Biological invasions, in print, 2019, “post-print”
doi:10.1007/s10530-019-02052-3

Public preferences for the management of different invasive alien forest taxa

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

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 strong, they can have a detrimental effect on local biodiversity (Simberloff et al. 2013; Vila` 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; Ja¨ger 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; Vila` 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 emphasizes 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 ineterests 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 (Garcia- 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, nonlethal 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[1] 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 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 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	'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)

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 $b_{attribute,c}$ is a class-specific attribute related coefficient and $b_{payment,c}$ 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 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.

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—incorect; 1—corect	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[a]	AIC3[b]
Model with no covariates					
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]$BIC = (-2 * LL) + (\log(N) * P)$, [b]$AIC3 = (-2 * LL) + (3 * P)$

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.	*s.e.*	Coeff.	*s.e.*	Coeff.	*s.e.*	Coeff.	*s.e.*
ASC[a]	− 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[e]	
Constant	.97	1.09	1.28	.84	.95	.78		
Gender[b]	.50	.66	1.37**	.61	.63	.52		
Personal income	.27**	.12	.00	.00	.00	.00		
Visiting forest[c]	− .31	.17	− .13	.16	.18	.14		
Type of settlement[d]	− 1.27**	.62	− 1.96***	.61	− 1.37**	.54		

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

[a]Alternative specific constant; [b]0—woman, 1—men; [c]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; [d]0—urban, 1—rural; [e]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 nonlethal 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 plenitude 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 sociodemographic 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***	40.0***	3.6	1.2
	[9.8, 31.4]	[23.5, 56.5]	[− 1.5, 8.7]	[− .8, 3.2]
Mechanical removal	22.2***	45.1***	5.4	.9
	[9.8, 34.7]	[26.8, 63.3]	[− 1.5, 12.3]	[− 1.1, 2.9]
Complete removal	13.3***	4.1	2.3	− .4
	[6.7, 19.9]	[− .2, 8.3]	[− .8, 5.5]	[− 2.0, 1.2]
Removal in urban areas	6.5***	− .3	− 1.8	− .1
	[1.6, 11.4]	[− 4.0, 3.5]	[− 5.3, 1.6]	[− 1.7, 1.5]
EWRR functioning	13.9***	12.7***	7.4***	1.8**
	[7.4, 20.4]	[6.5, 18.9]	[3.7, 11.0]	[.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; Garcı´a-Llorente et al. 2008; Philip and MacMillan 2005). However, some studies found lack of support for controling 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 (Garcia-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 nonlethal 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.

Acknowledgements This research was funded by LIFE ARTEMIS (LIFE15 GIE/SI/000770).

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. This species are referred to as alien species.

By his 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 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 (Dryocosmus kuriphilus)	Yes; No
western conifer seed bug (Leptoglossus occidentalis)	Yes; No
Japanese knotweed (Fallopia japonica)	Yes; No
goldenrods (Solidago spp.)	Yes; No
Eutypella canker (Eutypella parasitica)	Yes; No
tree of heaven (Ailanthus altissima)	Yes; No
common ragweed (Ambrosia artemisiifolia)	Yes; No
Chalara ash dieback (Hymenoscyphus fraxineus)	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 (Dryocosmus kuriphilus)	This one
western conifer seed bug (Leptoglossus occidentalis)	This one
Japanese knotweed (Fallopia japonica)	This one
goldenrods (Solidago spp.)	This one
Eutypella canker (Eutypella parasitica)	This one
tree of heaven (Ailanthus altissima)	This one
common ragweed (Ambrosia artemisiifolia)	This one
Chalara ash dieback (Hymenoscyphus fraxineus)	This one
	I do not know

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

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

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

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

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

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

Species	Which one is on the photo above
chestnut gall wasp (Dryocosmus kuriphilus)	This one
western conifer seed bug (Leptoglossus occidentalis)	This one
Japanese knotweed (Fallopia japonica)	This one
goldenrods (Solidago spp.)	This one
Eutypella canker (Eutypella parasitica)	This one
tree of heaven (Ailanthus altissima)	This one
common ragweed (Ambrosia artemisiifolia)	This one
Chalara ash dieback (Hymenoscyphus fraxineus)	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 it the following task has also a payment attached. It is a hypothetical amount, which would be payed 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	☐	☐	☐

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 (*Dryocosmus kuriphilus*)	47% (yes); 53% (no)	
	Western conifer seed bug (*Leptoglossus occidentalis*)	9% (yes); 91% (no)	
	Japanese knotweed (*Fallopia japonica*)	47% (yes); 53% (no)	
	Goldenrods (*Solidago* spp.)	49% (yes); 51% (no)	
	Eutypella canker (*Eutypella parasitica*)	24% (yes); 76% (no)	
	Tree of heaven (*Ailanthus altissima*)	11% (yes); 89% (no)	
	Common ragweed (*Ambrosia artemisiifolia*)	68% (yes); 32% (no)	
	Chalara ash dieback (*Hymenoscyphus fraxineus*)	44% (yes); 56% (no)	
	7. Which IAS is in the photo?		
	Chestnut gall wasp (*Dryocosmus kuriphilus*)	35% (correct)	
	Western conifer seed bug (*Leptoglossus occidentalis*)	35% (correct)	
	Japanese knotweed (*Fallopia japonica*)	17% (correct)	
	Goldenrods (*Solidago* spp.)	36% (correct)	
	Eutypella canker (*Eutypella parasitica*)	22% (correct)	
	Tree of heaven (*Ailanthus altissima*)	13% (correct)	

Public preferences for the management

Questionnaire part	Question (numbered)	Descriptive statistics				Statistical methods used in analysis
	Common ragweed (*Ambrosia artemisiifolia*)	43% (correct)				
	Chalara ash dieback (*Hymenoscyphus fraxineus*)	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 (*Dryocosmus kuriphilus*)	.67	.10
Western conifer seed bug (*Leptoglossus occidentalis*)	− .11	.81
Japanese knotweed (*Fallopia japonica*)	.58	.07
Goldenrods (*Solidago* spp.)	.74	− .03
Eutypella canker (*Eutypella parasitica*)	.08	.64
Tree of heaven (*Ailanthus altissima*)	− .02	.68
Common ragweed (*Ambrosia artemisiifolia*)	.79	− .14
Chalara ash dieback (*Hymenoscyphus fraxineus*)	.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 (*Dryocosmus kuriphilus*)	.07	.63
Western conifer seed bug (*Leptoglossus occidentalis*)	.13	.62
Japanese knotweed (*Fallopia japonica*)	.76	− .06
Goldenrods (*Solidago* spp.)	.74	− .04
Eutypella canker (*Eutypella parasitica*)	.06	.63
Tree of heaven (*Ailanthus altissima*)	.68	.05
Common ragweed (*Ambrosia artemisiifolia*)	.51	.17
Chalara ash dieback (*Hymenoscyphus fraxineus*)	− .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'	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 randomutility 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; . . .; 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 e. The latter is an error term comprising non-observable features that affect choices of respondents and is of a type 1 extreme distribution: $U_{ijjc} = V_{ijjc} + e_{ijjc} = b_c x_{ij} + e_{ijjc}$; where x is the vector of observed attributes, b is a parameter vector (Boxall and Adamowicz 2002).

The deterministic part of utility V_{ijjc} 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:

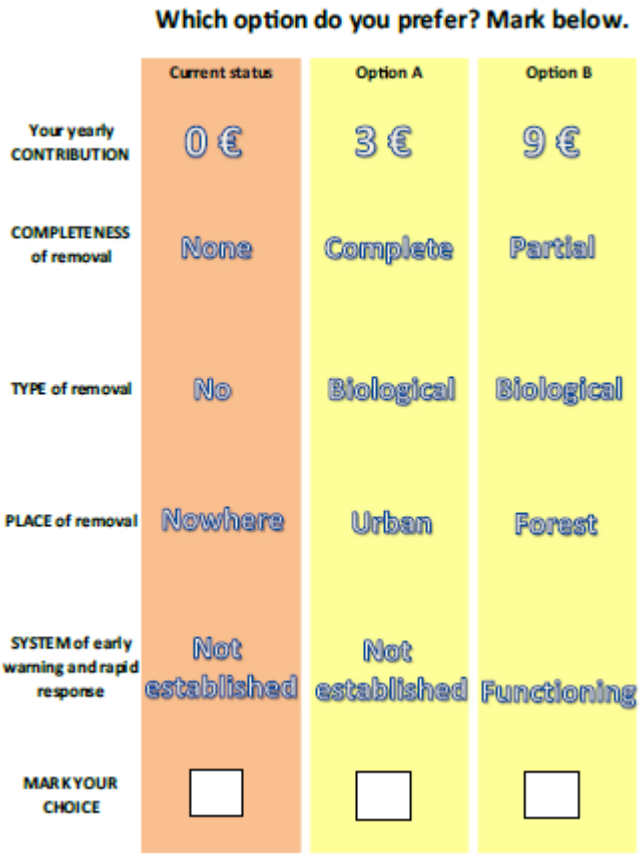
$$Pr_{ij|c} = \sum_{c=1}^{C} \left(\frac{e^{\theta'_c z_i}}{\sum_{c=1}^{C} e^{\theta'_c z_i}} \right) \times \left(\frac{e^{\beta'_c x_{ij}}}{\sum_{k=1}^{I} e^{\beta'_c x_{ik}}} \right),$$

where z_i is a vector of respondent-specific characteristics and θ'_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 conditioned on membership in class c.

θ'_c and β'_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



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?		
Dependent var.	Binomial: 0—no, I have not; 1—yes, I have			Binomial: 0—no, I do not; 1—yes, I do		
Independent var.	β	s.e.	z-value	β	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?		
Dependent var.	Binomial: 0—no; 1—yes								
Independent var.	β	s.e.	z-value	β	s.e.	z-value	β	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)		
Dependent var.	Binomial: 0—no; 1—yes					
Independent var.	β	s.e.	z-value	β	s.e.	z-value
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)		
Dependent var.	Binomial: 0—not correctly recognized; 1—correctly recognized					
Independent var.	β	s.e.	z-value	β	s.e.	z-value
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?		
Dependent var.	Ordinal: 1—do not support; 2—partially support; 3—mostly support; 4—fully support								
Independent var.	β	s.e.	z-value	β	s.e.	z-value	β	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

Reference

Ansong M, Pickering C (2015) What's a weed? Knowledge, attitude and behaviour of park visitors about weeds. PLoS ONE 10:e0135026

Bardsley D, Edwards-Jones G (2006) Stakeholders' perceptions of the impacts of invasive exotic plant species in the Mediterranean region. GeoJournal 65:199–210

Bateman IJ, Carson RT, Day B et al (2002) Economic valuation with stated preference techniques: a manual. Edward Elgar, Cheltenham

Bertolino S, Genovesi P (2003) Spread and attempted eradication of the grey squirrel (Sciurus carolinensis) in Italy, and consequences for the red squirrel (Sciurus vulgaris) in Eurasia. Biol Cons 109:351–358

Boxall PC, Adamowicz WL (2002) Understanding heterogeneous preferences in random utility models: a latent class approach. Environ Resour Econ 23:421–446

Bozdogan H (1987) Model selection and Akaike's information criterion (AIC): the general theory and its analytical extensions. Psychometrika 52:345–370

Bremner A, Park K (2007) Public attitudes to the management of invasive non-native species in Scotland. Biol Cons 139:306–314

Carlson AK, Vondracek B (2014) Synthesis of ecology and human dimensions for predictive management of bighead and silver carp in the United States. Rev Fish Sci Aquac 22:284–300

Carroll SP (2011) Conciliation biology: the eco-evolutionary management of permanently invaded biotic systems. Evol Appl 4:184–199

Chang W-Y, Lantz VA, MacLean DA (2009) Public attitudes about forest pest outbreaks and control: case studies in two Canadian provinces. For Ecol Manag 257:1333–1343

Cherry TL, Shogren JF, Frykblom P et al (2001) Valuing wildlife at risk from exotic invaders in Yellowstone Lake. The handbook of contingent valuation. Edward Elgar, Northampton, pp 307–323

Clout MN, Williams PA (2009) Invasive species management: a handbook of principles and techniques. Oxford University Press, Oxford

Courchamp F, Fournier A, Bellard C et al (2017) Invasion biology: specific problems and possible solutions. Trends Ecol Evol 32:13–22

Crosby AW (2015) Ecological imperialism. Cambridge University Press, Cambridge

Crowley SL, Hinchliffe S, McDonald RA (2017a) Conflict in invasive species management. Front Ecol Environ 15:133–141

Crowley SL, Hinchliffe S, McDonald RA (2017b) Invasive species management will benefit from social impact assessment. J Appl Ecol 54:351–357

Domencich TA, McFadden D (1975) Urban travel demand—a behavioral analysis. North-Holland, Oxford

Dukes JS, Pontius J, Orwig D et al (2009) Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America: What can we predict? This article is one of a selection of papers from NE Forests 2100: a synthesis of climate change impacts on forests of the Northeastern US and Eastern Canada. Can J For Res 39:231–248

European Commission (2015) Public opinion in the European Union. Stand Eurobarom 83(2015):220

Fischer AP, Charnley S (2012) Private forest owners and invasive plants: risk perception and management. Invasive Plant Sci Manag 5:375–389

Flint CG (2006) Community perspectives on spruce beetle impacts on the Kenai Peninsula, Alaska. For Ecol Manag 227:207–218

Ford-Thompson AES, Snell C, Saunders G et al (2015) Dimensions of local public attitudes towards invasive species management in protected areas. Wildl Res 42:60–74

Fuller L, Marzano M, Peace A et al (2016) Public acceptance of tree health management: results of a national survey in the UK. Environ Sci Policy 59:18–25

Garcı´a-Llorente M, Martı´n-Lo´pez B, Gonza´lez JA et al (2008) Social perceptions of the impacts and benefits of invasive alien species: implications for management. Biol Cons 141:2969–2983

Garcı´a-Llorente M, Martı´n-Lo´pez B, Nunes PA et al (2011) Analyzing the social factors that influence willingness to pay for invasive alien species management under two different strategies: eradication and prevention. Environ Manag 48:418–435

Hair JF (2010) Multivariate data analysis. Prentice Hall, Englewood Cliffs

Hanley N, Mourato S, Wright RE (2001) Choice modelling approaches: a superior alternative for environmental valuation? J Econ Surv 15:435–462

Hensher DA, Rose JM, Greene WH (2005) Applied choice analysis: a primer. Cambridge University Press, New York Hole AR (2007) A comparison of approaches to estimating confidence intervals for willingness to pay measures. Health Econ 16:827–840

Hufbauer RA, Facon B, Ravigne´ V et al (2012) Anthropogenically induced adaptation to invade (AIAI): contemporary adaptation to human-altered habitats within the native range can promote invasions. Evol Appl 5:89–101

Hulme PE, Pysˇek P, Jarosˇı´k V et al (2013) Bias and error in understanding plant invasion impacts. Trends Ecol Evol 28:212–218

Ja¨ger H, Kowarik I, Tye A (2009) Destruction without extinction: long-term impacts of an invasive tree species on Gala´pagos highland vegetation. J Ecol 97:1252–1263

Jeschke JM, Bacher S, Blackburn TM et al (2014) Defining the impact of non-native species. Conserv Biol 28:1188–1194

Jetter K, Paine TD (2004) Consumer preferences and willingness to pay for biological control in the urban landscape. Biol Control 30:312–322

Keller RP, Geist J, Jeschke JM et al (2011) Invasive species in Europe: ecology, status, and policy. Environ Sci Europe 23:23

Koo WW, Mattson JW (2004) Economics of detection and control of invasive species: workshop highlights. North Dakota State University, Center for Agricultural Policy and Trade Studies

Kus Veenvliet J, Jogan N (2014) Awareness raising on alien species in Slovenia. EPPO Bull 44:243–247

Lancaster KJ (1966) A new approach to consumer theory. J Polit Econ 74:132–157

Lederach J (2015) Little book of conflict transformation: clear articulation of the guiding principles by a pioneer in the field. Skyhorse Publishing Inc, New York

Lindemann-Matthies P (2016) Beasts or beauties? Laypersons' perception of invasive alien plant species in Switzerland and attitudes towards their management. NeoBiota 29:15–33

Liu S, Hurley M, Lowell KE et al (2011) An integrated decision support approach in prioritizing risks of non-indigenous species in the face of high uncertainty. Ecol Econ 70:1924–1930

Lockwood JL, Hoopes MF, Marchetti MP (2013) Invasion ecology. Wiley, New York

Luce RD (1959) Individual choice behavior: a theoretical analysis. Wiley, New York

Mackenzie BF, Larson BMH (2010) Participation under time constraints: landowner perceptions of rapid response to the emerald ash borer. Soc Nat Resour 23:1013–1022

Madden F, McQuinn B (2014) Conservation's blind spot: the case for conflict transformation in wildlife conservation. Biol Cons 178:97–106

Marzano M, Dandy N, Bayliss HR et al (2015) Part of the solution? Stakeholder awareness, information and engagement in tree health issues. Biol Invasions 17:1961–1977

Marzano M, Allen W, Haight RG et al (2017) The role of the social sciences and economics in understanding and informing tree biosecurity policy and planning: a global summary and synthesis. Biol Invasions 19:3317–3332 McDermott SM, Irwin RE, Taylor BW (2013) Using economic instruments to develop effective management of invasive species: insights from a bioeconomic model. Ecol Appl 23:1086–1100

McFadden D (1973) Conditional logit analysis of qualitative choice behavior. In: Zarembka P (ed) Frontiers in econometrics. Academic Press, New York, pp 105–142

Menard S (2010) Logistic regression: from introductory to advanced concepts and applications. Sage, London Meyerson LA, Mooney HA (2007) Invasive alien species in an era of globalization. Front Ecol Environ 5:199–208

Milon JW, Scrogin D (2006) Latent preferences and valuation of wetland ecosystem restoration. Ecol Econ 56:162–175

Mooney HA (2005) Invasive alien species: a new synthesis. Island Press, Washington

Nanayakkara L, Jurdi-Hage R, Leavitt PR et al (2018) In lakes but not in minds: stakeholder knowledge of invasive species in prairie lakes. Biol Invasions 20:633–652

Nimmo DG, Miller KK (2007) Ecological and human dimensions of management of feral horses in Australia: a review. Wildl Res 34:408–417

NLOGIT5 (2012) 5th ed. Econometric Software, Inc., New York

Novoa A, Shackleton R, Canavan S et al (2018) A framework for engaging stakeholders on the management of alien species. J Environ Manag 205:286–297

Owens S (2000) 'Engaging the public': information and deliberation in environmental policy. Environ Plan A 32:1141–1148

Perrings C, Williamson M, Barbier EB et al (2002) Biological invasion risks and the public good: an economic perspective. Conserv Ecol 6

Perrings C, Dehnen-Schmutz K, Touza J et al (2005) How to manage biological invasions under globalization. Trends Ecol Evol 20:212–215

Philip LJ, MacMillan DC (2005) Exploring values, context and perceptions in contingent valuation studies: the CV market stall technique and willingness to pay for wildlife conservation. J Environ Plan Manag 48:257–274

Pimentel D (2002) Biological invasions: economic and environmental costs of alien plant animal, and microbe species. CRC Press, Boca Raton

Pimentel D, Lach L, Zuniga R et al (2000) Environmental and economic costs of nonindigenous species in the United States. Bioscience 50:53–65

Porth EF, Dandy N, Marzano M (2015) ''My garden is the one with no trees:'' residential lived experiences of the 2012 Asian Longhorn Beetle Eradication Programme in Kent, England. Hum Ecol 43:669–679

Ridder B (2007) An exploration of the value of naturalness and wild nature. J Agric Environ Ethics 20:195–213

Robinson BS, Inger R, Gaston KJ (2017) Drivers of risk perceptions about the invasive non-native plant Japanese knotweed in domestic gardens. Biol Invasions 19:2927–2940

Rolfe J, Windle J (2014) Public preferences for controlling an invasive species in public and private spaces. Land Use Policy 41:1–10

Scarpa R, Thiene M (2005) Destination choice models for rock climbing in the Northeastern Alps: a latent-class approach based on intensity of preferences. Land Econ 81:426–444

Schwarz G (1978) Estimating the dimension of a model. Ann Stat 6:461–464

Shackleton CM, Shackleton RT (2016) Knowledge, perceptions and willingness to control designated invasive tree species in urban household gardens in South Africa. Biol Invasions 18:1599–1609

Shackleton SE, Shackleton RT (2018) Local knowledge regarding ecosystem services and disservices from invasive alien plants in the arid Kalahari, South Africa. J AridEnviron 159:22–33

Shackleton CM, McGarry D, Fourie S et al (2007) Assessing the effects of invasive alien species on rural livelihoods: case examples and a framework from South Africa. Hum Ecol 35:113–127

Shackleton RT, Richardson DM, Shackleton CM et al (2019a) Explaining people's perceptions of invasive alien species: a conceptual framework. J Environ Manag 229:10–26

Shackleton RT, Shackleton CM, Kull CA (2019b) The role of invasive alien species in shaping local livelihoods and human well-being: a review. J Environ Manag 229:145–157

Sharp RL, Larson LR, Green GT (2011) Factors influencing public preferences for invasive alien species management. Biol Cons 144:2097–2104

Shrestha BB, Shrestha UB, Sharma KP et al (2019) Community perception and prioritization of invasive alien plants in Chitwan-Annapurna Landscape, Nepal. J Environ Manag 229:38–47

Simberloff D, Martin J-L, Genovesi P et al (2013) Impacts of biological invasions: what's what and the way forward. Trends Ecol Evol 28:58–66

SPSS (2008) SPSS statistics for windows, Version 17.0. SPSS Inc., Chicago

Subroy V, Rogers AA, Kragt ME (2018) To bait or not to bait: a discrete choice experiment on public preferences for native wildlife and conservation management in Western Australia. Ecol Econ 147:114–122

Swait J (1994) A structural equation model of latent segmentation and product choice for cross-sectional revealed preference choice data. J Retail Consum Serv 1:77–89

Tabachnick BG, Fidell LS (2007) Using multivariate statistics. Allyn & Bacon/Pearson Education, Boston

Taylor BW, Irwin RE (2004) Linking economic activities to the distribution of exotic plants. Proc Natl Acad Sci 101:17725–17730

Temple SA (1990) The nasty necessity: eradicating exotics. Conserv Biol 4:113–115

Vaz AS, Kueffer C, Kull CA et al (2017) Integrating ecosystem services and disservices: insights from plant invasions. Ecosyst Serv 23:94–107

Veblen TT, Mermoz M, Martin C et al (1992) Ecological impacts of introduced animals in Nahuel Huapi national park, Argentina. Conserv Biol 6:71–83

Verbrugge LN, Van den Born RJ, Lenders HR (2013) Exploring public perception of non-native species from a visions of nature perspective. Environ Manag 52:1562–1573

Vila` M, Espinar JL, Hejda M et al (2011) Ecological impacts of invasive alien plants: a meta-analysis of their effects on species, communities and ecosystems. Ecol Lett 14:702–708

Walther G-R, Roques A, Hulme PE et al (2009) Alien species in a warmer world: risks and opportunities. Trends Ecol Evol 24:686–693

White PCL, Ward AI (2010) Interdisciplinary approaches for the management of existing and emerging human–wildlife conflicts. Wildl Res 37:623–629