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Agrária
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Diogo Ferreira Valente

Relatório de estágio apresentado à Escola Superior Agrária de Coimbra para cumprimento dos requisitos necessários à obtenção do grau de mestre em GESTÃO AMBIENTAL

Orientadores: Professoras Hélia Marchante e Elizabete Marchante

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Abstract

Invasive alien species are a global issue with negative repercussions on the environment, society, and economy. Portugal is heavily invaded by many invasive plants and *Cortaderia selloana*, introduced by aesthetic porpuses, is one of the most widespread along the central-north litoral areas. The high seed production and low nutrient requirements contribute for its invasiveness. The Iberian Project LIFE+ Stop Cortaderia (2018 - 2022) included amongst its main goals to manage the invasion, focusing on sensibilization, awareness campaigns, and interventions to control the species. As part of this project, environmental and land management entities in Portugal and Spain were invited to join the Transnational strategy to combat *Cortaderia selloana* in the Atlantic Arc (developed by the project) as a way to raise awareness, encourage and facilitate coordination and joint commitment, and promote more successful control of the species. The present work aims to analyse, by means of a questionnaire survey, what has been done by the entities that have joined the Strategy in Portugal (and also by those that have been invited but have not yet joined). It also aimed to reinforce the invitation for non-adherent entities to endorse the Strategy and further collect suggestions to improved it. The Questionnaire was sent to 480 entities and answered by 98. Most answers were from Municipalities with *C. selloana* invaded areas. The entities showed quite good knowledge about invasive plant species in general and praised the quality of the technical-scientific material developed by the Stop Cortaderia Project about the species. However, in general, the entities didn't show much ability to control *C. selloana* in the invaded areas or to raise awareness about it. Endorsing entities were a bit more successful in dissemination and awareness campaigns but the success in controlling invaded areas was limited. Better communication and follow-up between the Stop Cortaderia Project and the participanting entities is suggested in order to improve the entities' capacity of to manage the species and implement more effective actions on the ground.

Keywords: biological invasion, management of invasive plants, *Cortaderia selloana*, environmental and land management entities, questionnaires

Resumo

As espécies exóticas invasoras são um problema global com repercussões negativas no ambiente, na sociedade e na economia. Portugal é fortemente invadido por várias plantas invasoras e *Cortaderia selloana*, introduzida por motivos estéticos, é uma das mais difundidas ao longo das áreas do litoral centro-norte. A elevada produção de sementes e a baixa exigência em termos de nutrientes contribuem para o seu carácter invasor. O projeto ibérico LIFE+ Stop Cortaderia (2018 - 2022) incluiu entre os seus principais objetivos a gestão da invasão, com foco na sensibilização, campanhas de consciencialização e intervenções de controlo da espécie. No âmbito deste projeto, as entidades ambientais e de gestão do território em Portugal e Espanha foram convidadas a aderir à Estratégia transnacional de combate a *Cortaderia selloana* no Arco Atlântico (desenvolvida pelo projeto), como forma de sensibilizar, incentivar e facilitar a coordenação e o compromisso conjunto, e promover um maior sucesso no controlo da espécie. O presente trabalho tem como objetivo analisar, através de um inquérito por questionário, o que foi feito pelas entidades que aderiram à Estratégia em Portugal (e também por aquelas que foram convidadas mas ainda não aderiram). Pretendeu-se ainda reforçar o convite às entidades não aderentes para subscreverem a Estratégia e recolher sugestões para a sua melhoria. O Questionário foi enviado a 480 entidades e respondido por 98. A maioria das respostas foram de Municípios com áreas invadidas por *C. selloana*. As entidades demonstraram bastante conhecimento sobre as espécies de plantas invasoras em geral e elogiaram a qualidade do material técnico-científico desenvolvido pelo Projeto Stop Cortaderia sobre a espécie. No entanto, em geral, as entidades não demonstraram grande capacidade de controlo de *C. selloana* nas áreas invadidas ou de sensibilização para a mesma. As entidades aderentes tiveram um pouco mais de sucesso nas campanhas de divulgação e sensibilização, mas o sucesso no controlo das áreas invadidas foi limitado. Sugere-se uma melhor comunicação e acompanhamento entre o Projeto Stop Cortaderia e as entidades participantes, de forma a melhorar a capacidade das entidades de gerir a espécie e implementar acções mais eficazes no terreno.

Palavras-chave: invasão biológica, gestão de plantas invasoras, *Cortaderia selloana*, entidades ambientais e de ordenamento territorial, questionários

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List of abbreviations

IPBES – Intergovernmental Science-Policy Platform on Biodiversity & Ecosystem Services

IAS – Invasive Alien Species

ERH – Enemy Release Hypothesis

IPMA – Instituto Português do Mar e da Atmosfera

N – Nitrogen

Strategy – Transnational strategy to combat *Cortaderia selloana*

ICNF – Instituto da Conservação da Natureza e das Florestas

Introduction

Invasive Alien Species: what they are and how they manifest

Invasion by alien species is a growing problem for many countries and communities as globalization intensifies and expands (Keller et al., 2011; Intergovernmental Science-Policy Platform on Biodiversity & Ecosystem Services, 2023). With globalization, transportation of goods and people all around the globe became easier and faster, making it possible for species to be transferred to ecosystems where they are not native. But only a small number of non-native (alien) species become invasive (Keller et al., 2011). For a species to become invasive, some steps need to be achieved. First, it must be entrained in a *pathway* and survive transit. When it arrives in a region beyond its native range it's referred to as *introduced* or *alien (non-native, aloctonous, etc.)*. Alien species that are not able to maintain self-sustaining populations in the new location, but that are occasionally found beyond cultivation, are often termed *casual* species. Next, if an alien species survives, escapes, and begins reproducing without direct human intervention it is referred to as *established or naturalized*. Finally, an alien species is considered *invasive* if it spreads widely and causes measurable environmental, economic, or human health impacts (Colautti and MacIsaac 2004).

The total reported costs of invasions reached a minimum of US$1.288 trillion (2017 US dollars) over the past few decades (1970–2017), with an annual mean cost of US$26.8 billion (Diagne et al., 2021; IPBES, 2023). Much of these costs are caused by the impacts of Invasive Alien Species (IAS) and not by their management, with terrestrial ecosystems being the most accounted for (Cuthbert et al., 2021; Diagne et al., 2021). The best way to prevent these costs is to prevent IAS from establishing. The prevention costs are far below the costs of their impacts (in agriculture, forestry, etc.) and, if applicable, their management (Cuthbert et al., 2021; Diagne et al., 2021). This management, however, is often influenced by the species's public appeal, ethical or cultural priorities, and land-use agendas, with science having sometimes a small role in decision-making (Shine and Doody, 2011; Shackleton et al., 2019).

The "Tens Rule" indicates that only 10 % of the introduced species become established, and of those, 10 % become invasive (Williamson and Brown (1986), Williamson and Fitter (1996)). Though this rule is still in use, there is valid criticism. For example, it has been analyzed that this rule does not work with freshwater fish as the rule is extremely conservative leading to poor conclusions (Cvijanovic, 2012). Furthermore, since the Rule characterizes invasive species as "Pests" but did not portray a definition of what it meant, originates an ambivalence on what is considered a "pest" leading to a variability of

interpretations (Cvijanovic, 2012; Keller et al., 2011). Even though “The Tens Rules” helps predicting possible invasive taxon its applicability is poor, especially outside the field of terrestrial plants (Keller et al., 2011). Nevertheless, the recent IPBES report (IPBES, 2023) shows that of the 37000 alien species introduced worldwide 3500 became invasive.

The introduction of a species to an ecosystem to which it’s not native can be categorized into three general mechanisms: importation, arrival with a transport vector, and range expansion by the species itself (Hulme et al., 2008). Importation is intrinsically related to the transport of goods and can be the good itself or come with it. Importation of a species as a good to a non-native area comes associated with qualities that certain species can provide like it was with the importation of New-World crops to Europe in the Age of Discoveries or, as a more recent example, the importation of plants for ornamental purposes like *Cortaderia selloana* (Schult. & Schult.f.) Asch. & Graebn in Europe (Domènech et al., 2007). It can also happen that the species comes with the goods, such as non-native diseases and parasites. A case of that is the crayfish plague disease introduced to Europe on North American crayfish imported for aquaculture. This disease escaped and established, infesting and endangering native crayfish populations across Europe (Holdich et al., 1999).

The transport vector refers to species that hitchhike on human modes of transportation to reach areas well beyond their native range (Keller et al., 2011). This can happen even in remote areas and far from civilization. Non-native species were found in Antarctica in soil residues from construction vehicles imported from South Georgia and the Falkland Islands. Those included meiofauna, microorganisms, micro arthropods, and plants from Antarctic environments found on the islands (Hughes et al., 2010). These vehicles are needed to help in the activities of the research stations in Antarctica (Hughes et al., 2010).

Lastly, the dispersal can be done by the species itself aided by infrastructure corridors or unaided. These corridors exist in canals, roads, railways, and other types of infrastructure. For example, the opening of the Suez Canal created a connection between the Mediterranean Sea and the Red Sea introducing species of each area to the other. Moreover, in an unaided scenario, we have the example in Europe of the invasive horse-chestnut leafminer moth. Even though it was only introduced into a small area, with time it has developed large populations and spread through the continent (Olenin et al., 2010).

Invasion Ecology: what factors contribute to the *invasiveness* of a species?

Many invasive species are r-strategist ruderals (Rejmánek and Richardson, 1996), thriving in habitats disturbed by human activities. Consequently, often invaders are particularly successful in the early stages of succession and can outcompete native species in high-resource environments (Daehler, 2003). However, that's insufficient to explain invasiveness. There are many hypotheses trying to explain what other possible advantages a non-native species must have to become invasive and outcompete native species. However, as Catford et al. (2009) demonstrated, all those hypotheses can be unified under PAB (Fig. 1). A relationship is expected between propagule pressure (P), abiotic and biotic characteristics (A and B) interaction to drive invasion (I), and the way humans (H) can modify each of these parameters results in invasion.

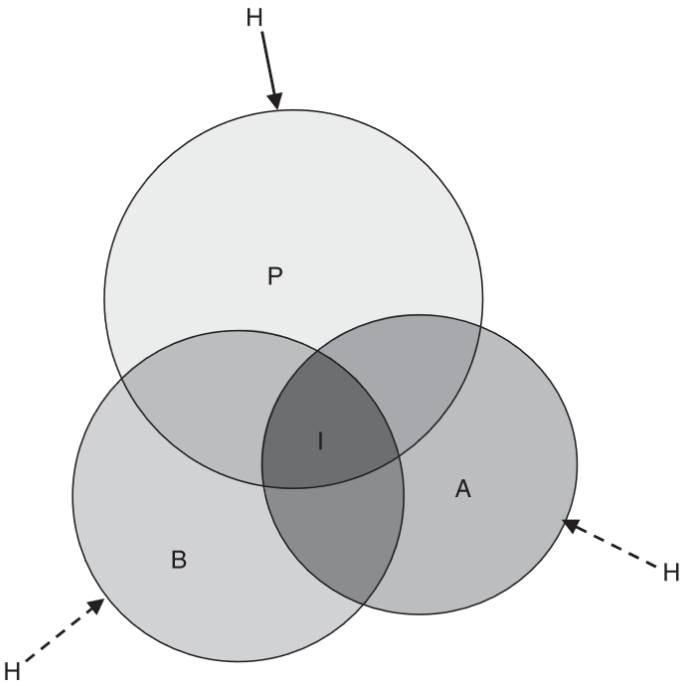

Figure 1 - Schematic diagram illustrating how propagule pressure (P), abiotic characteristics (A), and biotic characteristics (B) interact to drive invasion (I), and how humans (H) may modify P, A, and B. Invasion occurs where all three factors (i.e. circles) overlap. PAB must all be accommodating for invasion to be successful but the strength and extent of influence from each factor can vary. The circles also illustrate situations where one or two factors might limit invasion. The depth of shading represents the strength of factor influence and the size of the circles indicates the extent of their influence, both of which can change in space and time. In this example, the darker circle of A indicates that A drives invasion, followed by B, then P. P has the greatest extent (time and space) so limits invasion the least. The arrows indicate human interference, which may not necessarily occur but is highly likely with P (solid line; as opposed to dashed lines for A and B). **The figure and description are taken from Catford et al. (2009)**.

"Propagule pressure (P) is a concept that encompasses variation in the quantity, quality, composition and rate of supply of alien propagules resulting from the transport conditions and pathways between source and recipient regions" as in Lockwood et al., (2005). It's a key factor when assessing the establishment' success and then, if that's the case,

invasion. Some scenarios exist in which establishment success happened with only one female as it was presumed with the introduction of the European solitary bee *Lasioglossum leucozonium* in North America (Zayed et al. 2007), or with few individuals like the introduction of encyrtid *Anarhopus sydneyensis* in California that had an initial population of just eight specimens (Clausen 1978). However, generally, the establishment success is highly correlated to increased propagule size and introduction attempts (Forup and Memmott, 2005; Ahlroth et al., 2003; Verwey and Veltman, 1996).

Propagule pressure can also explain the "Lag Time Phenomenon", an event in which a population of an alien species remains small for a relatively long time and then explodes in numbers and becomes established or even invasive (Simberloff, 2009). One such explanation derives from quorum sensing, a behavior observed in some bacteria where they emit chemical signals to each other (Liu et al., 2007; Miller and Bassler 2001) and their population while small are inactive but viable. As soon as population increases and a certain threshold of chemical signaling is met, it changes their gene expression, triggering their infectious stage. Simberlof (2009) believes this behavior can be extrapolated to animals and plants reasoning on the Allee Effect (Allee 1931; Dennis 2002), which can be translated into: the lower a population is, the harder it is to reproduce. For plants, it can be explained by reduced pollination when densities are low, leading to a low seed set (Simberloff, 2009). To note that the "Lag Time Phenomenon" can also be attributed to abiotic causes like environmental changes (an increase in temperature for example) that can result on a species proliferation (Salisbury 1961). And to biotic causes, when certain species do not proliferate until the arrival of other non-native species or the inclusion of a female/male specimen. A prime example of the later is the expansion of *C. selloana* in Portugal. This species had a stable population, mainly constituted by female specimen due to their bigger plumes and as such bigger esthethic value, until the mid 20th century; by then, the introduction of pollen donor specimens (hermaphodytes in this case) caused a fast proliferation and invasion of the territory (González et al., 2020).

Abiotic characteristics (light, humidity, temperature, episodic disturbance, etc.) affect resource availability, which also plays a crucial role in triggering an invasion (Simberloff, 2009). Every species has its own needs and, logically, it's not possible to generalize isolated characteristics for all of them, even less so for all taxonomic groups. Because this thesis is about *Cortaderia selloana*. I'll focus on abiotic characteristics affecting plants.

Broadly, as Levine et al. (2004) pointed out, abiotic characteristics tend to have a bigger impact on regulating invasions than biotic ones, although there are exceptions. Part of the reason is because native plant communities that can outcompete invasive plants do it when the invasives lack already resources to maintain their physiological needs. Episodic disturbance has been, for a long time, associated with invasion and increased resource availability (Elton, 2020; Rejmánek and Richardson, 1996; Davis and Pelsor, 2001), but not always (Sher and Hyatt, 1999; Huston, 2004; Buckley et al., 2007). Plants, as other sessile organisms, need a space to grow and develop, implying that any process resulting in increased space availability may increase resource availability and invasion (Catford et al., 2009).

Biotic characteristics can either facilitate or prevent the establishment of non-native species and derive from interactions between communities and ecology-evolutionary interactions (Ricciardi and Atkinson, 2004; Joshi and Vrieling, 2005; Eppinga et al., 2006; Mitchell et al., 2006; Lau, 2008 as cited in Catford et al., 2009). As Catford et al. (2009) explored, the enemy release hypothesis (Keane and Crawley, 2002), evolution of improved competitive ability (Blossey and Notzgold, 1995), allelopathy (Callaway and Ridenour, 2004), symbiosis (Richardson and Pysek, 2006) and invasional meltdown (Simberloff and Holle, 1999) can help to explain invasion. The enemy release hypothesis (ERH) defends that the lack of predators (e.g., insect herbivorous) or other natural enemies, that IAS had in their native habitat, in the introduced environment gives a competitive advantage to the invaders (Crawley 2009; Liu and Stilling 2006; Müller and Martens, 2005). This can be seen with *C. selloana* which in its' native range is negatively affected by *Spanolepis selloanae*, a gall midge insect that greatly reduces the seed production of its' host plant up to a fourth (Fagúndez et al., 2021). In invaded territories, where the insect is not present, *C. selloana* shows more seed production which in turn increases its' invasiveness. This suggests that this insect may be used as a biological control of the plant in invaded territories (Fagúndez et al., 2021).

The evolution of improved competitive ability hypothesis demonstrated by Blossey and Notzold (1995) affirms that IAS are more successful in the new environment because, since there's a lack of predators in the new habitat, the energy and resources required for their defense needs are allocated to growth. However, this hypothesis may only hold in stressful situations (Müller and Martens, 2005) and varies with different chemicals (involved in defense) and resources.

Allelopathy is the harmful effects of chemical compounds from a species, in this case, the IAS on the recipient plant community (Hierro and Callaway, 2003). The invasive plant

community did not co-evolve with the IAS and, as such, it lacks the required defences to chemical effects limiting their growth (Hierro and Callaway, 2003). It is important to note that allelopathy may also interferes with abiotic conditions like soil chemical composition (Wardle et al., 2011).

Symbiotic relationships with IAS can be beneficial or harmful for their establishment and spreading (Kowalski et al., 2015; Parker and Gilbert, 2004). For example, the purple nutsedge (*Cyperus rotundus*) invasion in many tropical and temperate areas around the world (Holm et al., 1977) is strengthened when the purple nutsedge becomes infected by the fungus *Balansia cyperi* (an epiphytic fungus) not only causing increased plant growth but also increased reproduction.

Lastly, the invasional meltdown hypothesis (IMH) states that non-native species facilitate one another's invasion, increasing their likelihood of survival, ecological impacts, and possibly the magnitude of their overall impacts (Simberloff and Holle, 1999; Braga et al., 2018). One example confirming this hypothesis is the mutualistic relationship between a pollinator and a plant: the pollinating fig wasp (*Parapristina verticillata*) of the fig tree in Florida; the introduction of the fig wasp turned the stable populations of fig trees, both non-native to Florida, into a big invasive population (Kaufman et al.1991)

However, there are also other hypothesis like biotic resistance (Parker and Hay, 2005), biotic containment (Levine et al., 2004), and interspecific competition (Burke and Grime, 1996), especially from dominant species (Emery and Gross, 2006), that can constrain invasion (Catford et al., 2009).

Contrary to ERH, the biotic resistance hypothesis argues that native consumers can prefer alien species since alien prey may be poorly adapted for deterring them (Parker and Hay, 2005). However, it's highly unlikely that generalists' consumption of alien species can deter it (Parker and Hay, 2005). Studies done in California showed a big vulnerability in young seedlings of *C. selloana*, that is invasive to the region, to generalist herbivory (Lambrinos, 2002).

Biotic containment can be considered as a variation of the biotic resistance hypothesis, and it can be translated into native biotic interactions that limit the spreading of an already established invasive species population and/or its' rise to dominance in the ecosystem (Levine et al., 2004). This hypothesis can be translated to, for example, allelopathic properties of native flora on the invasive species. *Fallopia* x *bohemica* is one of the most widespread and impactfull invasive species in Europe (Bailey and Wisskirchen, 2004), with a high growth rate and huge biomass above and underground and capable of dispersing by rhizomes and achenes. However, *Sambucus ebulus* (a plant native to

Europe) can limit the growth, in clonal rhizomes and achenes, of *F.* x *bohemica* due to its allelopathic properties .

Independently of the hypothesis behind it, the number and spread of IAS, including plants continues to increase around the world (IPBES, 2023) and Portugal is not immune to this global phenomenon. Considering only vascular plants, there are more than 667 alien taxa (Almeida and Freitas, 2012) and of these more than 100 are considered invasive (Decree-Law nº 92/2019, Ministério do Ambiente, 2019). One of the most common and widespread invasive plant along the central-north coast of Portugal is *C. selloana* (Marchante et al., 2014), and this is the focus of the present work.

Cortaderia selloana - Native distribution, taxonomy, and morphology

The native range of *Cortaderia selloana,* commonly known as Pampas-grass (Fig. 2), is the moist riparian areas from South America mainly south Brazil, Uruguay, and north Argentina (González et al., 2020). However, nowadays the species has spread much farther, being present in the rest of Brazil, Colombia, and metropolitan regions of Chile (González et al., 2020). Furthermore, it was introduced in other continents and became invasive in New Zealand, Australia, the west of the United States of America (mainly California), and the south of Europe (Testoni and Villami, 2014).

Figure 2 - Left, a close-up of Cortaderia selloana; right, an invaded area where it is visible the amount of flowering it can produce and the quantity of individuals present in a small area.

All species of *Cortaderia* are native to South America; the *selloana* group includes *C. selloana* (Schult. and Schult.f.) Asch. & Graebn, *C. jubata* (Lemoine) Testoni & Villamil, *C. araucana* (Spaf), and *C. speciosa* (Spaf) (Testoni et al., 2017; Testoni and Villami, 2014). The *selloana* group forms big tussocks ranging from 1,5 to 3 meters in diameter and up to 4 meters in height, with strongly cutting leaf edges. The panicles are much larger than in most other species of the genus, being also plumose and very showy. *Cortaderia selloana* differs from the other species of the group by having a flowering season in austral summer, in contrast to *C. araucana* which flowers in austral spring,

being generally larger than *C. araucana* and *C. speciosa*, and having a somewhat different leaf anatomy from *C. speciosa* (Testoni et al., 2017). Between *C. selloana* and *C. jubata*, the latter has inflorescences extending far beyond the foliage and panicles of pink coloration (Testoni et al., 2017).

Cortaderia selloana was originally described as dioecious, but Astegiano et al. (1995) showed that it is gynodioecious, and Testoni and Villamil (2014) recorded several populations with only pistillate individuals (so presumably apomictic) in central and northern Argentina. This species presents the greatest morphological variability and geographical range in the genus. The morphological characterization is also complicated by interbreeding between natural populations and cultivated plants (Testoni et al., 2017). In the native range, the flowering season happens in the austral summer (January and February) and in the following month occurs the spread of seeds. It's a wind-pollinated plant, dispersing the seeds up to 20 meters away from the plants (Saura-Mas et al., 2005). The panicles can have as many as 1 000 000 seeds per mature plant for females and 100 000 for hermaphrodites (Lambrinos, 2002). Furthermore, the seeds produced by female plants are covered by long hairs, a characteristic absent from hermaphrodites, that help their dispersion by wind and adherence to surfaces. The seed bank lifespan is around one year which restricts establishments in non-favorable conditions (Manual of good practices). However, caution must be taken when assessing this since is possible for recruitment of *C. selloana* seeds from adjacent invaded areas (Manual of good practices).

Introduction and distribution of *Cortaderia selloana* in Portugal

In the Iberian Peninsula, *C. selloana* introduction is thought to have occurred in the 18th and 19th centuries for gardening purposes including the harvest of panicles, limited to the more showy female plants (González et al., 2020). Small populations or isolated plants, in gardens, remained stable due to the absence of pollen, as the hermaphrodites weren't much appealing to gardening and as such weren't introduced, since they have smaller panicles. This changed with accidental introductions of seeds that germinated and produced hermaphrodite plants and started the invasion process (González et al., 2020). Nowaday, countries in the Mediterranean basin like Portugal (Almeida and Freitas, 2012), Spain (Pardo-Primoy and Fagúndez, 2019), France (Tarabon et al., 2018), and Italy (Bacchetta et al., 2010) are the most affected by *C. selloana* invasion.

Although the proliferation and impacts of *C. selloana* in Portugal are evident at least since the end of the 20th century (Almeida, 1999), only since 2019 *C. selloana* was declared an invasive species in Portugal (Decreto-Lei nº 92/2019, being part of the

National List of Invasive Species). This listing allowed for better implementation of measures for its control and prevention and also prohibiting every economic activity involving any part of the plant that may have any viable propagule. This *Decreto-Lei* follows the Invasive Alien Species Regulation of the European Union, namely the Regulation nº 1143/2014 (European Union, 2014) of which Portugal is a member-state. Yet, so far, only *Cortaderia jubata* is included at the Union List (List of invasive species of Union concern).

Most of the territory in Portugal has a Mediterranean climate, that is a temperate climate (temperature of the warmest month greater than or equal to 10°C, and temperature of the coldest month less than 18°C but greater than –3°C) consisting of a dry and hot Summer (from June to September) with precipitation less than 30 mm and less than one-third of the wettest month of the winter half, but a mild and rainy season stretching from November to the beginnings of April. In the Summer, drought conditions are experienced (Instituto Português do Mar e Atmosfera, 2023). Furthermore, it's possible to divide the territory into 2 Koppen climate types: Csa and Csb (Hot-summer Mediterranean climate and Warm-summer Mediterranean climate, respectively). Csa has a temperate climate with a dry and hot summer (temperature of the warmest month 22°C or above) being mostly present in the interior regions and in the south of the country (usually attributed to regions south of the Tagus River). Csb has a milder but still dry Summer (the temperature of each of the four warmest months is 10°C or above but the warmest month is less than 22°C) usually belonging to the littoral regions of the Centre and North of the country (IPMA, 2023). Fire occurrences in Mediterranean Ecosystems, like the ones found in Portugal, tend to increase due to the increasing temperatures and dryness caused by Climate change (Moriondo et al., 2006; Keeley et al., 2016).

In Portugal, *C. selloana* invasion is widespread (González et al., 2020). It is present mainly in littoral areas from Lisbon up to the northern border however, it is also present in southern and some interior zones of the country. This distribution overlaps mainly regions experiencing Csb climate and also some Csa zones in the South, which despite diferent is relatively similar to the conditions experienced in the native range of *C. selloana* that has a Cfa climate: temperate, with precipitation evenly distributed along the year, and temperature of the warmest month 22°C or above (Britannica, 2018). Overall, the areas where the invasion is present have an annual mean temperature of 15,8°C (IPMA, 2023) that increases going south. On Summer (June-September) the mean temperature is above 20°C and annual precipitation is around 627mm (from data compiled between 1970 and 2000 from IPMA accessed in 2023), increasing as one travels north.

The substantial invasion on the littoral contrasting with much lower presence in the interior regions of the country may be due to increased temperature ranges and drier weather conditions caused by the continentality factor, affecting their fitness and competitiveness (Stanton and DiTomaso, 2004). Moreover due to lack of hermaphrodite plants found on interior regions there is not sufficient propagule pressure. Recent records on citizen science platforms show that more observations of *C. selloana* are being submitted in interior regions (as seen in the platform INVASORAS.PT or BioDiversity4All/iNaturalist). However, it's not clear if this increase in observations is due to the spread of the invasion or just to greater awareness among citizens.

Climate Change in Portugal is expected to increase annual temperatures and decrease precipitation levels, with these changes being more significant in the south of the country (Paulo et al., 2012). As such the invasion pattern of *C. selloana* might change not only because of the direct abiotic effects but also due to changes in the habitats coping with it, weakening their resilience and resistance thus facilitating an invasion (Mainka and Howard, 2010).

Ecology, Invasion process and environmental impacts of *Cortaderia selloana*

The temperature where *C. selloana* shows higher biomass growth ranges from 20 to 25°C, being the most important attribute limiting its geographical distribution, and regulating growth and reproduction. Regarding light, even though it tolerates low light conditions, its growth is severely limited under such conditions, preferring sunny environments. However, when temperatures and light conditions are fulfilled, water becomes the limiting factor (Stanton and DiTomaso, 2004).

Cortaderia selloana invades more efficiently ruderal habitats, habitats disturbed by human activities, taking advantage of low resources and competition, but having trouble sprouting and growing in well-established grasslands or non-disturbed habitats. It's not that it can't establish in non-ruderal habitats, but in those situations the number of individuals is lower and so is the recruitment of new specimens (Pausas et al., 2006; Domènech and Vilà, 2007). Furthermore, it also tolerates a wide range of environmental conditions although preferring low pH and sandy soils (Domènech and Vilà, 2007). Availability of N soil plays a big role in *C. selloana* growth, existing a strong correlation between increased N soil availability and biomass production. Moreover, this species has shown good N use efficiency when the resource is scarce, allowing it to compete in soils with low N availability (Vourlitis and Kroon, 2013). High N use efficiency allied with the long time dead leaves remain attached to the mother plant (decreasing N inputs)

may explain why soils invaded by *C. selloana* tend to have lower N concentrations than those not invaded (Domènech and Vilà, 2007), thus hardening the success chances of other plants growing. Additionaly, increased P assimilation is strongly related to increased N assimilation (Vourlitis and Kroon, 2013). *Cortaderia selloana* decreases the water use efficiency when water is highly available and increases when it's less available, meaning increased water use when the resource is less available (Vourlitis and Kroon, 2013). Ultimately, it can negatively impact the recruitment of riparian species since soil water availability is crucial for seed germination and growth (Domenèch and Vilà, 2008). This flexibility in water use can contribute to a competitive advantage in drought-experiencing habitats present in Mediterranean climates (Lambrinos, 2002). *Cortaderia selloana* is also a very flammable plant that combined with the dry and hot summers in Mediterranean climates helps ignite and fuelling fires. This is an example of the grass-fire cycle, destabilizing ecosystems and not allowing the successful establishment of other species perpetuating indefinitely the cycle (Zedler et al. 1983; Haidinger and Keeley 1993; Arianoutsoua and Vilà 2012).

Another factor helping the invasiveness of *C. selloana* is their high seed production with long dispersal distances and their adult size that outcompetes native grasses and herbs for space and resources (Pausas et al., 2006). The long dispersal distances and independence from pollinators permit dispersion alongside human corridors: roads, highways, and railways, which are also strongly disturbed sites and present virtually everywhere (Pardo-Primoy and Fagúndez, 2019).

Consequences of the invasion by *C. selloana* on society, the economy, and health

Like with many other IAS the damages caused by *C. selloana* stretch far beyond the environmental impacts. Allergies from grass pollen affect 20% of the world's population (García-Mozo, 2017), and *C. selloana* is no exception from this phenomenon (Rodríguez et al., 2021). Studies conducted in invaded territories by the species showed people with allergies also reacted to *C. selloana* pollen. This situation is aggravated by the fact that their flowering season is from mid-August to September in contrast with the majority of other flora that have their flowering season in Spring (north hemisphere Spring). In areas invaded by *C. selloana,* there are two allergies seasons, that add up to the nuisance to allergic people in their day-to-day routine, to the economic expense for them and the health sector, and an inductor for other diseases like asthma (García-Mozo, 2017).

Furthermore, areas highly invaded by *C. selloana* are unproductive, not only because its´ commercialization is forbidden in Portugal and other countries, but also because

those areas are incapable of sustaining farming, forestry, and grazing (Dunlop and Coup, 1950). Additionally, the economic resources needed to control *C. selloana* populations are extensive, because of high dispersal rates, big seed banks, good establishment in ruderal areas, and capability to sprout after cut or fire (by diminishing biodiversity, competition, and disturbing the soil). Successful control takes time, machinery with people able to work with it and/or chemical applications, and knowledge to restore the habitats (Manual of good practices, 2020). Furthermore, the deterioration of natural areas decreases their appeal and beauty conditioning possible tourism revenues (González et al., 2020).

In this context of significant negative impacts and widespread invasion, in the last decade some efforts have been done to manage *C. selloana* invasion with the correct technical and scientific approach. One of such efforts is the Project LIFE Stop Cortaderia developed mainly in Portugal and Spain, from 2018 to 2022.

Project Life Stop Cortaderia[1]

The Project Stop Cortaderia was funded by the Program LIFE, an instrument of the European Union that aims to fulfill the objectives and goals of Europa 2020 concerning Environment. It was also co-funded by Regional Governments, Municipalities, and Companies. This Project had a total of 20 actions to be implemented by a team of six partners in Portugal and Spain from 2018 to 2022. One of the key goals of the Project consisted on the development and implementation of the Transnational Strategy to fight *Cortaderia selloana* in the Atlantic Arc (Fig. 3), an area including Portugal, north of Spain, and southwest of France.

The objectives of the Project can be summarized in seven topics: i) engage stakeholders that share the interest of managing *C. selloana* to develop a Strategy and form a dedicated Workig Group; ii) maintain the Strategy Working Group active after the end of the Project, serving as a forum for exchanging experiences and divulgation of methodologies and materials; iii) stop the propagation of *C. selloana* in Cantabria (a Spanish Province heavily invaded by *C. selloana*) in areas with low invasion level and (yet) not invaded; iv) reduce the presence of the species in habitats of Cantabria important for conservation namely in Rede Natura 2000; v) geolocate and quantify the distribution of the species in Cantabria and northern Portugal; vi) test new methodologies for *C. selloana* control and disseminate the knowledge obtained; and vii) increase

[1] The information presented in this chapter was based on *Cortaderia* Kit available on the webpage of the Project (http://stopcortaderia.org/language/pt/kit-stop-cortaderia-pt/).

awareness amongst the population of the Atlantic Arc regarding the impacts of *C. selloana*.

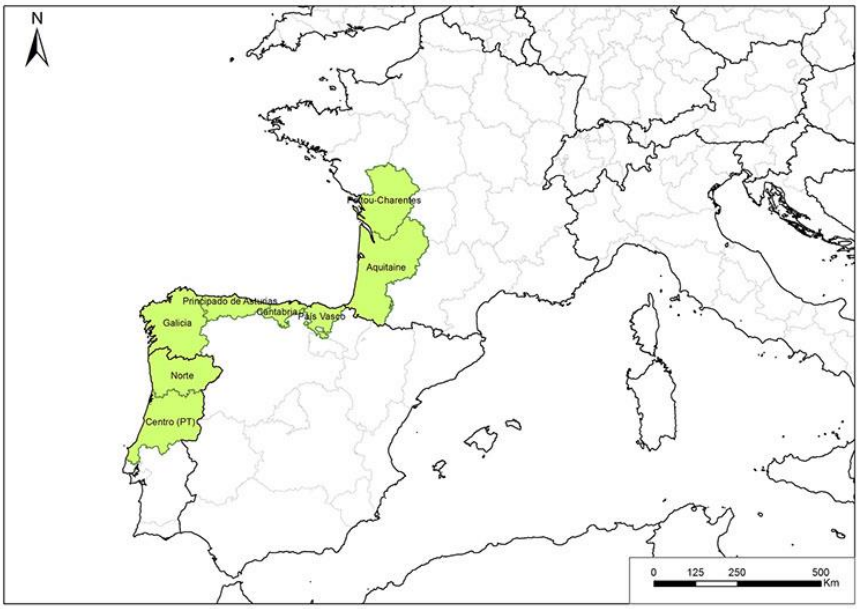

Figure 3 - Representation of the Atlantic Arc and respective national subdivisions (at NUTS II level), which also correlate to the most affected areas by the invasion of the species Cortaderia selloana. Source: LIFE Stop Cortaderia.

The priorities of the Transnational strategy to combat *Cortaderia selloana* are centered on prevention and early detection of isolated or dispersed specimens and consequent rapid control or eradication in areas of high ecological value (Natural Protected Areas, NPA). The Strategy follows a scheme that prioritize prevention in areas where the species still hasn't invaded, especially in NPA that have habitats with high ecological relevance; elimination of isolated and dispersed specimens; control and/or elimination in NPA, depending on characteristics of invasion, terrain and budget; specimen control in areas neighboring high-density areas and, if possible, proceeding to their eradication; control of high-density areas and acting accordingly to the resources available; amongst other goals (González et al., 2020).

To join the Strategy, an entity should be aware of the problem that *C. selloana* represents in the territory, accept the criteria and objectives of the Strategy, and establish a compromise with actions, investments, integration, diffusion, and others according with its own competences. The Entities that joint the Strategy are diverse and include Organisms of the Public Administration that have a role in land management or Environment, such as Municipalities, Natural Park Managers, infrastructure constructors, etc; private and public companies related to gardening, forestry, or construction; factories

or other types of industries that may hold land; universities and investigation centers; foundations, associations or Non-Governamental Organizations (NGOs) related to environmental protection; and media (Transnational strategy to combat *Cortaderia selloana*). By endorsing the Strategy, entities compromised to do their best in fighting the invasion. In this context and in the present work, a questionnaire was developed and sent to the entities some time after their endorsement to know what was being done and to evaluate their progress regarding the control of the invasion. This was sent not only to endorsing entities but also as an invitation to entities who had still not joined the Strategy.

A *Cortaderia* Kit was developed and distributed to entities identified as possible valuable partners of the Project. This kit included a Manual of good practices (LIFE STOP Cortaderia, 2020), which explains how to manage the species, and also the Transnational strategy to combat *Cortaderia selloana* in the Atlantic arc, which defines the main strategic criteria of how to handle the invasion. In 2020, this Kit was sent with a letter to entities across the country to present the Project, its objectives and invite them to join the Strategy.

The use of Surveys in Science and Project goals evaluation

Surveys are used in science and in different contexts such as evaluation of project goals, as a very useful tool to acquire information, e.g., on public knowledge and perception about a subject, and allow collecting answers from a large number of individuals. Different formats can be used, namely questionnaires, in-person interviews, panel sampling between others (Van Selm and Jankowski 2006; The InMoment Team, 2023). For this work the survey method chosen was the questionnaire.

A questionnaire is a research tool consisting of a series of questions that are used to gather data from individuals. They can be administered in various ways, such as in person, by phone, through mail, or online (Bird, 2009). Online questionnaires have their merits and demerits. On one side they are fast to construct and depending on the software used allow customization of questions, the lack of direct social interaction prevents biased results due to social pressure, and can be done wherever and whenever the respondent are available. However, this comes with the impossibility of confirming the true identity of the respondent. The questionnaire needs to be very well written and structured since it is difficult to follow up, and the information transmitted through the internet is not 100% guaranteed to be confidential (Roopa and Rani, 2012).

Questions can be classified into four types: i) contingency questions/cascade format, ii) matrix questions, iii) open-ended questions, and iv) closed-ended questions (Roopa and Rani, 2012). The first type are questions only possible to be answered if a particular response is given to a previous question; matrix questions are identical response categories assigned to a question; open-ended questions allow respondents to provide free-form responses, while closed-ended questions offer pre-determined response options. Closed questions are typically more difficult to construct but easier to analyze whereas open questions are easy to construct but more difficult to analyze (Sarantakos, 2005). Closed questions are often used within quantitative research while open questions are used within qualitative research (Bird, 2009).

The design of a questionnaire is crucial and it must follow a logical structure. Questions about a specific topic need to be grouped for smoother reading and to prevent the respondent from getting “lost”. Any question relating to more personal/private matters should be kept in the end because the first questions influence the willingness of the respondent to answer. The questions should be concise, simple, and written with a synthetic vocabulary known by the respondents to avoid misinterpretations and wrong answers. It must accommodate all possible responses to a question, and as such in closed-ended questions it should be made possible the inclusion of “other” as an answer preventing the respondent from inaccurate answers and bias the results. A questionnaire doesn’t need more questions than necessary but must ensure that every question serves a purpose and a clear role (Bird, 2009; Roopa and Rani, 2012).

A pre-test should be done to allow feedback from the target-respondents about the questions, if they are correctly formulated, well understood, correctly placed, and if any question needs to be added or eliminated. This allows correcting mistakes and the possibility of improving possible flaws (Roopa and Rani, 2012). For example, questions that tend to have the same answer from most of the respondents may be due to the question being vague or hard to understand and closed-ended questions with the majority of answers being “other” may show that either the options don’t correspond to the question or the question is not correctly formulated to the answers we pretend to acquire. Pre-testing is even more important in an online questionnaire, since it is harder to follow up and help effectively to clarify any doubt (Roopa and Rani, 2012).

Overall, questionnaires are a useful and versatile tool for collecting data in scientific and technical research. They can be used to gather information about a wide range of topics and can be administered in a variety of ways to suit the needs of the study. The survey in this study used an online questionnaire.

Objectives of this work

In the context of the LIFE STOP Cortaderia project and as a follow up to the Transnational Strategy to combat Cortaderia selloana, this work has the main objective to evaluate the impact of the Project LIFE Stop Cortaderia in the management actions of the portuguese entities eligible to join the Transnational Strategy, through an online questionnaire. From this main objective is possible to specify in three main points: i) to assess what activities the entities that have joined the Strategy have been carrying out in the scope of the Strategy; ii) to understand the reasons why some entities have not joined the Strategy, despite having being invited to do so; iii) to further publicize the LIFE Stop Cortaderia project, specifically the Strategy, with the aim of getting more entities to join.

Methods

Target audience

The target audience for the questionnaire were the entities that had joined/were invited to join the Transnational strategy to combat *Cortaderia selloana* in the Atlantic Arc, from Municipalities of mainland Portugal and the Autonomous Regions to local Environmental Non Governmental Organizations, linear infrastructures companies, electricity companies, and Botanical Gardens. This audience was chosen to include the entities invited to join the Strategy and as such with some jurisdiction over areas and/or resources to work on the territory and entities that had public exposition to large audiences.

The first version of the questionnaire was sent by email to a test group composed by some Municipalities and NGOs that had received the invitation in 2020 to endorse the Strategy developed by the Project Life Stop Cortaderia (served as test for feedback). After some minor changes the final version of the questionnaire was sent by email with a short message explaining its goals and then answered on an online platform (*Google Forms*), the message had slight variations depending if: i) the entity had already received in 2020 a letter with an invitation to adhere to the Project Life Stop Cortaderia (of which the entity adhered to the Project or didn't adhere to the Project); ii) the entity didn't receive the 2020 invitation to endorse the Strategy and belongs to a distinct tipoly: linear infrastructures companies (such as roads or electrical lines companies) with responsibilities in maintaining road strips without vegetation and/or maintaining fire breaks; Zoological or Botanical Gardens or Centres of Science communication; plant nurseries.

Questionnaires

The questionnaire was constructed on *Google Forms* and divided into five sections with 27 questions (see Tables A1 and A2 in Supplementary Material). Some of the questions included an image but most questions were only text. Of the 27 questions, most were closed-ended (18) and open-ended (7), but questions 15 and 20 were contingency and matrix questions, respectively (see Table A2 in Supplementary Material). In most of the questions it was possible to write a personalized answer after selecting the option "Other". When the respondent entity answered "No" in question 15 the last section of the questionnaire was blocked, making it only possible to answer 16 other questions (see Table A1 in Supplementary Material).

The first section included a small explanatory note and asked for the e-mail of the respondent. This question was important to detect if an entity answered the questionnaire more than once. The second section was composed by two questions aiming to characterize the respondent entity regarding its tipology and main focus of operations. The third section was composed by seven questions that analyse the general knowledge abou IAS and activities developed by that the entity to control IAS and/or raise awareness about it. The fourth section included six questions aimed at knowing if the entity knew the Project Life Stop Cortaderia and its Strategy, whether they had received/ accessed the Cortaderia kit, and, if so, what they liked most and what suggestions they had for improving it. The fifth and final section included 11 questions and was answered only by entities that had joined the Strategy. This section aimed to know what activities had been carried out targeting *C. selloana*, including control, dissemination, prevention, etc. It was also asked what could be done to improve the Strategy and other ways to extending the Strategy to more entities.

The questionnaires varied slightly depending on whether the entities had already been invited to joint the Strategy in 2020 or not, and on the tipoly of entities, namely linear infrastructures companies (such as roads or electrical lines companies) with responsibilities in maintaining road strips without vegetation and/or maintaining fire breaks; Zoological or Botanical Gardens or Centres of Science communication; plant nurseries.

The questionnaires were accompanied with a short message explaining its goals and would need to be answered on *Google Forms*. A total of 480 e-mails were sent with the questionnaire attached to it (see Table A3 in Supplementary Material). In the message sent it was asked to respond to the Questionnaire in fifteen days.

On 17 November 2021, a first e-mail with the attached questionnaire was sent to a test group composed of 18 entities that had received an invitation in 2020 to join the Strategy. The message and the questionnaire were sightly changed following the analyses of the answers received from the test group. Later, from 21 January to 2 March 2022, a second group of e-mails was sent to the remaining enities previously described. To boost a few more answers before closing the questionnaire, a friendly reminder was sent to some randomly chosen non-respondent entities, by e-mail, on 29 and 30 March 2022. The questionnaire was closed on the 8th of April.

Data collection and analysis

Since the questionnaire was made available in *Google Forms*, the data was automatically compiled as the respondents answered in an online datasheet. When the

questionnaire was closed, the collected data was exported from *Google Forms* to *Microsoft Excel* where it was analyzed.

Respondents' profile data were analyzed using descriptive statistics. Answers to open-ended questions or multiple choice were rearranged into coherent categories to facilitate further analysis. Question 13 was addressed to entities that had received the kit, but we also got answers from those who haven’t; those answers were not considered.

Results

Characterization of the respondents

In total 101 answers were received (success rate of 20,4%), but only 98 (97%) were considered valid because three were duplicates; in such cases, only the more recent answer was considered.

Regarding the type of entity (Question 2), the majority of respondents were “Municipalities”, but also many “Associations, foundations or different NGO, related to environmental conservation, natural patrimony, and environmental education and sensibilization” answered, with these two types of respondents counting for 93,9 % of all answers. From other types of entities, only a few answers were received (Fig. 4).

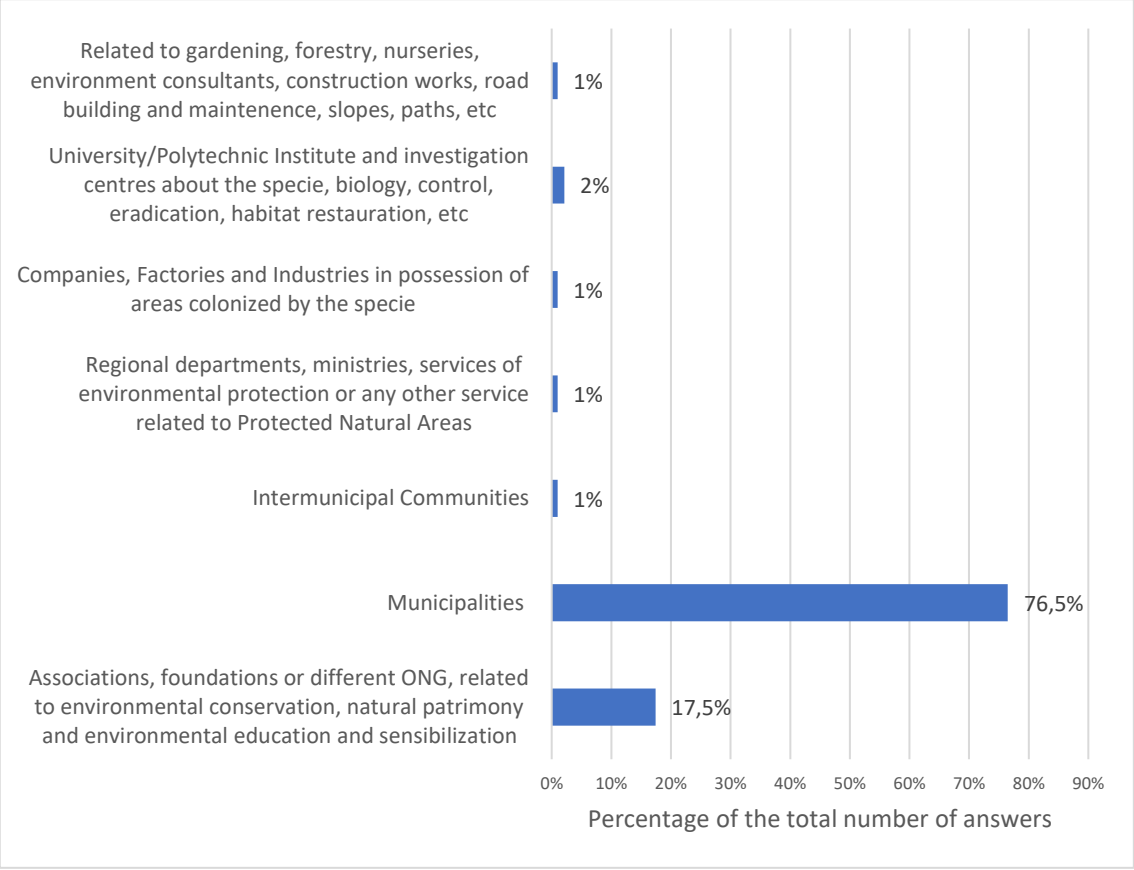

Figure 4 – Type of entity responding the questionnaire (Question 2). N= 98

Question 3 asked about geographical areas of intervention, and each entity could choose more than one option and, as such, the total number of answers was higher than the number of respondents, totaling 119 answers from 98 entities. The districts with more answers were Coimbra, Porto and Lisboa by a relatively large margin, but there were respondents from all districts and islands (Fig. 5).

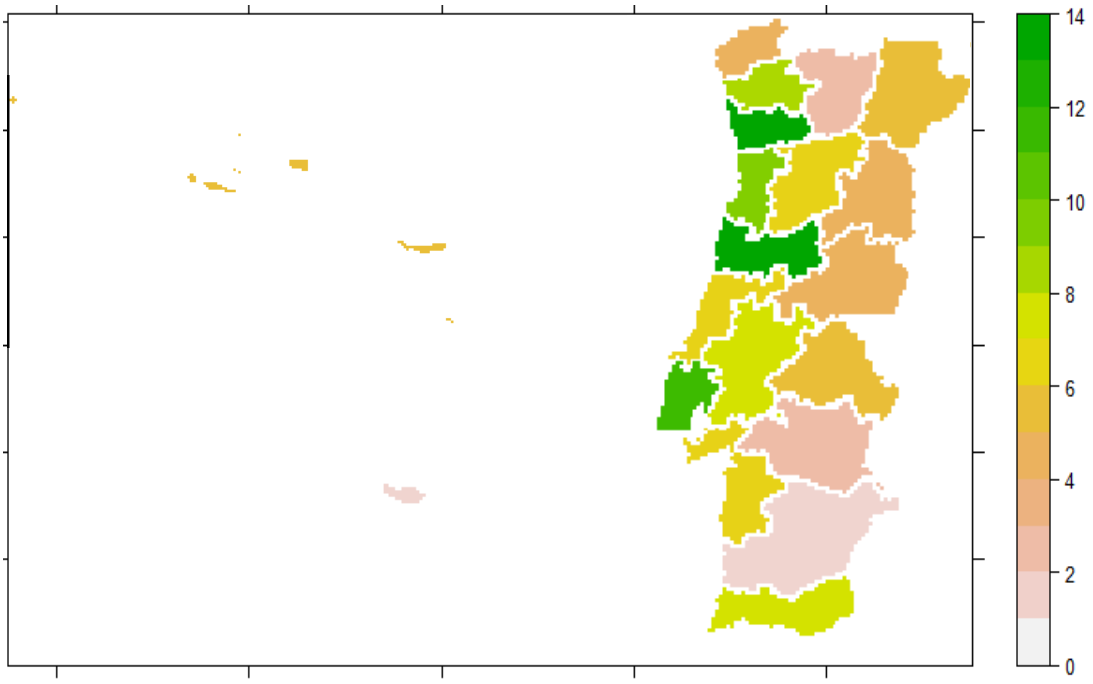

Figure 5 – Geographic distribution of the areas where the respondent entities may intervene (Question 3), with greener areas being intervened by more entities. The districts with more answers were Coimbra, Porto and Lisboa by a relatively large margin, but there were respondents from all districts and islands. The islands and mainland are not in scale. Total of 119 answers from 98 entities.

Perceptions and activities of entities concerning invasive alien species

When asked what invasive species are (Question 4), the majority of respondents (87%) selected the most correct and complete option: “An alien species that establishes and disperses in the territory by its own means and promotes negative impacts on ecosystems, the economy and/or human health”. The other answers, with the exception of “none of options”, though not incorrect, were incomplete.

Question 5 aimed to know how well the respondents could distinguish native and invasive plant species, showing them different pictures of plants. For all invasive species shown (options A-B-C-D) (Table 1), at least 76,5% of respondents could identify the species as invasive, with all respondent correctly pointing *C. selloana* as invasive (the only species where that happened).

Table 1 - Number of times and its percentage of an option selected by the respondents when asked what of the following options (accompanied by an image of the respective species) portrayed an invasive plant species. It was possible to choose more than one option.

Options available in the question	Number of times option was selected	Percentage
A - mimosa (*Acacia dealbata*)	90	91.8%
B - bons-dias (*Ipomoea indica*)	75	76,5%
C - erva-das-pampas (*Cortaderia selloana*)	98	100%
D - tintureira (*Phytolacca americana*)	78	79,6%
E - carvalho (*Quercus faginea*)	1	1.0%
F - milho (*Zea mays*)	0	0%
None of the options	0	0%

When asked to name other invasive plant species (Question 6) the answers showed that in general the respondents knew other common invasive alien plant species such as *Hakea* spp., *Ailanthus altissima, Carpobrotus edulis,* and *Eichhornia crassipes*. Respondents also showed an understanding of the distinction between weeds and invasive species, with none of the answers including weeds.

Most of entities answered that they did control invasive plants (79,6%, Question 7), although most did not do so regularly (Table 2). Five entities responded “Others” and justified reasons for not doing control, including “there were no means available” or “only whenever is necessary”.

Table 2 - Number of times and its percentage of an option selected by the respondents when asked if they did invasive plants control (Question 7). It was only possible to choose one option.

Options available in the question	Number of respondents	Percentage
No, not yet, but intends to do so	8	8,2%
No, it does not perform because it considers that it does not suit its competences	7	7,1%
Yes, but only occasionally	44	44,9%
Yes, regularly	34	34,7%
Others	5	5,1%
Total	98	100,0%

Answers to Question 8 showed that 69,4% of the entities carried out awareness activities about invasive plants, with about a third doing it regularly and another third occasionally (Table 3). The remaining entities (31,60%) answered that they had not done so, but more than 25% intend to start doing it shortly. Of the 30 entities regularly doing sensibilization activities, 20 were municipalities (with 1 Intermunicipal Community) showing an overwhelming positive response when compared to other entities.

Table 3 - Number of times and its percentage of an option selected by the respondents when asked if carries awareness activities about invasive species. It was only possible to choose one option.

Options available in the question	Number of respondents	Percentage
No, not yet, but intends to do so	25	25,5%
No, it does not perform because it considers that it does not suit its competences	5	5,1%
Yes, but only occasionally	38	38,8%
Yes, regularly	30	30,6%
Total	98	100,0%

Questions 9 and 10 were only answered by entities that chose “Yes” in Question 8, so a maximum of 68 answers could be expected. In Question 9 it was possible to choose more than one option about the methods used for awareness actions, so the number of answers was higher than the number of respondents. Overall, the most used means to raise awareness about invasive species were social media, activities to control invasive species with volunteers, and activities in schools. But several entities carried out training sessions (either promoted individualy or in collaboration with other entities), lectures and seminars, and different types of publications. Very few used other means of awareness not listed in the questionnaire, for example, a radio spot and documentaries and multimedia contents (Fig. 6).

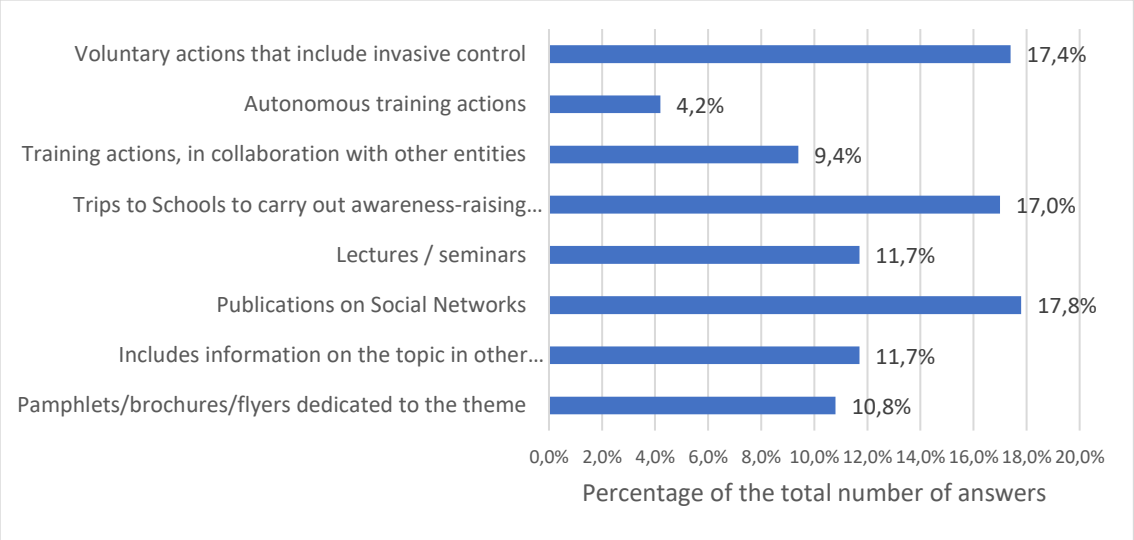

Figure 6 - Percentage of options selected by the respondents, it was possible to choose more than one (Question 9). N= 68. The “Others” section is not shown in the figure, but in total they were two with one using a radio spot and other producing documentaries and multimedia content.

Only 50 entities answered (73,5%) when asked about the focus-species in the awareness activities (Question 10), referring that *Acacia dealbata* and *Carpobrotus edulis* were the species most targeted during such activities while *Cortaderia selloana* was mentioned very few times.

Project LIFE Stop Cortaderia

Almost 3/4 of the respondents knew the Project Life STOP Cortaderia (74,5%, Question 11). But when they were inquired about having received the Cortaderia Kit, of the 88 entities (Question 12, which was directed to entities answering "Yes" to Question 11, but also got some responses from other entities, and so 88 answers were obtained and not the expected 73), only half (53%) answered "Yes", with 40,90% saying they had not received the Kit and 5,70% selecting the option "Other" and justifying why they hadn't received it; these answers included: "We don't know"; "Perhaps the last Executive [of the municipality] got it"; "We might have received it, but for now we don't know for sure".

The entities that recived the Kit (Fig. 7) considered it to be very accessible and well structured, with the Manual of Good Practices, and to a lesser extenct the Strategy, being very well received (Question 13).

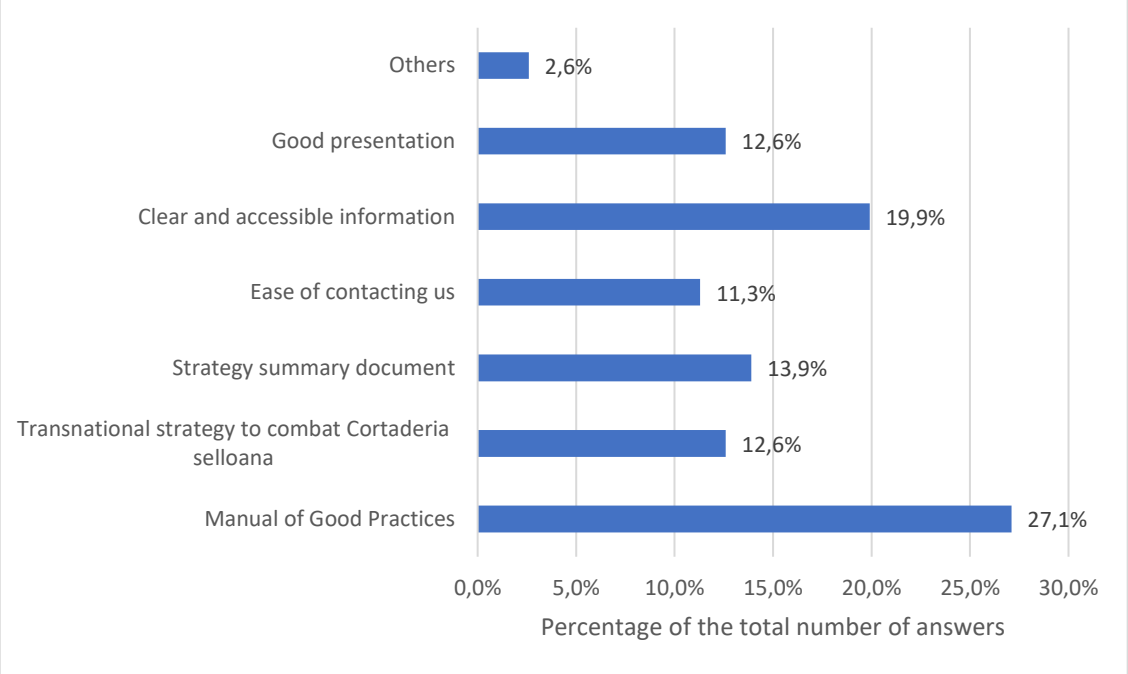

Figure 7 - Percentage of options selected by the respondents, it was possible to choose more than one option (Question 13). N= 47. The "Others" section was used to tell they haven't seen with the Kit with proper attention.

All respondents considered that the *Cortaderia* Kit of good quality and that it need not to be improved (Question 14). Nevertheless, one interesting suggestion was made: make the Kit more accessible to children and young people. Overall, the Kit was received and praised even by entities that were not aware of the Project.

When asked whether they adhered to the Strategy (Question 15), of the 97 answers (one entity did not respond), only 26,9% adhered, while the remaining 73,1% of respondents did not. Further analysis[2] showed a huge discrepancy in endorsing between entities from interior and litoral regions with interior having only one endorsing from a total of 23 while litoral had 22 endorsing from a sample of 66 (see Fig. 8).

Figure 8 - Percentage of endorsing and not endorsing entities to the Strategy from interior (left image) and litoral regions of Portugal (right image), relating to Question 15. N= 97; Litoral had 66 while Interior had 23.

Regarding the awareness campaigns and divulgation (Question 8), most entities that did such activities (23) had joined the Strategy, with far less non-subscribing entities (4) involved in raising awareness (fig. 9).

[2] Notes: (i) were considered as "interior" the districts of Beja, Bragança, Castelo Branco, Évora, Guarda, Portalegre, Vila Real and Viseu; and as litoral Aveiro, Braga, Coimbra, Faro, Leiria, Lisboa, Santarém, Setúbal, Viana do Castelo and Porto; (ii) Entities from the Autonomous Regions of Açores and Madeira weren't counted; (iii) Entities with a nacional range, with more than 2 districts selected in Question 3, were not counted; (iv) with the restrictions of point 2 and 3 the total of Entities is 89 (23 interior and 66 litoral).

Figure 9 - Percentage of endorsing and non endorsing Entities that do divulgation and awareness campaigns (left image) with those who don't (right image), relates with Question 8 and 15.

Question 16 asked about the motives for not subscribing the Strategy: 70 responses were received, with half of the entities stating that they had not yet had the opportunity to endorse the Strategy, while 22,9% claimed they had not received information about joining and another 20% gave other reasons; only a few entities said that it was not important or that they were still reluctant to join (Table 4). The "Others" option included justifications such as the fact that the area invaded by *C. selloana* does not justify endorsing, or that there were only a few specimens with most of them in private gardens. Three entities said they will endorse the Strategy soon.

Table 4 - Number of times and its percentage of an option selected by the respondents when asked the motives to not endorse the Strategy. It was only possible to choose one option (Question 16).

Options available in the question	Number of respondents	Percentage
No opportunity to join yet	35	50,0%
We have not received information on how to join	16	22,9%
We do not consider it important to join	3	4,3%
We are reluctant	2	2,8%
Others	14	20,0%
Total	70	100%

Endorsing impact on the Strategy

It is important to know what the Strategy endorsing entities have been doing in response to that (Question 17). 25% of the respondents started controlling *C. selloana* even though not completely, with a few entities opting for containement throug plume removal. Several entities made species' awareness and control actions with the help of volunteers and training session (19,6%, 14,3% and 12,5%, respectively). However, 12,5% said they had not done anything yet (Fig. 10). The "Others" option included training sessions to learn how to control the plants, organizing voluntary work groups, and announcing the full removal of the specimen in their territory.

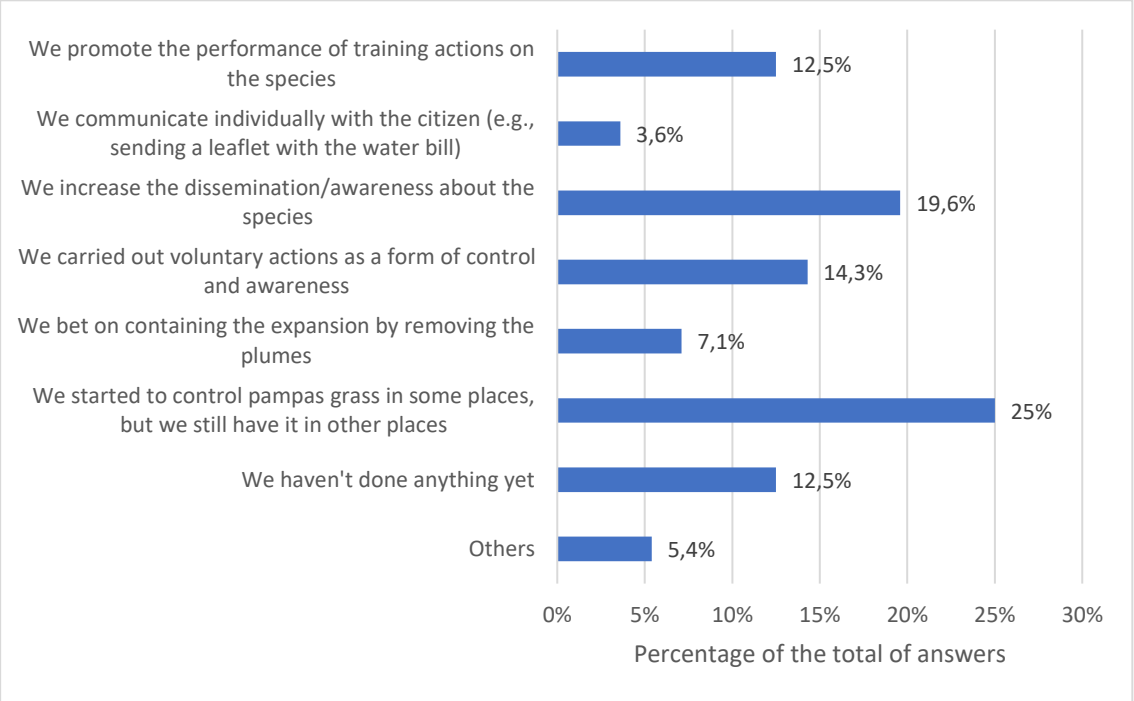

Figure 10 - Percentage of options selected by the respondents when asked what type of activities has/have been carried out within the scope of the "Transnational strategy to combat *Cortaderia selloana*", it was possible to choose more than one option (Question 17). N= 26. The "Others" option included training sessions to learn how to control the plants, organizing voluntary work groups, and announcing the full removal of the specimen in their territory.

Of the entities doing some activities (26) a bit less than half (46,10%) disseminated the activities done, while the other 53,90% did not (Question 18); most of those who disclosed their awareness activities were municipalities (9), with the rest being a Polytechnic School and two NGOs. The strategies/means used in this dissemination (Question 19) included mainly social and traditional media, but others were also used such as seminairs/lectures, school visits, publications and the use of pamphlets/brochures/flyers (Table 5). Lastly the "Others" option (4,9%) included E-mail and outdoors.

Table 5 - Number of times and its percentage of an option selected by the respondents when asked the strategies used in disclosuring the actions done within the scope of the Strategy. It was possible to choose more than one option (Question 19).

Options available in the question	Total answers	Percentage
Pamphlets/brochures/flyers	4	9,8%
Social Media posts	9	22%
Lectures/ seminars	7	17%
School visits	7	17%
Traditional Media (journals, radio, television)	8	19,5%
Information about the theme in other types of publications (such as Mensal summaries, Newsletters, Magazines, etc)	4	9,8%
Others	2	4,9%
Total	41	100,0%

More than half of the entities were not successful in controlling the species, with only a small percentage (11,5%) stating they were able to decrease significantly the invaded area and number of individuals sprouted (Question 20, Fig. 11).

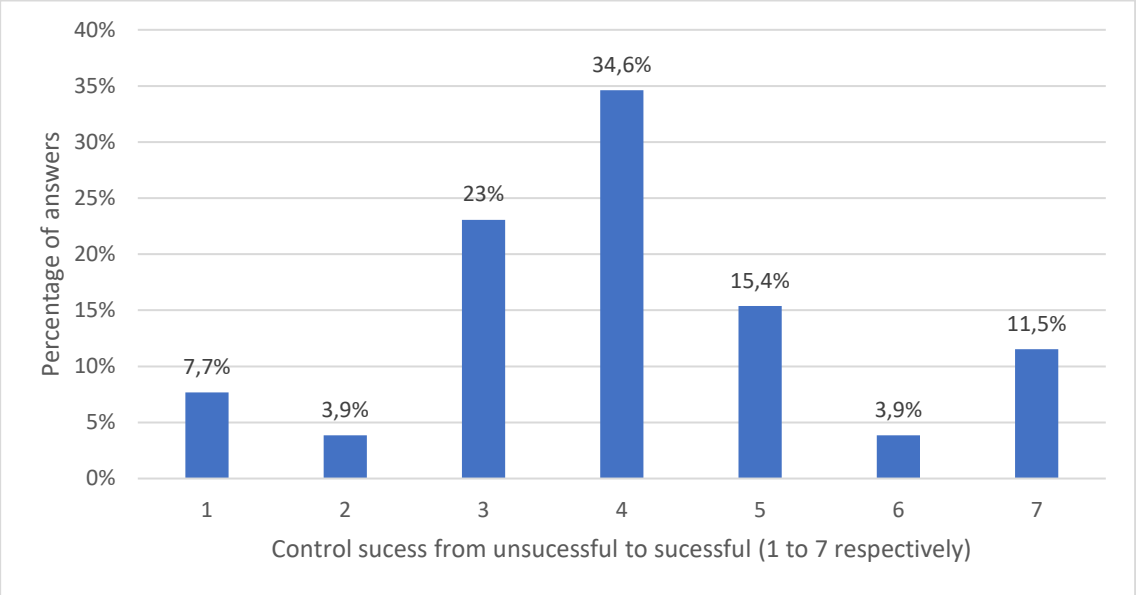

Figure 11 - Control success of *C. selloana* on a scale from one to seven (with one being extremely unsuccessful and seven extremely successful), Question 20. N= 26.

The majority of entities (23 out of 26) considered that the Strategy provided good enough tools to better deal with *C. selloana*; three entities argued that it was too early to know for sure if the Strategy helped (Question 21). When asked in which aspect did the Entities learn to better deal with the species (Question 22), of the 24 entities answering this question, most claimed to acquired more information about the species, that they were better prepared to carry out control actions, were more aware of the impacts caused by the species, and also more alert and able to detect *C. selloana* (Table 6).

Table 6 - Number of times and its percentage of an option selected by the respondents when asked what did the Strategy teached them in dealing with *C. selloana*. It was possible to choose more than one option (Question 22).

Options given in the question	Total answers	Percentage
We acquired more information about the species	19	28,3%
We are better prepared to carry out the control of the species	16	23,9%
We are more alert in the detection of the species	14	20,9%
We are more aware of the impacts and consequences of invasive plants	16	23,9%
Others	2	3%
Total	67	100,0%

Regarding what could be optimized to better implement the Strategy (Question 24, open answer), there was a strong emphasis on increasing divulgation and good articulation with Forest Services (in this case Instituto e Conservação da Natureza e Florestas) and private owners. It was also suggested a better timing on funding programs used to control the species (e.g., funding being available before the flowering season and as such improving its' efficiency), more adhesion by the municipalities, and increasing awareness campaigns not only targeting the population but also stakeholders involved in creating and maintaining green spaces.

Question 25 was targeted to municipalities and entities that have direct contact with the public, and aimed to know how to disseminate the Strategy to a bigger audience, suggesting as an example the possibility of doing it through the water receipt. There were many responses, from agreeing with the suggestion of using the water receipt (that is issued by the municipality), divulgating it in municipal magazines, websites and social media, use of outdoors, paying for a space in the local/regional media and collaborating with the schools.

To increase the success of *C. selloana* management (Question 26, Fig. 12) most entities suggested raising more funding (21%), increasing inspection (by the authorities), greater disclosure, and better technical follow-up (15,8% each). Increase awareness campaings either for older or younger people was also pointed, as well as changes in legislation. One entity suggested that a good measure could be to get to know the owners of the invaded property.

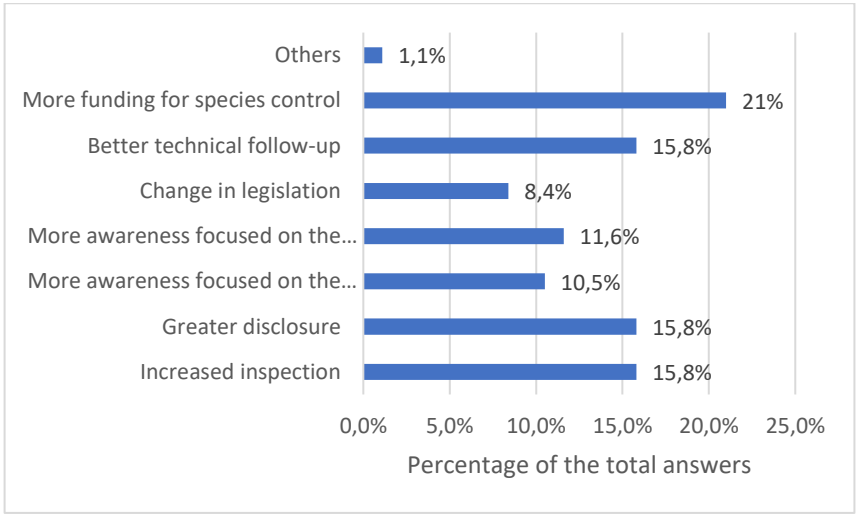

Figure 12 - Percentage of options selected by the respondents when asked what what could be done to improve C. selloana control and management, it was possible to choose more than one option (Question 26). N= 26. The "Others" option was a suggestion to get to know the owners of the invaded territory.

Discussion

Some studies (Cordeiro et al., 2020; Kirk et al., 2020; Roldão Almeida et al., 2023) already tackled the perception of public opinion about invasive species, with the first specifically targeting *Cortaderia selloana* in the Iberian Peninsula. This work, although similar, has a different target public and motif resembling the one made by Shackleton et al. (2019) which aimed building a framework able to understand the public perception of invasive species and its' solutions.

The Questionnaire wasn't answered by ca. 80% of the recipients Entities, despite the insistence; other ways to engage and motivate responses of these Entities are needed. Perhaps in these cases, more personal interaction must be aproached, since Literature shows people are more willing to answer and comply with requests done in person (Roopa and Rani, 2012), like taking advantage of public events, and meetings with the people in charge, etc.

The main responses came from Coimbra, where one of the parters of LIFE Stop Cortaderia in Portugal is localized and as such contacts were already established making it easier to obtain their response to the Questionnaire; and Porto and Lisbon who are the biggest districts (population wise) of Portugal. In some Districts and Regions, the samples were very small, like Évora and Beja which compromise significant part of the South although small in population. Thus, there is a large area that we do not know how the invasion is handled by Entities and how strong is the invasion by *C. selloana*.

Entities' perception of invasive alien plants

This study corroborate previous findings about public perception of invasive plants (Roldão Almeida et al., 2023; Marchante et al., 2017), stressing that not only the general public but also professionals (technicians from entities) identify the problem and are able to distinguish species of invasive flora from native ones. However, on dissemination/awareness activities, *C. selloana* was only mentioned by a handful of entities indicating that awareness about this invasive species is still lacking. In fact, despite there is a trend to decrease, it is still possible to find *C. selloana* in public gardens in Portugal confirming this lack of awareness (H. Marchante, personal communication).

Several authors refer that the better a person's environmental knowledge, the greater their perception and willingness to control invasive plants (Roldão Almeida et al., 2023; Verbrugge et al., 2013). However, in this work that was not always confirmed. In fact, although most of the entities were able to identify invasive plant species, many do not control invasive populations (and when they do they are not always successful) nor have

they showed initiative to prevent their establishment. This difference may possibly explained by the target-audience, since more than perception or willingness entities need to find the means and resources to manage the species, which is no easy task. That is, the investment needed to control invasive species and the lack of know-how of how to manage them may be the reason for inaction (Epanchin-Niell et al., 2010; Oreska, et al., 2011; Buhle et al., 2005).

What can be done to improve awareness and control of invasive species?

Regarding sensibilization, most entities claimed they carry out awareness-raising activities about invasive species, and some do so regularly. This was mainly conducted through social media platforms, activities in schools, and control sessions with volunteers. Social media platforms can be an excellent tool to communicate and disseminate science and other activities due to their range, easy access, and virtual presence around the globe; however, the lack of quality control that these platforms generally have makes it easier for fake news to spread, damaging the credibility of the platform and its users. In addition, emotional content (current events, natural disasters, politics, etc.) spreads more quickly and has more engagement, outcompeting more technical content such as science in terms of views and a spot in the *feed* (Van Eperen and Marincola, 2011; Hwong et al., 2017; Weingart and Guenther, 2016).

School awareness activities have frequently two approaches: students traveling to a place partaking in some kind of activity (e.g., hands-on activities to control invasive species; trails to identify invasive species,…) or technicians from the entities visiting schools and giving a “talk” or doing a workshop with the students. Invasive plants control sessions with volunteers are done in groups for a few hours and are a pro-active way to involve people and at the same time teach them how to deal with the invasive species. In the Questionnaire it wasn’t asked specifically how the sensibilization was done, but information available (e.g., at entities webpages and/or social media) indicates that both approaches are promoted. Relating to school activities, unless visits engage the students in active learning through games and teamwork, may be expected that they will not express enjoyment and engage with the subject being taught (Tal and Morag, 2007), which may end up with an opportunity for learning and dissemination being lost. As such it’s important to be available to talk in a simpler yet correct form, scientific jargon is not enthusiastic for young students, and do more than just a knowledge exposition (Tal and Morag, 2007). Most of the respondent entities that promote sensibilization activities in schools were municipalities with less being ENGOs or environmental associations. Municipalities may have more tools to thrive here (personnel, easy communication with

schools, facilities) and it's very positive that work on this parameter. School visits are for many students their first connection with the subject of invasive species and a unique moment that should be taken advantage of (Larsen and Jenssen, 2004).

Invasive species control activities are a great way to engage the community and at the same time, contribute to sensibilize and fight the problem. That's why having over 79% of respondents entities promoting activities to control invasive species is good news, even if some could argue they are just complying with the national legislation that forbids detaining invasive species (DL 92/2019). However, successful control of invasive species requires regular monitoring and follow ups and proper training, since each species has specific control techniques that shouldn't be generalized in order to improve success. Furthermore, local communities sometimes oppose species control measures (Shackleton et al. (2019) even if they are invasive. The motives for this include appreciation of the plant as many plants like *C. selloana* were primarily introduced for aesthetic purposes. On this topic, science sometimes plays a minor role (particularly when citizens lack clear, correct information about invasive species), with the organism's public appeal, ethical or cultural priorities, and land-use agendas, being more decisive in decision-making (Shine and Doody, 2011). People with environmental knowledge are much more disposed to put those topics aside in favor of science (Cordeiro et al., 2020), reinforcing the importance on providing more information to citizens. That said, invasive species control activities are pivotal for putting communities and people in contact with nature and science, making them more supportive to both policies against invasive species and actions for their identification and control.

Are the respondent entities mostly from heavily invaded regions?

Respondent entities were mainly from *C. selloana* heavily invaded regions, suggesting that they are more alert for the invasion, but also a stronger willingness to answer in more invaded regions. This further alert for the difficulty in convincing entities to focus efforts in preventing invasive species establishment in a phase when the species is not (yet) visible. In fact, the public only tends to acknowledge the negative impacts of invasive species when the invasion becomes clearly visible: damaging crops, destroying natural heritage, creating public health problems, or being too expensive to control; again, the exception are people environmentally active or with education in environmental areas that more easily recognize the impacts (Caplat and Coutts, 2011; Cordeiro et al., 2020). It is, therefore, reasonable to expe; ct that the more active entities in fighting *C. selloana* are those from the most affected areas, which this work supports.

The main interventions carried out and/or the entity responsible for it are from the littoral, precisely where the invasion by *C. selloana* is most widespread (Plantas invasoras em Portugal, 2020), however, it is also the most populated area with more easy access to information. Thus, these results may be somewhat biased, especially considering that in recent times there have been more records of *C. selloana* in interior areas (Plantas invasoras em Portugal, 2020), without knowing for sure if that derives from expanding distribution of the species or just recent increase of awareness of the problem.

Municipalities are present in the whole territory and can be considered relatively "homogenous" entities, as they all have essentially equivalent responsibilities and autonomy, despite frequently working in different ways. Most municipalities that answered the Questionnaire are indeed from the littoral coast, ranging mostly from Lisbon to northern border, with the ones from interior regions largely ignoring the Questionnaire with only a few answering. This is worrying, especially because the most effective way to fight ecological invasions is by preventing them from happening (Cuthbert et al., 2021; Diagne et al., 2021). This suggest that this important message is eventually not being delivered properly to those that can be more effective in preventing invasions, as are municipalities and other land management entities.

Did adherence to the Strategy proved useful in managing the invasion?

Not yet. The benefits highlighted by the entities like acquiring more information about the species, improving knowledge about controlling it, being more sensitized to it, and more awareness of invasive species in general contrasted with what was claimed to be done by the entities. Successful *C. selloana* control was low, contrasting with the success achieved in the areas directly managed by Project LIFE Stop Cortaderia in Cantabria (data from the Final Report of the Project). This may suggest that more technical follow-up and rigor in following the guidelines provided for the species management are needed by adhering entities. The promotion of raising-awareness/sensibilization activities, which are also a key point for invasion management, were also more promoted by adhering relative to non-adhering entities.

The answers given about the control success of *C. selloana* may have been biased by a unaccurate formulation of the question itself. The number of options was an odd number (one to seven), and most of the respondents may have chosen number four as a neutral stance. When controlling a species there is always, at least, a slight increase or decrease in the area invaded (that option would be three and five, respectively). As Van Selm and Jankowski (2006) suggest, when doing these types of questions, it should be with even

numbers to force the respondents to take a position and not seek refuge in a neutral stance.

As for invasive species in general, awareness-raising/sensibilization activities on *C. selloana* were centered around social media posts, lectures/seminars, school visits, and traditional media (journals, radio, television). Municipalities were most active participants in divulgation compared with other entities like companies, ENGOs, or Educational Institutions. However, since it wasn't asked the motives for not carrying out such activities it is not possible to know for sure the motifs. Nowadays, science divulgation can reach a big audience thanks to social media (Van Eperen and Marincola, 2011; Hwong et al., 2017), thus future projects aiming to promote divulgation activities about invasive species (or a species in particular such as *C. selloana*) may provide a platform, tools or contents (specifically focused on awareness activities) to facilitate the work of entities endorsing such a Strategy.

How influential and useful was the *Cortaderia* Kit?

The *Cortaderia* Kit proved to be highly useful, being even used by entities that have not yet endorsed the Strategy. Respondents recognized that it had clear and accessible information, a good presentation, and it was easy to contact project technicians for help; the Good practice Manual was very positively regarded. One entity suggested that the Kit could have a section adapted to younger people, and this could be a good addition as the Kit is one of the nuclear outputs of the project and could reach a wider audience. In fact, the earlier the access to information is, the easier to tackle this problem (Verbrugge et al., 2021); this adaptation could be used as a didactic tool in schools activities which are a reasonable part of sensibilization done by respondent entities. The positive remarks highlighted should also be seen by other projects that include sensibilization, stressing the importance of not disregarding good communication, well-designed media, and technical/scientific follow-up.

What can be done to further disseminate the Strategy and project to the general public and entities

Answers were diverse, although with a common point: better and more divulgation with better articulation with entities. Dissemination of the Strategy was mostly focused on public entities responsible for land management, since this was selected as the target-audience more capable of implementing the Strategy. Because of that, it didn't reach the "general public" directly which may be a crucial actor in detecting, preventing, and fighting *C. selloana* invasion. Yet, the general public was targeted by other tasks of the project. Nowadays, any project needs to reach and be presented to a large and

diversified audience and this should include a good social and traditional media presence handled by professionals (Hwong et al., 2017; Perea et al., 2021). It should be noted the audiences of each social media, since they are not the same, e.g., Instagram is more image and video focused and could prove useful for invasive species divulgation by taking advantage of the appeal and beauty of species and nature. A good media platform isn't the only thing that can be done, working with local communities and being present at events may also facilitate endorsement: brand awareness (Huang and Sarigöllü, 2012). Brand awareness sticks an idea to a brand, in this case, the Project/Strategy, increasing the willingness to be part of it. It should be noted, however, that good science communication must avoid scientific jargon, know well the target-audience, establish a relationship with the audience, and be succinct (Luisi et al., 2019).

Concerning the good articulation with the various entities, a recurrent critique is the lack of coordination between municipalities since the invasive species do not recognize political frontiers, spreading and growing wherever they see fit. In this context, the fight against invasive species should include preferentialy Intermunicipal Communities or even regions working together, or municipalities working in articulation. The Forest Services (ICNF) should also be present and guide the entities, and private landowners, to achieve better goals and facilitate technical support and follow-up. However, this desire for better articulation has a problem: the highly bureaucratized and slow services that public services are known for (Wang and Feeney, 2016), which is also a reality in Portugal. A possible solution to this problem could be the transition to a more oriented e-government (a more digital, transparent, and direct approach to governing), but, as Wang and Feeney (2016) concluded, that transition has its hardships: i) it may require qualification of the personnel in technology; ii) the entity must possess risk-taking approach because e-government requires external services to maintain and protect the servers and administration procedures changes, that without support from the top management, it can't be done; iii) a very centralized organization finds it difficult to make risky decisions.

Outdoors can also be used for passing a message to an audience (Iveson, 2012), but while it could interesting to raise-awarenss about *C. selloana*, would not make much sense for the dissemination of the Strategy. In addition, these can be very cost-effective and serve as the main advertiser to people following their everyday life. Another option suggested by the respondents (and included in the question itself) was the dissemination along with the water receipt. Frequently, the water services are paid to the municipality and so every month residents receive a letter from it. Therefore, this communication between municipalities and residents could be used for other means, such as

dissemination about invasive species, namely *C. selloana*. Most entities supported the idea and its implementation.

Entities that joined the Strategy were invited to effectively control *C. selloana*, but by law the species has to be controlled either way and be included in sensibilization campaigns. Thus, it's surprizing to perceive reluctance to adhere to the Strategy, with only a small number of entities having joined the Strategy when the questionnaire was done. The reasons for this can be attributed to lack of opportunity to join, not receiving information on how to join, not considering adhering to it important, and reluctance to join. Moreover, some entities stated that the area invaded by *C. selloana* did not justify adherence or that the invasion was already being controlled. The latter reasons are worrying and need to be tackled because as was already discussed here, prevention is the best way to fight biological invasions (Cuthbert et al., 2021; Diagne et al., 2021).

The Kit in terms of scientific and technical communication was very well developed (as it was already mentioned and asserted by the entities), and even entities who didn't know about the Project had the Kit. A real obstacle is the effort and communication needed to convince entities to adhere to the Strategy, since they are often overloaded with multiple tasks and responsabilities. It is a shame, especially considering that entities unanimously proclaimed they learned to better deal with *C. selloana* invasion with the Kit. A possible solution, as already explained previously, would be a more personal communication to engage the entities to adhere, for example, taking advantage of public events, meetings with the people in charge, etc. It needs to be assured of the benefits of joining and share the results that adherence brought to entities.

It should be said that after responding to the questionnaire some entities adhered to the Strategy, once again reaffirming that the main obstacle to adhering is above all communication.

Conclusion

Even though the entities know and recognize the impact invasive species in general have on ecosystems and society, most did not endorse the Transnational strategy to combat Cortaderia selloana in the Atlantic Arc and the few that endorsed it have only modest results in fighting *C. selloana*. Many contacted entities (the majority being municipalities) didn't fill out the questionnaire, but those who did it were mainly from regions most heavily invaded by *C. selloana*, showing a relation between invasive impact and willingness to manage it. This needs to be changed since prevention is the best approach to fight biological invasions and those who could better prevent the establishment of *C. selloana* aparentely are not yet engaged to do it. The Kit proved to be a very valuable tool to many entities, being used and very well regarded by its technical content. Furthermore, the endorsed entities showed mild progress in controling *C. selloana* and complying with divulgation and sensibilization activities to the larger public, with some involving local communities. One of the major problems seems to be communication. Some entities endorsed the Strategy after completing the questionnaire, suggesting that the lack of endorsing isn't due to lack of technical support or scientific content, but because of difficulty on reaching the entities. For that reason, it's recommended that similar projects can create and manage divulgation and sensibilization content in social and traditional media. By doing so the reliance on adherent entities to produce that content (that may or not be good and relevant) reduces and allows for projects to build their name which in turn increases visibility and facilitates communication to and adhesion by entities.

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Supplementary Material

The Questionnaire can be accessed through this Link (last checked on 6 of December 2023).

Table A 1 - Questions included in the questionnaire. *Depending on the response to Question 15 the questionnaire followed different routes. If the answer was “No”, respondent would go to Question 16 and finish the questionnaire; if the answer was “Yes”, respondent would go to Question 17 and answer to all the 27 questions.

Number of the question	The question
1	Email
2	Which institution/entity do you belong to?
3	In which district(s) is your institution/entity located [considering, in particular, where the focus of your operations takes place]?
4	Sellect the option that, in your opinion, best defines what an invasive species is: 1. An exotic species 2. A species able to proliferate by their own means without human assistance 3. A species who promotes negative impacts on ecosystems, economy and health 4. An exotic species able to establish and disperse by their own means who promotes negative impacts on ecosystems, economy and health 5. None of the options above mentioned 6. Other [write your answer]
5	Among the following photographs, mark the ones showing invasive plants.
6	Do you know other invasive plants? If yes, list up to three species different from those included above. If not, write "I don't know".
7	Does your institution/entity control invasive plants? 1. Yes, regularly 2. Yes, but only punctually 3. No, not yet but intends to do 4. No, it doesn’t adequate to our competencies 5. Other [write your answer]
8	Does your institution/entity carry out dissemination/awareness actions on invasive plants? 1. Yes, regularly 2. Yes, but only punctually 3. No, not yet but intends to do 4. No, it doesn’t adequate to our competencies 5. Other [write your answer]
9	If you answered "Yes" to the previous question, please sellect the strategy(s)/means used: 1. Pamphlets/brochures/flyers dedicated to the theme 2. Includes information on the topic in other publications (e.g. Monthly Bulletins, Newsletters, Magazines, etc.) 3. Publications on Social Networks

	4. Lectures / seminars 5. Trips to Schools to carry out awareness-raising actions 6. Training actions, in collaboration with other entities 7. Autonomous training actions 8. Voluntary actions that include invasive control 9. Other [write your answer]
10	If you answered "Yes" to Question 8, please indicate which species(ies) you focused more on the dissemination/awareness activities.
11	Do you know the LIFE Stop Cortaderia Project? 1. Yes 2. No
12	If yes, did you receive the Cortaderia Kit (http://tiny.cc/KIT_STOP_Cortaderia)? 1. Yes 2. No
13	If you received the Kit, what did you find most useful? 1. Manual of Good Practices 2. Transnational strategy to combat Cortaderia selloana 3. Strategy summary document 4. Ease of contacting us 5. Clear and accessible information 6. Good presentation 7. Other [write your answer]
14	Do you think that the Cortaderia kit could be improved in any way?
15*	Have you joined the Transnational Strategy to fight *Cortaderia selloana* in the Atlantic Arc (http://stopcortaderia.org/language/pt/estrategia-pt/)? 1. Yes 2. No
16	If you answered "No" to the previous question, please indicate the reason 1. No opportunity to join yet 2. We have not received information on how to join 3. We do not consider it important to join 4. We are reticent 5. Other [write your answer]
17	Please indicate what type of activity(ies) has/have been carried out within the scope of the Transnational strategy to combat *Cortaderia selloana* by your institution/entity: 1. We haven't done anything yet 2. We started to control pampas grass in some places, but we still have it in other places 3. We bet on containing the expansion by removing the plumes 4. We carried out voluntary actions as a form of control and awareness 5. We increase the dissemination/awareness about the species

	6. We communicate individually with the citizen (e.g., sending a leaflet with the water bill) 7. We promote the performance of training actions on the species 8. Other [write your answer]
18	Did you disclose the activity(ies) carried out? 1. Yes 2. No
19	If you answered "Yes" to the previous question, please tick the strategy(s)/means used: 1. Pamphlets/brochures/flyers 2. Information on the topic in other publications (e.g. Monthly Bulletins, Newsletters, Magazines, etc.) 3. Publications on Social Networks 4. Lectures / seminars 5. School trips 6. Traditional media (newspapers, radio, television) 7. Other [write your answer]
20	If you have already controlled Cortaderia populations, indicate how successful the control was.
21	Do you believe that adhering to the Strategy has provided your institution/entity with tools/information to better deal with this invasive species? 1. Yes 2. No
22	If you answered "Yes" to the previous question, please indicate which aspect: 1. We acquired more information about the species 2. We are better prepared to carry out the control of the species 3. We are more alert in the detection of the species 4. We are more aware of the impacts and consequences of invasive plants 5. Other [write your answer]
23	If you answered "No" to the penultimate question, please indicate which aspect: 1. The available documents are hard to understand and/or not useful 2. The available documents are utopic 3. No opportunity to think about it 4. Other [write your answer]
24	What do you think could be done to optimize the implementation of the Transnational Strategy to fight Cortaderia selloana in the Atlantic Arc?
25	If you work in a Municipality/other entity that has contact with the public, what do you think can be done to disseminate this strategy to the citizens/target audience? For example, disclose the water bill.
26	What do you think could be done to increase the success of Cortaderia selloana's management? 1. Increased inspection 2. Greater disclosure

	3. More awareness focused on the younger sections of the population 4. More awareness focused on the older sections of the population 5. Change in legislation 6. Better technical follow-up 7. More funding for species control 8. Other [write your answer]
27	If you would like to be contacted to know the results of this survey, please leave your email below:

Table A 2 - Categorization of the Questionnaire by sections and type of answer allowed.

Section	Question	Type of Question
Section I	1	Open-ended
Section II	2, 3	Closed-ended
Section III	4, 5, 7, 8, 9	Closed-ended
	6, 10	Open-ended
Section IV	11, 12, 13, 16	Closed-ended
	15	Contingency
	14	Open-ended
Section V	17, 18, 19, 21, 22, 23, 26	Closed-ended
	20	Matrix
	24, 25, 27	Open-ended

Table A 3 - Total E-mails sent and their recipient.

Municipalities	308
Municipalities Associations	24
ONGs	61
Road Companies	14
Electricity Companies	2
Zoological/ Botanical Gardens and Centres of Science Communication	47
Association of Plant Nurseries	1
Intermunicipal Communities	21
Others	2
Total	480