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1-13

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Abstract
Debates surrounding the use of prevention and control policies to avoid further spread of invaders have highlighted the need to establish priorities in public resource allocations. The aim of this study was to explore the consistency or discrepancy among stakeholders involved in the risk and control management of invaders, in order to identify the extent to which different factors may influence stakeholder choices of major relevant plant invaders. We focus on the process of stakeholder ranking of invasive plants to explore the reasons behind stakeholders' support on policy management which affects these invaders. Data were collected through semi-structured interviews in Galicia, Spain, where a catalogue of prohibited entry and trade of invasive species is currently in the public debate arena. We estimate a rank-ordered logit model that uses information from semi-structured interviews that were conducted with several groups of stakeholders: the public administration sector, the ornamental sector, research and social groups. The characteristics of plant invaders that provoke stakeholders to rank higher are, a wide distribution of plant invasion, the existence of public control programmes, the use and sale of the species in the ornamental sector and the level of media coverage. Stakeholder groups differ in the influence these aspects have in their ranking.

Keywords: invasive plants, stakeholder choices, rank-ordered logit, factor analysis, Galicia, Spain.

1. Introduction

The prevention and control of biological invasions are important elements for the conservation of biodiversity and ecosystem services (MEA 2005, Perrings *et al.* 2010, Vilà *et al.* 2011), and are the subject of an increasing number of policy responses (Butchart et al. 2010). The success of control and eradication of invasive species, as well as the policies governing their management in general (e.g. inspection regulations, codes of conduct, or economic incentives to reduce threats) are highly dependent on the acceptance and support by all affected stakeholders (Bremner and Park 2007, Fischer and van der Wal 2007, García-Llorente et al. 2008, Sharp et al. 2011, Ford-Thompson et al. 2012). The high percentage of invasive species, which are either deliberately or accidentally introduced for socio-economic reasons linked to commerce (e.g. Mack and Erneberg 2002, Pyšek et al. 2002, Westphal et al. 2008, Dehnen-Schmutz et al. 2007, Carrete and Tella 2008, Hulme 2009), and the rising social costs of invaders (e.g. Pimentel 2005, Xu et al. 2006), illustrate the need for stakeholder analysis when managing invasions. In fact, stakeholder analysis is increasingly recognised as a key factor in the success of managing natural resources (Reed et al 2009, White and Ward 2010), as stakeholders are not only affected by policy managing decisions but they also have the power to influence their outcome.

Invasive species that are often deliberately introduced for commercial purposes provide a particular interesting example of how stakeholders with conflicting interests from a wide range of backgrounds may be affected. This is the case for ornamental plants where the horticultural industry and consumers benefit from the use of non-native plants, which in some cases are invasive species or at risk of becoming invasive, if widely planted (Barbier and Knowler 2006, Dehnen-Schmutz et al. 2007, Pemberton and Liu 2009). Different perceptions on ornamental plants may develop over time when highly regarded species become invasive and develop into an expensive management problem (Bailey and Conolly 2000, Starfinger et al. 2003; Dehnen-Schmutz and Williamson 2006). However, the more challenging aspects for policy and management could mean that species may generate income for some stakeholder groups (e.g. nurseries, gardening firms or forestry owners), while causing damage and management costs for other stakeholder groups or both at the same time in the one group. A study in Belgium found that even though nursery owners were aware of the problem of invasive species in general, 45% of them reported not to sell any invasive species; all of them were selling at least one species listed in the Belgian invasive species inventory (Vanderhoeven et al. 2011). With an increasing number of invaders and limited financial resources, policy-makers have a critical interest in understanding how stakeholders differ in their level of concern about biological invasions and how they perceive key invaders.

We pay particular focus on invasive plants given the importance of deliberate introduction, mainly through ornamental trade, as a key pathway for the introduction of non-native plant species as it has been shown in other countries (Perrings et al. 2005, Hulme 2009, Bradley et al. 2012). Several papers have analysed different stakeholder perceptions on invasive species. Previous studies that have focused on stakeholders in the horticultural industry, have aimed to decipher, for instance, the levels of knowledge about invasions (Vanderhoeven et al. 2011), acceptance and support for existing management and potential new policies (Coats et al. 2011) or voluntary measures (Burt et al. 2007). Some papers also include a stakeholder analysis on invasive species issues, which are not specific to the horticultural trade. They may analyse questions in reference to specific species, for example, to name known invasive species or to identify species in a list provided. To understand how stakeholder knowledge and perceptions on biological invasions at the species level is formed, is important as this may influence policy coherence and the identification of management criteria. Bremner and Park (2007) illustrate that the level of support for control and eradication programmes is influenced by specific species that are currently being managed. Bardsely and Edward-Jones (2007) illustrate certain levels of consensus across stakeholders in the Mediterranean islands (Sardinia, Mallorca, Crete), when asked to name five invasive plants. While on the other hand, García-Llorente et al (2008) show that stakeholder groups (local users, tourists and conservation professionals) varied in the number and particular species they mentioned, as well as in their willingness to pay for eradication programmes for given species. These studies conclude that people are more aware of species that have been subject to information or education campaigns. Andreu et al. (2009) focused more on the species-level criterion for management and conclude that according to the interviews undertaken with natural resource managers, the most frequently managed species are the most widespread in each region and the ones perceived as causing the highest impacts. Eiswerth et al. (2011) measure invasion awareness by local residents' ability to name at least one aquatic species.

In this paper, we aim at studying the determinants of stakeholders' preferences over an open list of invasive plant species. We analyse how stakeholders involved in the deliberate introduction and spread of non-native plants, as well as stakeholders affected by invasions, choose key invasive plant species and prioritise them throughout a survey analysis. In the classical setup, individuals are asked to select their most preferred option out of a fixed set of alternatives, but more information can be obtained if individuals are asked to rank a set of alternatives instead. We therefore asked stakeholders to name and rank the six most important invasive plants for the interest of their working organisation, and we econometrically evaluate the factors that influence these rankings. A rank-ordered logit analysis was used to explain the stakeholders' ranking of plant invaders influenced by: species life-form, its use in the ornamental sector, public control activities and advertising of particular species through media coverage. We identify consistencies and discrepancies in the perceptions and stakeholders' rankings representing the interests of the public administration sector, the ornamental sector, research and social groups. Thus, we investigate the entire multi-stakeholder framework. We also acknowledge that perceptions may vary within institutions/individuals within each of these groups and therefore, a re-estimation of the rank-ordered logit for stakeholder groups is required, classified by their general knowledge on invasions, the level of awareness and concern, and their interests for the development of policy measures. This allows for exploring the variability in awareness and prioritisation of particular invaders across different social groups, taking into account the influence of their different perceptions on the problem of biological invasions in general. This study contributes to the development of invasive species management practices by assessing stakeholders' perceptions and the determinants of their preferences in their choice of plant invaders.

2. Material and methods

2.1 Study area

This study takes place in Galicia, in the northwest of Spain, where over the past five years (2005-2011) the Galician government has spent about 1.1 million Euros on control and eradication measures of invasive plants in natural protected areas[1]. The government has also funded the publication of a report of invasive plants in the region (Xunta de Galicia 2007). This report includes 73 species of which 31 are classified as a significant threat or as having the potential to do so. Out of the 31 species, 68% are associated with introductions for ornamental use, being a significant pathway for Galicia also. The Spanish Law 42/2007, on Natural Heritage and Biodiversity, establishes a basic legal framework for nature conservation and proposes the creation of a national catalogue of invasive species; while entitling different Spanish regions to establish their own catalogues. This law specifies that the inclusion of any species in the catalogue implies the general prohibition of possession, transportation, traffic or trade of such species. The national catalogue of invasive species was regulated at the end of 2011 (Royal Decree 1628/2011)[2]. However, only a few months later, stakeholder pressure from hunting and fishing groups, lead to the exclusion from the catalogue of certain invaders, and therefore, claims of certain regions led to the cancelation in this regulation of the list of potentially invasive species[3]. So far, Galicia does not have its own catalogue of alien species to which legally binding limitations would specifically apply. In fact, only Valencia (south-east of Spain) has such regional regulation on exotic alien species[4].

2.2 Survey design and administration

This study was conducted with personal interviews using a semi-structured questionnaire, in order to study the determinants of stakeholder prioritisation of most relevant invasive plants, as well as general information about their awareness and

1 Information verbally taken.

2http://www.magrama.gob.es/es/biodiversidad/legislacion/real_decreto_1628_2011_listado_exoticas_invasoras_tcm7-211976.pdf.

3 http://www.boe.es/diario_boe/txt.php?id=BOE-A-2012-3893
http://www.boe.es/diario_boe/txt.php?id=BOE-A-2012-8569

4 http://www.cma.gva.es/web/indice.aspx?nodo=73375&idioma=C

perceptions. Four stakeholder groups were interviewed: the ornamental plant sector, public sector environmental management, research institutions and experts, and representatives of different social groups (e.g. environmental NGOs, agricultural unions, forest managers, hunting and fishing associations, and political parties). Thus, the respondents were public or private organizations/individuals (*i*) involved in the introduction or spread of invasive plants, (*ii*) affected by impacts, and/or *(iii)* involved in management. Stakeholder interviews include corporate production/sale of ornamental plants, public and private technical gardening, forestry associations, industries, and public sector administration; nature conservation, water resource management, environmental NGOs, agricultural unions, hunters and recreational fishermen associations, political parties, and research centres and experts. Fieldwork was undertaken between December 2009 and March 2010. All stakeholders were first contacted by letter; this was followed by a telephone call, in order to correctly identify the person to be interviewed in each institution/organization involved and to formalize the date of the interview. The initial recipients of the letters and their contact details were identified through internet, and by the snowball sampling technique[5] (e.g. Kumar and Kant 2007, Bardsley and Edward-Jones 2006, Andreu et al. 2009). In relation to gardening and plant production firms, a list of 82 firms from ASPROGA (Galician Association of Ornamental Plant Growers http://www.asproga.com/) and AGAEXAR (Galician Association of Gardening Firms http://www.agaexar.com/) was produced. 40% of these firms were randomly selected to be contacted by post. The initial list excluded 27 plant growers, who were highly specialized in single species groups (camellias, kiwis, hedges, etc.), and large garden centres that were part of ASEJA (Spanish Association of Gardening Firms http://www.aseja.com/) for not having a registered business in Galicia. However, ASEJA members were also considered in the study as they were involved in the management of urban parks. Our data include the views of urban park managers for three Galician cities.

All respondents were informed that the purpose of the questionnaire was to collect the views of the organization they represent. The introductory section of the questionnaire included a definition of invasive species as those that establish and spread outside their natural range, producing adverse effects. It also provided an illustrated list of 29 plants selected for their current and potential impacts in the studied region (Xunta de Galicia 2007, Sánz-Elorza et al. 2004), in order to provide an identical framework to all respondents. Interviewees were asked about their knowledge of the invasive species in the list and asked to mention other known invasive plants. The survey included a question to assess which were the most important invasive plants for the stakeholders' organisation, who were then requested to rank up to six of the most relevant invasive plants among those mentioned. We restricted the ranking set to six plants, given that it

[5] As defined by Kumar and Kant (2007), "snowball sampling technique is a special non-probability method used when the desired sample characteristic is rare. It may be extremely difficult or cost prohibitive to locate respondents in these situations. Snowball sampling relies on referrals from initial subjects to generate additional subjects".

has been shown in the literature that respondents may not be able to prioritize between their less-preferred alternatives if they are faced with too many options to rank (e.g. Chapman and Staelin 1982). Stakeholders were also asked about a) perceived impacts; b) knowledge and assessment of alternative public administration measures; and c) general perception of invasive species relative to other environmental problems. The questionnaire used questions on a Likert-like five-point scale (from 1=”none” to 5=”extremely high”) to explore perceptions of the problem of biological invasions, environmental issues (wildfires, habitat loss, climate change, pollution, overfishing, urbanisation), and their willingness to support given policy options (eradication and social awareness, voluntary codes of conduct, measures for high risk activities, preventive measures, establishing early warning system, eradication and control, habitat restoration). No socio-demographic information was required because respondents acted as representatives of their organisations. A total of 61 personal interviews were undertaken, 57 of which provided the ranking on invasive plants and were used in this analysis.

2.3 Factor Analysis

We used factor analysis (FA) to explore our data for patterns on stakeholders' perceptions (Gorsuch 1983). Given the large set of correlated variables derived from stakeholders' responses to the questionnaire, we identified the latent dimensions that best reflect their common variance. The suitability of our survey data for FA was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. We identified the latent factors of our data using Iterative Principal Factoring with the following extraction criteria. Firstly, variables with factor loadings lower than 0.3 were excluded. Secondly, we employed the screen test and the Kaiser's criterion to identify the set of significant factors. Thirdly, the Cronbach's alpha was used as a reliability measure of how well a set of variables measures a single one-dimensional latent construct, which ensures that factors are meaningful and interpretable. The 95% confidence intervals for the Cronbach's alpha were obtained using bootstrap. Factor scores were imputed for those isolated cases where missing values resulted from no responses or responses corresponding to “Don't know”. In addition, our dataset included binary variables for which an underlying latent continuous dimension could not be assumed as cross-tabulations of any two variables were not symmetric. In particular, this was the case for stakeholders' acknowledgement of invasive plant impacts (ecological, economic, social and health). For these variables, a nonparametric scale construction was calculated with the Mokken cumulative scaling analysis. This method assumes that the probability of a positive response for the different impacts increases monotonically with increasing values of a latent construct. The Loevinger coefficients (H_i) were calculated to test for this monotonicity assumption, and the factor was calculated as the total number of positive responses. Finally, stakeholders' perceptions captured on the questionnaire variables and the latent factors derived from the FA, were compared using nonparametric Kruskal-Wallis and Fisher's exact tests.

2.4 Rank-ordered logit model

The standard procedure to handle rank data is the rank-ordered logit model[6]. In the economics literature, this model was first introduced by Beggs, Cardell, and Hausman (1981) and further developed by Hausman and Ruud (1987), building on the well-known conditional logit (CL) regression model introduced by McFadden (1974). This model was independently formulated under the name of exploded logit model in the marketing literature (Punj and Staelin 1978, Chapman and Staelin 1982). Allison and Christakis (1994) introduced it in sociology and generalized it to accommodate ties in the rankings.

In its general formulation, we consider a model with N respondents and J invasive species, where i represents the respondent and j indicates the species. Each respondent is asked to assign a rank to the complete set of J plant invaders. For ease of exposition, we assume that all plant invaders are ranked and there are no ties. Thus, each respondent i gives to plant invader j a rank R_{ij}, which can take any integer value from 1 to J, where 1 represents the "best" rank (the most prioritized invader) and J the "worst" (the least prioritized). Without loss of generality, we treat J as a constant; although, in general, J can differ across respondents. The rank-ordered logit model can be derived from a familiar random utility model as in the usual CL model. Thus, for each plant invader j, a respondent i associates a level of impact in his utility U_{ij}, which is the sum of a systematic component μ_{ij} and a random component ε_{ij}:

$$U_{ij} = \mu_{ij} + \varepsilon_{ij}.$$

The systematic component could be decomposed into a linear function of a set of column vectors of variables related to the characteristics of the respondent x_i, attributes of the ranked plant z_j, and attributes that may vary with both respondent and plant w_{ij}:

$$\mu_{ij} = \beta_j x_i + \gamma z_j + \theta w_{ij}\,,$$

(1)

where β_j, γ, and θ are the row parameter vectors of interest[7]. The model is estimated assuming that the random component is independent and identically distributed with a Type-I extreme value distribution[8].

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[6] The list of invasive plant species is an unordered choice set as we cannot specify that species 1 is more invasive than species 2, based on a natural ordinal ranking. Thus, we cannot use alternative methods to analyze rank ordered data such as the ordered probit model used in Paudel *et al.* (2007) to analyse the ranking of hypothetical termite control options in the United States.

[7] Parameter identification requires setting one of the β_j vectors to zero. Also, to avoid linear dependence, the number of zj variables must be less than or equal to *J-1*. See Allison and Christakis (1994) for further details on identification requirements.

[8] It is also known as Gumbel or double exponential distribution, and it has the following cumulative distribution function $Pr(\varepsilon_{ij} \leq t)=exp(-exp(-t))$.

Even though the level of impact U_{ij} is unobserved, we can observe stakeholder decisions. Assuming that a respondent i will give plant invader k a higher rank than invader j, whenever $U_{ik} > U_{ij}$, a complete set of rankings of invaders from a stakeholder, implies a complete ordering of the underlying utilities. To interpret the model, we can treat data as a sequence of choices, in which the plant invader with the highest importance is chosen over the entire set of J plant invaders. When this choice has been made, among the J-1 remaining species, the plant with the second highest importance is chosen, and so on. Thus, the observed rank ordering of the J plant invaders is exploded into J-1 independent observations. This implies the following likelihood for a single respondent:

$$L_i = \prod_{j=1}^{J} \left[\frac{\exp(\mu_{ij})}{\sum_{k=1}^{J} \delta_{ijk} \exp(\mu_{ik})} \right],$$

(2)

where δ_{ijk} denotes an indicator variable such that $\delta_{ijk} = 1$ if $R_{ij} \geq R_{ik}$, and 0 otherwise. The rank-ordered logit model can be seen as a series of CL models, where the probability of a complete ranking is made up of the product of separate CL probabilities, one for each species ranked. This explosion is possible due to the well-known independence from irrelevant alternatives (IIA) assumption, which characterizes the CL model and states that the relative preference for species k over species j is invariant to all other features of the choice set. Based on (2), the estimation of this model implies the following log-likelihood for a sample of N independent respondents:

$$\log L = \sum_{i=1}^{N} \sum_{j=1}^{J_i} \mu_{ij} - \sum_{i=1}^{N} \sum_{j=1}^{J_i} \log \left[\sum_{k=1}^{J_i} \delta_{ijk} \exp(\mu_{ik}) \right].$$

It is worth noting that J_i can vary across respondents in our likelihood model. We take into account that we have different choice sets for different respondents, as stakeholders were asked to rank only plant invaders that were important for their organization. Following the literature (e.g. Drewes and Michael 2006), this simply requires the assumption that all the plant invaders that were not chosen by the stakeholder are ranked lower than his last choice invader. We estimate a simple model where explanatory variables are only plant attributes, thus (1) reduces to $\mu_{ij} = \gamma z_j$. We use the *rologit* command in STATA to obtain maximum likelihood estimates of the γ coefficient vector.

In addition, for the estimated value of γ, we can produce a set of predicted choice probabilities for each individual in the sample. In particular, if invader k is the top-ranked plant invader, i.e. it has the highest utility among the entire set of J invaders, this leads to the well-known expression for the probability that species k is the most preferred by individual i in a CL model:

$$P_{ik} = \Pr[U_{ik} \geq \max\{U_{i1},...,U_{iJ}\}] = \frac{\exp(\gamma z_k)}{\sum_{j=1}^{J}\exp(\gamma z_j)} .$$

(3)

Based on (3), we can also compute the marginal effect on the probability of alternative k being top-ranked when one of its attributes changes as:

$$\frac{\partial P_{ik}}{\partial z_k} = P_{ik}(1-P_{ik})\gamma .$$

Turning to explanatory variables, the independent variables included in this study aimed to assess the effects of the species life-form, the extent of the geographical distribution in the region, the role of pathways of introduction of invasive species, the existence of public control activities and information on the publicity of the species in the media. Life-form was captured with a dummy that indicates, whether the ranked plant invader is a tree. For the geographical distribution in Galicia we used the records 10x10 km sized quadrants covering Galicia as used in the SITEB (Territorial Information System of Biodiversity) database[9]. The role of the pathway of introduction, and the existence of public control activities were included with dummies that indicate, whether the ornamental sector sells or uses the plant, and if a control is applied by the public sector, respectively. Finally, to address the potential of social influences on the stakeholders' invader ranking we included media coverage which has been associated with individual and institutional decisions about hazardous perceptions (e.g. Vilella-Villa and Costa-Font 2008, Donovan et al 2011). We measured media coverage by focusing on newspaper articles and searched with the words "plant invaders", "invasive species", "biological invasions" and "exotic species" for the two years previous to our survey in the digital libraries of national newspapers with a regional edition for Galicia (2), regional newspapers (2), and provincial and local newspapers (6). If an article explicitly mentioned a plant invader that appeared in the stakeholders' rankings, we recorded the number of words in the article. Stakeholders' decisions may also be influenced by public control and eradication activities for particular species. We use a dummy variable that indicates for each species in the dataset, if control activities in natural areas were undertaken by the Nature Conservation Department of the regional government (Xunta de Galicia). Table 1 reports the descriptive statistics for these plant attributes, used as predictors in the sample of plant invaders, included in the stakeholders' ranking choice.

3. Results

3.1 Sample characteristics

The results show that respondents are aware of more than 90% of the species included in the Galician list of most problematic invasive plants (Xunta de Galicia 2007).

9 The SITEB database can be consulted at http://inspire.xunta.es/siteb/acceso.php

Seventy-five percent of those interviewed stated to be affected by invasive plants in their working activities. Stakeholders recognize the ecological (88%), economic (59%), social (37%), and health (16%) impacts. For all stakeholders, the level of concern about biological invasions has a mean value of 3.7 in a five-point Likert scale, which is similar to the concern expressed for environmental pollution or overfishing problems. About a third (28%) of the stakeholders considers invasions as extremely important, while for wildfires and habitat loss this value reaches 60%. All stakeholders show a significantly higher concern about invasive plants, compared to how they estimate the concern of the Galician population on the topic (Kruskal-Wallis *p-value*<0.001). This is also true for all other environmental issues assessed with the exception of forest fires. Over 75% of the respondents believe that Galician population cares little or nothing about biological invasions.

Following, we analysed the data by stakeholder groups, namely public administration sector, research experts, ornamental sector, and social groups. Table 3, shows that stakeholders in the public sector and research experts are significantly more familiar with invasive plants in the region, indicating a higher number of species that are important for the interests of their organisations. They are also more concerned about biological invasions. We also found that stakeholders do not significantly differ in their degree of support for alternative policies. Therefore, there is no policy particularly preferred by any group. However, for the pooled data of stakeholders, we found that the most highly regarded policy was education and social awareness, followed by habitat restoration; while the policy with the lowest support was "measures for high risk activities e.g. a tax on sales". That is, stakeholders significantly express a different degree of support on a five-point Likert scale assessment of the proposed policy options (Kruskal-Wallis *p-value*<0.001).

When respondents were asked about the relevance non-native species had on their organization, only a total of 44 plants were mentioned. This list includes two weed species, *Rumex spp.* and *Chenopodium spp.,* which were known by the respondents at the genus level only and cannot be categorised as native or non-native; and one species considered native *Pinus pinaster* (Carrión et al. 2000), mentioned by two stakeholders. These three species were excluded from our analysis. Four of the remaining species are not included in the report of non-native invasive plants published by the regional government (Xunta de Galicia 2007). This is the case for *Quercus rubra,* which may just be planted but not propagating itself, and *Baccharis halimifolia*, which seems to be just recently recognized as problematic in one single locality in Galicia but seems to be spreading in estuaries in Northern Spain in recent years (Caño et al. 2013). Both were mentioned by one stakeholder. Six stakeholders from the ornamental sector mentioned bamboo (probably mostly referring to *Phyllostachys spp*.), which seems to be a problem in gardens, and its impacts outside gardens are increasingly recognized in the study area (La Voz de Galicia 2012). The most striking case of discrepancy in the perception of invasiveness between stakeholders and the regional administration is *Eucalyptus globulus*. It is not included in the regional government publication, even though at the national level it is classified as invasive for this region (Sánz-Elorza et al. 2004), and was frequently mentioned by the stakeholders. The ten most frequently mentioned species were *Acacia dealbata.* (41 responses), *Eucalyptus globulus* (30), *Cortaderia selloana* (30), *Carpobrotus edulis* (19), *Robinia pseudoacacia* (12), *Stenotaphrum secundatum* (11), *Azolla filiculoides* (9), *Acacia melanoxylon* (9), *Ailanthus altissima* (9), and *Cyperus* eragrostis (7). With the exception of *S. secundatum*, all these species were deliberately introduced for ornamental use and forestry purposes.

This species set is consistent with the choices stakeholders made when asked to select and rank the six most important invasive plants, which lead to a total number of 30 species included in the ranking. The average number of invaders ranked by each stakeholder is 2.84 (Table 1). The data show a strong positive correlation between the number of species listed by stakeholders as important for their interests, and those that they subsequently included in the ranking (Spearman correlation=0.80, $p<0.001$). Table 2 reports the fifteen plant species that most frequently appear in the ranking, and also in the first three positions.

3.2 Latent perception factors on plant invasions

Description of the latent perception factors supported by the FA is presented below. Table 3 shows the results for the five perception factors extracted: plant invasion awareness, environmental concern, perceived population environmental concern, recognised impacts, and policy measure acceptability. The KMO measure of sampling adequacy showed adequate fit (KMO ranged from 0.63 to 0.78). The internal consistency of the items within each factor is satisfactory. The Cronbach's alpha ranged from 0.60 to 0.79. Overall, we found that invasive plant perception factors do not differ substantially between stakeholder groups with the exception of their level of awareness (Table 3). This suggests that perceptions of these factors do not clearly depend on this stakeholder classification, i.e. none of our stakeholder groups can be associated with a unique perceptional set of values related to their level of awareness, environmental concern, impacts, and support for the development of policy measures.

- *Awareness and concern about invasions*

The FA analysis of awareness gave rise to an optimal one-factor solution that accounted for 100% of the variance; and the eigenvalue for this factor was 1.37. It consisted of three variables and its factor loadings ranged from 0.50 to 0.84 (Appendix). We named it “awareness score”, and the three items contributing to it are *(i)* the concern on biological invasions, *(ii)* the knowledge of invasive plants in Galicia, and *(iii)* the number of invasive plants perceived that have an impact on stakeholder organisations. Table 3 shows that respondents in the research and public administration groups score significantly higher, as expected.

- *Perception towards other environmental problems*

The second factor consisted of five variables, related to stakeholders’ scores to different environmental problems (habitat loss, climate change, pollution, overfishing and urbanization). This factor accounts for the 100% of the observed variance, and its factor loadings range from 0.55 to 0.89 (Appendix). It was named “environmental concern score” as it expresses the stakeholder’s overall perception of main environmental conservation issues. The average degree of environmental concern for each of the problems explored is high, but there are no significant differences among stakeholder groups, with the exception of climate change (Table 3).

- Perceived opinion of Galician population to environmental problems

The FA analysis of the respondents’ scores related to their opinion on the perception of the Galician population on environmental problems resulted in an optimal one-factor solution (Appendix). The loading factors relating the observed variables to the factor range from 0.39 to 0.69 (Appendix). Given that this factor assesses the weight that stakeholders place on the environmental concern of the general population, it was named “perceived population environmental concern score”. It could be interpreted as the perceived environmental conscience in the stakeholders’ social surroundings.

- Perceived invasion impacts

The estimated Loevinger H-coefficients confirm that the three items related to economic, social and health impacts follow a Mokken scale. The values of these H-coefficients vary between 0.55 and 0.70 (Appendix). These results show that the impact more easily recognised is the economic impact, followed by the social and the health impacts. Acknowledgment of the ecological impacts is not included in this analysis as almost the whole sample of respondents recognised this type of impacts.

- Perceptions on invasive species management options

The stakeholders’ support for alternative policy measures was also explored in the FA analysis, emerging one factor with a large eigenvalue (2.37), which accounts for 100% of the total variance. The four variables included have factor loadings that range from 0.65 to 0.91 (Appendix). This factor, named “policy measures acceptability score”, represents the stakeholders’ acceptability of policy measures based on economic instruments, regulations that either disincentive or limit the use of particular plant invaders, as well as early warning systems, and control/eradication measures.

3.3 Determinants of Stakeholders Invasive Species Ranking

The rank-ordered logit model was estimated in order to explore the role played by natural and social attributes of the plants in shaping stakeholder’s ranking of the plant invaders. Table 4 shows coefficient estimates and standard errors for the model when the full sample of stakeholders is considered. It also includes the results when stakeholders are classified according to their represented interests: public sector, research, ornamental sector, and social groups. When considering the full sample of stakeholders, all plant attributes considered have a positive and statistically significant influence on the rank-order of plant invaders. However, we found differences in the significance of the role played by these predictors across stakeholder groups. Media coverage is the only predictor that is consistently significant at the 1% level across stakeholder groups (5% level for the public administration). That is, higher media coverage of an invader increases its probability of being higher in the ranking; all else being equal. The distribution of the species, however, is not statistically significant for those respondents working in the public sector. However, the use of a species in the ornamental sector has a significant effect on the choice of those stakeholders working in this sector who rank higher plant invaders with this attribute. If public administration undergoes some control or eradication measures in natural parks, only the ranking of the stakeholders in this sector and those holding position in the social groups is significantly affected.

Table 5 shows the results for the rank-ordered model with stakeholders classified according to their perceptional latent dimensions, i.e., where each group includes those respondents with score perceptional values higher than the median. Again, even though signs are consistent, some predictors are no longer statistically significant for some stakeholder groups attending this classification. For instance, results show that woody life-form has no significant effect in the probability of choosing a plant over other species in the ranking, except for those stakeholders who are more highly aware of the impacts and have a higher perception of the concern of the Galician population over biological invasions. On the contrary, only highly environmentally aware stakeholders do not include the existence of public control programmes as a significant determinant for the rank-order of the plant invaders. For all different groups presented in Table 5, the extent of the distribution of the plant is significant at the 1% level. Finally, stakeholders with higher invasion awareness, environmental concern, recognition of impacts and more willingness to accept policy developments rank higher those plants that are being used in the ornamental sector (5% level of significance).

Table 6 reports the marginal effects on the probability of a plant invader with mean attribute values of being the top-ranked choice when one of its attributes changes for all stakeholders. A hypothetical plant with average characteristics has a 1.69% probability of being ranked first. For the continuous variables, we estimated the elasticities. A 1% increase in the average plant distribution increases the probability of the plant first chosen in the ranking by 1.4%. Similarly, a 1% increase in the average number of words in press articles about a plant will increase the probability that it is the first invader in the ranking by over 0.3%. For dummy variables, values in table 6 show the proportional change in the probability of an invader being top-ranked when there is a discrete change of the dummy variable from zero to one.

Our results also provide probability estimates of ranking a particular species first for different stakeholder groups (Table 7). This analysis shows the differences between stakeholder group rankings, in particular for those species that more frequently appear in the newspapers, and are more clearly associated with forestry impacts. According to our predictions, stakeholders in the social group have a 40% probability for choosing as top-ranked invader *Acacia dealbata*, while also assigning 28% probability of having *Eucalyptus globulus* as a first choice. In contrast, natural resource managers in the public administration only assign to these probabilities a 15% and 12%, respectively. Similarly, the ornamental sector has much lower probabilities to choose these species as the top-ranked invaders. Some stakeholder groups seem to be indifferent between

Eucalyptus globulus and *Crapobrotus edulis,* i.e. they have similar probabilities of choosing one of these as top-ranked species. In contrast, other stakeholders, such as those with higher awareness and environmental concern, have a higher probability of choosing as a top-ranked invader *Carpobrotus edulis* over *Eucalyptus globulus.*

4. Conclusions

Public authorities need to identify invasive species, prioritize their ecological and economic impacts, and allocate resources to minimize overall damages. However, the allocation of these public resources in order to manage particular invaders' eradication or control from the public administration perspective is not always consistent with the key invader, which should be controlled from the stakeholder's perspective. In this study we evaluate stakeholders' perceptions toward invasions, their impacts and policies, and compare them across stakeholder groups, including, regional administration, research, ornamental sector and social groups, since their views are essential in the development of public policies in this area. Our analysis reveals that these stakeholder groups are not associated with a unique set of values related to their level of awareness, environmental concern, impacts, and support for the development of policy measures.

This study also reveals that a rather small group of particular species are perceived as key invaders by all stakeholder groups. Even though the choice set of species ranked by the stakeholders included thirty plants, only a group of four species have a significant probability of being top-ranked invaders. Thus, only *Acacia dealbata*, *Eucalyptus globulus, Carpobrotus edulis*, and *Cortaderia selloana* have around 10% probability or more of being ranked in the first place, among all these plants mentioned by stakeholders as relevant for their organisations. In fact, the invasion of *Acacia dealbata*, seems to be a particular concern for the social groups interviewed, being the priority species for 40% cent of those in this group. All these species are deliberate introductions, which are still generating commercial benefits, even though they are spreading in natural areas.

This paper also provides some insights on the determinants of stakeholder ranking of invasive plants. We explore how different stakeholder group rankings are affected by the path of introduction, the geographical distribution, the adoption of public control measures, and/or media coverage. Results from the rank-ordered model indicate that most of these explanatory variables were significant, with some differences between stakeholders groups. In addition, we provide evidence that media coverage plays an important role in the rank-order choice that all stakeholders made in their perception of the key invaders in the region. The fact that the most widespread species receive the most attention from the media, does not necessarily imply that stakeholders would not support early management intervention or prevention policies against species not yet wide spread or subjected to public attention. Therefore, this underlines the importance of highlighting the pathways of introduction, and the role of deliberate planting as significant contributors to the problems in any media campaign, thus building the foundation for the support of prevention policies.

This analysis has several implications for environmental policy, not just in the studied region. Firstly, the lack of strong different viewpoints among these stakeholder groups implies that an open dialogue on this topic, if promoted by the public administration, may lead to a political consensus to curb invasions. Secondly, it illustrates that stakeholders would be receptive to education and increasing awareness through media campaigns. As our econometric model shows, this would influence their perceptions of the risk posed by different species. Thirdly, single wide spread invasive species with high media attention could be used to highlight the role of the deliberate introduction and planting of alien plants to gain support for prevention policies for less well known species.

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Table 1: Descriptive Statistics

Variable	Mean	Standard deviation
Life form: 1 if woody species	0.30	0.46
Distribution	1.93	0.77
Total nº words of articles in press	2628.23	3934.47
Ornamental sector use: 1 if sell/use	0.8	0.40
Control administration: 1 if control applied		
Stakeholders	0.50	0.50

Number of plant invaders chosen	
Mean	2.84
Standard deviation	1.56
Minimum	1
Maximum	6

Table 2. Alien invasive plants perceived as most important for the stakeholders.

Plant name	% among the six most important	% ranking: first place	% ranking: second place	% ranking: third place
Acacia dealbata	73	36	21	9
Eucalyptus globulus	54	27	11	9
Cortaderia selloana	54	13	13	4
Carpobrotus edulis	34	2	9	9
Robinia pseudoacacia	21	2	5	7
Stenotaphrum secundatum	20	0	2	7
Acacia melanoxylon	16	4	5	5
Ailanthus altisima	16	4	5	2
Azolla filiculoides	16	2	2	5
Cyperus eragrostis	13	5	2	0
Bamboo (group)	11	0	4	0
Ipomoea indica	9	2	4	2
Tradescantia fluminensis	9	0	2	2
Reynoutria japonica	7	2	0	2
Oxalis pescaprae	7	0	4	2

Table 3: Means and standard deviations of identified perception factors by stakeholder group with non-parametric difference tests.

Variable	**Stakeholders categories**				Diff. stat. (*p*-value)[a]
	Administration (n=10)	Research (n=13)	Ornamental sector (n=21)	Social group (n=17)	
Awareness score Items= 3; Cronbach's alpha=0.69 (0.56, 0.83)[d]	0.23 (0.84)	0.52 (0.72)	-0.14 (0.76)	-0.40 (0.97)	0.019**
Knowledge of invasive plants in Galicia	22.7 (0.98)	26.1 (8.32)	19.9 (8.87)	16.3 (10.05)	0.025**
Number of key plant invaders for stakeholder	6.3 (2.40)	7.4 (3.82)	4.2 (3.73)	5 (3.48)	0.013**
Score concern on biological invasions[b]	4.1 (0.56)	4 (1.15)	3.86 (0.72)	3.35 (0.14)	0.050**
Environmental concern score Items= 5; Cronbach's alpha=0.79 (0.67, 0.90)[d]	0.14(0.61)	0.29(0.67)	0.07(0.83)	-0.44(1.25)	0.446
Concern over habitat loss [b]	4.4 (0.70)	4.7 (0.75)	4.38 (0.74)	4.18 (1.07)	0.201
Concern over climate change [b]	3.2 (0.63)	3.8 (0.93)	3.0 (0.97)	3.9 (1.3)	0.037**
Concern over pollution [b]	3.8 (0.79)	4 (0.91)	3.8 (1.06)	3.5 (1.33)	0.883
Concern over overfishing [b]	4 (1.05)	4.08 (0.76)	4.2 (1.07)	3.6 (1.05)	0.625
Concern over urbanization [b]	4.6 (0.52)	4.5 (0.52)	4.2 (1.09)	3.7 (1.26)	0.220
Perceived population environmental concern score Items= 6; Cronbach's alpha=0.73 (0.61, 0.85)[d]	0.078(0.87)	-0.28(0.68)	0.19(1.09)	-0.04(0.71)	0.476
Perceived Galician population concern over forest fires [b]	4.2 (0.79)	4.5 (0.88)	4.3 (1.07)	4.5 (0.87)	0.396
Perceived Galician popul. concern over habitat loss [b]	2.2 (0.63)	2.1 (0.55)	2.6 (1.12)	2.7 (0.92)	0.004***
Perceived Galician popul. concern over climate change[b]	2.7 (0.82)	2.5 (1.05)	3.4 (1.23)	3.2 (1.03)	0.062*
Perceived Galician popul. concern over pollution[b]	3.5 (0.85)	3.0 (0.70)	3.1 (1.04)	3.2 (1.09)	0.985
Perceived Galician popul. concern over overfishing[b]	3.2 (1.13)	2.5 (0.78)	3.1 (1.32)	2.4 (0.96)	0.480
Perceived Galician popul. concern over urbanization[b]	2.9 (1.45)	2.6 (1.12)	3.2 (1.28)	2.8 (1.11)	0.362
Invasion impacts score Items= 3; Cronbach's alpha=0.60 (0.42, 077)[d]	0.23(0.93)	-0.004(1.03)	-0.37(0.85)	0.27(1.12)	0.253
Dummy: 1 if economic impact recognised	70%	61%	52%	59%	0.844
Dummy: 1 if social impact recognised	50%	38%	14%	53%	0.052*
Dummy: 1 if health impact recognised	20%	15%	14%	29%	0.712
Policy measures acceptability score Items= 4; Cronbach's alpha=0.79 (0.68, 0.90)[d]	0.40(0.65)	0.055(0.99)	-0.31(0.87)	0.08(1.00)	0.176
Measures for high risk activities (e.g. taxes)[c]	2.7 (1.42)	3 (1.41)	2.4 (1.14)	3.23 (1.48)	0.529
Preventive measures (e.g. red list)[c]	4.7 (0.67)	3.77 (1.36)	3.5 (1.46)	3.59 (1.54)	0.173
Establishing early warning system[c]	4.4 (1.07)	4 (1.47)	3.4 (1.46)	3.88 (1.31)	0.836
Eradication and control[c]	4.6 (0.70)	4.23 (1.16)	3.86 (1.23)	4.12 (1.26)	0.971

Factor scores estimated are standarised values. Standard deviation values in parenthesis. Group size may change as observations with missing values removed. Values for dummy variables represent percentage answered "yes".[a] Kruskal Wallis analysis of variance was applied when variable is continuous; while significant differences for categorical variables were explored with Fisher's exact test. [b] Categorical on a scale from 1= "low relevance" to 5= "strongly high relevance"; [c] Categorical on a scale from 1="no agreement" to 5="strongly high agreement". [d] Bootstrap confidence interval at 95% for the sample statistic alpha in brackets.

Table 4: Rank-Ordered Logit Estimates

Variable	All Stakeholders	**Stakeholders categories**			
		Administration	Research	Ornamental sector	Social group
Life form: 1 if woody species	0.405** (0.03)	0.467 (0.202)	0.381 (0.287)	0.248 (0.486)	0.488 (0.263)
Distribution	0.732*** (0.000)	0.232 (0.435)	0.660** (0.018)	0.695** (0.016)	1.608*** (0.000)
Total nº words of articles in press	1.2E-04*** (0.000)	1.0E-04** (0.020)	1.5E-04*** (0.000)	1.3E-04*** (0.003)	1.6E-04*** (0.000)
Ornamental sector use: 1 if sell/use	0.907*** (0.005)	0.871 (0.291)	1.027 (0.128)	1.352** (0.019)	0.174 (0.788)
Control administration: 1 if control applied	0.622** (0.014)	0.914* (0.096)	0.707 (0.145)	-0.290 (0.541)	1.683*** (0.006)
LR-test	299.07 (0.000)	44.67 (0.000)	96.23 (0.000)	55.19 (0.000)	144.65 (0.000)
Sample size	1710	540	390	300	480

p-values in parentheses. *Significance of parameter at 10%. ** Significance of parameter at 5% *** Significance of parameter at 1%.

Table 5: Rank-Ordered Logit Estimates

Variable	**Overall score**	**Stakeholders classification by factors**				
		Awareness	Environmental concern	Population envir. concern	Impacts	Policy acceptability
Life form: 1 if woody species	0.255 (0.272)	0.353 (0.121)	0.368 (0.151)	0.616** (0.019)	0.420* (0.063)	0.243 (0.304)
Distribution	0.517*** (0.005)	0.471*** (0.009)	0.523*** (0.009)	0.579*** (0.005)	0.649*** (0.000)	0.615*** (0.001)
Total nº of articles in press	1.4E-04*** (0.000)	1.5E-04*** (0.000)	1.4E-04*** (0.000)	1.40E-04*** (0.000)	1.40E-04*** (0.000)	1.2E-04*** (0.000)
Ornamental sector use: 1 if sell/use	0.930** (0.037)	0.890** (0.033)	1.00** (0.036)	0.435 (0.333)	0.945** (0.024)	0.823* (0.054)
Control administration: 1 if control applied	0.718** (0.026)	0.535* (0.089)	0.531 (0.126)	0.771** (0.040)	0.702** (0.023)	0.820** (0.013)
LR test	196.14 (0.000)	184.33 (0.000)	156.68 (0.000)	161.91 (0.000)	226.31 (0.000)	149.00 (0.000)
Sample size	960	870	870	870	1140	870

p-values in parentheses. * Significance of parameter at 10%. ** Significance of parameter at 5% *** Significance of parameter at 1%.

Table 6: Marginal Effects

Variable	**All Stakeholders**
Prob. of being first choice for plant invader with average attributes	1.69 (0.025)
Marginal effects	
Distribution	1.39 (0.114)
Total nº words of articles in press	0.331 (0.047)
One-unit change of dummies from 0 to 1	
Life form: 1 if woody species	0.74 (0.036)
Ornamental sector use: 1 if sell/use	1.21 (0.125)
Control administration: 1 if control applied	1.07 (0.156)

p-values in parentheses.

Table 7: Probabilities that a given plant would be rank in the first place among those most mentioned by stakeholders.

Variable	All stakeholders	Stakeholders categories				Stakeholders classification by factors				
		Administration.	Research	Ornamental sector	Social Group	Awareness	Environ. concern	Pop_env. concern	Impacts	Policy acceptability
Acacia dealbata	23.07	15.42	23.66	16.63	39.63	19.62	20.24	24.10	23.22	19.79
Eucalyptus globulus	16.86	12.09	16.36	12.19	28.20	13.71	14.35	16.96	16.46	14.86
Carpobrotus edulis	13.81	12.44	17.42	12.01	9.60	17.59	16.46	14.69	15.82	14.82
Cortaderia selloana	8.38	8.45	9.69	7.33	5.59	9.95	9.53	8.39	9.15	9.41
Robinia pseudoacacia	4.87	2.99	3.89	8.82	2.67	3.95	4.28	3.91	4.13	4.75
Acacia melanoxylon	4.55	6.12	4.29	3.44	3.02	4.43	4.52	4.97	4.57	3.72

Probabilities shown for those six plants with higher probabilities. Values for all thirty plant invaders in the choice set available upon request.

APPENDIX: RESULTS OF FACTOR ANALYSIS

Group 1: Awareness and concern about invasions
Cumulative variance explained by the factor=100%

Variables[a]	Mean	SD	Factor loadings
Concern on biological invasions [a]	3.72	1.06	0.51
Knowledge of invasive plants in Galicia	20.82	9.73	0.63
Number of invasive plants perceived to impact on stakeholder organisation	5.54	3.62	0.84
Factor name: AWARENESS SCORE	Cronbach's alpha[b]=0.69		
		(0.56, 0.83)	

[a] Variables range from 1=”no importance” to 5=”extremely high importance”.
[b] Bootstrap confidence interval at 95% for the sample statistic alpha in brackets.

Group 2: Perception towards other environmental problems
Cumulative variance explained by the factor=100%

Variables[a]	Mean	SD	Factor Loadings
Concern over habitat loss	4.42	0.82	0.59
Concern over climate change	3.5	1.04	0.55
Concern over pollution	3.75	1.07	0.87
Concern over overfishing	3.94	1.00	0.62
Concern over urbanization	4.24	1.02	0.89
Factor name: ENVIRONMENTAL CONCERN SCORE[a]	Cronbach's alpha[b]=0.79		
		(0.67, 0.90)	

[a] Variables range from 1=”no importance” to 5=”extremely high importance”.
[b] Bootstrap confidence interval at 95% for the sample statistic alpha in brackets.

Group 3: - Perceived opinion of Galician population to environmental problems

Cumulative variance explained by the factor=100%

Variables[a]	Mean	SD	Factor loadings
Perceived Galician population concern over forest fires	4.39	0.94	0.39
Perceived Galician population concern over habitat loss	2.44	0.91	0.60
Perceived Galician population concern over climate change	2.95	1.08	0.62
Perceived Galician population concern over pollution	3.16	0.98	0.69
Perceived Galician population concern over overfishing	2.73	1.08	0.64
Perceived Galician population concern over urbanization	2.87	1.25	0.42
Factor name: PERCEIVED POPULATION ENVIRONMENTAL CONCERN SCORE	Cronbach's alpha[b]=0.73 (0.61, 0.85)		

[a] Variables range from 1=”no importance” to 5=”extremely high importance”

[b] Bootstrap confidence interval at 95% for the sample statistic alpha in brackets.

Group 4:Perceived Invasion Impacts

Variables[a]	Mean	SD	Loevinger H coeff
Economic Impact	0.60	0.50	0.70
Social Impact	0.37	.49	0.55
Health Impact	0.19	0.40	0.56
Factor name: INVASION IMPACTS SCORE	Cronbach's alpha[b]=0.60 (0.42, 0.77)		

[a] Dichotomous variable 0=”no recognised impact” and 1=”recognised impact”.

[b] Bootstrap confidence interval at 95% for the sample statistic alpha in brackets.

Group 5: Perceptions on invasive species management options

Cumulative variance explained by the factor=100%

Variables[a]	Mean	SD	Factor loadings
Instruments for high risk activities (e.g. taxes)	2.81	1.38	0.66
Preventive measures (e.g. red list)	3.87	1.38	0.83
Establishing early warning systems	3.87	1.36	0.91
Eradication and control measures	4.17	1.15	0.65
Factor name: POLICY MEASURES ACCEPTABILITY SCORE	Cronbach's alpha[b]=0.79 (0.68, 0.90)		

[a]Variables range from 1="no acceptability" to 5="strongly high acceptability"

[b] Bootstrap confidence interval at 95% for the sample statistic alpha in brackets.