI.4 (Question 4) Correlation test for the number of correct answers to the name and status of the plant

Correlaciones

			Correct status	Correct name
Rho de Spearman	Correct status	Coeficiente de correlación	1,000	,756**
		Sig. (bilateral)	.	,000
		N	276	276
Correct name	Correct name	Coeficiente de correlación	,756**	1,000
		Sig. (bilateral)	,000	.
		N	276	276

** . La correlación es significativa en el nivel 0,01 (2 colas).

PI.4 (Question 4) Regression test for the number of correct answers for the name and the colonization status of the plant

Resumen del modelo

Modelo	R	R cuadrado	R cuadrado ajustado	Error estándar de la estimación
1	,722 ^a	,522	,520	1,564

a. Predictores: (Constante), right_name

ANOVA^a

Modelo		Suma de cuadrados	gl	Media cuadrática	F	Sig.
1	Regresión	731,250	1	731,250	298,798	,000 ^b
	Residuo	670,562	274	2,447		
	Total	1401,812	275			

a. Variable dependiente: right_status

b. Predictores: (Constante), right_name

Coefficientes^a

Modelo		Coeficientes no estandarizados		Coeficientes estandarizados	t	Sig.
		B	Error estándar	Beta		
1	(Constante)	1,714	,206		8,326	,000
	right_name	,631	,037	,722	17,286	,000

a. Variable dependiente: right_status

PI.6 (Question 6). Alfa de Cronbach and Principal Component Analysis performed for the willingness of participation in engagement activities in different type of areas on Terceira Island.

Alfa Cronbach reliability 1-5 scale

Estadísticas de

fiabilidad_plant_and_remove

Alfa de Cronbach	N de elementos
,815	5

PCA correlation:

Varianza total explicada									
Componente	Autovalores iniciales			cuadrado			Sumas de rotación de cargas al cuadrado		
	Total	% de varianza	% acumulado	Total	% de varianza	% acumulado	Total	% de varianza	% acumulado
1	4,865	60,809	60,809	4,865	60,809	60,809	3,015	37,683	37,683
2	1,004	12,551	73,360	1,004	12,551	73,360	2,854	35,676	73,360
3	,629	7,864	81,224						
4	,596	7,448	88,671						
5	,342	4,274	92,946						
6	,301	3,756	96,702						
7	,169	2,110	98,812						
8	,095	1,188	100,000						

Método de extracción: análisis de componentes principales.

Correlation Matrix:

Matriz de correlaciones									
		Plant_protected_area	Plant_road_sides	Plant_public_garden	Plant_private_area	Remove_protected_area	Remove_road_sides	Remove_public_garden	Remove_private_area
Correlación	Plant_protected_area	1,000	,455	,565	,366	,725	,528	,513	,376
	Plant_road_sides	,455	1,000	,683	,534	,362	,624	,571	,451
	Plant_public_garden	,565	,683	1,000	,561	,475	,676	,722	,527
	Plant_private_area	,366	,534	,561	1,000	,258	,432	,470	,569
	Remove_protected_area	,725	,362	,475	,258	1,000	,679	,654	,430
	Remove_road_sides	,528	,624	,676	,432	,679	1,000	,889	,605
	Remove_public_garden	,513	,571	,722	,470	,654	,889	1,000	,583
	Remove_private_area	,376	,451	,527	,569	,430	,605	,583	1,000
Sig. (unilateral)	Plant_protected_area		,000	,000	,000	,000	,000	,000	,000
	Plant_road_sides	,000		,000	,000	,000	,000	,000	,000
	Plant_public_garden	,000	,000		,000	,000	,000	,000	,000
	Plant_private_area	,000	,000	,000		,000	,000	,000	,000
	Remove_protected_area	,000	,000	,000	,000		,000	,000	,000
	Remove_road_sides	,000	,000	,000	,000	,000		,000	,000
	Remove_public_garden	,000	,000	,000	,000	,000	,000		,000
	Remove_private_area	,000	,000	,000	,000	,000	,000	,000	

*Values highlighted in yellow color are those most statistically relevant (value of R ≥0.7)

PI.6 (Question 6) Chi square tests performed for the variables highlighted in yellow in the correlation matrix above from the PCA analysis.

Academic_background * Remove_protected_area

Tabla cruzada

Recuento

		Remove_protected_area					Total
		Non motivated	2	3	4	Very motivated	
Academic background	Nature_related to nature	2	5	31	25	43	106
	Non-related to nature	18	20	42	39	49	168
Total		20	25	73	64	92	274

Pruebas de chi-cuadrado

	Valor	gl	Sig. asintótica (2 caras)
Chi-cuadrado de Pearson	13,577 ^a	4	,009
Razón de verosimilitud	15,351	4	,004
N de casos válidos	274		

a. 0 casillas (,0%) han esperado un recuento menor que 5. El recuento mínimo esperado es 7,74.

Medidas simétricas

	Valor	Aprox. Sig.
Nominal por Nominal Coeficiente de contingencia	,217	,009
N de casos válidos	274	

Birthplace * Remove_protected_area

Tabla cruzada

Recuento

		Remove_protected_area					Total
		Non motivated	2	3	4	Very motivated	
Birthplace	Azores	16	21	60	43	54	194
	Other	4	4	13	21	38	80
Total		20	25	73	64	92	274

Pruebas de chi-cuadrado

	Valor	gl	Sig. asintótica (2 caras)
Chi-cuadrado de Pearson	14,433 ^a	4	,006
Razón de verosimilitud	14,798	4	,005
N de casos válidos	274		

a. 0 casillas (,0%) han esperado un recuento menor que 5. El recuento mínimo esperado es 5,84.

Birthplace* Remove_roadsides

Tabla cruzada

Recuento

		Remove_roadsides					Total
		Non motivated	2	3	4	Very motivated	
Birthplace	Azores	18	18	70	42	45	193
	Other	6	8	16	17	33	80
Total		24	26	86	59	78	273

Birthplace* Remove_public_garden

Tabla cruzada

Recuento

		Remove_public_garden					Total
		Non motivated	2	3	4	Very motivated	
Birthplace	Azores	16	21	66	45	45	193
	Other	7	6	18	16	33	80
Total		23	27	84	61	78	273

Pruebas de chi-cuadrado

	Valor	gl	Sig. asintótica (2 caras)
Chi-cuadrado de Pearson	9,828 ^a	4	,043
Razón de verosimilitud	9,607	4	,048
N de casos válidos	273		

a. 0 casillas (,0%) han esperado un recuento menor que 5. El recuento mínimo esperado es 6,74.

PI.6 (Question 6)

Chi square test for the overall willingness to participate in planting and removing plants activities.

	Valor	gl	Sig. asintótica (2 caras)
Chi-cuadrado de Pearson	11,367 ^a	4	,023
Razón de verosimilitud	11,391	4	,023
N de casos válidos	273		

a. 0 casillas (,0%) han esperado un recuento menor que 5. El recuento mínimo esperado es 7,03.

PI.7 (Question 7)

Correlation test for the influence of previous experiences in the willingness to participate in planting and removing plants activities.participation

Correlaciones no paramétricas						
			Plant recodificado	Remove recodificado	Experiencia	
Rho de Spearman	Plant recodificado	Coeficiente de correlación	1	,681**	-,183**	
		Sig. (bilateral)	.	0	0,003	
		N	274	271	260	
	Remove recodificado	Coeficiente de correlación	,681**	1	-,270**	
		Sig. (bilateral)	0	.	0	
		N	271	272	258	
	Experiencia	Coeficiente de correlación	-,183**	-,270**	1	
		Sig. (bilateral)	0,003	0	.	
		N	260	258	262	
	**. La correlación es significativa en el nivel 0,01 (2 colas).					

PI.8 (Question 8) Correlation test. Influence of supporting environmental in the willingness to participate in planting and removing plants activities.

Rho de Spearman		
Correlaciones no paramétricas		Plant recodificado
Associationism_cat		-0,057
		0,348
		272
Rho de Spearman	Remove recodificado	,681**
		0
		271
	Plant recodificado	1
		.
		274
**. La correlación es significativa en el nivel 0,01 (2 colas).		

PI. 9 (Question 9) Chi square test for choosing native or invasive plants related to educational level and academic background area.

Tabla cruzada

Recuento

	Academic_level		Total
	Under bachelor	Bachelor or above	
Status_plant	20	51	71
EN	25	125	150
II	23	26	49
Total	68	202	270

Pruebas de chi-cuadrado

	Valor	gl	Sig. asintótica (2 caras)
Chi-cuadrado de Pearson	18,419 ^a	2	,000
Razón de verosimilitud	17,417	2	,000
N de casos válidos	270		

a. 0 casillas (0,0%) han esperado un recuento menor que 5. El recuento mínimo esperado es 12,34.

Tabla cruzada. Recuento

	Academic_background_category		Total
	Nature_related	Nature_unrelated	
Status_plant	19	55	74
EN	74	79	153
II	13	36	49
Total	106	170	276

Pruebas de chi-cuadrado

	Valor	gl	Sig. asintótica (2 caras)
Chi-cuadrado de Pearson	955,118 ^a	4	,000
Razón de verosimilitud	830,152	4	,000
N de casos válidos	1380		

a. 1 casillas (11,1%) han esperado un recuento menor que 5. El recuento mínimo esperado es 2,84.

Pruebas de chi-cuadrado

	Valor	gl	Sig. asintótica (2 caras)
Chi-cuadrado de Pearson	14,407 ^a	2	,001
Razón de verosimilitud	14,698	2	,001
N de casos válidos	276		

PI.9 (Question 9) Mann-Whitney U test for choosing native species as favourite related to the number of correct answers in question P4.

Rangos

	Status_plant_cod	N	Rango promedio	Suma de rangos
Correct status	Invasive or introduced	49	50,04	2452,00
	Endemic or native	153	117,98	18051,00
	Total	202		

- a. 0 casillas (0,0%) han esperado un recuento menor que 5. El recuento mínimo esperado es 18,82.

Estadísticos de prueba^a

	right_status
U de Mann-Whitney	1227,000
W de Wilcoxon	2452,000
Z	-7,163
Sig. asintótica (bilateral)	,000

- a. Variable de agrupación: Status_plant_cod

ANNEX 5. ONLINE SURVEY THROUGH QUESTIONNAIRE

Percepções sobre o património natural da Ilha Terceira e dos Açores

INFORMAÇÕES PRÉVIAS

Este estudo faz parte de uma tese de Mestrado em Gestão e Conservação da Natureza da Universidade dos Açores. O objetivo deste trabalho é conhecer as perspetivas da população local sobre o património natural dos Açores e captar as suas impressões acerca das plantas, quer originais (nativas) quer introduzidas, do arquipélago e da Ilha Terceira.

Gostaríamos de saber a sua opinião sobre este tema, uma vez que ela ajudará a definir estratégias para valorizar a biodiversidade local. A sua participação consiste em responder a um questionário que poderá demorar cerca de 10 minutos.

Desde já asseguramos que:

- este questionário não é um teste de avaliação de conhecimentos, não existem respostas certas nem erradas, interessa-nos apenas saber a sua opinião sobre o tema;
- as suas respostas são anónimas e confidenciais;
- as publicações que derivem dos resultados deste estudo serão exclusivamente utilizadas para definir estratégias de comunicação e divulgação e produzir informação científica atualizada para valorizar a biodiversidade local.

Face a estas informações, por favor indique se aceita participar no estudo: *

Sim, avançar para o questionário

QUESTIONÁRIO (PART I)

1. Quando pensa em “plantas introduzidas nos Açores” que palavras lhe ocorrem? (Escreva até 5 palavras).

2. Dos seguintes itens, escolha ATÉ 3 OPÇÕES que considere serem os principais problemas para a conservação da natureza e do ambiente nos Açores.

- a) A poluição do ar causada pela utilização de carros e outros veículos
- b) A introdução de espécies (plantas ou animais) que não pertencem aos ecossistemas naturais Açorianos
- c) As atividades humanas que põem em causa a biodiversidade marinha (por exemplo: barulho dos barcos, atividades turísticas no mar ou a poluição com lixo (como plásticos)).
- d) A gestão de resíduos urbanos (por exemplo: reciclagem, gestão de resíduos não recicláveis ou o tratamento das águas urbanas).
- e) A perda de biodiversidade nativa (original) e única (endémica) das ilhas.
- f) A fragmentação da paisagem pelas atividades humanas (por exemplo: abertura de novos trilhos pedestres, atividade agropecuária...).
- g) A falta de programas e atividades de sensibilização sobre o meio natural dirigidas para o público em geral.
- h) Os efeitos das alterações ambientais que pousam pôr em risco o ambiente (por exemplo: períodos de seca, o incremento do nível do mar ou a degradação dos habitats onde vivem espécies únicas das ilhas).
- i) A falta de mais espaços verdes nas áreas urbanas
- j) O número crescente de turistas, que ameaçam a conservação da natureza
- k) A falta de áreas protegidas
- l) Outro (...)

3.Tendo por base 1 DAS RESPOSTAS que deu na pergunta anterior, indique:

3.1. Resposta escolhida (digitando ou indicando a letra):

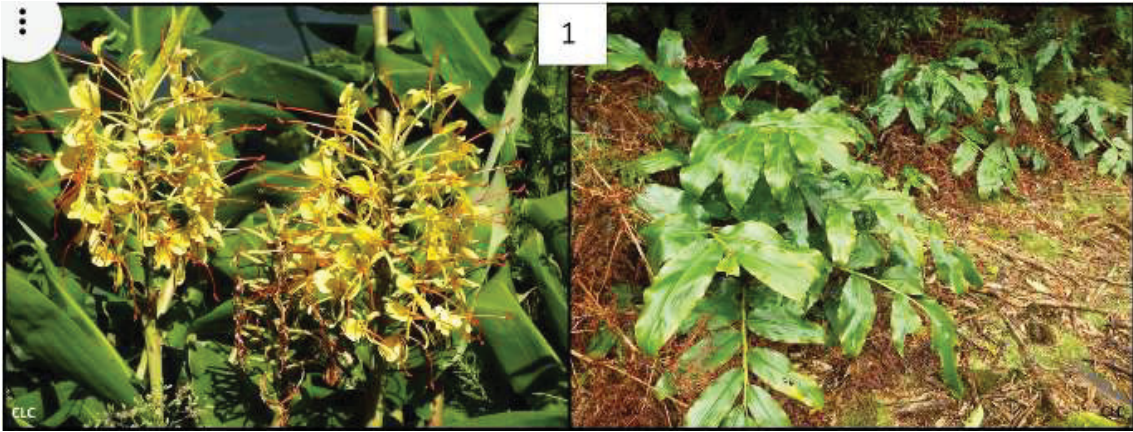
3.2 De quem acha ser a responsabilidade para resolver esse problema? (Pode escolher mais do que 1 opção):

- a) Do Governo Regional dos Açores
- b) Das Câmaras Municipais
- c) Das associações ambientalistas
- d) Dos cidadãos
- e) Dos cientistas da Universidade dos Açores
- f) Outro (...)

4.De seguida apresentam-se fotografias de 8 plantas que existem na Ilha Terceira e no arquipélago dos Açores.

Por favor, indique a seguir de cada planta apresentada (1-8):

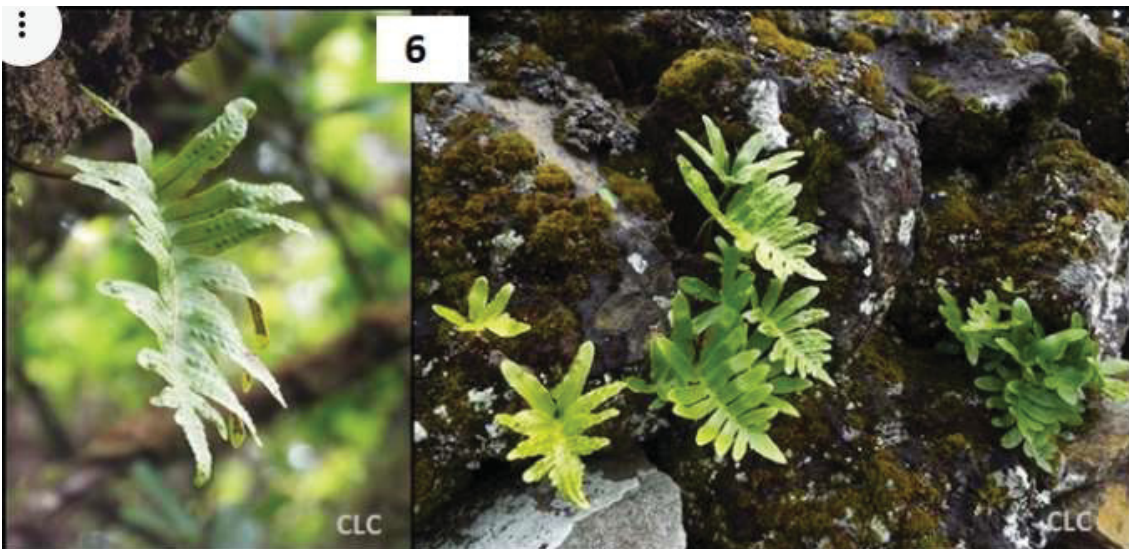
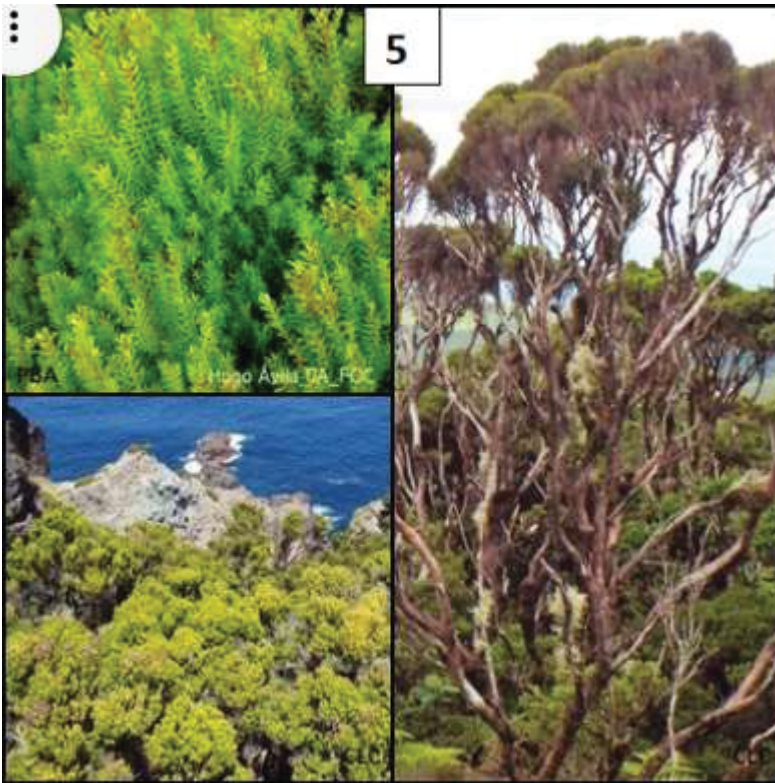
- Como é que se chama esta planta?
- Se conhece a planta, lembra-se onde a costuma ver?
- Acha que é uma planta NATIVA (faz parte da natureza original da Terceira e chegou sem ajuda dos humanos), ou INTRODUZIDA (trazida para a Terceira pelo Homem)?

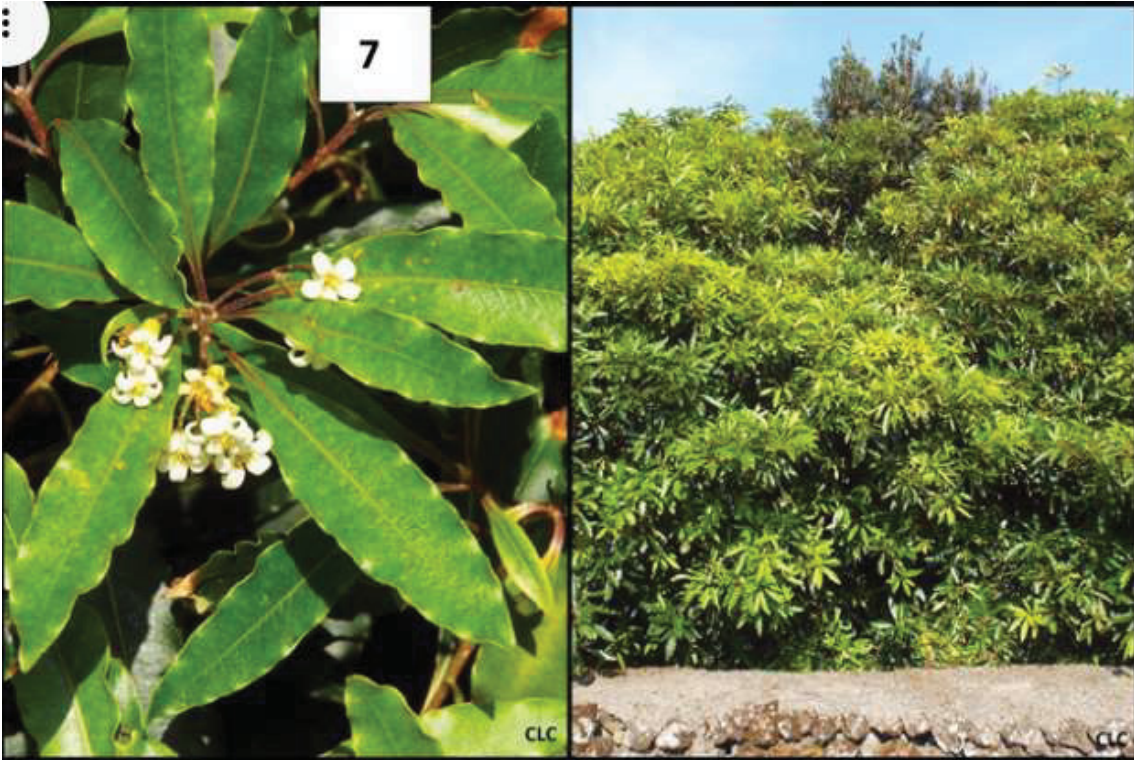




4







5. Em relação à introdução de plantas não originárias dos Açores na Ilha Terceira:

5.1 Acha que estas plantas poderiam se tornar INVASORAS e ser um problema na Ilha Terceira? (por exemplo: transmitir doenças, ser prejudicial para a biodiversidade nativa (original)/ para a economia local)

a) Sim

b) Não

c) Não sei

5.2 Em relação à pergunta anterior, se acha que a introdução de plantas não originárias dos Açores (de fora do arquipélago) é um problema para a biodiversidade original (nativa), indique qual é o seu grau de preocupação.

	1	2	3	4	5	
Nada preocupado	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Muito preocupado

6.1 Indique quanto estaria disposto a participar numa atividade para PLANTAR PLANTAS NATIVAS (originais da Terceira/Açores) ou ENDÉMICAS (que só existem na Terceira/Açores):

6.1.1 Numa área natural protegida da Ilha Terceira:

	1	2	3	4	5	
Nada disposto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Muito disposto

6.1.2 Na berma da estrada da sua Parish:

	1	2	3	4	5	
Nada disposto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Muito disposto

6.1.3 No jardim público da sua Parish:

	1	2	3	4	5	
Nada disposto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Muito disposto

6.1.4 Num terreno/serrado, quintal ou jardim seu:

	1	2	3	4	5	
Nada disposto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Muito disposto

6.2 Indique quanto estaria disposto a participar numa atividade para a REMOÇÃO de PLANTAS INVASORAS (prejudiciais para a biodiversidade nativa (original da Terceira/Açores), para a economia local / transmitir doenças):

6.2.1 Numa área natural protegida da Ilha Terceira:

	1	2	3	4	5	
Nada disposto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Muito disposto

6.2.2 Na berma da estrada da sua Parish:

	1	2	3	4	5	
Nada disposto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Muito disposto

6.2.3 No jardim público da sua Parish:

	1	2	3	4	5	
Nada disposto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Muito disposto

6.2.4 Num terreno/serrado, quintal ou jardim seu:

	1	2	3	4	5	
Nada disposto	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Muito disposto

7. Em relação à possibilidade de participação em atividades de conservação da natureza:

7.1 Alguma vez participou em alguma atividade ambiental/de conservação da natureza?

a) Sim

b) Não

c) Não sei

7.2 Se respondeu “sim” à questão anterior, qual foi a atividade?

8. Em relação a associações ambientais:

8.1 Faz parte de alguma associação ambiental (apoiando economicamente os seus projetos, participando em atividades ou divulgando as suas ações)?

a) Sim

b) Não

c) Não sei

8.2 Se respondeu "sim" à questão anterior, indique qual(ais):

9. Se tiver de escolher uma planta para representar a Ilha Terceira num concurso de biodiversidade dos Açores, qual escolheria?

Planta:

9.1 Porquê?

DADOS DE CARATERIZAÇÃO (PART II)

1. Sexo

a) Feminino

b) Masculino

2. Idade (número de anos):

3. Naturalidade:

3.1 Naturalidade (PAÍS onde nasceu):

3.2 Naturalidade (ILHA onde nasceu, se aplicável):

4. O local onde nasceu é:

4.1 Uma área urbana (zonas que fazem parte da estrutura urbanística principal e continuada daquela área e onde se desenvolvem principalmente atividades do sector terciário; por exemplo, educação, bancos, comércio).

4.2 Uma área peri-urbana (zonas localizadas no limite das zonas urbanas mas na quais a atividade agrícola ainda não é a atividade principal desenvolvida).

4.3 Uma área rural

4.4 Outra: _____

5.1 Local de Residência (PAÍS onde mora):

5.2 Ilha de Residência (ILHA onde mora, se aplicável):

6. O local onde mora é:

6.1 Uma área urbana (zonas que fazem parte da estrutura urbanística principal e continuada daquela área e onde se desenvolvem principalmente atividades do sector terciário; por exemplo, educação, bancos, comércios).

6.2 Uma área peri-urbana (zonas localizadas no limite das zonas urbanas mas na quais a atividade agrícola ainda não é a atividade principal desenvolvida).

6.3 Uma área rural

6.4 Outra: _____

7 Há quanto tempo mora neste local? (número de anos):

8 Qual é a sua área profissional?

- Sector primário (Por exemplo: agricultura, pecuária, silvicultura, extração mineira, apicultura, pesca)
- Sector Secundário (Por exemplo: indústria, construção civil, obras públicas, fornecimento de água, gás ou eletricidade)
- Sector Terciário: (Por exemplo: saúde, educação, bancos, transportes, turismo, seguros)
- Outra: _____

9. Quais são as suas habilitações literárias?

a) Ensino Básico

b) Ensino Secundário

c) Licenciatura

d) Mestrado

e) PhD

f) Outra: _____

9.1. Em relação à pergunta anterior: Qual é a área das suas habilitações literárias?

10. Tem acesso a alguma área onde possa plantar ou cultivar o que lhe apetecer (terreno/serrado, quintal, jardim, horta)?

- Sim
- Não
- Não sei

10.1 Se respondeu "sim" à questão anterior, qual é a área?

CONFIRMATION MESSAGE

“A sua resposta foi registada com sucesso.

Para saber mais sobre a biodiversidade das plantas dos Açores e/ou plantas introduzidas e invasoras em Portugal, visite os sites Portal da Biodiversidade dos Açores (<http://azoresbioportal.uac.pt/pt/>), Flora-on Azores (<http://acores.flora-on.pt/>), e Plantas Invasoras em Portugal (<http://invasoras.pt/>).

Se quiser receber informações sobre os principais resultados do inquérito, colocar uma dúvida, ou partilhar algum comentário pode contactar-nos através do endereço de e-mail: 20167119@aluno.uac.pt

Muito obrigada pela sua participação!” :)

ANNEX 6. LIST OF ENTITIES WHERE THE ONLINE QUESTIONNAIRE WAS SENT THROUGH EMAIL OR SOCIAL MEDIA:

- ALL PRIMARY SCHOOLS AND HIGH SCHOOLS OF TERCEIRA ISLAND
- DISTRIBUTION MAILING LIST OF THE UNIVERSIDADE DOS AÇORES
- TERCEIRA NATURAL PARK
- HOTELS OF TERCEIRA ISLAND: ALL THAT HAD A GENERAL EMAIL CONTACT AVAILABLE ON THEIR WEBSITE
- TOURISM STORES OF TERCEIRA ISLAND: ALL CONTACTABLE THROUGH SOCIAL MEDIA
- FLOWER AND PLANT STORES ON TERCEIRA ISLAND: ALL CONTACTABLE THROUGH SOCIAL MEDIA OR WITH A GENERAL EMAIL CONTACT AVAILABLE ON THEIR WEBSITE
- ENVIRONMENTAL ASSOCIATIONS OF THE AZORES: ALL
- FACEBOOK GROUPS DEDICATED TO ACTIVITIES IN NATURE ON TERCEIRA ISLAND (HIKING, CYCLING, GEOCATCHING)
- FACEBOOK GROUPS AND PAGES DEDICATED TO TERCEIRA ISLAND AND THE AZORES (CONTAINING GENERAL CONTENTS)
- MEDIA OF TERCEIRA ISLAND (RADIO, TV)
- AZORES GOVERNMENT: SECTIONS OF TOURISM, EDUCATION AND ENVIRONMENT
- CITY TOWN HALLS OF TERCEIRA ISLAND: ANGRA DO HEROISMO AND PRAIA DA VITORIA.
- ALL “JUNTAS DE FREGUESIA” (PARISHES MANAGEMENT PLACES) OF TERCEIRA ISLAND

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Plantas invasoras na Ilha Terceira

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[DM]



[2019]