



Research article

Do people care about pine invasions? Visitor perceptions and willingness to pay for pine control in a protected area

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ABSTRACT

Tree invasions are increasing globally, causing major problems for biodiversity, ecosystem services and human well-being. In South America, conifer invasions occur across many ecosystems and while numerous studies address the ecological consequences of these invasions, little is known about social perceptions and people's attitudes toward their control. The social perceptions on the effect of invasive conifers can include recreational, cultural and conservation dimensions. This study, conducted in the Malalcahuello National Reserve, aims to assess visitor's perception about invasive pines (*Pinus* spp.) and their effects on the endangered *Araucaria araucana* forests and determine their willingness to pay for pine control. We used a questionnaire to survey visitors to the reserve in both winter and summer (n = 138 for each season). When confronted with six images of araucaria and pine forests with and without snow, visitors consistently preferred landscapes without pines and disliked those completely dominated by pines the most. Almost half, 46.5%, of the visitors expressed their willingness to pay (WTP) for pine control and after given a brief explanation about pine impacts, this number rose to 79%. Visitors who said they were unwilling to pay argue ethical, aesthetic and pragmatic considerations relating closely to a number of social value systems and beliefs. Our study shows that there is a high variation in how people assess the threat of invasive pine species in natural areas, but education even in a very brief format can help to increase awareness of the problem and build social and financial support for its control.

1. Introduction

Tree invasions are becoming a major conservation problem because of their ecological and social impacts. Due to the continuous increase in afforestation with non-native species, where many of them are or have the potential to become invasive in adjacent natural and/or anthropogenic ecosystems, tree invasions are becoming a regular component of landscapes worldwide (Dickie et al., 2014; Richardson et al., 2014). If not managed, tree invasions cause severe impacts on biodiversity, by displacing natural communities, but also by changing water availability and fire regimes (Simberloff, 2010) and decreasing ecosystem services with negative effects on human well-being (Dickie et al., 2014). Invasive trees also cause social impacts such as affecting landscape aesthetics, potential for recreation and other cultural ecosystem services (Tveit et al., 2006; Musacchio, 2009; Daniel et al., 2012). They can also negatively affect local livelihoods, through income reductions and health effects (see Shackleton et al., 2018a).

Visual impacts of invasive trees are linked to the process of biotic

homogenization (Villéger and Brosse, 2012) and an overall reduction in landscape naturalness (Tveit et al., 2006), which can be particularly negative for people seeking experiences with natural or wild environments (Buijs et al., 2009). Research shows that the more people seek to see themselves as part of nature, the more they are willing to support biodiversity conservation to preserve an aesthetically idealistic perception of nature (Frantz et al., 2005; Gosling and Williams, 2010; Buijs et al., 2009; Chan et al., 2012). Scenic beauty, therefore could function as a decisive factor affecting how the degree of naturalness in a landscape is perceived (Khew et al., 2014). Presumably, pro-environmental attitudes and behavior correlate with various concepts and cultural images of nature, with different degrees of domestication (Buijs et al., 2009; Iwata, 2001). Therefore, cutting down invasive trees simply because they are exotic may be perceived as detrimental for the environment, as trees in general are conspicuous and iconic components of the landscape and for many people, regardless of their origin (Buijs et al., 2009; van Wilgen, 2012; Dickie et al., 2014). Moreover, protected areas are also visited during different seasons by people from different

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places, who have different motivations and demographic profiles (Monz et al., 2010; Moyle et al., 2017). For example, winter and summer visitors use, perceptions, attitudes and motivations to the same protected area are expected to vary, as highlighted in studies within mountain national parks and reserves in Europe and North America (Görner and Čihaj, 2011; Needham et al., 2011; Petrovic et al., 2016). Within the same group protected areas visitors' perceptions may also be highly variable, depending on factors such as income, education, place attachment and origin and this diversity needs to be taken into account (Kim, 2014; Kyle et al., 2005; Moyle et al., 2017; Gardener et al., 2010).

Although understanding the social dimensions of invasive species has been judged to be crucial for a successful management, there are limited studies addressing this issue using empirical research – especially in South America (Estévez et al., 2015). In fact, social perceptions on invasive species has been applied to participatory management and environmental decision-making (Santo et al., 2015; Shackleton et al., 2018c), and for invasive plants research has focused on determining management strategies and effectiveness of policies (Head, 2017). Indeed, perception and attitudes towards invasive species among stakeholders can be diverse, which can create complexity and conflicts of interest (Dickie et al., 2014; Estévez et al., 2015; Novoa et al., 2017; Shackleton et al., 2018b). For example, people might declare a negative perception of or attitude towards a particular invasive species, and at the same time, be against its eradication or control by lethal measures for ethical reasons (García-Quijano et al., 2011; Gardener et al., 2010). In other cases, often for the general public, the distinction between exotic and native species is challenging, and their landscape preference depends strongly on their cultural background and personal history (Buijs, 2009; Buijs et al., 2009), or even the landscape context, including differences in invasive species public awareness between urban, rural or natural areas (Novoa et al., 2017; Potgieter et al., 2018). Many invasive species can also gain cultural significance during decades of colonization (Pfeiffer and Voeks, 2008). Social contested values, perceptions and attitudes toward invasive species and control measures can result in social conflict between decision-makers, environmental managers and other stakeholders from the local community (Estévez et al., 2015). It is vital for policy makers and managers to understand local perceptions and the role that invasive species play in people's livelihoods (Pfeiffer and Voeks, 2008).

Invasive species management programs should consider, for example, the broader socio-ecological costs and benefits of any management action, and for that purpose, public opinion on these alternatives may be very informative (Shackleton et al., 2007, 2017; Verbrugge et al., 2013). However, systematic assessments of the effect of invasive trees on visual landscapes and social perceptions are lacking (see examples in other taxa, Epanchin-Niell and Wilen, 2015; Shackleton et al., 2017), even though there are many ecosystems with high recreational, cultural and conservation value being transformed by tree invasions (Bustamante and Simonetti, 2005; Pejchar and Mooney, 2009; Andersson et al., 2016). Thus, landscape change by tree invasion remains a major challenge for invasion ecologists and environmental managers to better document not only the biophysical changes, but also how the public perceives this problem and how society can support invasive tree management and reduce their socio-ecological impacts (Andersson et al., 2016; Dickie et al., 2014; Head, 2017; Novoa et al., 2017).

Previous studies have shown that conservation-related education may have a significant effect on raising awareness about environmental protection issues, and help people to look beyond particular aesthetics to appreciating more biodiversity-friendly landscapes. Lack of knowledge can hamper conservation efforts, but fortunately, environmental education and environmental awareness techniques could trigger positive response to critical issues (Merenlender et al., 2016). For example, ecological knowledge (via formal and informal education) can be a necessary cognitive “pre-condition” of responsible behavior and action, enhancing people's capacity to perceive and value biodiversity

and the environment and take appropriate actions for ecosystem and landscape conservation and sustainability (Musacchio, 2009). This knowledge-based ability of environmental interpretation and personal decision-making can be understood together as an environmental literacy (U.S. Department of Education, 1992; McBride et al., 2013).

Considering the scenario of rapid social-ecological change (Lewis and Maslin, 2015), biological invasions should be addressed and managed considering their social and ecological context (Pfeiffer and Voeks, 2008). It is important for any strategy on the management of invasive species to assess and monitor how the public, that enjoys the benefits of these ecosystems, perceives invasive species impacts. Assessment should not just capture the basic perception or attitudes towards particular species, but should also include a more in depth-look at the social and environmental context that will determine whether a particular management action can be implemented (Guo et al., 2017). One simple way to measure public support for invasive species control is using the willingness to pay (WTP) approach (García-Llorente et al., 2008; Estévez et al., 2015; Rolfe and Windle, 2014). This can be a relevant proxy of how committed people are to reduce invasive species impacts (Guo et al., 2017). Assessing visitors WTP could help local conservation agencies to estimate potential funding for invasive species, particularly in recreational settings or in areas where most of the income comes from visitors fees (Hovardas and Poirazidis, 2006; Baral and Stern, 2011; Liu et al., 2015). Furthermore, it is clear that socially-supported invasive species control can positively affect ecological restoration outcomes. For example, WTP is also a measurement of how much time and effort people are willing to invest in controlling the threat, and it may be useful to estimate for example how much volunteer workforce will be available in case such activities be developed (Buizer et al., 2012).

The southern hemisphere has been particularly affected by the establishment and expansion of invasive *Pinus* spp, where many of these large-scale plantations have spread to adjacent landscapes, often colonizing areas of high conservation value (Richardson, 2006; Simberloff et al., 2010; Pauchard et al., 2016). In fact, invasive pines have become major concern for the ecosystems of southern South America (Pauchard et al., 2016). For example, areas invaded by pines accumulate high fuel loads, which may increase fire frequency and intensity. As a result, risk of wildfires has increased, damaging soils and biodiversity, and leaving surfaces bare and eroded (Cowling et al., 2009; Cobar-Carranza et al., 2014; Braun et al., 2017; García et al., 2018). This situation is particularly extreme in areas where the native vegetation is treeless such as steppe and grassland environments (Franzese et al., 2017). Although, ecological impacts of pine invasions in South America are becoming increasingly well studied, public perception of pine invasions remains poorly understood.

A striking example of pine invasions in South America, is occurring in the *Araucaria araucana* forests of the Andes, which are being invaded by *Pinus contorta* and other cold-tolerant non-native pines (Cobar-Carranza et al., 2014; Peña et al., 2008). *Araucaria araucana* (common name, araucaria) is an emblematic tree for Chile and Argentina, and also for the native indigenous Pehuenche communities because of its aesthetics but also because it is the source of the *piñon*, a seed of high culinary, nutritious and spiritual value (Reis et al., 2014; Hechenleitner et al., 2005). At the Malalcahuello National Reserve in south-central Chile, pines are invading the native forest and treeless environments, where araucaria is conserved. For more than a decade, invasive pines control has been recommended to local authorities for this reserve and several other protected areas in Chile, but with relatively low concrete effect (Peña et al., 2007). Furthermore, besides the obvious management and ecological uncertainties, little is known about the social impacts of invasive pines and how much support any management effort aimed at reducing pines and restoring native ecosystems would have.

Thus, this study, conducted in the Malalcahuello National Reserve, aims to 1) characterize visitation motivation and ecological literacy both in winter and summer visitors, 2) assess visitors perception about

invasive pines (*Pinus* spp.) and their effects on endangered *Araucaria araucana* forests, and 3) determine their willingness to pay for pine control in this area before and after receiving additional information about invasive pines. We hypothesize that a) visitors have a negative perception of invasive pines and their effects on the visual landscape affecting cultural ecosystem services (e.g. aesthetics, recreation), b) visitors with higher environmental literacy have a higher awareness of the impacts of pines and are more willing to pay for their control, c) informing people about the ecological impacts of pine increases awareness for visitors and their willingness to pay, d) winter and summer visitors have different demographics and show a high variability in the perception of the problem of invasive pines and willingness to pay for pine control, which is associated with their income and education.

2. Methods

2.1. Study model and site

The Malalcahuello National Reserve is located in the Andean Cordillera of the La Araucanía region (71° 28' and 71° 35' W, 38° 23' and 38° 30' S), in the municipality of Curacautín. The climate is humid Mediterranean, with an annual average temperature of 8.5 °C and annual rainfall of 3,083 mm and 1–2 dry months per year (Cóbar-Carranza et al., 2014; CONAF, 1996). The Reserve contains representative samples of the High Andean and *Araucaria araucana* forests and the mixed deciduous forest of *Nothofagus* spp. (CONAF, 1996). Araucarias are iconic native trees of cultural and Pehuenche indigenous heritage significance (*Pehuen* = araucaria; *che* = people). Araucaria was declared a Natural Monument species and it is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (CONAF, 1996). The Reserve has outstanding scenery features such as the Lonquimay volcano (2,806 m a.s.l.). Thus, the Reserve is valued for tourism and bi-seasonal recreational, including winter sports, nature observation, hiking, fishing, nature photography during summer and other cultural services (Cóbar-Carranza et al., 2014; CONAF, 1996). The reserve and its surrounding matrix are experiencing increasing pressure from tourism, which is causing an unprecedented rise in real estate development, road construction and overall human footprint on the reserve. Visitors to the reserve in 2016 reached 104,237 compared to 9046 in 2006, more than a tenfold increase, and currently, foreigners account for only 4% of the visits (CONAF, 2016).

In the Malalcahuello National Reserve, experimental plantations of *P. contorta*, *P. sylvestris*, *P. ponderosa* and *Pseudotsuga menziesii* (Mirb.) Franco were established by the Forest Institute (INFOR) in 1970's (Peña et al., 2008). These plantations were never harvested commercially and are now abandoned. The most invasive tree in the area is *P. contorta* (Langdon et al., 2010; Peña et al., 2008). Peña et al. (2008) determined that *P. contorta* has invaded more than 78 ha, but current estimates are triple that area (unpublished data). The areas most affected by the invasion include *A. araucana* and *Nothofagus* forests, but invasive pines have been reported even in alpine vegetation and bare volcanic soil.

2.2. Questionnaire and comparisons

A questionnaire was conducted with Malalcahuello National Reserve visitors, both for Chileans and internationals, who were 18 years or older. A pilot questionnaire was tested in January of 2015, with a total of 50 surveys, and improvements were included in the final version (Supp. mat. 1). Surveys were conducted both in English and Spanish due to visitation of international tourists to the Reserve. Considering that the Reserve is used both in winter and in summer, different visitor profiles were expected for each season (Görner and Čihář, 2011) and as reported in other studies in mountain reserves, winter and summer visitors perceptions can be substantially different (e.g., Needham et al., 2011). The winter survey, with a total of 138 responses,

was carried out on 30 and 31 July and 1 August 2015 in the coffee shop of the Corralco Ski Center and in sports equipment rental businesses near the limits of the reserve. Visitors were personally approached in these places and invited to participate by answering the survey. The summer survey (9–11 January 2016, total of 138 responses) followed the same method, although summer visitors were contacted at the entrance of the Reserve.

The questionnaire had four sections. The first section contained questions relating to personal and demographic information, including place of origin, family income, and education level. The second section included questions about the trip motivation, including means of transportation, number of previous visits, and questions about landscape visual aspects. In this section five phrases were read to each respondent, where they had to answer very strongly, agree, disagree, strongly disagree or not know. The phrases were 1) I do not tolerate when nature is damaged, 2) Humans are part of nature, 3) Forests are important for human welfare, 4) Native forests are more attractive than planted forests, and 5) I am informed about environmental issues. The third section sought to determine the aesthetic perception of the landscape with and without pine trees. To this end, the interviewees were presented at the same time with six images reflecting different types of vegetation cover in winter and summer: Two images of araucaria forest in summer and winter, two images of araucarias and pine forests in summer and winter, and two images of pine forest in summer and winter (Fig. 1). Respondents were then asked to sort out the images according to their aesthetic preferences, from the most scenic image the least scenic image. In the fourth section, visitors were asked if they would be willing to pay to reduce or eliminate the presence of pines within the reserve and how much would they be willing to pay. After this first round of questions, interviewees who shown no willingness to pay were given the following the brief explanation about the impacts that pines generate in natural ecosystems “Pines are a species introduced in Chile for commercial purposes, that is, they provide goods and services to society. However, they can be invading, that is to say they reproduce beyond where they are planted, which means that they compete for resources like light and water with the native species, displacing them and avoiding their development”. The respondent was then asked to answer the WTP question again, considering the information provided. Respondents who said they were unwilling to pay, even after the brief explanation about pine impacts, were asked to give a short reason of why they would not economically support this initiative. Finally, all visitors interviewed were asked to provide comments or suggestions for the implementation of pine invasion control within the reserve.

Comparisons between variables segregated by groups were made based on percentages and statistical significance was determined using Chi-squared ($p > 0.05$; SPSS 12.0).

3. Results

3.1. Visitors' basic characterization and environmental awareness

Most visitors surveyed in the Malalcahuello National Reserve were Chilean nationals (90% in winter and 80%; Table 1). Of all the visitors, both seasons, foreign visitors came from Argentina (6.2%), Brazil (3.3%), United States, Spain and Germany (1.1% each). Chilean visitors came mainly (> 60%) from the nearby regions of Biobío and La Araucanía. In summer and winter, the Capital city, Santiago de Chile was the third most common place of origin. Most of respondents were male (52% in winter and 61% in summer), and winter visitors were on average younger (40%, 18–27 years old) than summer visitors (Table 1; Supp. mat. 1). The majority of visitors had a college education (58% in winter and 62% in summer), with a slightly higher postgraduate level in winter visitors (Table 1). With respect to family income, 41% of visitors had an income greater than 25,001 USD in winter, while in summer 30% of the respondents had a income between 15,001 and 20,000 USD (Table 1).



Fig. 1. Images used in the questionnaire to assess landscape preferences. Visitors were asked to sort the images from the highest to the lowest preference (1–6). Images include three vegetation types in two seasons (AW: Araucaria forest in winter, APW: Araucaria forest with pines in winter, PW: Pine forest in winter, A: Araucaria forest in summer, AP: Araucaria forest with pines in summer and P: Pine forest in summer). All pictures were taken near the entrance of the reserve in 2016.

Regarding reasons for visiting the Malalcahuello NR, in winter, 45% of respondents said that the main reason was winter sports activities, followed by spending time with family (22%), while in summer the main reason was quietness and relaxation (38%), followed by spending time with family (28%) and summer sports activities (8%) (Supp. mat. 2). Interestingly, “learning about nature” was ranked very low in both seasons, especially in winter (Supp. mat. 2). In winter, 72% practiced skiing followed by 23% who practiced snowboarding, while in summer the main sport was trekking or hiking, corresponding to 65% of the respondents (Supp. mat. 2).

Responses to environmental literacy questions showed a very high and consistent level of agreement with statements associated to environmental awareness (Q1 to Q4) (Supp. mat. 2). However, when asked about how “I’m informed about environmental issues” less than half

of the surveyed population listed “Strongly agree” and 10% of respondents recognized their insufficient knowledge of environmental issues.

3.2. Visitor perceptions of pine invasions

Both summer and winter visitor respondents, preferred pure araucaria landscapes when asked to sort landscape images (Fig. 1) - with the only difference being that winter visitors prefer snow-covered araucaria forests (48%), and visitors of summer prefer them without snow (38%) (Fig. 2 A). With regard to which image they like the least (dislike the most), in both surveys the image of pure pine invasion in summer obtained the highest percentage of selection (47% in winter and 43% in summer survey), followed by the pure pine invasion image in winter

Table 1

Visitor characteristics (Origin, Gender, Age proportion, Last education level approved, and Annual family income) in winter (n = 138) and summer (n = 138) surveys. Only visitors 18 yrs or older were surveyed.

	Winter survey	Summer survey
Origin		
National	90%	80%
Foreign	10%	20%
Gender		
Female	48%	39%
Male	52%	61%
Education		
Primary	–	7%
Secondary	40%	24%
Undergraduate	48%	62%
Postgraduate	12%	7%
Age (yrs)		
18 - 27	40%	17%
28 - 37	22%	24%
38 - 47	14%	20%
48 - 57	14%	17%
> 58	10%	22%
Family income (USD/year)		
< 10,000	11%	24%
10,001–20,000	22%	30%
20,001–30,000	9%	12%
30,001–40,000	17%	10%
> 40,000	41%	20%
Does not answer	–	4%

(29% in the winter 28% in the summer survey) (Fig. 2 B).

The majority (63%) of winter respondents said they were aware of pine invasion in the Reserve, which was even higher for summer visitors (86%) (Table 2). The Chi-squared analyses showed that there were no significant differences in landscape preferences among the different groups surveyed (age, education, income; Chi-squared, $p < 0.05$). However, visitors with more experience of the area (more than one visit) showed a relatively higher dislike for pure pine stands in summer conditions (without snow) (Chi-squared, $p < 0.05$; Fig. 3).

3.3. Willingness to pay to reduce or eliminate pines in the reserve

The presence of pines in the Reserve was known by 86% of summer visitors and only 63% of the respondents in winter. A lower proportion (41%) of winter respondents were willing to pay to reduce or eliminate pines in the reserve, while in summer it raised to 52% (Table 2). After the interviewee was given the brief explanation about the impacts of pine invasions, the number of visitors willing to pay to reduce or eliminate the pines in the reserve increased to 75% in winter and 83% in summer (Table 2). Regarding how much they would be willing to pay, the results indicate that before the informative explanation about pine invasions, only 36% of summer respondents are willing to pay the lowest amount proposed (< 10 USD annual pay per person) and 26% were willing to pay the highest amount (> 30 USD annual pay per person per year). Conversely, 36% of the winter visitors prefer pay the highest amount and 25% were willing to pay the lowest amount. Following the brief explanation about pine impacts, a higher percentage of summer visitors were willing to pay for control, but no change was detected on the amount they were willing to pay. In winter, the brief explanation about pine impacts increase the number of visitor willing to pay and also the amount of such payment, with 23% of the winter visitors willing to pay the highest amount and 30%, the lowest amount. However, after explanation about pine invasions, as more people was willing to pay, the median of what they were willing to pay decreased from between 20 and 30 USD per person to between 10 and 20 USD per person. The older the visitor, the more he or she was willing to pay (Chi-squared, $p < 0.05$; Fig. 4). Also, people in the winter survey showed higher personal income (Chi-squared, $p < 0.05$; Supp. mat. 1),

which is certainly determined by the more expensive and restrictive winter sports. Given that age, education level and income are positively correlated, all these variables were also positively associated to WTP (Chi-squared, $p < 0.05$).

The reasons argued by visitors who said they were unwilling to pay, even after the brief explanation about pine impacts, encompasses ethical and aesthetical viewpoints (e.g. pines are natural and beautiful elements) to more pragmatic reasons (e.g. not my problem) (Table 3). Visitors also added comments or suggestions for the possible implementation of this control of invasion of pines within the reserve that vary from very local and practical solutions, to broader policy-oriented suggestions (Table 4).

Depending on the proportion of visitors and type of payment preferred, the potential total annual revenue from WTP available to reserve generates different scenarios. As an example, if we consider the summer values (the season that showed a lower amount to pay per person), the modal WTP value, the proportion of people WTP and the annual number of visitors for 2016; 565,000 USD could be raised. However, with an educational program, this amount could increase to 902,000 USD.

4. Discussion

Worldwide, when dealing with management of invasive species in natural areas, there is always the tension to determine 1) who should decide which actions should be taken, 2) who is responsible for implementing the plan and 3) who should pay for controlling these species. Managing invasive species require the commitment and agreement of multiple stakeholders. Thus, what should be the role of visitors who directly enjoy and benefit from the natural landscapes to tackle this complex issue? Our study suggests that visitors show high variability in their knowledge and perception of tree invasions, but given the necessary scientific information, they can support invasive species control and financially contribute to the implementation of management actions.

Visitors may contribute funding for invasion control, and also question their own responsibility for biological invasions and turn the responsibility towards government authorities and protected areas agencies (García-Llorente et al., 2008). However, several factors can influence positively the willingness to pay of protected areas visitors, including individual's knowledge and perception of invasive species, interest in nature-based recreation, and socio-demographic attributes (García-Quijano et al., 2011). In any case, willingness to pay for invasive species control actions can show authorities the public support and potential private sources of funding for conservation and protected areas management and visitor education (Guo et al., 2017; Hovardas and Poirazidis, 2006). Thus, our findings support the notion that some of financial support for management could come from visitations if appropriate mechanisms of fundraising were established together with the implementation of visitor education programs.

Visitor contribution to funding for controlling invasive pines in our study may be rather marginal on a per capita basis, as people in our survey were reluctant to make considerable monetary contributions in the form of entrance or annual fees. However, if a systematic funding program is implemented and given the high visitation rate of this reserve, our data suggest that up to ca. 1 million US\$ could be collected annually. One potential reason for the relatively low support is the lack of awareness of the problem of invasive species in natural areas or the motivation for visitation which is, by far in this case, for the enjoyment of winter sports and outdoor activities with family and friends, instead of nature learning and contemplation. Even though they recognize that there is such potential in the area, they are more attracted to sports, independently of the season, age or income levels. Our sample was dominated by national Chilean visitors (ca. 85%), and thus we do not have the sample size to test whether foreigner visitors were more prone to conservation. However, from their comments at the end of the

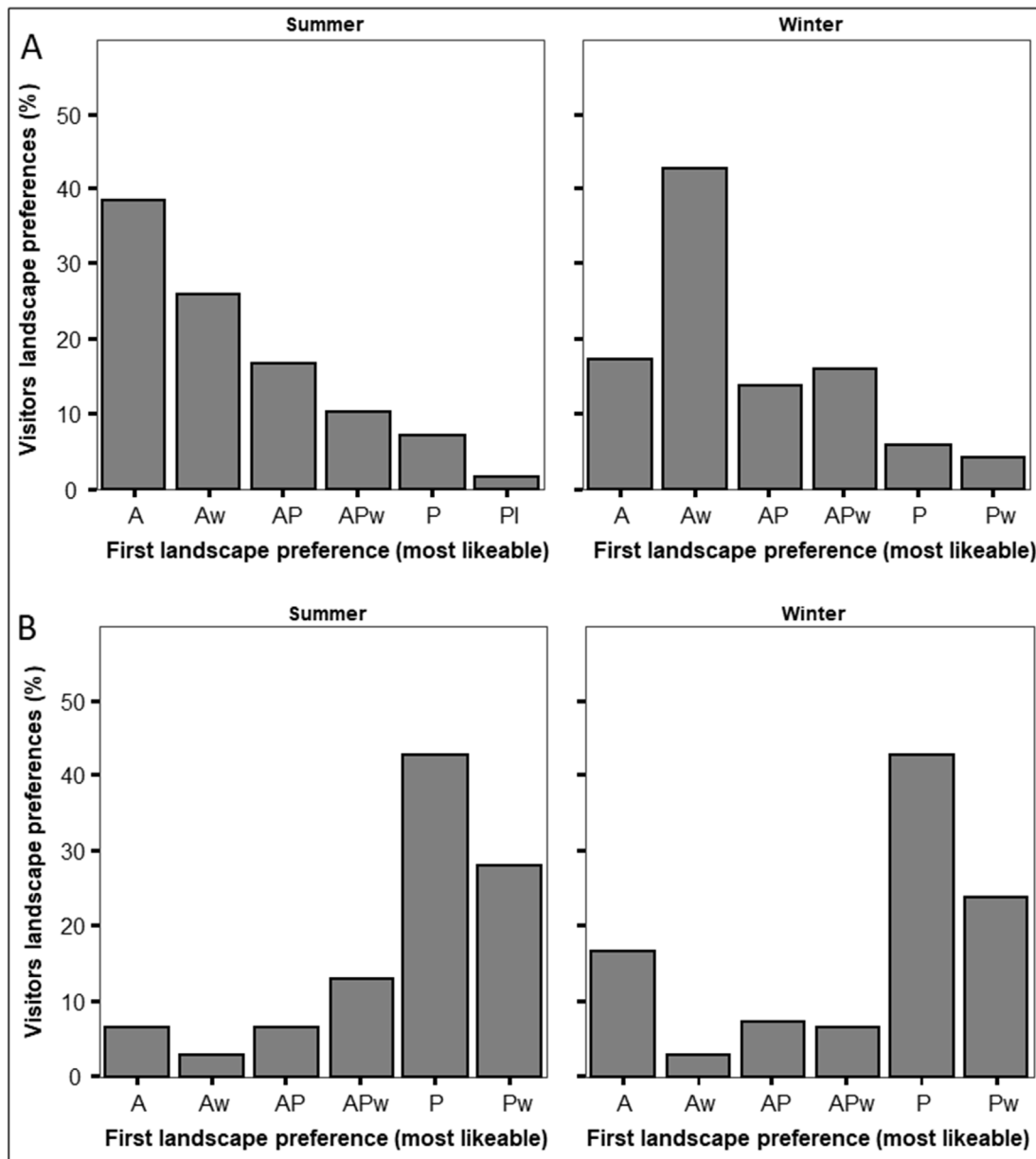


Fig. 2. Visitors landscape preferences in relation to the season of visit to the Malcalahuello National Reserve. A) First landscape preference (most likeable) and B) Last landscape preference (less likeable). Images include three vegetation types in two seasons (Fig. 1; AW: Araucaria forest in winter, APW: Araucaria forest with pines in winter, PW: Pine forest in winter, A: Araucaria forest in summer, AP: Araucaria forest with pines in summer and P: Pine forest in summer).

Table 2

Visitor awareness about pine presence and willingness to pay (Yes, No) for controlling pine invasions in the Malcalahuello National Reserve. Values of knowledge of pines represent the perception before any addition information was given to them. Willingness to pay results show the response for visitors who originally responded No (pre-information), but change their answer to Yes after a brief explanation about the impacts that pines generate in natural ecosystems (post information) (n = 138 for each season).

	Winter survey		Summer survey			
	Knowledge of pine presence	Willing to pay		Knowledge of pine presence	Willing to pay	
		Pre information	Post information		Pre information	Post information
Yes	63%	41%	75%	86%	52%	83%
No	37%	59%	25%	14%	48%	17%

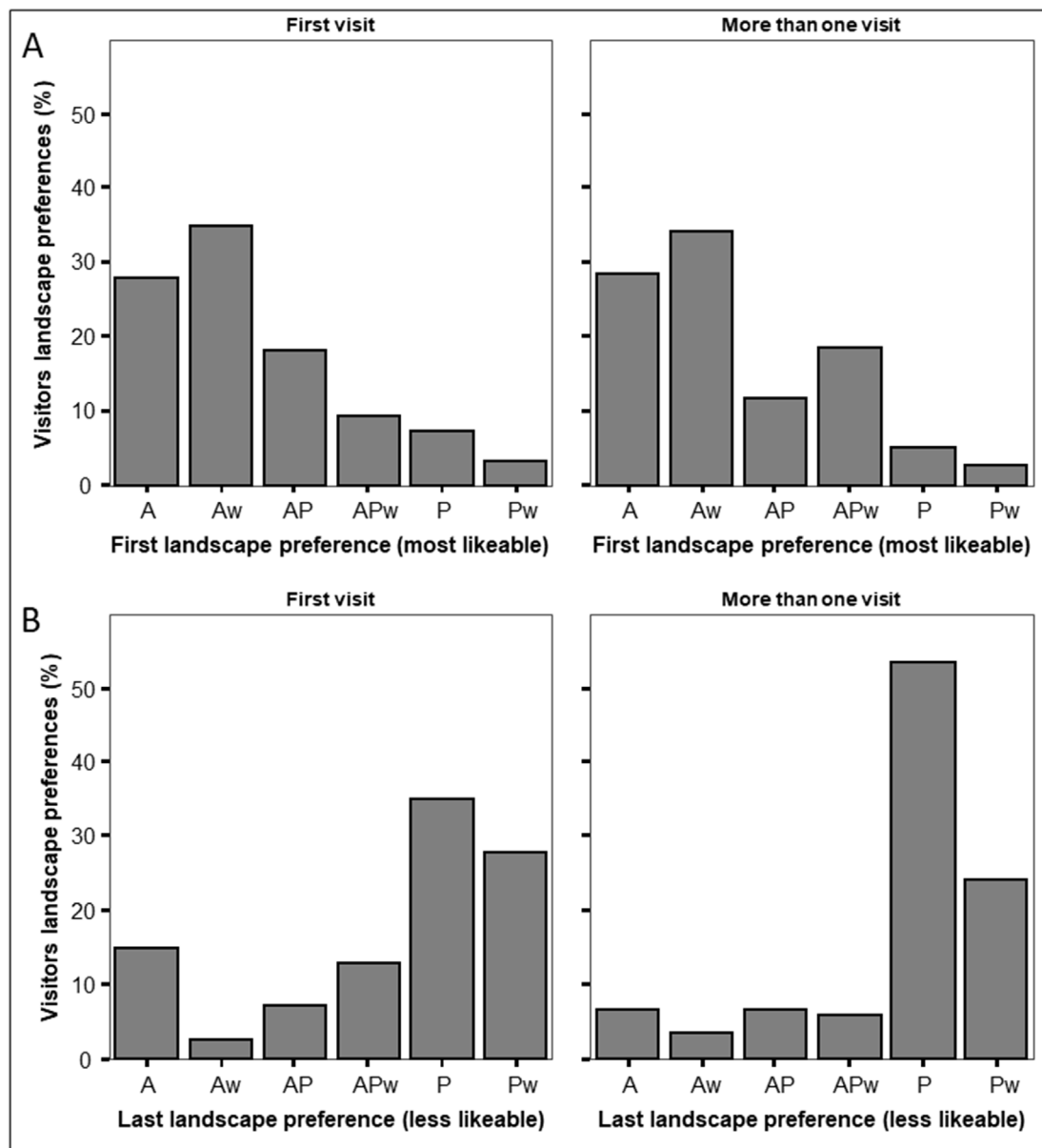


Fig. 3. Visitors landscape preferences in relation to the number of visits to the Malcalahuello National Reserve. A) First landscape preference (most likeable) and B) Last landscape preference (less likeable). Images include three vegetation types in two seasons (Fig. 1; AW: Araucaria forest in winter, APw: Araucaria forest with pines in winter, Pw: Pine forest in winter, A: Araucaria forest in summer, AP: Araucaria forest with pines in summer and P: Pine forest in summer).

surveys, we can hypothesize that foreigners seem to be more aware that pines were not native and invasive in the area. Questionnaires can also be complemented with qualitative data collection and mixed-methods approaches, including for participant observation activities to more precisely capture what we missed using structured surveys (Creswell, 2007; Wheeldon, 2010).

Aesthetic values and environmental literacy seem to play an important role in how visitors judge pine invasions. In our study, both winter and summer visitors to the Malcalahuello National Reserve preferred the visual aesthetics of araucaria landscapes not invaded by pines. However, they were not necessarily aware of the environmental problems caused by pine invasions and therefore they were hesitant to pay for control efforts. Overall, it seems to be a very low level of environmental literacy among visitors, in spite of their strong preference for non-invaded araucaria landscape. After the brief explanation about pine impacts, visitors showed a much stronger support for paying to control pine invasions, which is consistent with the literature on environmental education effectiveness (Hovardas and Poirazidis, 2006;

Liefländer et al., 2015; U.S. Department of Education, 1992; Cole et al., 2018). Thus, even short in-site environmental education about invasive species and their consequences may have a significant positive influence over public support for invasive species control in natural areas (Guo et al., 2017). It is also relevant to emphasize that personal experience makes a difference in how people perceive the problem. We were able to detect some differences among winter and summer visitors that may be related to the fact that winter visitors spend most of the time above the treeline and have little access to the forest. Thus, summer visitors are much more aware of the importance and value of native forests which are the main threats to this reserve.

Although our work focused on the effect of invasive pines, another interesting perspective is to consider the effect of araucarias over landscape preferences and people's commitments to invasive species control. Our results suggest that beside other environmental and aesthetic considerations, the prevalent cultural image of araucarias strongly influences visitor landscape preferences. As explained above, araucarias are charismatic and biocultural keystone tree species (Reis

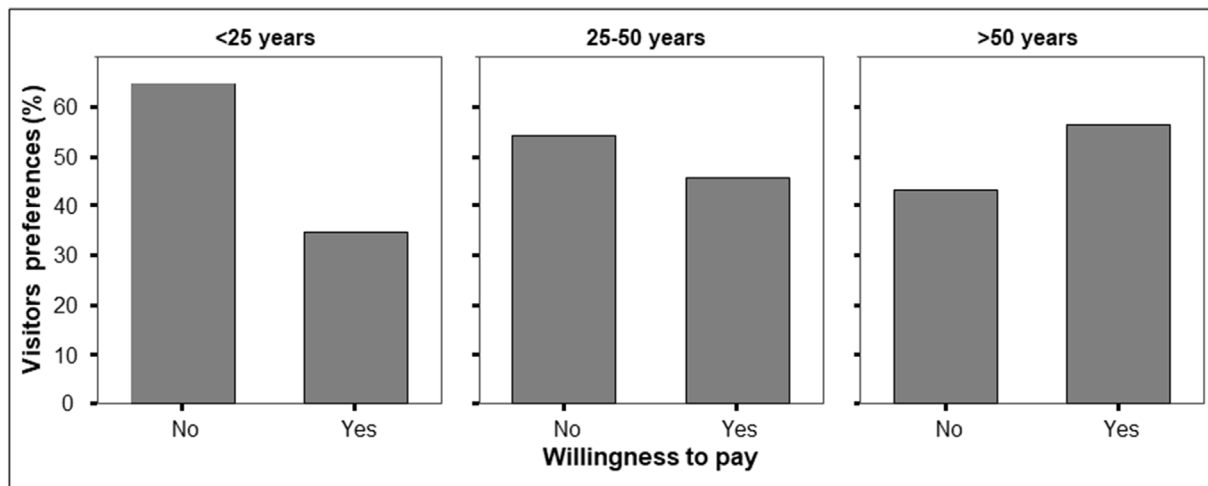


Fig. 4. Visitor willingness to pay (Yes, No) for controlling pine invasions in the Malalcahuello National Reserve. Visitors by age group (< 25, 25–50, > 50 yrs old).

Table 3

Examples of reasons given by visitors to respond No when asked if they were willing to pay to reduce or eliminate the presence of pines in the Malalcahuello National Reserve.

“They are natural of the ecosystem”	“They are part of nature”
“They are natural heritage”	“They are part of the landscape”
“It does not correspond to me”	“They have been here for long time”
“They are needed in the environment”	“They are not harmful”
“It’s not within my priorities”	“Nature should be taken care of”
“They do not hurt”	“It would destroy more than necessary”
“It does not matter to me”	“Artificial it’s beautiful”
“Pines are attractive, they give a plus to the landscape”	“They have attitude”
“They are beautiful”	“It’s up to the government”

Table 4

Examples of suggestions given by visitors on how pines should be managed within the reserve.

“There should be more pine control and more information should be given to visitors”
“They must make the cut (control) in low-tourist season and at suitable schedules”
“There should be posters declaring that what you see is a pine invasion”
“It is very important to create a tourism law and an entity that manages the protected areas in Chile”
“They should be controlled with caution”
“They should make a management plan and perform thinning in summer”
“They should do it gradually to reduce impacts”
“They must do it in a season that causes less impacts to tourism and is done in conjunction with the locals”

et al., 2014; Sarmiento et al., 2017), and they, in this case, not only drove visitors' attention and landscape preferences but also their willingness to support invasive pines control, once they were alerted about the negative effects of pine over the emblematic araucaria forest. Interestingly, Krüger (2005) shows that nature-based recreation initiatives that promote charismatic species conservation have higher chances to be more sustainable than regular ecotourism, and this observation can be an important opportunity to unite invasive species control and conservation efforts of highly cultural significant species and ecosystems as the araucaria forest. In other natural areas, where charismatic species are absent, positive public perception about invasive species control may be much harder to achieve, and some degree of conflict should be prevented or assumed as “normal” by conservation and restoration initiatives (Dickie et al., 2014).

The lack of education may hamper perceptions of the environmental

risk and associated biodiversity loss and ecosystem services (Kollmann and Agyeman, 2002; Reiners et al., 2013; Rozzi et al., 2012). For invasive species management, little is known about this connection, but invasive species problems (which are usually harder to grasp for a non-expert audience than other more obvious environmental problems) can be linked to visitor educational strategies to prevent littering, vandalism, and wildfires (Guo et al., 2017; Kuo, 2002; Monz et al., 2010). In this way, we can communicate the negative outcome not only of a littered or burned forest but also invaded ecosystems which decrease the recreational, aesthetic and cultural value of the landscape, and cause biotic and biocultural homogenization (Pfeiffer and Voeks, 2008; Rozzi et al., 2012). Alternatively if scientific information is not well communicated to the public, visitors may see invasive trees as a positive element in the natural landscapes, which should not be removed. These contradictory social perceptions may lead to management conflict within protected areas (Estévez et al., 2015).

In particular, protected areas education programs in Chile should focus their efforts on increasing awareness about native biodiversity and the threats it faces, including education on species endemism, cultural significance and ecosystem services and not focus only on the “native vs. non-native and invasive” species dilemma (Daniel et al., 2012; Head and Atchison, 2008; Winthrop, 2014; Simberloff, 2012; Larson and Kueffer, 2013). In this case, controlling the invasive conifers and conserving the biocultural legacy of the araucaria forests should be jointly addressed. This approach can also benefit the combination of natural and cultural tourism and promote indigenous tourism in Latin America and beyond (Pereiro, 2016).

Our study shows that there is a high variation in how people assess the threat of invasive pine species in natural areas. Factors such as age, income and education may affect how people perceive pine invasions, but also how much they are willing to pay for their control. Unfortunately, there are not simple generalizations that can be drawn across visitors. Experience in the area and environmental literacy may also affect perception and interest in supporting invasion control. Environmental education, even as limited as brochures, short talks or posters, may help to increase awareness and social support of invasive species control. Finally, more needs to be done to understand the adverse social impacts of invasive species control to better mitigate these impacts before large-scale management is designed and developed.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jenvman.2018.07.018>.

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