



# Public preferences for the management of different invasive alien forest taxa

Anže Japelj · Jana Kus Veenvliet · Judita Malovrh · Andrej Verlič · Maarten de Groot

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**Abstract** Invasive alien species (IAS) require management to mitigate their impact on ecosystems. The success of management decisions often depends on whether they are socially acceptable and to what extent people are willing to be actively involved in an early warning and rapid response system (EWRR). We administered a nation-wide public poll to assess people's knowledge on plant, insect and fungal IAS; their perception of IAS as an environmental problem; and their support for different IAS management measures. Most respondents (76%) knew the term IAS, and more than half (62%) provided a correct definition. Species with more media attention and those that are easily visible are more frequently identified correctly. Almost all respondents (97%) support an EWRR system; however, there is heterogeneity in terms of the types of actions people approve of. Non-lethal measures garner more support than lethal ones. Gender and previous knowledge also affect the level of agreement. The willingness-to-pay

question largely confirmed this, as people were divided into four classes according to their preferences for either biological, mechanical or chemical measures to control IAS; completeness and location of removal; and having an EWRR established. Mechanical removal is the most preferred treatment in two of the four classes, and complete removal is preferred over partial removal in one of the four classes. Having an EWRR is consistently supported in all classes, and removal in urban areas is preferred over removal in forestland in only one class.

**Keywords** Early warning and rapid response system · Public attitudes · Management measures · Alien insects · Alien plants · Alien fungi

## Introduction

We are witnessing an era of extensive dispersion and establishment of species into areas where they are not native. This is occurring due to the breakdown of natural barriers that had once confined plant, animal and fungal species to specific areas (Crosby 2015; Mooney 2005). These barriers are now being bypassed by new transport routes, increasing trade, tourism activities and climate change (Keller et al. 2011; Meyerson and Mooney 2007; Perrings et al. 2005; Walther et al. 2009). If alien species have the ability to adapt to a new environment and are competitively

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A. Japelj (✉) · A. Verlič · M. de Groot  
Slovenian Forestry Institute, Vecna pot 2, 1000 Ljubljana, Slovenia  
e-mail: anze.japelj@gozdis.si

J. Kus Veenvliet  
Institute Symbiosis, Metulje 9, 1385 Nova vas, Slovenia

J. Malovrh  
Institute of the Republic of Slovenia for Nature Conservation, Tobacna ulica 5, 1000 Ljubljana, Slovenia

strong, they can have a detrimental effect on local biodiversity (Simberloff et al. 2013; Vilà et al. 2011), as they can easily cohabit with native species and establish novel communities (Carroll 2011; Hufbauer et al. 2012). Alien species invasions can significantly change habitats and diminish the reproductive success of native species (Cherry et al. 2001; Veblen et al. 1992). In fact, invasive alien species (IAS) are considered to be one of the major causes of biodiversity loss (Bremner and Park 2007; Jäger et al. 2009; Lockwood et al. 2013; Pimentel et al. 2000), which in turn also negatively affects economic livelihoods and human well-being, etc. (Hulme et al. 2013; Koo and Mattson 2004; Perrings et al. 2002; Pimentel 2002; Taylor and Irwin 2004; Vilà et al. 2011). However, IAS can also provide benefits to society, such as food, fibre, erosion control and aesthetic enjoyment. In addition, IAS can mitigate the effects of pests (see Vaz et al. (2017) for an overview); this is one of the goals of conciliation biology (Carroll 2011), which emphasises the potential benefits of native and alien species coexisting in one place.

Since IAS problems are mostly related to human activities, it is essential to understand public perceptions towards IAS management. Public support is a key element for effective IAS-control policies, as the public needs to understand the benefits of such policies to accept them and to assist in their implementation. If managers ignore public opinion and do not account for public attitudes, they risk the loss of public support for IAS-management measures (Crowley et al. 2017a; Nimmo and Miller 2007). In such cases or cases where conflict of interests are critical (Novoa et al. 2018), hard opposition or simple non-compliance may occur, which could delay or even lead to the complete failure of management measures. There is often an unfavourable perception of IAS-management measures, as they can involve lethal control or other non-humane methods (Temple 1990). People are often reluctant to support the killing of species, which triggers sympathy and may not even have an impact on a large number of native species (Courchamp et al. 2017). A proactive approach that involves the public is likely to increase public engagement in citizen science projects (Crowley et al. 2017b; Novoa et al. 2018), as increased public awareness generates interest, increases the willingness to act (Ridder 2007) and also influences the values people attribute to IAS and

their management (Jeschke et al. 2014; Liu et al. 2011; Shackleton and Shackleton 2018; Vaz et al. 2017).

There are several ways of involving the public in IAS management. Public involvement can be achieved passively through educational campaigns (García-Llorente et al. 2011), but this approach is thought to be ineffective (Owens 2000). Another option is to use more advantageous participatory approaches such as conflict transformation (Lederach 2015), which adds the element of building a constructive partnership to solve challenges (Madden and McQuinn 2014). Thus, we firstly propose an early warning and rapid response system (hereafter EWRR) (Clout and Williams 2009) based on key elements of conflict transformation, which involves individuals in a system of reporting on IAS findings and fosters cooperation among laymen, IAS-management professionals and governmental bodies, with a mandate to develop and implement IAS-relevant policies. It does not include prevention. We then assess public support for the hypothetical implementation of an EWRR in Slovenia. Since public agencies in charge of IAS-management are underfunded, the involvement of citizens in an EWRR can bring multiple benefits. It can raise public awareness of the vulnerability of nature, and it gives citizens an opportunity to contribute to nature conservation and to a common societal goal. Therefore, we assume that such a system has multiple benefits.

An EWRR is a response mechanism of competent organizations for the detection of IAS. The system defines their roles and protocol of action: monitoring the presence and abundance of species, informing the public about the possible threat and the coordination of IAS removal. Such a system encourages the involvement of the public via citizen science, covers a large area at a relatively low cost and facilitates rapid action through publicly-available web-based applications for reporting IAS findings. With respect to public involvement, an EWRR creates awareness and a sense of cooperation, which increases the chances that the public will support the implementation of control or eradication (hereafter management) measures. When all mechanisms are set in place, an EWRR for IAS can prevent the establishment of invasive alien species and reduce the costs associated with their management.

Several studies have been published on the attitudes of the public towards alien species and possible management measures (Ansong and Pickering 2015; Fischer and Charnley 2012; Ford-Thompson et al.

2015; Lindemann-Matthies 2016; Nanayakkara et al. 2018; Porth et al. 2015; Rolfe and Windle 2014; Subroy et al. 2018; Verbrugge et al. 2013). However, most of these studies focused on only one taxonomic group—similar to the findings of Courchamp et al. (2017)—from which the invasive plant species were best studied. We could find only a few studies covering several taxonomic groups of species. These include that of Nanayakkara et al. (2018) addressing fish, plants and shellfish and that of Bremner and Park (2007) investigating preferences for management for several animal and plant species. Such focused studies are appropriate for tackling issues related to the addressed species; however, they might not be useful for extrapolating insights to other IAS (Shackleton et al. 2019a). Furthermore, while few studies investigated whether financial contributions related to people's support for management measures affect their willingness to cooperate (Rolfe and Windle 2014; Verbrugge et al. 2013), none did this in combination with several taxonomic groups of IAS.

In this study we focus on groups of invasive alien species that are most detrimental to Slovenia's forests. Forest ecosystems in Europe are characterized by high biodiversity and are also important from an economic perspective. However, due to increasing pressure because of climate change, forests may become less resistant to biological invasions (Dukes et al. 2009). Therefore, an EWRR in forests is needed. We aimed at understanding the socioeconomic factors underlying the acceptance of different IAS-management measures and potential support for introducing an EWRR. First, we investigated the general attitude towards IAS and determined which socioeconomic factors are most influential. Second, we were interested whether the taxonomic group of IAS affected perspectives on the eradication method. For this sub aim we used species from fungal, insect and plant taxonomic groups. Third, we investigated whether people were in favour of an EWRR even if a monetary contribution was attached. Therefore, we prepared a choice experiment offering data for estimating the willingness-to-pay (WTP) for implementing different IAS-management measures.

## Materials and methods

Data were primarily collected through a public survey using a questionnaire. The first part contained four sets

of questions addressing (1) general awareness of IAS-related problems, (2) support for establishing an EWRR and willingness to act, (3) awareness of IAS and the layperson's recognition, and (4) support for IAS-related management measures. For the last section, we decided to extend the set of measures so that it not only covered fungal, insect and plant taxa, but also vertebrates, which might be introduced into Slovenia and become invasive in the future. Questions were mainly designed as closed-format questions with several options to which the interviewee could respond by either a binary-type answer (e.g. 'yes' or 'no') or a rank of agreement. The third section included a particular task where a respondent was presented with characteristic photos of either an IAS or the symptoms it causes and asked to indicate which species it was. Under each photo (see questionnaire in "Appendix 1") one could select one IAS among all eight species. An 'I do not know' option was also available.

We designed two versions of the questionnaire: a basic version with the three parts described above and an extended version with a choice experiment as the fifth (5) part of the questionnaire. It was designed to elicit WTP measures for implementing specific sets of IAS-management measures. Both versions ended with a set of questions on the socio-economic characteristics of the respondents.

Those five sections can be related to three out of four types of challenges that Courchamp et al. (2017) listed as those hampering the success of invasion biology: understanding, alerting, support and implementation. The first and third part of the questionnaire were devoted to determining the level of IAS-related knowledge among the public, since poor understanding makes it more difficult of to control the spread of IAS. The second, fourth and fifth parts mainly focused on public support for both an EWRR and various measures for IAS control, with the second part additionally investigating the potential of implementing an EWRR as an alert system. Thus, our research aims to elucidate those issues in the case of Slovenia so that decision makers can have a realistic perception of public involvement in IAS management.

The questionnaire: timing, sample frame

First, the questionnaire was tested for wording, clarity and consistency on a pilot sample of 47 respondents.

This was followed by the main survey, which was administered in the week of January 3, 2017. A sample of 953 respondents was surveyed, among which 276 completed the extended version of the questionnaire. The sample was drawn from a larger panel of a major market research company and was stratified according to age and gender to be representative for the nation. Respondents were selected randomly from those strata and surveyed via a web-based interview. The sample population of Slovenes above 18 years of age at that time was 1,701,642 people (Statistical Office of the Republic of Slovenia).

### Binomial and ordinal logistic regression

Data deriving from the first three parts of the questionnaire, which contained eight questions in total, was analysed by either binomial or ordinal logistic regression. Those questions are as follows:

- Have you already heard of the term IAS?
- Do you think invasive IAS pose a problem?
- Do you support the establishment of an EWRR?
- If an IAS appeared on your land, would you be willing to remove it?
- Would you be willing to report the finding of an IAS to the relevant institution?
- Have you heard about the IAS?
- Can you recognize the IAS in the photo?
- How strongly do you support lethal measures, non-lethal measures for plants, and non-lethal measures for animals?

Their basic descriptive statistics and information on statistical methods used for their analysis is given in “Appendix 2”.

Binomial logistic regression was used for questions with two possible outcomes: questions no. 1–7 (see “Appendix 2”). Ordinal regression was used for question no. 8, where respondents expressed their level of support for IAS control measures. In this case, a cumulative logit model was used, as it is suitable when the dependent variable represents a crude measurement of an underlying continuous or interval ratio variable (Menard 2010). In public opinion surveys, this also relates to statements of agreement, where there is an underlying ‘amount’ of agreement with the statement, but for the sake of simplicity, we measured it in terms of order (ranks). We assumed that

the coefficients for independent variables are equal across logistic functions and across cases, which practically implies that the odds of a respondent selecting one category as opposed to selecting the next one are equal regardless of which two categories are being compared (Menard 2010).

Exploratory factor analysis (EFA) was used prior to regression analysis for the questions ‘Which IAS have you heard of?’, ‘Which IAS is in the photo?’ and ‘How strongly do you support different measures of control of IAS?’ (see “Appendix 2”) because those questions had complex sets of possible answers and were reduced into fewer dimensions. These dimensions were later used as dependent variables in the regression analysis to explain the underlying structure of responses. This was done in SPSS (2008), with principal component analysis (PCA) as the extraction method, since we were primarily interested in data reduction (Hair 2010). We used a combination of latent root (min eigenvalue at 1.0) and a scree test criterion for deciding on the number of factors. Thus, we did not consider the eigenvalues themselves exclusively, but we also examined the eigenvalue plot. In fact, if the number of variables is less than 20, the latent root criterion tends to preclude too few factors (Hair 2010). Furthermore, we expected the factors to be uncorrelated; thus, we used one of the orthogonal rotation methods, namely ‘Varimax’. This choice was based on the prior use of the oblique rotation method (‘direct oblimin’) and examination of the factor correlation matrices, where correlations never exceeded .32, which is indicated by Tabachnick and Fidell (2007) to suggest that there is less than a 10% overlap in variance among factors.

PCA run on ‘Which invasive alien species have you heard of?’ indicated two factors with eigenvalues  $> 1$  (details in “Appendix 3”, see Table 7). High loadings on the first factor indicate invasive alien species commonly receiving high media<sup>1</sup> attention in Slovenia, whereas loadings contributing to the second factor indicate species with less media coverage. Only one—Chalara ash dieback (*Hymenoscyphus fraxinus*)—has a weak relation to either of the two factors..

PCA run on responses where respondents were asked to identify the IAS in a photo indicated two factors with an eigenvalue  $> 1$  (details in “Appendix

<sup>1</sup> TV, radio, internet, public talks, exhibitions, social media, etc.

3”, Table 8). Invasive alien plant species that are large enough to be easily spotted contribute high loadings on the first factor, and are thus named ‘easily visible’. The second factor covers species that either cause hardly detectable symptoms or are themselves difficult to spot (such as small insects) and is thus labelled as ‘not easily visible’.

PCA run on the question asking respondents to rate their support for different measures aimed at controlling the spread of IAS (1—I do not support this measure, ..., 4—I fully support this measure) suggested three distinguishable dimensions (“Appendix 3”, Table 9). High loadings on the first factor were linked to measures for the eradication of the species, and was thus named ‘lethal measures’. The second factor was labelled as ‘non-lethal measures for plants’, as it comprised measures focusing on plants that do not eliminate the species but merely decrease its rate of spread. The last factor was labelled as ‘non-lethal measures for animals’, which comprises measures focused on animals that do not eliminate the species but tend to control its rate of spread.

In addition to factor loadings acting as dependent variables in ordinal regression models, several other variables were used as independent predictors (Table 1). These were the same in all models.

### The choice experiment

The additional part included only in the extended version of the questionnaire was designed as a choice experiment. The methodological approach is

presented in the following subsections, with more detailed description of the theoretical framework in “Appendix 4”. The choice experiment was used to elicit public preferences for several elements of IAS control measures not directly related to specific species. It also dealt with support for establishing EWRR. Thus, it extends the question from previous section addressing peoples’ preferences for different types of measures to control specific taxa of IAS.

### *Design of the choice experiment*

The choice experiment was designed by taking steps to ensure consistency of question formats and bias-free responses to the greatest extent possible. First, the attributes were defined. According to the goal of the research—to define public support for IAS management measures—two focus groups with experts from the field of IAS were organized. Four attributes were selected (Table 2). Next, levels for each attribute were defined, with one always representing the current state (i.e. business-as-usual, BAU) and the others indicating possible alternative states which could be implemented in the future. A cost attribute indicating a yearly amount to be paid by every Slovene of 18 years of age and more into a fund dedicated to support the implementation of management measures was also added.

A sequential fractional factorial design was used to construct 108 alternatives, which were used to populate 36 choice sets with three alternatives. One alternative always presented the current state, holding

**Table 1** Multivariate OLS regression models and the variables used in those models

Dependent variables	Independent variables
Knowing IAS with high media attention	‘gender’ (0-female; 1-male), ‘forest ownership’ (0-do not own a forest; 1-own a forest), ‘have you heard about IAS before’ (0-no; 1-yes), ‘frequency of visiting forest’ (1-never, ..., 8-each day), ‘age’ (y. of age), ‘household size’ (no. of members), ‘type of settlement’ (1-rural; 2-urban), ‘personal monthly income’ (net income in EUR), ‘education’ (1-unfinished elementary school, ..., 12-finished PhD)
Knowing IAS with low media attention	
Recognizing easily visible IAS	
Recognizing not easily visible IAS	
Support for lethal measures	
Support for non-lethal measures for plants	
Support for non-lethal measures for animals	

**Table 2** Attributes and their levels used to construct the choice experiment

Attributes	BAU-level	Alternative levels
Type of removal	No removal	Mechanical: mowing, mulching, trapping Chemical: use of biocides Biological: use of natural enemies
Completeness of removal	No removal	Partial: preventing further spread Complete: total eradication
Place of removal	No removal	Forestland: removal in forests Urban areas: removal in urban areas
EWRR system	Not operational	EWRR is fully functioning
Payment in Euros	0	3, 6, 9, 12, 15, 17

EWRR is a mechanism of rapid response of competent public services when IAS emerge. The system defines organizations' roles and protocols of action: monitoring of IAS spread, early warning of the public on possible problems, and coordinating actions of IAS removal

only the BAU-level of attributes, while the other two comprised combinations of alternative attribute levels and the BAU-level for the attribute EWRR, presenting outcomes of the implementation of management measures. Each respondent was asked to select a preferred alternative. To optimize the trade-off between the cognitive burden of respondents and the sample size, choice sets were grouped into three blocks of 12 so that each respondent was presented with not 36 but 12 choice opportunities. An example of a choice set is in "Appendix 5".

#### *Estimating the empirical model of the choice experiment*

Before estimating the model, all protest answers (those where a respondent chose the BAU alternative 12 times successively;  $n = 21$ ) were removed from the database and analysis was done on a sample of 255 respondents. The remaining respondents' choices were analysed by a random utility model-based latent class logit model (LCLM), which assumes a discrete distribution of a population into a limited number of classes with within-class homogenous preferences. Should the population be segmented—and this is what this study aims to prove—LCLM surpasses the random parameter logit model, an alternative model to address heterogeneity of preferences. The latter, however, assumes a continuous distribution of taste parameters. We estimated the number of classes of the LCLM by employing Bayesian information criteria

(*BIC*) (Schwarz 1978) and Bozdogan-Akaike information criteria (*AIC3*) (Bozdogan 1987), and additionally considered the plausibility of parameter estimates and the size of classes.

The LCLM was estimated with NLOGIT5 (2012) software. Modelling was done so that attributes in Table 2 were treated as independent variables, which either had linear effects and were design coded (payment) or were categorical variables (type, completeness and place of removal, and functioning of EWRR system) and coded as dummy variables for each level. Additionally, several other socio-demographic and behavioural variables were introduced into the model.

Afterwards, mean WTP estimates were calculated for each attribute for all four classes separately:

$$WTP_{i|c} = - \sum_{c=1}^C p_{ic} \times \left( \frac{\beta_{attribute,c}}{\beta_{payment,c}} \right),$$

where  $\beta_{attribute,c}$  is a class-specific attribute related coefficient and  $\beta_{payment,c}$  is a class-specific payment coefficient. The confidence intervals for these estimates were calculated with the Delta method according to (Hole 2007).

## Results

Results of the binomial and ordinal regression are presented in a summarized outline (Table 3). Indications of a predictor being statistically significantly

**Table 3** Indicative estimation results of binomial and ordinal regression for eight questions on general awareness of IAS related problems, support for having an EWRR, recognition of selected IAS and support for various IAS-related control measures

Question	Dependent variable	Independent variables								
		Gender	Age	Owning a forest	Visiting frequency	Knowing term 'IAS'	Household size	Type of settlement	Personal income	Education
Have you already heard of the term IAS?	Binomial: 0—no; 1—yes	Male	—	—	—	—	—	—	—	High
Do you think invasive IAS pose a problem?		—	High	—	Freq.	Yes	—	—	—	—
Do you support the establishment of an EWRR?		—	—	—	—	—	—	—	—	—
If IAS appeared on your land, would you be willing to remove it?		—	High	—	Freq.	—	—	—	—	—
Would you be willing to report the finding of an IAS to a relevant institution?		—	High	—	—	—	—	Urban	—	—
Have you heard about the IAS listed? (those with high media attention)		—	—	—	Freq.	Yes	—	—	—	—
Have you heard about the IAS listed? (those with low media attention)		—	—	Yes	Freq.	Yes	—	—	—	—
Can you recognize the IAS in the photo? (not easily visible IAS)	Binomial: 0—incorrect; 1—correct	Female	—	—	Freq.	Yes	—	—	—	—
Can you recognize the IAS in the photo? (easily visible IAS)		—	—	Yes	Freq.	Yes	—	—	—	—
How strongly do you support lethal measures?	Ordinal: 1—do not support; 2—partially; 3—mostly; 4—fully support	Male	—	—	—	—	—	—	—	—
How strongly do you support non-lethal measures for plants?		—	—	—	—	Yes	—	—	—	—
How strongly do you support non-lethal measures for animals?		—	—	—	—	—	—	—	—	—

A dash (—) indicates a non-significant parameter estimate, whereas parameters significantly different from zero are indicated with a figurative interpretation of its estimated value; 'freq.' stands for frequent

**Table 4** Test results for different number of classes of the latent class model

Number of classes	Number of observations (N)	Number of parameters (P)	Log-likelihood (LL)	BIC <sup>a</sup>	AIC3 <sup>b</sup>
<i>Model with no covariates</i>					
1	3060 (= 255)	7	− 2863.96	5752.33	5748.93
2		15	− 2528.08	5108.44	5101.15
3		23	− 2434.70	4949.57	4938.40
4		31	− 2400.79	4909.64	4894.58
5		39	− 2387.26	4910.46	4891.52
6		47	− 2355.14	4874.11	4851.28
7		55	− 2354.20	4900.12	4873.40

$${}^a\text{BIC} = (-2 * LL) + (\log(N) * P), {}^b\text{AIC3} = (-2 * LL) + (3 * P)$$

different from zero are descriptive rather than numerical to ease interpretation. Numerical estimations of regression parameters with standard errors and *z*-values are given in “Appendix 6”. Estimations of the discrete choice model are given in its original format in Table 5 and associated WTP estimates in Table 6.

#### General awareness of IAS-related problems

More than three quarters (76%) of respondents from the larger sample (basic version of the questionnaire) had already heard about the term ‘alien species’, but of those, only 62% provided a correct definition of the term, while 25% defined it only partially correctly.

**Table 5** Estimates of the LCLM for support of IAS-management measures

Variable	Coefficients of the estimated indirect utility function							
	Class 1		Class 2		Class 3		Class 4	
	Coeff.	<i>s.e.</i>	Coeff.	<i>s.e.</i>	Coeff.	<i>s.e.</i>	Coeff.	<i>s.e.</i>
ASC <sup>a</sup>	− 3.49***	1.05	1.84***	.42	− 2.22***	.23	− .51	.41
Biological removal	1.79***	.56	3.40***	.38	.23	.16	.38	.32
Mechanical removal	1.93***	.43	3.83***	.37	.35	.20	.29	.33
Complete removal	1.15***	.29	.35**	.16	.15	.10	− .12	.27
Removal in urban areas	.56**	.22	− .02	.17	− .12	.12	− .02	.26
EWRR functioning	1.21***	.38	1.08***	.21	.48***	.10	.57**	.28
Payment	− .09***	.02	− .08***	.02	− .06***	.01	− .32***	.04

  

Variable	Coefficients of the estimated latent class membership function							
	Class 1		Class 2		Class 3		Class 4 <sup>c</sup>	
	Coeff.	<i>s.e.</i>	Coeff.	<i>s.e.</i>	Coeff.	<i>s.e.</i>	Coeff.	<i>s.e.</i>
Constant	.97	1.09	1.28	.84	.95	.78		
Gender <sup>b</sup>	.50	.66	1.37**	.61	.63	.52		
Personal income	.27**	.12	.00	.00	.00	.00		
Visiting forest <sup>c</sup>	− .31	.17	− .13	.16	.18	.14		
Type of settlement <sup>d</sup>	− 1.27**	.62	− 1.96***	.61	− 1.37**	.54		

Estimated coefficients are statistically different from zero at 5% (\*\*) or 1% (\*\*\*) significance level

<sup>a</sup>Alternative specific constant; <sup>b</sup>0—woman, 1—men; <sup>c</sup>1—each day, 2—3–6 times per week, 3—1–2 times per week, 4—a few times per month, 5—once per month, 6—a few times per year, 7—less than a few times per year, 8—never; <sup>d</sup>0—urban, 1—rural; <sup>e</sup>reference class



The two most important reasons respondents provided an incomplete definition was that respondents related the term alien species only to plant species or thought that all alien species cause damage to either nature or society. Less than a tenth (8%) provided an incorrect definition and 5% did not know the meaning of alien species despite having heard of the term.

The likelihood of a respondent having already heard of the term alien species increases by being male or having higher education. Furthermore, more than three-quarters (83%) replied 'yes' to the question 'Do you think IAS pose a problem?'. Being older, being a more frequent forest visitor or already having heard of IAS increases the likelihood of stating that IAS are a problem.

Support for establishing an early warning and rapid response system and willingness to act

A large majority of respondents (97%) expressed support for establishing an EWRR, and almost the same proportion (96%) of respondents would be willing to remove an IAS if it appeared on their land. Almost nine tenths of all (89%) respondents would also report the finding of an IAS to a relevant organization. No socio-economic characteristics significantly predict support for having an EWRR, while older respondents are more likely to remove IAS and report the finding of IAS. Those who visit the forest more often are also more likely to remove IAS on their land, whereas those living in urban areas are more likely to report the finding of an IAS.

Awareness of IAS and the layperson's recognition

Having heard about IAS with high media attention is related to two predictors: being a more frequent forest visitor and having already heard about the term alien species. Having both characteristics also increases the likelihood of having heard about IAS with low media attention, but in this case, owning a forest also contributes to this.

Next, respondents were asked to indicate the name of the IAS below a characteristic photo of the IAS. Correct recognition of the both species that are easy to see and those which are not can be related to several predictors. The parameter estimates suggest that being a woman, being a more frequent forest visitor or one who has already heard about the term alien species

increases the likelihood of correctly recognizing IAS that are not easily visible. Furthermore, being a more frequent forest visitor, having already heard the term IAS or owning forest increases the chances of one correctly identifying the IAS that are easily visible.

Support for IAS-management measures

When asking respondents about their support for various measures, which were grouped according to PCA into three groups, only gender seems to predict support for lethal measures, while being male increases the level of support. In the case of non-lethal measures for plants, the level of support increases with the respondents' familiarity with IAS. The model for predicting support for non-lethal measures for animals does not contain any statistically significant variables.

WTP for different types of IAS management

Before estimating the LCML, we needed to determine the number of latent classes. According to both *BIC* and *AIC3*, a model with six classes is best (Table 4); however, after investigating further, several shortcomings became obvious.

The model had two classes with no statistically significant parameters, which makes it irrelevant. Since the values of information criteria increased for a model with seven classes, we continued to a model with five classes. It contained a class with no statistically significant parameters and one class with only the cost parameter being non-zero. Next, a model with four classes was examined. The increase in values of information criteria was insignificant; however, all four classes had significant parameters with reasonable signs, and classes were of relevant sizes. This led to the decision that the four-class model was optimal.

Coefficient estimates of the four-class model representing the marginal values for changing the five attributes from Table 2 are given in the upper part of Table 5. Additional variables, such as socio-demographic characteristics of respondents and their recreational habits, three of which were statistically significant in terms of affecting respondents' class membership, are in the lower part of the table. Parameters for those four independent variables were normalized to zero for class 4; thus, classes 1 through 3 are interpreted relative to class 4.

According to class-membership probabilities, respondents were classified into classes 1–4 as 23.9%, 21.8%, 41.1% and 13.2%, respectively.

McFadden's adjusted- $R^2$  was 0.29, which is equivalent to an  $R^2$  of approximately 0.6 for linear models (Domencich and McFadden 1975).

Parameter estimates from the indirect utility functions in Table 5 were used to calculate the WTP estimates (Hensher et al. 2005). Estimates (Table 6) with the associated confidence intervals are given in parentheses.

Respondents in class 1 expressed positive preferences for biological and mechanical removal over chemical removal of IAS. They were willing to pay 20.6 EUR per year for implementation of biological instead of chemical removal, and 22.2 EUR per year for implementation of mechanical instead of chemical removal. They also support complete (13.3 EUR per year) over partial removal, and removal in urban areas (6.5 EUR per year) over removal in forestland. Respondents also support the establishment and functioning of an EWRR, for which they are willing to pay 13.9 EUR per year. This class is comprised of respondents who have higher personal income than those in class 4, or are more likely to live in urban areas than in rural areas.

The respondents in class 2 had similar preferences to those in class 1 but were indifferent about the place and plentitude of removal. They expressed a WTP of 40.0 EUR per year for implementing biological control and 45.1 EUR per year for mechanical instead of chemical removal, which is more than twice the amounts in class 1. Respondents in class 2 were also

willing to pay 12.7 EUR per year for having a functioning EWRR. Respondents in this class are more likely to be male and live in urban areas compared to those in class 4.

In class 3, the largest class of all, respondents were supportive of having an EWRR implemented and are willing to pay 7.4 EUR per year for it. They were indifferent about attributes other than payment. Respondents in this class are more likely to live in urban areas compared to those in class 4.

Class 4 is comprised of the smallest share of all respondents and is characterized by indifference towards IAS-management related attributes, which is similar to those in class 3; however, their willingness to pay for having an EWRR in place, at 1.8 EUR per year, is by far the lowest. With respect to socio-demographic characteristics and recreational habits, class 4 was the reference class and cannot be interpreted directly.

Respondents in all classes were resistant to having to pay for the proposed changes, which indicates respondents do not trade on the most important attribute—payment. This is consistent with the hypothetical market situation where respondents were asked to make trade-offs.

## Discussion

An understanding of social preferences concerning programs for the management of IAS is important for discovering relevant groups of stakeholders, determining the level of their support, detecting potential

**Table 6** Mean WTP estimates with 95% Delta confidence intervals in parentheses

Variable	Latent class model			
	Class 1	Class 2	Class 3	Class 4
Biological removal	20.6*** [9.8, 31.4]	40.0*** [23.5, 56.5]	3.6 [− 1.5, 8.7]	1.2 [− .8, 3.2]
Mechanical removal	22.2*** [9.8, 34.7]	45.1*** [26.8, 63.3]	5.4 [− 1.5, 12.3]	.9 [− 1.1, 2.9]
Complete removal	13.3*** [6.7, 19.9]	4.1 [− .2, 8.3]	2.3 [− .8, 5.5]	− .4 [− 2.0, 1.2]
Removal in urban areas	6.5*** [1.6, 11.4]	− .3 [− 4.0, 3.5]	− 1.8 [− 5.3, 1.6]	− .1 [− 1.7, 1.5]
EWRR functioning	13.9*** [7.4, 20.4]	12.7*** [6.5, 18.9]	7.4*** [3.7, 11.0]	1.8** [.1, 3.5]

Estimated coefficients are statistically different from zero at 5% (\*\*) or 1% (\*\*\*) significance level

opposition, designing strategies for mitigating conflicts among stakeholders, creating policies for the implementation of well-accepted measures and earmarking funds. Given the increasing number of IAS in Slovenia (Kus Veenvliet and Jogan 2014), the relatively high level of concern for nature among Slovenes and increasing media coverage of IAS issues, this study aimed to elucidate several of these aspects. This was achieved through the assessment of support for various IAS management measures related to insects, plants and fungi. The analytical approach combined ranking-type questions, open-format sections and a non-market valuation experiment.

The study showed that many Slovenes are familiar with the term alien species, which is very similar to findings of Verbrugge et al. (2013), but fewer are aware of the correct definition of the term. This highlights the need for further efforts to raise public awareness. If people are expected to be involved in an EWRR, their competencies will need to be developed. The share of people who believe IAS are a problem is quite high, which may be related to two main drivers: the relatively high apprehension among Slovenes when it comes to environmental issues within the EU energy policy (European Commission 2015) and continual media coverage focusing only on the negative effects of IAS. Both facilitate strong awareness among Slovenes regarding IAS related issues, which is important to consider when creating an EWRR given that the programs rely on the involvement of citizens.

This is further underpinned by the high level of support for establishing an EWRR, with survey results indicating almost absolute unanimity (97% of respondents). This is key information for policy makers, as they can rely on solid support for designing an effective system for the management of insect, plant and fungi IAS, which also includes the involvement of the general public. Such firm support also indicates very low risk of public opposition in terms of both implementing measures and spending public money. The willingness of respondents to remove IAS from their property is almost as high (96% of respondents), which additionally confirms potentially reliable public backing. This is in line with other studies indicating that the removal of potentially detrimental IAS is supported (Bardsley and Edwards-Jones 2006; Bremner and Park 2007; García-Llorente et al. 2008; Philip and MacMillan 2005). However, some studies found

lack of support for controlling IAS, either by the general public (Shackleton and Shackleton 2016) or interest groups (Bertolino and Genovesi 2003). The willingness to share information on IAS findings with relevant organizations is lower (89% of respondents), albeit still relatively high. This shows that involvement decreases when people are expected to make an active contribution. We can establish that people are willing to act and consider managing IAS as their responsibility, which is in line with previous research. This may also coincide with the fact that a potentially stronger association with 'official' institutions may curtail involvement. This may stem from mistrust or fear of exposing personal information on the ownership of land.

An EWRR relies heavily on people's knowledge about IAS, which, according to several studies (Ansong and Pickering 2015; Carlson and Vondracek 2014; Ford-Thompson et al. 2015; Nanayakkara et al. 2018; Sharp et al. 2011), can affect their capacity to participate in managing IAS and therefore successfully implement the system. In our research, the media obviously plays a key role in informing the public about IAS and, as confirmed by Marzano et al. (2015), significantly contributes to the public's understanding of IAS related issues. We defined two clusters of IAS (those with a great deal of media attention vs. those with less media attention) that differ in terms of how often people have heard about them. Species with abundant media coverage [e.g. common ragweed (*Ambrosia artemisiifolia*), goldenrods (*Solidago* spp.), chestnut gall wasp (*Dryocosmus kuriphilus*), Japanese knotweed (*Fallopia japonica*, *F. x bohemica*) and Chalara ash dieback (*H. fraxinus*)] were related to significantly higher levels of positive response to the question 'Have you heard about ... (one of eight species)?'

We found no clear distinction between two additionally designed clusters of IAS (how easy they are to spot) in terms of their successful recognition in photos. Those that are easy to observe are *A. artemisiifolia*, *Solidago* spp., *F. japonica* and *A. altissima*, and those that are not are *D. kuriphilus*, *Leptoglossus occidentalis*, *Eutypella parasitica* and *H. fraxinus*. This may imply either that species with high media attention are recognized more often, indicating the importance of the media, or that respondents also relied on guessing and trying to link IAS with a host plant, e.g. *D. kuriphilus* or *L. occidentalis*. For example, *F. japonica*

is easily visible, but was the second least recognized species.

The success of rapid response relies heavily on public support for implementing IAS management measures, which is strongly associated with people's pre-existing knowledge on various measures (Jetter and Paine 2004; Nanayakkara et al. 2018; White and Ward 2010), demographic variables (Fuller et al. 2016; Marzano et al. 2017; Nanayakkara et al. 2018), environmental values (Flint 2006; Nanayakkara et al. 2018), perceived threat from IAS (Fischer and Charnley 2012), emotional factors (Shackleton et al. 2019a), economic impacts (McDermott et al. 2013; Shackleton et al. 2019b), IAS ecology/biology (García-Llorente et al. 2008; Robinson et al. 2017; Shackleton et al. 2007; Shrestha et al. 2019) and finally to clear and consistent communication by relevant organizations (Mackenzie and Larson 2010; Porth et al. 2015). Thus, we focused our attention on investigating these relationships.

In our research more than two thirds of respondents consistently—both mostly and fully—support non-lethal measures for plants and animals, whereas lethal measures garner lower levels of approval. This is similar to the outcomes of a study in Australia by Subroy et al. (2018), where trapping and community engagement were preferred over the use of poison to control feral predators. We established that the use of herbicides is mostly or fully supported by almost half of the respondents despite obviously being lethal, whereas similarly harmful measures proposed for animals (insecticides, shooting, lethal injection and using poison) are less tolerable. This is obvious particularly for the last three measures, which are used principally for highly developed animal species such as birds and mammals, which are more likely to lead to the '*bambi*' effect common for megafauna. This is consistent with results from a study by Rolfe and Windle (2014), who established that WTP for total eradication of fire ants is preferred over containment, as insects are rarely defined as 'charismatic' species. Our results show that men are more likely to support lethal measures than women, which is in line with research by Fuller et al. (2016), where men were found to be more supportive of 'strong' management practices than women. Increasing respondents' knowledge of the term alien species is associated with increased support for non-lethal measures for plants. This indicates that more knowledgeable respondents also

recognize the benefits of measures most commonly related to media releases on IAS issues. Such measures are also most likely to be implemented by the public, thus indicating that a system involving people should, at least in the early stages, build on those or similar activities. Other measures perhaps require more skilled staff or equipment and are less likely to be used to a large extent.

An investigation of WTP estimates from the choice experiment shows that respondents consistently support the establishment of an EWRR; however, WTP is lowest for those in class 4, who are more likely to live in rural areas. This indicates that the designers of an EWRR need to focus heavily on these people, as they can potentially act over large swaths of land where IAS occur. People living in urban areas seem to be more aware of the positive effects of an EWRR, which could also be attributed to the negative impacts of IAS being more obvious due to more frequent encounter between people and IAS. Fuller et al. (2016) provides an extensive summary of the 'urban vs. rural' disparity in terms of IAS-related pre-existing knowledge and control preferences and concludes that patterns are not as straightforward as we may expect but are rather very context dependent. Furthermore, we also established that people from class 4 are indifferent to all other aspects of the IAS management programme, as none of the other WTP estimates were statistically significant. The same is true for respondents in class 3, which, together with class 4, contain more than half (54%) of the sample. Those in class 1 seem to support complete removal versus removal only in forests, which further indicates their concern for strong IAS management, and would also approve of removal in urban areas instead of in forestland. Furthermore, mechanical removal appears to be the most preferred option (highest WTP), followed by biological removal and finally chemical treatment of IAS. Similar results were reported by Jetter and Paine (2004), who investigated WTP for controlling urban forest pests, where biological control was the most preferred and the use of insecticides by far the least preferred measure. Some other studies have found similar preferences (Chang et al. 2009; Fuller et al. 2016). This is in line with respondents indicating that pollution of soils, water and air is the most important environmental problem in one of the introductory questions. Respondents are generally very concerned about pollution and seem to be sceptical of measures

triggering environmental degradation. Mechanical removal of IAS is then the obvious option to fight the spread of IAS.

## Conclusion

Our results show that various stakeholder groups differ significantly with respect to their level of knowledge about IAS, perceptions of the negative effects of IAS and attitudes towards different management options to control IAS. These facts need to be considered when designing EWRR to minimize possible opposition and garner stronger public support. Older people, those who live in urban areas or those who visit forest more frequently seem to be more willing to be involved in EWRR-related activities such as removing IAS and informing relevant organisations, which is partially also supported by previous research (Jetter and Paine 2004; Philip and MacMillan 2005). The information transfer about the EWRR therefore differs between the groups which are in favour or not in favour of the EWRR related activities. For people who would like to be involved information material and other activities should be developed how they can be involved, while

of the non-favourable group information and activities should be developed to get them involved. Non-lethal measures are preferred over more lethal ones and those that contribute to environmental pollution. This would mean that it is necessary to consider first the non-lethal options before continuing with lethal options. When lethal options are the only or the best option, the general public should be informed, with a communication campaign, about those options and why it is the best option. Important is that the general public will know what is to come when the IAS is not removed. EWRR building upon this public momentum would most likely receive more support from society in general.

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## Appendix 1: The extended version of the questionnaire (the basic version had no discrete choice experiment part)

### A SURVEY ON OPINION OF SLOVENES ABOUT INVASIVE ALIEN SPECIES

Within European project LIFE ARTEMIS, the Slovenian Forestry Institute, Institute of the Republic of Slovenia on nature protection, Slovenia Forest Service and Institute Symbiosis are carrying out a public opinion poll on insects, plant and fungi, which are not native in Slovenia and were introduced either intentionally or unintentionally due to myriad human activities. These species are referred to as alien species.

By this we wish to explore:

- your knowledge on invasive alien species,
- your readiness to participate in implementation of measures related to invasive alien species,
- your opinion on measures related to invasive alien species on a national level.

Responses are anonymous, results of the poll will be used for research purposes only and will not be shared with third persons.

#### QUESTIONS (\*in both short and extended version of the questionnaire)

1. Have you already heard the term “invasive alien species”?

Yes

No

2. What do you think the term alien species refers to?

Please describe \_\_\_\_\_.

The following questions refer to “invasive alien species”, which are for the purposes of this poll defined as *“Invasive alien species are plant, animal and fungi species, which originate from other countries or even continents and are currently spreading rapidly in Slovenia. Favourable living conditions and/or the lack of natural enemies/competition allows those species to thrive in Slovenia. Thus, we refer to them as invasive alien species.”*

3. Do you think invasive alien species pose a problem?

Yes

No

4. Do you support the establishment of the Early Warning and Rapid Response system as described here: *“System of Early Warning and Rapid Response system is a mechanism of response of competent organizations upon arrival of invasive alien species. The system sets their role and protocol of action: monitoring of spread, informing the public on potential inconveniences, coordinating removal of invasive alien species and prevention of new introductions.”*

Yes

No

5. Would you be willing to remove an invasive alien species if it was to appear on your land (e.g. garden)?

Yes

No

6. Would you be willing to inform competent organisation about the finding of invasive alien species on your land?

Yes

No

7. For which among below listed invasive alien species have you already heard of?

Species	Already heard of
chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	Yes; No
western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	Yes; No
Japanese knotweed ( <i>Fallopia japonica</i> )	Yes; No
goldenrods ( <i>Solidago</i> spp.)	Yes; No
<i>Eutypella</i> canker ( <i>Eutypella parasitica</i> )	Yes; No
tree of heaven ( <i>Ailanthus altissima</i> )	Yes; No
common ragweed ( <i>Ambrosia artemisiifolia</i> )	Yes; No
<i>Chalara</i> ash dieback ( <i>Hymenoscyphus fraxineus</i> )	Yes; No

8. Can you mark the name of invasive alien species, for which you believe is displayed on a photo?



Species	Which one is on the photo above
chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	This one
western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	This one
Japanese knotweed ( <i>Fallopia japonica</i> )	This one
goldenrods ( <i>Solidago</i> spp.)	This one
<i>Eutypella</i> canker ( <i>Eutypella parasitica</i> )	This one
tree of heaven ( <i>Ailanthus altissima</i> )	This one
common ragweed ( <i>Ambrosia artemisiifolia</i> )	This one
<i>Chalara</i> ash dieback ( <i>Hymenoscyphus fraxineus</i> )	This one
	I do not know



Species	Which one is on the photo above
chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	This one
western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	This one
Japanese knotweed ( <i>Fallopia japonica</i> )	This one
goldenrods ( <i>Solidago</i> spp.)	This one
<i>Eutypella</i> canker ( <i>Eutypella parasitica</i> )	This one
tree of heaven ( <i>Ailanthus altissima</i> )	This one
common ragweed ( <i>Ambrosia artemisiifolia</i> )	This one
Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	This one
	I do not know



Species	Which one is on the photo above
chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	This one
western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	This one
Japanese knotweed ( <i>Fallopia japonica</i> )	This one
goldenrods ( <i>Solidago</i> spp.)	This one
<i>Eutypella</i> canker ( <i>Eutypella parasitica</i> )	This one
tree of heaven ( <i>Ailanthus altissima</i> )	This one
common ragweed ( <i>Ambrosia artemisiifolia</i> )	This one
Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	This one
	I do not know





Species	Which one is on the photo above
chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	This one
western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	This one
Japanese knotweed ( <i>Fallopia japonica</i> )	This one
goldenrods ( <i>Solidago</i> spp.)	This one
Eutypella canker ( <i>Eutypella parasitica</i> )	This one
tree of heaven ( <i>Ailanthus altissima</i> )	This one
common ragweed ( <i>Ambrosia artemisiifolia</i> )	This one
Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	This one
	I do not know



Species	Which one is on the photo above
chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	This one
western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	This one
Japanese knotweed ( <i>Fallopia japonica</i> )	This one
goldenrods ( <i>Solidago</i> spp.)	This one
Eutypella canker ( <i>Eutypella parasitica</i> )	This one
tree of heaven ( <i>Ailanthus altissima</i> )	This one
common ragweed ( <i>Ambrosia artemisiifolia</i> )	This one
Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	This one
	I do not know



Species	Which one is on the photo above
chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	This one
western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	This one
Japanese knotweed ( <i>Fallopia japonica</i> )	This one
goldenrods ( <i>Solidago</i> spp.)	This one
Eutypella canker ( <i>Eutypella parasitica</i> )	This one
tree of heaven ( <i>Ailanthus altissima</i> )	This one
common ragweed ( <i>Ambrosia artemisiifolia</i> )	This one
Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	This one
	I do not know



Species	Which one is on the photo above
chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	This one
western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	This one
Japanese knotweed ( <i>Fallopia japonica</i> )	This one
goldenrods ( <i>Solidago</i> spp.)	This one
Eutypella canker ( <i>Eutypella parasitica</i> )	This one
tree of heaven ( <i>Ailanthus altissima</i> )	This one
common ragweed ( <i>Ambrosia artemisiifolia</i> )	This one
Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	This one
	I do not know



Species	Which one is on the photo above
chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	This one
western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	This one
Japanese knotweed ( <i>Fallopia japonica</i> )	This one
goldenrods ( <i>Solidago</i> spp.)	This one
<i>Eutypella</i> canker ( <i>Eutypella parasitica</i> )	This one
tree of heaven ( <i>Ailanthus altissima</i> )	This one
common ragweed ( <i>Ambrosia artemisiifolia</i> )	This one
Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	This one
	I do not know

9. How strongly would you support different measures for removing invasive alien species?

For animal species	Level of support	For plant species	Level of support
Using poison	1 2 3 4	Mowing/cutting	1 2 3 4
Lethal injection	1 2 3 4	Excavation	1 2 3 4
Hunting	1 2 3 4	Herbicides	1 2 3 4
Sterilization	1 2 3 4	Natural enemies	1 2 3 4
Insecticides	1 2 3 4		
Shooting	1 2 3 4		
Transfer into shelters	1 2 3 4		

Note: 1 – I do not support; 2 – I partially support; 3 – I mostly support; 4 – I fully support

### CHOICE EXPERIMENT

The following part of the questionnaire is more dynamic and perhaps interactive. In a distinct way, we will ask you upon your preferences for how should control over invasive alien species be implemented in Slovenia. We will display twelve different combinations of modes of control over invasive alien species. Those modes are described by:

- different means of removal of invasive alien species
  - mechanical removal: mowing, mulching, trapping
  - chemical removal: use of biocides
  - biological removal: use of natural enemies
- completeness of removal
  - partial removal: preventing further spread
  - complete removal: total eradication
- place of removal
  - forest lands: removal in forests
  - urban lands: removal in urban areas

No one is implying that either of those options might in fact come true. Every time when three options will be displayed, select the preferred one. The first one will always present the current situation (no measures are taken), whereas the other two are depicting alternative scenarios, which would be possible to achieve if proposed measures would be implemented.

Ministry of environment and spatial planning has funds for such measures, but they are limited. Thus, additional measures, which would bring more control over invasive alien species would need to be financially supported directly by Slovenes. Each option in the following task has also a payment attached. It is a hypothetical amount, which would be paid by you yearly into a designated fund of the ministry. Funds could be used exclusively for proposed measures. Contributions from citizens of 18 years and more would be collected for at least three years, while the realization of this program would depend upon the support of the majority. Contribution would be accepted from all apt citizens or none.

This task is truly hypothetical, however we call upon your most realistic judgment. If you do not wish for any changes and/or you are not willing to pay for that, please select the 'current state' option. There is not right or wrong in your responses, we are interested in your opinion only. Also, consider that the money you would spend on this program would not be available for you to be spent on other things.

(\*an illustrative example of a choice experiment card; a choice set)

Which option do you prefer? Mark below.

	Current status	Option A	Option B
Your yearly CONTRIBUTION	0 €	3 €	9 €
COMPLETENESS of removal	None	Complete	Partial
TYPE of removal	No	Biological	Biological
PLACE of removal	Nowhere	Urban	Forest
SYSTEM of early warning and rapid response	Not established	Not established	Functioning
MARK YOUR CHOICE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

#### SOCIO-DEMOGRAPHIC CHARACTERISTICS

10. Gender

Female

Male

11. Are you a forest owner?

Yes

No

12. Where do you live?

Large city (e.g. Ljubljana, Maribor, Kranj, ...)

Smaller city (e.g. Trzin, Grsuplje, Logatec, ...)

Sub-urban settlements with significant urbanized character

Rural areas (e.g. small villages)

## 13. Of what age are you?

18-25 years

26-35 years

36-45 years

46-55 years

56-65 years

more than 65 years

## 14. What is your level of achieved education?

less than elementary school

elementary school

vocational school

high-school

higher school

university graduate school

post-graduate school

I do not wish to answer

## 15. What is your personal net monthly income

I have no income

1 do 365 €

366–550 €

551–730 €

731–920 €

921–1100 €

1101–1280 €

1281–1460 €

1461–1830 €

1831–2200 €

2201 and more

I do not wish to answer

## 16. What is your activity status?

student

employed



unemployed

retired

other: please specify \_\_\_\_\_

17. In which statistical region do you live?

Pomurska

Podravska

Koroška

Savinjska

Zasavska

Spodnjeposavska

Jugovzhodna Slovenija

Osrednjeslovenska

Gorenjska

Notranjsko-kraška

Goriška

Obalno-kraška

**Appendix 2: Questions 1–8 comprising the first four parts of the questionnaire with basic descriptive statistics and statistical method used in the analysis of associated responses**

Questionnaire part	Question (numbered)	Descriptive statistics	Statistical methods used in analysis
General awareness of IAS-related problems	1. Have you already heard of the term IAS?	76% (yes); 24% (no)	Binomial logistic regression
	2. Do you think IAS pose a problem?	83% (yes); 17% (no)	
Support for establishing an EWRR and willingness to act	3. Do you support the establishment of an EWRR?	97% (yes); 3% (no)	
	4. If IAS appeared on your land, would you be willing to remove it?	96% (yes); 4% (no)	
	5. Would you be willing to report the finding of an IAS to the relevant institution?	89% (yes); 11% (no)	
Awareness of IAS and the layperson's recognition	6. Which IAS have you heard of?		Exploratory factor analysis (extraction by principal component analysis) and Binomial logistic regression
	Chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	47% (yes); 53% (no)	
	Western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	9% (yes); 91% (no)	
	Japanese knotweed ( <i>Fallopia japonica</i> )	47% (yes); 53% (no)	
	Goldenrods ( <i>Solidago</i> spp.)	49% (yes); 51% (no)	
	Eutypella canker ( <i>Eutypella parasitica</i> )	24% (yes); 76% (no)	
	Tree of heaven ( <i>Ailanthus altissima</i> )	11% (yes); 89% (no)	
	Common ragweed ( <i>Ambrosia artemisiifolia</i> )	68% (yes); 32% (no)	
	Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	44% (yes); 56% (no)	
	7. Which IAS is in the photo?		
	Chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	35% (correct)	
	Western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	35% (correct)	
	Japanese knotweed ( <i>Fallopia japonica</i> )	17% (correct)	
	Goldenrods ( <i>Solidago</i> spp.)	36% (correct)	
Eutypella canker ( <i>Eutypella parasitica</i> )	22% (correct)		
Tree of heaven ( <i>Ailanthus altissima</i> )	13% (correct)		

Questionnaire part	Question (numbered)	Descriptive statistics				Statistical methods used in analysis
	Common ragweed ( <i>Ambrosia artemisiifolia</i> )	43% (correct)				
	Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	18% (correct)				
Support for IAS-related management measures	8. How strongly do you support different measures of control of IAS?	Do not	Partially	Mostly	Fully	Exploratory factor analysis (extraction by principal component analysis) and Cumulative ordinal logistic regression
	Using poison—animals	52%	29%	12%	6%	
	Lethal injection—animals	41%	29%	18%	12%	
	Hunting—animals	19%	34%	29%	19%	
	Sterilization—animals	8%	19%	34%	39%	
	Insecticides—animals	31%	33%	22%	14%	
	Shooting—animals	40%	33%	16%	11%	
	Transfer into shelters—animals	18%	27%	28%	26%	
	Mowing/cutting—plants	4%	19%	16%	62%	
	Excavation—plants	2%	16%	11%	71%	
	Herbicides—plants	37%	20%	27%	18%	
Natural enemies—plants	11%	20%	27%	42%		

### Appendix 3: Results of factor analysis (extraction by principal component analysis) for questions 6–8

See Tables 7, 8 and 9.

**Table 7** Factor loadings for the general level of information on IAS

Which invasive alien species have you heard of?	High media attention	Low media attention
Chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	.67	.10
Western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	– .11	.81
Japanese knotweed ( <i>Fallopia japonica</i> )	.58	.07
Goldenrods ( <i>Solidago</i> spp.)	.74	– .03
Eutypella canker ( <i>Eutypella parasitica</i> )	.08	.64
Tree of heaven ( <i>Ailanthus altissima</i> )	– .02	.68
Common ragweed ( <i>Ambrosia artemisiifolia</i> )	.79	– .14
Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	.34	.37

**Table 8** Factor loadings for the recognition of IAS

Which invasive alien species is in the photo?	Easily visible	Not easily visible
Chestnut gall wasp ( <i>Dryocosmus kuriphilus</i> )	.07	.63
Western conifer seed bug ( <i>Leptoglossus occidentalis</i> )	.13	.62
Japanese knotweed ( <i>Fallopia japonica</i> )	.76	– .06
Goldenrods ( <i>Solidago</i> spp.)	.74	– .04
Eutypella canker ( <i>Eutypella parasitica</i> )	.06	.63
Tree of heaven ( <i>Ailanthus altissima</i> )	.68	.05
Common ragweed ( <i>Ambrosia artemisiifolia</i> )	.51	.17
Chalara ash dieback ( <i>Hymenoscyphus fraxineus</i> )	– .14	.79

**Table 9** Factor loadings for the support of control measures

How strongly do you support different measures of control of invasive alien species?	Lethal measures <sup>a</sup>	Non-lethal meas. plants	Non-lethal meas. animals
Using poison—animals	.83	– .15	.00
Lethal injection—animals	.84	– .08	– .02
Hunting—animals	.69	.15	.09
Sterilization—animals	.27	.20	.59
Insecticides—animals	.73	– .03	.10
Shooting—animals	.85	.01	– .04
Transfer into shelters—animals	– .10	– .04	.92
Mowing/cutting—plants	– .03	.87	– .03
Excavation—plants	– .06	.89	.04
Herbicides—plants	.54	.25	– .12
Natural enemies—plants	.05	.64	.05

#### Appendix 4: Theoretical framework of the choice experiment

Lancaster's consumer theory (Lancaster 1966) provides grounding to the choice experiment technique by establishing that the utility of a good can be broken down into the utilities of its individual attributes. Furthermore, the random utility model (RUM) derived from the work of (Luce 1959) and (McFadden 1973) provides a basis for empirical modelling of respondents' choices, indicating trade-offs among the attributes of the assessed good (Bateman et al. 2002; Hanley et al. 2001). Accordingly, the goods being investigated are described by bundles of attributes. Levels (quantitative or qualitative values) of those attributes can be varied, and by doing so, different combinations of attribute levels can be generated and grouped into so-called alternatives. Each respondent is

presented with a set of alternatives, commonly organized into several consecutive choice sets, and asked to pick the ones he/she likes best (i.e. maximizes his/her utility) from each choice set. This is done via various survey formats. One of the alternatives in each choice set usually presents the current situation indicating a 'scenario' without any changes, which is commonly referred to as a business-as-usual (BAU) alternative. Other alternatives represent situations where the attribute levels are changed due to some hypothetical actions which we wish to investigate. Each alternative also has an additional cost attribute indicating the hypothetical amount of money needed to be allocated for implementing the changes of the attributes. Obviously, the BAU alternative has zero cost assigned. A respondent selecting among alternatives is implicitly making trade-offs between the levels of attributes across alternatives (Hensher et al. 2005).

Having a cost attribute makes it possible to calculate the marginal values of the changes in attribute levels.

Empirical analysis of choices grounds on RUM, which states that utility  $U$  obtained by respondent  $i$  by choosing an alternative  $j(j = 1, \dots, I)$  and conditioned on being in class  $c$  can be modelled as a function (indirect utility function) of a deterministic component  $V$ , which can be observed by the researcher and related to attributes, and of a random component  $\varepsilon$ . The latter is an error term comprising non-observable features that affect choices of respondents and is of a type 1 extreme distribution:

$$U_{ij|c} = V_{ij|c} + \varepsilon_{ij|c} = \beta_c x_{ij} + \varepsilon_{ij|c},$$

where  $x$  is the vector of observed attributes,  $\beta$  is a parameter vector (Boxall and Adamowicz 2002).

The deterministic part of utility  $V_{ij|c}$  can be divided into two parts, one related to a respondent's specific characteristics, such as socio-demographic characteristics, perceptions, attitudes etc., and the other two choices of alternatives with respect to levels of the attributes (Boxall and Adamowicz 2002; Swait 1994). The probability of respondent  $i$  choosing alternative  $j$  conditional on being in class  $c$  is:

$$Pr_{ij|c} = \sum_{c=1}^C \left( \frac{e^{\theta'_c z_i}}{\sum_{c=1}^C e^{\theta'_c z_i}} \right) \times \left( \frac{e^{\beta'_c x_{ij}}}{\sum_{k=1}^I e^{\beta'_c x_{ik}}} \right),$$

where  $z_i$  is a vector of respondent-specific characteristics and  $\theta'_c$  are class-specific coefficients to be estimated. The first part of the right-hand side is the probability of a respondent being in class  $c$ , while the second part is the probability of choosing alternative  $j$  conditional on membership in class  $c$ .

$\theta'_c$  and  $\beta'_c$  in the LCLM are jointly estimated by employing the maximum likelihood estimation and are subsequently used to explain respondent choices. The number of classes needs to be determined prior to model estimation, which can be done through different approaches. Setting the number of classes is not straightforward, as there is no precise approach for choosing the optimal number of classes (Milon and Scrogin 2006). Some authors (Boxall and Adamowicz 2002; Scarpa and Thiene 2005) recommend using

statistical information criteria such as Bayesian information criteria ( $BIC$ ) (Schwarz 1978) and Bozdogan-Akaike information criteria ( $AIC3$ ) (Bozdogan 1987) and also recommend accounting for the plausibility (signs of the parameters and their significance) of the results and the size of classes.

**Appendix 5: A representative choice set**

Which option do you prefer? Mark below.

	Current status	Option A	Option B
Your yearly CONTRIBUTION	0 €	3 €	9 €
COMPLETENESS of removal	None	Complete	Partial
TYPE of removal	No	Biological	Biological
PLACE of removal	Nowhere	Urban	Forest
SYSTEM of early warning and rapid response	Not established	Not established	Functioning
MARK YOUR CHOICE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Appendix 6: Numerical estimation results of binomial and ordinal regression of questions 1–8**

See Tables 10, 11, 12, 13 and 14.

**Table 10** Estimation results of binomial regression for the questions ‘Have you already heard of the term alien species?’ and ‘Do you think invasive alien species pose a problem?’

Question	Have you already heard of the term alien species?			Do you think invasive alien species pose a problem?		
	Binomial: 0—no, I have not; 1—yes, I have			Binomial: 0—no, I do not; 1—yes, I do		
Independent var.	$\beta$	s.e.	z-value	$\beta$	s.e.	z-value
Intercept	− 1.75**	.54	3.25	− 1.24	.55	2.26
Gender	.53**	.19	2.75	.20	.21	.94
Age	.13	.06	2.20	.22**	.07	3.18
Owning a forest	.27	.21	1.29	.27	.24	1.11
Visit freq.	.13	.06	2.27	.18**	.06	2.77
Knowing the term ‘IAS’	n.a.	n.a.	n.a.	.76**	.23	3.28
Household size	.02	.05	.40	− .01	.02	.45
Type of settlement	.27	.20	1.36	− .32	.22	1.46
Personal income	.06	.05	1.19	− .03	.05	.54
Education	.64***	.14	4.70	− 1.24	.55	2.26

Estimated coefficients are significantly different from zero at 5% (\*\*) or 1% (\*\*\*) significance level

n.a. not applicable, which means the variable was not included in the model

**Table 11** Estimation results of binomial logistic regression models for ‘Do you support the establishment of an EWRR?’; ‘If IAS appeared on your land, would you be willing to remove it?’; and ‘Would you be willing to report the finding of an IAS to the relevant institution?’

Question	Do you support the establishment of an EWRR?			If IAS appeared on your land, would you be willing to remove it?			Would you be willing to report the finding of an IAS to the relevant institution?		
	Binomial: 0—no; 1—yes								
Independent var.	$\beta$	s.e.	z-value	$\beta$	s.e.	z-value	$\beta$	s.e.	z-value
Intercept	1.10	1.19	.92	− .16	.92	.18	− .38	.57	.67
Gender	− .39	.54	.73	.44	.41	1.07	− .03	.25	.11
Age	.19	.17	1.15	.55***	.16	3.38	.34***	.09	3.95
Owning a forest	.13	.57	.22	.34	.45	.76	− .09	.26	.36
Visit freq.	.03	.15	.17	.39**	.13	2.96	.13	.07	1.70
Knowing the term ‘IAS’	− .07	.61	.11	− .90	.57	1.58	− .18	.29	.62
Household size	.07	.20	.35	.01	.06	.17	.00	.03	.08
Type of settlement	− .19	.53	.36	− .25	.41	.60	.75**	.25	2.93
Personal income	.01	.13	.09	.13	.09	1.39	.13	.06	2.22
Education	1.12	.46	2.40	.24	.28	.84	.12	.17	.68

Estimated coefficients are significantly different from zero at 5% (\*\*) or 1% (\*\*\*) significance level

**Table 12** Estimation results of models for ‘Which IAS have you already heard of?’

Question	Have you heard about the IAS? (those with high media attention)			Have you heard about the IAS? (those with low media attention)		
	$\beta$	s.e.	z-value	$\beta$	s.e.	z-value
Dependent var.	Binomial: 0—no; 1—yes					
Intercept	-.89***	.18	4.95	-.70***	.17	4.22
Gender	-.15	.07	2.05	-.03	.07	.43
Age	.05	.02	2.36	.05	.02	2.21
Owning a forest	.17	.08	2.15	.21**	.08	2.62
Visit freq.	.07***	.02	3.55	.06**	.02	2.72
Knowing the term ‘IAS’	.58***	.09	6.34	.35***	.09	3.88
Household size	-.01	.01	1.37	-.01	.01	.96
Type of settlement	-.09	.08	1.22	-.06	.08	.77
Personal income	-.01	.02	.60	-.01	.02	.85
Education	.02	.05	.43	-.00	.05	.07

Estimated coefficients are significantly different from zero at 5% (\*\*) or 1% (\*\*\*) significance level

**Table 13** Estimation results of models for ‘Can you recognize the IAS in the photo?’

Question	Can you recognize the IAS in the photo? (easily visible IAS)			Can you recognize the IAS in the photo? (not easily visible IAS)		
	$\beta$	s.e.	z-value	$\beta$	s.e.	z-value
Dependent var.	Binomial: 0—not correctly recognized; 1—correctly recognized					
Intercept	-.89***	.18	4.95	-.70***	.17	4.22
Gender	-.89***	.18	4.95	-.03	.07	.43
Age	.05	.02	2.36	.05	.02	2.21
Owning a forest	.17	.08	2.15	.21**	.08	2.62
Visit freq.	.08***	.02	3.55	.06**	.02	2.73
Knowing the term ‘IAS’	.58***	.09	6.34	.35***	.09	3.88
Household size	-.01	.01	1.37	-.01	.01	.96
Type of settlement	-.10	.08	1.22	-.06	.08	.77
Personal income	-.01	.02	.60	-.01	.02	.86
Education	.02	.05	.43	-.00	.04	.07

Estimated coefficients are significantly different from zero at 5% (\*\*) or 1% (\*\*\*) significance level

**Table 14** Estimation of the model for ‘How strongly do you support different measures for IAS management?’

Question	How strongly do you support lethal measures?			How strongly do you support non-lethal measures for plants?			How strongly do you support non-lethal measures for animals?		
	$\beta$	s.e.	z-value	$\beta$	s.e.	z-value	$\beta$	s.e.	z-value
Dependent var.	Ordinal: 1—do not support; 2—partially support; 3—mostly support; 4—fully support								
Independent var.	$\beta$	s.e.	z-value	$\beta$	s.e.	z-value	$\beta$	s.e.	z-value
Intercept	-.09	.15	.58	-.51**	.17	2.92	.05	.11	.46
Gender	.43***	.07	5.89	.07	.07	.96	-.06	.07	.81
Age	-.01	.02	.45	.05	.02	2.02	.01	.02	.29
Owning a forest	.07	.08	.94	.15	.08	1.90	-.06	.08	.81
Visit freq.	-.02	.02	1.12	.01	.02	.53	-.02	.02	.98
Knowing the term ‘IAS’	-.13	.09	1.43	.24**	.09	2.67	.07	.09	.75
Household size	.01	.01	1.23	.00	.01	.09	-.01	.01	.97
Type of settlement	-.12	.07	1.61	.01	.08	.18	-.01	.07	.10
Personal income	.01	.02	.41	.02	.02	1.16	-.00	.02	.11
Education	-.01	.04	.20	.07	.05	1.57	.00	.04	.07

Estimated coefficients are significantly different from zero at 5% (\*\*) or 1% (\*\*\*) significance level

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