



Public perceptions of non-native plant species on a Chilean sub-Antarctic island

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ABSTRACT

Humans are the main drivers of the introduction, establishment and spread of non-native species worldwide but they have traditionally been excluded from management. Nowadays, the social component of non-native species is increasingly considered. In this paper, we investigated understanding, perceptions and attitudes towards management of non-native herbaceous plant species on Navarino, a remote Chilean sub-Antarctic island. Overall, our study showed a general understanding of the non-native species concept among the interviewees but revealed a lack of consciousness regarding non-native plants species in the local context. Interestingly, our study also revealed many positive values associated with non-native plants species on Navarino, particularly the esthetic value. Whilst some non-native plants were strictly associated with positive values, such as common daisy (*Bellis perennis*) and white clover (*Trifolium repens*), most species were associated with conflicting values. As a key result, our study lastly showed that most interviewees were indifferent about the management of the non-native herbaceous plant species. We, therefore, suggest (i) increasing the awareness of stakeholders with respect to non-native plants, (ii) incorporating stakeholder's values into future management decisions and (iii) considering the strategic location of Navarino Island as a potential stepping stone for the dispersion of non-native plants species towards the Antarctic.

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Introduction

The worldwide increase in commercial trade, transport, travel and tourism in recent years has contributed to the displacement of plant species around the world, some of which have successfully established in areas where they were formerly absent (Perrings, Mooney, & Williamson, 2010; Westphal, Browne, MacKinnon, & Noble, 2008). Non-native plant species are key drivers of environmental changes since they might interact with native plant communities through competition (Pyšek et al., 2012; Vilà, Williamson, & Lonsdale, 2004), alter pollination services (Vanbergen, Espíndola, & Aizen, 2018), influence the soil nutrient cycle (Ehrenfeld, 2003), modify ecosystem carbon and nitrogen cycles (Liao et al., 2008) as well as change public perceptions of landscapes (Binimelis, Born, Monterroso, & Rodríguez-Labajos, 2007).

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Consequently, attempts to preserve nature and ‘nativeness’ from non-native plant species have traditionally focused on their eradication (Mack & Foster, 2009) which reinforced the idea that nature should remain pristine and separated from humans (Berghöfer, Rozzi, & Jax, 2010). In addition to supporting a ‘bioxenophobic discourse’ (Warren, 2007, p. 435), these policies of ‘strict-indigenism’ contributed to a global depreciation of non-native species (Green, 2002; Kendle & Rose, 2000). Thus, the preferred typology to refer to non-native species often implied a negative meaning, such as ‘invasive’, ‘weed’, ‘alien’, ‘pest’, ‘disaster’, ‘threat’ (Chew & Laubichler, 2003; Colautti & MacIsaac, 2004; Early et al., 2016).

Although many studies on non-native species appear biased toward negative impacts and discourses (Colautti & MacIsaac, 2004; Pyšek et al., 2012), various of these species are also known to provide valuable benefits, such as estheticism (Lindemann-Matthies, 2016), food supply (Shackleton et al., 2007) or medicinal remedies (Rao, Sagar, & Sathyanarayana, 2011) which can contribute to their valorization. Nevertheless, when the benefits of a species are compared to the potential of the species to generate significant negative impacts, conflicts of interest often arise between stakeholders (Potgieter, Gaertner, O’Farrell, & Richardson, 2019).

Therefore, a growing number of conservation practitioners, decision-makers and researchers recognize that non-native species management is as much a social issue as a scientific one (Novoa, Dehnen-Schmutz, Fried, & Vimercati, 2017; Reaser, 2001; Stokes et al., 2006). As humans are the main drivers of the introduction, establishment, and spread of non-native species, it is necessary to understand perceptions and choices regarding their use and management (Bardsley & Edwards-Jones, 2006).

In recent years, an increasing effort to study public attitudes toward non-native species have been observed, but most of the studies employed either quantitative (Andreu, Vilà, & Hulme, 2009; Bremner & Park, 2007; García-Llorente, Martín-López, González, Alcorlo, & Montes, 2008) or economic (Marshall, Friedel, van Klinken, & Grice, 2011; Oreska & Aldridge, 2011) approaches. Moreover, studies on perception of non-native species have been largely animal-oriented (Aguirre-Muñoz et al., 2011; Cerri, Ferretti, & Tricarico, 2016; Fleming & Bateman, 2016; Kapitza, Zimmermann, Martín-López, & von Wehrden, 2019; Schüttler, Rozzi, & Jax, 2011).

Instead, this study aims to improve our understanding of public perceptions on non-native herbaceous plant species, using the case of Navarino, a remote sub-Antarctic island of Chile, where, to our knowledge, no research of this kind has been carried out before.

The earliest records of non-native plants species in Tierra del Fuego date back to 1882, thirteen years after the first resident Europeans arrived, but there is evidence that some may have arrived earlier (Moore & Goodall, 1977). No such early records have been established specifically for Navarino, however, the establishments of farms on Navarino in the early twentieth century contributed to the introduction of many herbaceous species for the creation of grazing meadows, such as yorkshire fog (*Holcus lanatus*) and cock’s-foot (*Dactylis glomerata*) (Rozzi, Charlin, Ippi, & Dollenz, 2004). Currently, several species of non-native plants are found on Navarino Island, including the dandelion (*Taraxacum officinale*) and the sheep sorrel (*Rumex acetosella*), two species that are among the most distributed throughout the sub-Antarctic (Frenot et al., 2005).

Since even widespread non-native species may have negligible effects (Hulme, 2012) and because most of the impacts from non-native species are context-dependent (Bartz & Kowarik, 2019), it cannot be alleged that these species will necessarily have an impact on Navarino. Nevertheless, as Simberloff et al. (2013) mentioned: ‘certain extremely consequential impacts, particularly at the ecosystem level, are not readily detected’, which reinforces the

need for a long-term monitoring of non-native species on Navarino island where little data on non-native plants are available.

To investigate public perceptions on non-native plant species on Navarino Island, we used interviews with members of different socio-cultural groups. In the absence of biological data, we aimed to explore (1) conceptualization and knowledge, (2) values and (3) attitudes towards management of non-native plant species of the island. Ultimately, this paper contributes to partly fill the knowledge gap on public perceptions of non-native herbaceous plant species and to provide important information for conservation managers. This is particularly relevant in face of a growing tourism and the national economic interests set in the region (Sernatur, 2014) that will likely contribute to the introduction of new and dispersion of existing non-native plant species. Also, this sub-Antarctic island represents a stepping stone between the South American continent and Antarctica and is therefore of particular interest for conservation efforts (Rozzi et al., 2007).

Methods

Study site

The study was carried out on Navarino (Figure 1), a Chilean island (55°S) located at the southern tip of the Tierra del Fuego region and within the Cape Horn Biosphere Reserve (CHBR). The vegetation of the region is composed of southern beech (*Nothofagus* spp.) evergreen and deciduous forest, treeless Patagonian steppe dominated by fescues (*Festuca* spp.), low shrubs and hard-cushion species and a matrix of peatlands of Magellanic moorlands (Arroyo, Riveros, Peñaloza, Cavieres, & Faggi, 1996; Godley, 1960; Pisano, 1981).

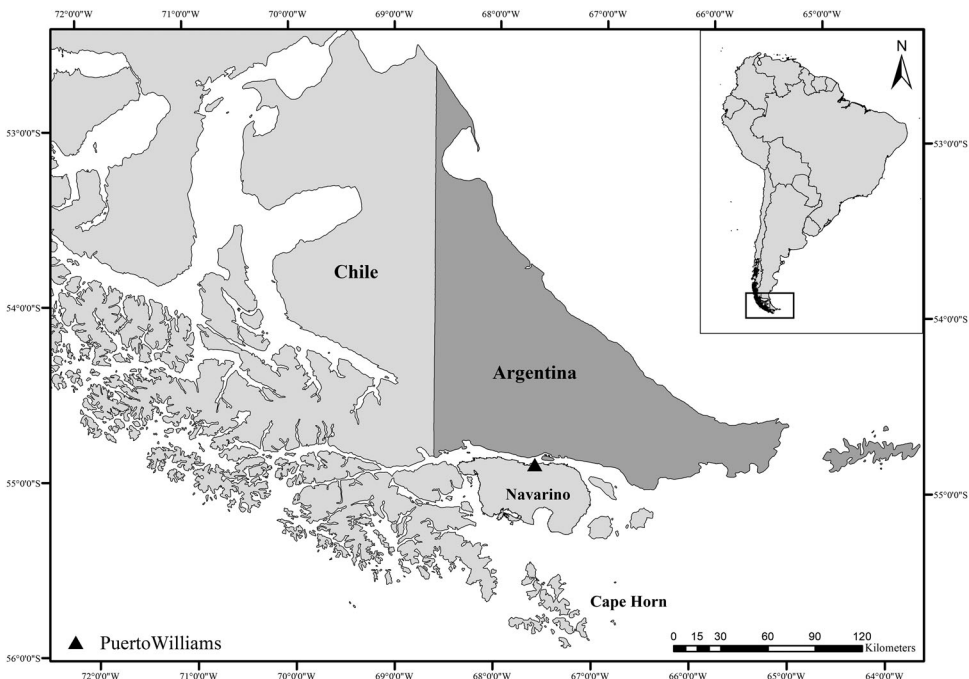


Figure 1. Sub-Antarctic Navarino Island, southern Chile, with Puerto Williams as the capital of the Chilean Antarctic Province.

The climate is dominated by its surrounded oceans and by permanent westerly winds that create a continuous stress factor for plant life throughout the area (Molina, Lumbreras, Benavent-González, Rozzi, & Sancho, 2016).

Puerto Williams, capital of the Chilean Antarctic Province and located on Navarino Island, is the largest settlement in the CHBR with approximately 2200 residents. The settlement includes the indigenous Yaghan community, the rotating personnel of the Chilean Navy, fishermen, public employees, and temporary residents (Berghöfer et al., 2010). The principal economic activities on Navarino are fishing, tourism, and small-scale livestock farming.

Data collection and analysis

A total of 21 semi-structured face-to-face interviews were carried out between December 2017 and March 2018 in Puerto Williams. The 21 participants were selected based on their belonging to the different targeted groups, namely: (i) indigenous Yaghan people, (ii) Chilean navy members, (iii) public services employees, (iv) civil residents of Puerto Williams, (v) elder residents who arrived before 1960 to Navarino, (vi) conservation practitioners and (vii) tourists. We interviewed three participants per group, totaling 7 women and 14 men. While it is true that a difference of status between the investigated groups (i.e. gender, ages, educational standard) may result in differences of non-native species perception (Bremner & Park, 2007), our purpose here, based on an explorative methodology, was to assure to sample every group, independently from the individual characteristics. We used snow-ball sampling for Yaghan people, Chilean navy members, public service employees, civil residents, elder residents and conservation practitioners (see Atkinson & Flint, 2004) and random sampling for tourists. Interviews were conducted in Spanish or English, when the latter was the native language of the participant, and lasted between 20 and 90 min. The structure of the interviews was based on three main themes, namely (1) conceptualization, understanding and observations, (2) perceptions and values and (3) perception of management of non-native plant species (Table 1). When we addressed the first theme, respondents were shown photographs of the non-native plant species present on Navarino (full list in Supplemental material) with their Latin and Spanish names and were asked to mention whether they had seen them on the island.

The interviews were digitally recorded and subsequently transcribed by a native Spanish speaker. We used a general inductive approach to content analysis which deduce categories

Table 1. Interview canvas on perceptions of participants of Navarino Island, southern Chile, towards non-native plant species, based on three main themes.

Theme 1. General knowledge on non-native herbaceous plant species

How would you define a non-native species?

Can you name some non-native plant species present on Navarino?

To your knowledge, what are the reasons why these species have arrived here?

Do you know any potential impacts of non-native plant species?

Are you sufficiently informed about non-native plant species?

Theme 2. Values associated with non-native herbaceous plant species

Between the non-native plant species found on Navarino and showed in these photographs, which ones do you particularly appreciate and why?

Between the non-native plant species found on Navarino and showed in these photographs, which ones do you like less and why?

Can you estimate the quantity on Navarino of each non-native plant that you recognize on these photographs (few, medium, many)?

Theme 3. Control of non-native herbaceous plant species

Have you ever tried to control/eradicate some of these species on Navarino?

What would be the best way to prevent the introduction of other non-native plant species on the island?

Table 2. Typology of values towards non-native plant species derived from the 21 interviews made with participants of Navarino Island, southern Chile and adapted from Alessa et al. (2008) and Kellert (1996) for the local context.

Values	Definition
Utilitarian	Species provide food and material to sustain people's live; Species can be exploited
Esthetic	Species are attractive
Biological	Species provide places for other organism; Species have ecosystemic functions
Philosophical	Species are valued just because they exist; Species deserve ethical relations
Negativistic	Species must be mastered and controlled; Species are avoided because of fear or aversion
Indifference	Species bring no interest or concern

from textual data (Bryman & Burgess, 2002; Hsieh & Shannon, 2005; Mayring & Fenzl, 2014). We included information from across the whole interview into the coding procedure of our three main themes. After the exploration of the data, we searched for theories that matched our categories. Values toward non-native plants species found through the interviews were derived and classified according to a typology that we adapted for the local context from Alessa, Kliskey, and Brown (2008) and Kellert (1996) presented in Table 2. We employed the esthetic value from both Alessa et al. and Kellert and we combined the subsidence value from Alessa et al. with the utilitarian value from Kellert. Additionally, we combined the biological and the life sustaining values from Alessa et al. and the ecological/scientific values from Kellert into one biological value. We also separated the indifference value initially combined into the negativistic value into two distinct values. Finally, a philosophical value was derived from the intrinsic value of Alessa et al. and from the moralistic value of Kellert.

We obtained prior informed consent from each participant. We used written consent for public services employees and for conservation-practitioners and used verbal consent for the other groups described above. For each participant, we explained the project aims, the lack of risks in participating, the possibility of not answering to some questions, the information regarding the use and access of the results, and the anonymous and voluntary nature of their participation. We obtained ethics certificates from the Scientific Ethical Committee of the University of Magallanes, Chile: (2017-08-21), and from the Ethics Committee for Arts and Science Research of the University of Montréal, Canada (CERAS-2016-17-203-D).

Results

Conceptualization, knowledge and local observations regarding non-native plant species

We first asked participants about their concept of the native/non-native framework in general. Many participants mentioned the North American beaver (*Castor canadensis*) and the American mink (*Neovison vison*) as non-native species they knew, which have both colonized Navarino Island at different times. Also, more than half of the participants could describe a non-native species as 'a species not from here'. However, about one third were not familiar with the framework, and classified, for example, native plants like Lenga beech (*Nothofagus pumilio*) and Calafate (*Berberis microphylla*) as non-native. Nevertheless, half of the interviewees accurately named examples of non-native plants species they had seen before on Navarino before seeing the photographs, the most mentioned species being the common daisy (*Bellis perennis*) and the dandelion (*Taraxacum officinale*): 'I saw dandelions. They are everywhere. Walking to

Williams and out' (civil resident #2). Among the stakeholder groups who could report examples, most came from conservation practitioners and civil residents. Interviewees were also asked to name factors related to the arrival and spread of non-native plants and about half said that humans were the main vector. Some specified further by pointing out that horticultural practices such as gardening: 'Residents bring in species from elsewhere, buying seeds and planting them in their gardens' (civil resident #3), multiple movements from tourism: 'I presume it comes from the Europeans ... The boats, the seeds under their feet ...' (tourist #1) and colonization: 'colonization brought in many exotic plant species' (Yaghan #3) were also important vectors of arrival and spread of non-native plants. Few participants also mentioned zoochory as a cause of arrival and dispersal: 'Plant dispersal may be related to birds when they eat the plants and disperse the seeds' (Yaghan #3) and one participant mentioned wind as a natural factor of seed dispersion.

Participants were then asked if they knew potential impacts of non-native plants. Few participants could name examples, but when they could, the impact mentioned was generally 'a possible harm to the local flora' (conservation practitioner #1). Nevertheless, tourists elaborated more on the potential impacts: 'The aggressiveness for the ecological niche could tip the balance in that type of ecosystem' (tourist #2); 'They do things like beavers. If they do not have natural predators, or if the conditions are better than their normal habitat, they expand and everything else dies then' (tourist #3). Some participants contrariwise argued that non-native plant species had no negative impacts on the environment: 'Each plant has its own space ... It does not affect the other ones' (Chilean navy member #1); 'I do not think that exotic plants have any influence in my sector, the forestry sector' (conservation practitioner #3). On the other hand, one participant showed a clear interest in better understanding the potential impacts: 'I do not know if these plants occupy a large part of the island, if they cause harm to native plants or if they spread and I would like you to tell me' (civil resident #2).

When presenting the photographs, the most frequently recognized species were the dandelion, the white clover (*Trifolium repens*), the common daisy, the common nettle (*Urtica dioica*) and the curly dock (*Rumex crispus*). For each recognized species, interviewees were asked their perception of its abundance (a few, a lot) and were asked to name places where they had seen it on Navarino Island. Among all species, participants classified four species as 'very abundant', namely the common daisy, the dandelion, the white clover and the curly dock (Figure 2).

Regarding the spatial location of non-native plants, interviewees observed them mostly in human-impacted areas within Puerto Williams and in near vicinity of roads, the airport, farms, hiking trails, the Omora Ethnobotanical Park (a research, education and conservation center for the Cape Horn Biosphere Reserve), landfill, houses and gardens. Some participants also observed more specifically non-native species on shell middens, defined as cultural deposits of which the principal visible constituent is shell of mollusks and other invertebrates (Waselkov, 1987). Shell middens in Tierra del Fuego are archaeological remnants of the previous Yaghan presence and form, in coastal areas, a ring of intentional accumulations of shellfish food-waste around the presumably former hut (García-Piquer & Estévez-Escalera, 2018; Orquera & Piana, 2009). Very few interviewees mentioned areas not directly accessible by car or boat.

It is important to note, however, that people are much more likely to frequent 'human-impacted' areas and report their observation from these sites. Although we recognize the bias induced by the question, it has been widely argued that non-native plant species are



Figure 2. Photographs of the four non-native plant species classified as ‘very abundant’ by most of participants of Navarino Island, southern Chile: (a) common daisy (*Bellis perennis*), (b) dandelion (*Taraxacum officinale*), (c) white clover (*Trifolium repens*) and (d) curly dock (*Rumex crispus*).

much more common in human-impacted areas (Early et al., 2016; Lodge, 1993; Mack et al., 2000; Mullin, Anderson, Ditomaso, Eplee, & Getsinger, 2000).

Values attributed to species

Utilitarian value

A wide range of uses has been associated with non-native plant species by the interviewees (Table 3). An elder resident even told us that all plants could be used in one way or another. Uses were mentioned by the participants when the photographs of the non-native plant species were shown to them. Species with the greatest number of uses were the dandelion, the common nettle and the curly dock. Groups reporting the highest number of uses were elder residents of Puerto Williams, Yaghan people and conservation practitioners. One of the Yaghan participants mentioned that, in her memory, she had always seen and used dandelion: ‘I have always been taught that the milk is used for injuries. I do not remember a time without dandelions’ (Yaghan #1). The perception of a higher utilitarian value of non-native plants as ornaments versus native plants was reported by a civil resident (#3):

We had a brainstorming session on environmental issues in the community’s environmental committee and one of the things I mentioned was promoting the use of native plants for our gardens, but they told me native plants are not useful for gardens since they take 30 years to grow.

Table 3. Participant's reported uses of non-native plants species showed on photographs during the qualitative interviews on Navarino Island, Southern Chile.

Non-native plant	Scientific name	Reported uses
Broadleaf plantain	<i>Plantago major</i>	Medicinal properties
Common nettle	<i>Urtica dioica</i>	Remedies; Expectorant; Fever; Hair
Curly dock	<i>Rumex crispus</i>	Injuries; Tonsillitis; Burns
Dandelion	<i>Taraxacum officinale</i>	Milk against injuries; Edible; Minerals in petals and flowers; Stomach pains
Flowers species in general		Ornaments in gardens
Grasses		Urinary disorders
Mint	<i>Mentha sp.</i>	Repellent for insect and rats
Pineapple weed	<i>Matricaria discoidea</i>	Stomach pain; Medicinal properties
Spair Thistle	<i>Cirsium vulgare</i>	Edible
White clover	<i>Trifolium repens</i>	Improve soil

Biological value

This value was mostly found among nature practitioners and concerned interactions between species: '[Non-native] flowers, ecologically, contribute to more pollinizers, which helps to ensure that there is an important fauna. (...) I believe then that they constitute a major contribution' (conservation practitioner #3). More specifically, the dandelion has been named as a species providing food to birds by two different participants. There was also a concern raised by a participant about the ecosystem consequences that may result from the non-acceptance of exotic plants: 'I imagine that the plants that are associated with the feeding of cows should be left, no? Because if they disappear by whatever we do, the other animals will also go away, those we live with and need' (conservation practitioner #3). Indeed, white clover has been named by participants from different groups as being widely used by cattle for grazing.

Esthetic value

Nearly half of the participants attributed an esthetic value to the different non-native plants. People appreciated especially flowers for their beauty: 'Flowers in general are all beautiful' (Chilean navy member #2); 'I do not find that [non-native] flowers are nuisances, in fact, I love flowers' (public service employee #2). The common daisy was the most appreciated non-native plant species by interviewees: 'The daisy yes, it is beautiful, I know it well. In the Omora [Ethnobotanical] park there are many. It stays there because it's been a few years since it's a park, before it was a farm where I presume they planted all these species' (civil resident #3). Some also valued dandelions: 'The dandelion has charisma because we can blow the seeds away and because it is very small' (conservation practitioner #3). Many participants also named flowers they had in their gardens that we had not showed on our photographs or mentioned (such as lupines, fuchsias), which confirmed a strong general interest for ornamental plants in all groups, except for tourists.

Philosophical value

Two participants raised arguments within a more philosophical framework, the first one argued that we might need to rethink the concept of non-native species in the era of the Anthropocene:

The dynamics of vegetation is in constant change, it is not stable, so our intention to conserve may be part of one of our human whims. We want nothing to change because we like it as it is, for esthetics itself ... Perhaps there is an unconscious part of me in which I want nature in one way, as I know it, and even if life and nature go in another direction, I want to keep in mind that

it will remain as it was ... If the temperature rises, I would think that it is the exotic plants that will eventually dominate, while native flora is accustomed here to the cold and more stable conditions and do not have the ability to acclimate in comparison to others. So sometimes, I do not like it, but I think it would be necessary to adapt to the change, because in the end, everything changes. (Conservation practitioner #3)

The other participant brought nuances to the framework of native/non-native species:

The spread of exotic plants is something that has existed since man is man. Men have always sown. The speech saying that anything new to happen is a disaster, I do not agree. It could be, but I cannot say it, otherwise the world would not be as it is today. All plants that are used to eat, for example. It's a phenomenon that started so long ago. There are introduced species on Navarino Island that have been introduced for more than 100 years. It is not a disaster either, the island is not carpeted with curly docks or dandelions, to name only these plants. It is not necessary to exaggerate either. (Civil resident #1)

Negativistic value

Most of the participants expressed disgust and aversion for the curly dock, describing it as 'ugly', 'horrible' or even 'a disaster'. Some also mentioned the hardness in getting rid of it: 'They grow bizarrely and big and everywhere. It's universal, it's just everywhere! You must take the soil out completely and the seeds still disperse' (civil resident #3). Dandelion was also characterized as a pest requiring control by most of the interviewees: 'I think it's impossible to eradicate dandelion. It's like a little demon. Every day in my greenhouse I have to remove the dandelion seeds that come in' (civil resident #3). On the other hand, spear thistle was frequently described as physically unappealing by interviewees, but most have mentioned the danger related to its spines-tipped stem and spine-leaves. Similarly, many participants raised the danger associated with the common nettle, having caused skin rashes and contributing to a feeling of fear towards the plant and its effects: 'I gave it [common nettle] to my son once to fight a virus, but I will never do it again! It is itchy ... Bad advice of alternative medicine' (public service employee #1).

Indifferent value

Indifference towards non-native species was also noted for a few participants, mostly Chilean navy members. One participant did not mention any benefit or consequence of the plants shown while another did not believe that species could have an impact on anything. Further, two participants mentioned the lack of importance of the theme. One participant argued: 'I do not think it is a priority in terms of what we are currently experiencing at the political and social level' (conservation practitioner #3) while another one claimed: 'The truth is that, here, nobody cares' (civil resident #1).

Attitudes towards management of species

One-third of the participants (including all interviewed tourists) were in favor of better control actions regarding non-native species on Navarino. Additionally, tourists expressed the wish to get more information about non-native species upon their arrival on the island and one suggested that: 'the way forward should also focus more on trails and not letting people avoid mud, for example, because afterwards, the trail is stepped everywhere' (tourist #3). One tourist also believed that 'animals that contribute to the dispersion of seeds should be managed' (tourist #2). On another side, one participant suggested that: 'it

should start with prevention in the sea and air entry ways, and then generate means of control and mitigation' (conservation practitioner #1). However, some participants had no interest in management:

Curly dock does not cause any economic harm to livestock. Our mission [at work] is to devote resources to invasive species or invasive plants that have political and economic consequences on the export or productivity of livestock, for example. In this case, the curly dock has no effect. (Public service employee #1)

Some participants also believed control measures would be difficult, if not impossible to apply: 'I think it's a complex subject ... I do not know what alternatives there are, how can this be controlled' (conservation practitioner #2); 'I do not know how ... So much seeds! I cut every curly dock in my garden and others appear, appear, appear' (public service employee #3).

On the other hand, some participants wished they could pursue their use of non-native species despite control measures: 'How can you eradicate them, eliminate them, I do not know. But if you can take advantage of them, it would be fantastic, and it could also go along with the creation of control measures' (conservation practitioner #1); 'I do not think it's necessary to make a management plan as such, and try to eradicate the curly dock, but I think we should still try to contain these plants in a small space to use them as medicine' (Yaghan #1). While all civil residents mentioned their willingness to get involved in a control program, they also mentioned the lack of awareness and interest of other people:

I would participate, I would be more than happy to participate, but, frankly spoken, that is science fiction. There is no culture, politically speaking. It is not profitable. Eradicate a couple of little plants. They spend millions of dollars to study, but to do concrete things, nothing ... (Resident #1)

'Yes, I am already involved in this topic in the environmental committee, but they consider exotic insects more of a priority. They seemed more concerned with the management of this type of species rather than plants' (resident #3). One participant mentioned that control should not happen through public policy, but rather through citizen participation: 'Maybe we can do community campaigns in which children, people, could better manage their gardens. I believe this would be more effective than a public policy' (conservation practitioner #2).

Discussion and conclusion

We investigated understanding, perceptions and attitudes towards management of non-native herbaceous plant species on a remote sub-Antarctic Chilean island. Overall, our study showed a general understanding of the non-native species concept among the participants but revealed a lack of consciousness regarding non-native plants species in the local context. Specifically, participants confounded native with non-native plants and were unaware of their potential environmental changes. These low levels of knowledge could be explained by a few underlying causes. Firstly, research on non-native species in southern Chile has been extensively focused on beavers and mink (Anderson, Griffith, Rosemond, Rozzi, & Dollenz, 2006; Crego, Jiménez, & Rozzi, 2018; Menvielle et al., 2010; Schüttler et al., 2011), while few studies have looked at plant species (Rozzi et al., 2004; Vidal et al., 2015). Secondly, the environmental changes generated by non-native plants may be less visible than those of some animals (for example, beavers as ecosystem engineers). Thirdly,

local efforts on the management of non-native species have also only focused on animals like beavers, mink and muskrats (*Ondatra zibethicus*) (Soto & Cabello, 2007). Lastly, it seems that media coverage or access to information does not allow people to obtain knowledge on non-native plants of the island. Fischer and van der Wal (2007, p. 256) pointed out that one common criticism is ‘that members of the general public might have insufficient knowledge and motivation to contribute to environment-related decision making in a valid and meaningful way’.

Remarkably, our study revealed positive values associated with non-native plant species on Navarino Island. Overall, the esthetic value of species, particularly flowers was the most highlighted. Positive interactions have also been mentioned by participants, such as feeding interactions between birds and seeds in general or between cattle, horses, common daisies and white clovers more specifically. Among the body of literature focusing on non-native species, positive ecosystem interactions remain under-researched (Kuebbing & Nuñez, 2015; Pyšek et al., 2012). While there are some studies on positive interactions between non-native and native species in other parts of the world (Fischer & van der Wal, 2007; Molina-Montenegro, Badano, & Cavieres, 2008; Simberloff & Von Holle, 1999; Tecco, Gurvich, Díaz, Pérez-Harguindeguy, & Cabido, 2006), those focusing on sub-Antarctic contexts are scarce, if not non-existent. This is crucial because interactions are scale and context-dependent and can develop and adapt over time. Indeed, some participants mentioned this challenge in a context of climate change (philosophical value). Interviewees questioned the forced claim on paralyzing nature in a changing world. In this spirit, Schlaepfer, Sax, and Olden (2011) argued that non-native species could fulfill important ecosystem and esthetic functions, particularly in places where native species cannot persist due to environmental changes. In fact, the principal issue in valuing native species in conservation is that it commits us to appreciate a flora and fauna that reflects a specific environmental and climatic state which is under constant change (Kendle & Rose, 2000). This new ecology (i.e. ‘the new wild’, Pearce, 2016) shows once more that the dichotomous concept of ‘good-natives’ and ‘bad-aliens’ as traditionally expressed in the invasion biology sub-discipline is a fractured concept.

Whilst some non-native plants were strictly associated with positive values (e.g. common daisy and white clover, two important species for livestock grazing), most species were associated with conflicting values. Specific species with conflicting values included the dandelion which, although some called it a pest, others rather called it a beauty of nature. Another example of conflicting values is the curly dock which most people characterized as a pest, but which also has medicinal properties that are used especially among Yaghans. Díaz (2010) found that 4% of the vascular plants used by the indigenous peoples of southern Patagonia are exotic species, such as curly dock and dandelion, two species that were naturalized early in the region due to the intentional introduction by settlers. Such values should undeniably be considered to avoid social conflicts in non-native species management (Estévez, Anderson, Pizarro, & Burgman, 2015). Social conflicts are disagreements arising between individuals and groups who express incompatible beliefs, values or goals (Crowley, Hinchliffe, & McDonald, 2017). Conflict can result when both sides of the argument fail to assess the trade-offs between them (Dickie et al., 2014). Value-based conflicts are inherently difficult to resolve because management authorities must balance the needs of different stakeholders while still conserving the environment (Zengeya et al., 2017). Power issues are embedded in biological invasions and increased interest around this topic is likely to make conflicts more widespread in the future (Dickie et al., 2014). Generally,

collaboration and levels of trust among stakeholders can be increased by an open and fair participation process (Estévez et al., 2015; Novoa, Kaplan, Wilson, & Richardson, 2016). We believe that a fair participation process involves also promoting the plurality of opinions as well as disclosing the controversial nature of debate around the management of non-native species. We thus agree with Schüttler et al. (2011, p. 181) that: ‘especially in settings with strong differences in power and education, as given on Navarino Island, the danger is great that an established dominant position will guide practice without any discussion, neglecting “silent voices”, not used to articulate themselves’.

As a key result, our study nevertheless showed that most participants were indifferent about the management of non-native herbaceous plant species. This was probably a result of either absent impacts of non-native plant species, poor experiences on negative consequences of non-native plant species and/or few information. Therefore, we, suggest implementing awareness campaigns in a way of promoting access to information and open discussion on non-native species since it is an essential tool for engaging different stakeholders. Similarly, Bardsley and Edwards-Jones (2006, p. 207) highlighted that:

To prevent a considerable local backlash against environmental policies that inhibit the activities of agricultural and horticultural producers, nursery owners and local residents in general, it could be necessary to evolve invasive species management with substantial local input via participatory approaches, rather than imposing programs from above.

Moreover, the high interest of tourists on non-native species suggests that it may be particularly relevant to implement activities directed towards this stakeholder group to improve their awareness of the risks related to non-native species introduction and dispersal on Navarino Island and in the CHBR. As the increase in the movement of non-native species is directly related to the growth in international trade, tourism and human mobility (Anderson, Roccliffe, Haddaway, & Dunn, 2015; Hall, 2015), reducing unintentional introductions through these vectors will require effective prediction, surveillance, awareness-raising and control (Tatem, 2009).

On Navarino, the exponential growth of the tourism industry through cruise ships (García, 2004), the construction of new roads and infrastructures (Sernatur, 2014), the spread of introduced beaver (*Castor canadensis*), which create forest corridors and open habitats (Anderson et al., 2006), are all anthropogenic disturbance that could confer competitive advantages to non-native plant species and thus facilitate their establishment and dispersal (Byers, 2002).

Furthermore, an increase in temperature and precipitation is expected in the Tierra del Fuego area (IPCC, 2013) which could facilitate the establishment of non-native species (Lebouvier et al., 2011). Since it has been shown that human influence associated with rapid social and economic changes at different scales can significantly influence the fate of local and regional biological diversity (Cerdeira, Barkmann, & Marggraf, 2014), it is particularly important to put non-native plant species onto the public agenda for the Chilean sub-Antarctic. Inspections of visitor’s footwear and luggage on arrival to pristine sites such as the Cape Horn Biosphere Reserve could be a way to substantially reduce propagule loads (Lee & Chown, 2009), as partially implemented in the Southern Ocean Islands (de Villiers et al., 2006) and in the Antarctic continent (Hughes et al., 2019).

As previously said, this is particularly relevant since the island represents a stepping stone between the South American continent and the Antarctic and non-native propagules might be transported from the CHBR further south (Rozzi et al., 2007). Currently, several

non-native species are found along the sub-Antarctic islands (Frenot et al., 2005; Lebouvier et al., 2011) which represents a significant challenge for the Antarctic, since some of them have yet been noticed in the peninsula (Cuba-Díaz, Troncoso, Cordero, Finot, & Rondanelli-Reyes, 2013; Fuentes-Lillo, Cuba-Díaz, Troncoso-Castro, & Rondanelli-Reyes, 2017; Olech & Chwedorzewska, 2011). Among the four species classified by participants as 'very abundant' (dandelion, common daisy, white clover and curly dock), only the curly dock has been found further south than Navarino (i.e. Baily Island) (Rozzi et al., 2004). Despite the fact that most species perceived as most abundant on Navarino have no records in Cape Horn and the Antarctic, we anticipate that they might reach out there shortly. This highlights the need of common conservation guidelines for the sub-Antarctic and Antarctic.

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