

Perception and Understanding of Invasive Alien Species Issues by Nature Conservation and Horticulture Professionals in Belgium

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Abstract We conducted a survey to determine how two professional sectors in Belgium, horticulture professionals and nature reserve managers (those directly involved in conservation), view the issues associated with invasive plant species. We developed and utilized a questionnaire that addressed the themes of awareness, concept and use of language, availability of information, impacts and, finally, control and available solutions. Using co-inertia analyses, we tested to what extent the perception of invasive alien species (IAS) was dependent upon the perception of Nature in general. Only forty-two percent of respondent horticulture professionals and eighty-two percent of nature reserve managers had a general knowledge of IAS. Many individuals in both target groups nonetheless had an accurate understanding of the scientific issues. Our results therefore suggest that the manner in which individuals within the two groups view, or perceive, the IAS issue was more the result of lack of information than simply biased perceptions of target groups. Though IAS perceptions by the two groups diverged, they were on par with how they viewed Nature in general. The descriptions of IAS by participants converged with the ideas and concepts frequently found in the scientific literature. Both managers and horticulture professionals expressed a strong willingness to participate in programs designed to prevent the spread of, and damage caused by, IAS. Despite this, the continued commercial availability of many invasive species highlighted the

necessity to use both mandatory and voluntary approaches to reduce their re-introduction and spread. The results of this study provide stakeholders and conservation managers with practical information on which communication and management strategies can be based.

Keywords Invasive alien plants · Ornamental · Horticulture · Nature conservation · Nature reserve management · Survey · Perception

Introduction

Humans are distributing species to parts of the world where they have not naturally dispersed. Some of these non-native species become invasive in their new environment, thereby altering ecosystem processes or causing problems for human activities (Mack and others 2000). The first step of the invasion process is intentional or accidental introduction by humans. From there, some species will naturalize and further, some will become invasive (Richardson and others 2000). Initial introduction of exotic plants frequently occurs from a desire to use them as ornamental species (Bell and others 2003; Dehnen-Schmutz and others 2007; Pyšek and others 2002; Reichard and White 2001; Starfinger and others 2003). Cultivation also fosters plant naturalization (Kowarik 2003; Mack and others 2000) and creates new habitats that favor species' expansion (MacDougall and Turkington 2005). Humans suffer the consequences of invasive alien species (IAS) but also have the capacity to alleviate the IAS problem through effective management strategies. Biological invasions, therefore, have an important social component that cannot be ignored when planning IAS management. Presently, however, the IAS problem is largely addressed from an ecological

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perspective, with little consideration of social implications. Reaser (2001) and Mack (2001) demonstrated that IAS are the result of human values, decisions and behaviors. They suggested that focusing on human belief systems, and the behavior that follows, might be a more effective long-term strategy for IAS management than concentrating only on ecological factors. In any IAS-management plan, human belief systems are not always unpredictable or well understood. Prior to the initiation of any given management project, it must be useful to generate public understanding and support. Communication is a crucial component of preventive and curative management strategies that must be built on sound ecological and social foundations.

To cope with the threat of biological invasions, several international policies, guidelines, agreements and conventions have been ratified and are being implemented (Genovesi and Shine 2004; Heywood and Brunel 2008; Shine and others 2000). States have expressed their concerns about the problem of IAS through the Convention on Biological Diversity (2002), which calls on Parties to “prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats, or species” (Article 8h). In that sense, all sectors engaged in IAS-related activities must have a role in implementing preventive and corrective actions (Hulme 2007; McNeely 2001). Preventive actions are recognized as much more effective than control actions because of a much higher cost/benefit ratio from both an ecological and economical perspective. Recent environmentally-focused efforts, particularly those designed to curtail the introduction of IAS, focus on voluntary self-regulation (Bell and others 2003; Burt and others 2007; Reaser and others 2008; Reichard 2004; Reichard and others 2005). These actions are seen as a practical alternative to mandatory approaches that impose strict regulations that may be onerous and face stiff opposition from the sectors they affect (Alberini and Segerson 2002). At a minimum, voluntary guidelines can be complementary to legal initiatives developed by national and regional authorities, and are strongly recommended as an effective IAS-control tools (Heywood and Brunel 2008). The presumed effectiveness of voluntary guidelines lies partially in their goal of enlisting the cooperation of the horticultural trade, industry and associated professionals. In addition to preventive actions, recent years have seen the increasing application of curative strategies (Genovesi 2005). For some management plans, an effort has been made to take into account public opinions and attitudes toward control and eradication (Andreu and others 2009; Bardsley and Edwards-Jones 2007; Bremner and Park 2007; Drew and others 2010; García-Llorente and others 2008; Kowarik and Schepker 1998). The first criterion for eradication success is that the sociopolitical environment is suitable (Panetta and Timmins 2004). Public perceptions of

IAS, therefore, are a crucial part of the evaluation of the management strategies and may be a key factor in the shaping of policy and procedure that is both effective and accepted by interested parties.

Assessing how concerned individuals and groups understand the IAS issue is an essential prerequisite for establishing programs and codes of conduct within given sectors. To that end, we aimed to gain an understanding of how IAS issues are perceived and understood by two important target groups. Horticulture professionals and nature reserve managers were chosen because of their role in the introduction, spread and management of IAS in Belgium. The issue was approached through questions that addressed topics of awareness and concern, understanding of concepts and language used, availability of information, dangers and effects and, finally, control and solutions. We evaluated whether the perception of IAS was correlated to the respondent's perception of Nature and environmental awareness. The aim is to provide stakeholders and conservation managers with a better understanding of public attitudes about IAS so they can implement communication strategies to better manage IAS.

Material and Methods

Study Region

Belgium is a federal state composed of three regions (the Flemish Region, the Brussels-Capital Region and the Walloon Region) having powers in fields of among others economy, agriculture, water policy, housing, public works, transport, environment, town and country planning, nature conservation, etc. The Federal State nevertheless retains important powers, including the control of importation, exportation and transit of species. The issue of biological invasions is thus under the jurisdiction of different authorities.

Survey and Study Population

A structured questionnaire was used in 2006 to survey the attitudes and perceptions of nature reserve managers (M) and horticulture professionals (N) with respect to IAS. For horticulture professionals, 1000 individual questionnaires were mailed by a professional horticultural association (Fédération Wallonne Horticole) to the affiliated members, including garden contractors, wholesalers, suppliers, horticulture professionals, distributors and retailers. For nature reserve managers, various nature conservation institutions and NGOs (IBGE, Natagora, Ardenne et Gaume and LRBPO) mailed the survey to 206 people. While some of these recipients were paid professionals and

others were unpaid volunteers, all were in charge of the management of one or more nature reserves. All surveyed persons belonged to the Walloon Region or the Brussels-Capital Region. Mailings were completed in September 2006. The recipients were given two months to answer with a postage-paid return envelope. All respondents were anonymous.

Recipients were asked to complete a comparable questionnaire. First, two series of questions addressed the general perception of nature through human-nature relationships (Q1) and the nature representations (Q2) of the respondents. The goal of these questions was not to obtain a precise description of nature perceptions of the two target groups but to assess whether IAS perception was driven by the general perceptions of the respondents to nature and natural habitats. The next six series of questions successively addressed IAS themselves through the themes of awareness and concern (Q3), concept description and language used (Q4), availability of information (Q5), dangers and effects (Q6) and, finally, control and solutions (Q7). The questionnaire is presented in its entirety in Appendix 1. Both open-ended questions, leaving the respondent free to answer with his own words, and close-ended questions were used. Finally, in order to better understand the importance of the commercialization of IAS, horticulture professionals were asked to indicate, from a provided list of exotic species from the 2006 version of the Belgian *Harmonia* Database, which plants they sold (Branquart 2008). Below we elaborate on the rationale for each question-group included in the survey (Appendix 1).

The Perception of Nature: Human-Nature Relationships (Q1) and Nature Representations (Q2)

Human-nature relationships and natural representations are closely associated with the cultural heritage of individuals (Buijs and others 2009). Emerging areas of social studies in Western Europe, and more particularly in the Netherlands, involve identifying a comprehensive value and belief framework, the intrinsic value that individuals place on Nature, and to utilize that information within the context of natural resource management (Buijs and others 2009; Jacobs and others 2002). This recent research formed the basis for the structure of our questions.

Socialization, and an individual's own personality, are key factors in how that individual will come to perceive and understand human-nature relationships (De Groot 1999; Jacobs and others 2002). There are four groupings of relationship: (1) human as the dominator of nature: the value of nature lies only in what it brings to the individual or society; nature has no intrinsic value; (2) human as a guardian of nature: nature has intrinsic value but is also considered as a resource for people who must maintain the

condition and usability of nature; (3) human as partner of nature: nature is considered a system or active commodity with which people can build a respectful and reciprocally equivalent relationship; (4) human as a component of nature: nature stands above humans, whose needs and values are not necessarily more important than that of nature as a whole. We investigated the human-nature relationships of horticulture professionals and nature reserve managers by asking the respondents whether they agree or disagree with a number of statements that describe their relationship with nature.

Nature representations can be understood as the idealized vision that individuals or groups assign to nature, and also on what feelings are associated with certain states or forms of nature (Jacobs and others 2002). Nature can be categorized into different forms (e.g., forests and oceans) which are characterized by their physical qualities. Nature representations can be categorized primarily in five different ways: (1) wilderness: nature as large-scale and independent areas; (2) autonomy: nature (large-scale and small-scale) that is independent of humans; (3) broad: nature encompasses all that grows and thrives, including people; (4) decorative: nature as an aesthetic and recreational component; (5) functional: nature is primarily for human exploitation on multiple scales. Horticulture professionals and nature reserve managers were asked whether they agree or disagree with several statements about nature representations.

Awareness and Concern (Q3)

While escalating problems associated with IAS are stimulating more research and media attention, this does not necessarily mean the general public has awareness of the problems. We wanted to know if the two target groups selected for this study were aware of the problem and, if so, whether it was of particular concern. Four questions were asked.

Concept and Language Used (Q4)

The terminology used when describing or dealing with exotic plant and/or animal invasions is recognized as technical, variable and highly controversial (Colautti and MacIsaac 2004; Pyšek 1995; Richardson and others 2000). These issues may lead to misinterpretations by the general public and a misunderstanding of the problem. We wanted to assess if the respondents had a good understanding of the IAS, and identify what terminology they used to describe it. We asked respondents to describe the characteristics of IAS, and to describe the issue. The respondents were then invited to react to the definition presented in the Convention on Biological Diversity (2002).

Availability of Information and Information Tools (Q5)

The accessibility and quality of information play a major role in the perception and awareness that people have about IAS and possible management strategies. We aimed at assessing information availability, available tools and expected tools. Three questions were asked concerning the availability of information.

Dangers and Effects (Q6)

Understanding the actual or potential impacts resulting from invasive species is very important since they affect how supportive the public is of management efforts to curb the impacts of IAS.

Control and Solutions (Q7)

Preparing effective strategies for dealing with IAS requires a clear understanding of the extent to which different sectors are willing to engage in management strategies, and the legal obligations which they deem acceptable. To increase understanding of this, several questions were asked in connection with control and mitigation of the IAS problem.

Data Analyses

For open-ended questions, results were summarized by identifying major ideas/concepts mentioned by respondents, and recording how many respondents mentioned each idea/concept. Also, for each respondent, the number of concepts addressed was recorded and prepared for statistical analysis. To this end, the data were transformed from numerical values into two categories: the number of concepts used for description was higher (H), or lower (L) than the mean number of used concepts.

We first tested if nature perception differed between horticulture professionals (N) and nature reserve managers (M). We considered nature perception as the combination of human-nature relationships (Q1) and nature representations (Q2). So we pooled results from these two questions for analysis by Multiple Correspondence Analysis (MCA) which allows analyzing the pattern of relationships of several categorical dependent variables (Abdi and Valentin 2007). A Monte-Carlo permutation test was utilized to determine if responses from the two groups were significantly different (999 permutations). This test was also used to determine differences in the responses given for each individual question (from Q3 to Q7). We then tested if the response to each set of questions (from Q3 to Q7) was linked to the nature perception of the respondents (Q1 and Q2). After removing outliers, we computed co-inertia

levels from the MCA results. Co-inertia analysis allowed us to test for the relationship between the two MCA data sets by performing permutations (999 permutations) (Dray and others 2003). Among multivariate analyses, it was used because it allows to investigate relationships between data sets without any a priori about the relation of cause and effect. The analysis was repeated for each group separately and for both groups pooled. All multivariate analyses were computed using the R package ‘ade4’ (Dray and others 2007; R Development Core Team 2009).

Results

Within two months after mailing, the questionnaire had been completed by 102 horticulture professionals, representing 10% of the recipients. This response rate is comparable to rates observed by the ‘Fédération Wallonne Horticole’ for similar surveys performed with of the same mailing list to their affiliated members. Within the two-month reply period, thirty-four nature reserve managers answered the survey, corresponding to 17% of the individuals contacted for this study.

Human-Nature Relationships (Q1) and Nature Representations (Q2)

Multiple correspondence analyses (Fig. 1) and Monte-Carlo permutations revealed that, despite an important overlap, the nature perceptions of the two target groups in the survey significantly differed ($P < 0.001$). This difference is primarily a result of contrasting nature representations. The statements that most drove the divergence between groups were Q 1.1, Q 1.5, Q 1.10, Q 2.1, Q 2.2, Q 2.3, Q 2.4, Q 2.5, Q 2.6 and Q 2.7 as these statements had the biggest weight in the analysis.

Most horticulture professionals viewed humans as a guardians of, or partners with, nature. The majority (89%) of horticulture professionals disagreed with the statement ‘humans have the right to change the environment drastically,’ 98% agreed with the statement ‘humans have to treat nature very carefully’. About half (49%) of the respondents believed that humans and nature should be considered as equals and nearly all (99%) agreed with the statement that ‘humans should not stand above, but work together with, nature’ (Table 1).

The attitude voiced by most nature reserve managers was that humans were ‘partners of nature’ and ‘participants with nature’. They all agreed with the statement that humans have a responsibility to oversee and conserve nature. Ninety-seven percent of reserve manager respondents agreed with the statement that ‘humans should not stand above, but work together with, nature’.

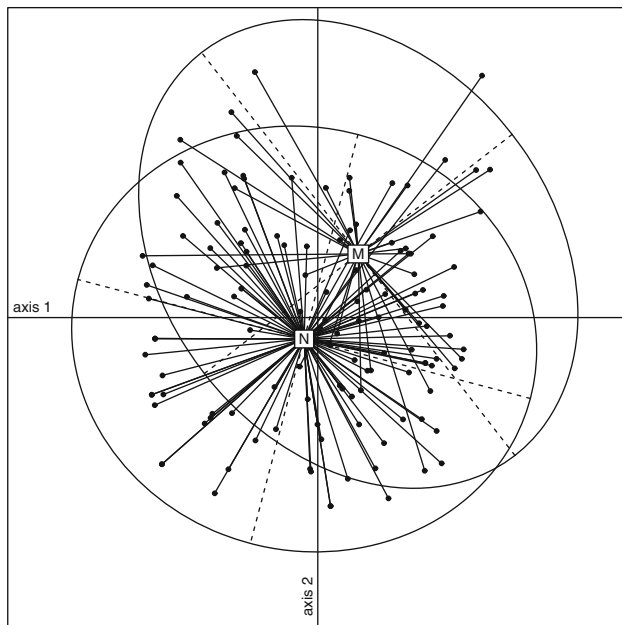


Fig. 1 Scatterplot of respondents along the first two components of the MCA using responses to Q1 and Q2. N-ellipse includes 95% of horticulture professionals respondents and M-ellipse includes 95% of nature reserve manager respondents

An important difference in the human-nature relationship between the two groups was the belief that advancements in science and technology would be sufficient to solve future environmental problems: 73% of horticulture professionals agreed with this statement but only 44% of nature reserve managers agreed. There were also differences in what the two groups saw as representing nature. A large number of horticulture professionals (87%) included the cultivation of plants as a part of nature, a definition that potentially encompasses a very large array of landscape types, including traditional and industrial farming as well as recreational gardening and constructed parks. On the other hand, 40% of horticulture professionals agreed with the statement ‘real nature can only be found in places where you are not aware of civilization’, indicating that nature is defined as being separate and autonomous from people. The nature representations preferred by nature reserve managers were autonomy and wilderness, indicated by a 73% positive response to the statement ‘real nature can only be found in places where you are not aware of civilization’

Awareness and Concern (Q3)

While 58% of horticulture professionals were aware of the problem of invasive alien species, only 42% stated they had a general knowledge of IAS. All (100%) of the nature reserve managers were aware of the problem, with 82% stating they had general knowledge about IAS. To illustrate

their knowledge, horticulture professionals gave examples of invasive plants and animals (21%) and presented 14 different concepts (see Appendix 2). The main concepts were the geographical expansion of species and their capacity to colonize areas (14%), general impacts of invasive species (11%) and exotic origin of such species (10%). Sixty-nine percent of horticulture professionals stated that they knew the geographical origin of the plants they sold. While the concepts presented by reserve managers were the same as for horticulture professionals (14), frequency differed. There was a significant difference (Monte-Carlo test; $P < 0.001$) between the two groups in the response to Q3. The concept most frequently invoked was the notion of impact (38%). Only 9% used examples to describe their own IAS knowledge. Both reserve managers (82%) and horticulture professionals (65%) expressed concern about the IAS problem. Analyses did not reveal any significant co-inertia between the ‘awareness and concern’ issue and the perception of nature for either group alone, or when data were pooled.

Concept and Language (Q4)

When asked to describe, in their own words, the problem(s) associated with IAS, 79% of nature reserve managers were able to do so. In addition, 65% were able to describe the species involved. For horticulture professionals, the response rates were 59% and 50%, respectively, to the same questions. There was a significant difference (Monte Carlo test; $P < 0.001$) between the two groups relative to their responses to Q4.

While $\geq 50\%$ of respondents from both groups were able to respond to the questions of problem and species, the actual number of expressed ideas or concepts varied. Invasive species characteristics used by horticulture professionals could be classified into 16 different concepts (see Appendices 2.3). Two of the most frequently expressed ideas were geographical expansion (24%) and impacts to indigenous species (23%). Fewer different ideas (13) were expressed by nature reserve managers to describe species. A majority (47%) opined that the impacts to the indigenous flora (56%) were a significant IAS problem and the dominant trait of invasive species (24%). Only 21% of reserve managers were unable to describe IAS. When asked about the CBD definition of IAS, some horticulture professionals wondered whether prejudices are real (3 responses), and if invasions are actually a result of human activity or are natural processes (3 responses). This response was also recorded twice for nature reserve managers.

Based on the CBD definition of IAS, 43% of the responding horticulture professionals defined themselves as concerned by the problem, although previously 66% had

Table 1 Percentage of agreement, disagreement and non-respondents (nr) with each statement concerning how nature is viewed (nature perception Q1–Q2) and percentage of yes, and non-respondents (nr) for Q3 to Q7

Nature perceptions (Q1 and Q2)	Horticulture professionals (n = 102)			Nature reserve managers (n = 34)		
	nr	Agree	Disagree	nr	Agree	Disagree
<i>Q1 Human-nature relationships</i>						
1. Humans have the right to make drastic changes to the environment	3.92	6.86	89.22	2.86	17.65	79.41
2. Humans must treat nature very carefully	0.98	98.04	0.98	2.86	94.12	2.94
3. Humans must conserve nature	1.96	97.06	0.98	0.00	100.00	0.00
4. Nature cannot be an obstacle to economic development	6.86	15.69	77.45	8.57	11.76	79.41
5. Technological developments will help to solve environmental problems in the future	12.75	72.55	14.71	20.00	44.12	35.29
6. Humans and nature are equal	8.82	49.02	42.16	2.86	41.18	52.94
7. Nature is indifferent to me	2.94	0.00	97.06	0.00	2.94	97.06
8. If humans actively manage nature it will improve	8.82	70.59	20.59	8.57	38.24	52.94
9. Humans are not superior to nature but should work together with nature	0.98	99.02	0.00	0.00	97.06	2.94
10. Through nature, I can experience the insignificance of humans	10.78	72.55	16.67	0.00	73.53	26.47
<i>Q2 Nature representations</i>						
1. Real nature can only be found where civilization is absent	4.9	40.2	54.90	0.00	26.47	73.53
2. If a nature reserve is left undisturbed, its value increases	6.86	53.92	39.22	14.29	17.65	67.65
3. Human must be able to recreate in nature reserves	5.88	34.31	59.80	11.43	32.35	55.88
4. Nature includes everything that grows and moves	8.82	41.18	50.00	11.43	14.71	73.53
5. An area is natural if humans do not have a significant impact on it	6.86	47.06	46.08	2.86	29.41	67.65
6. An area used primarily to produce food is not, by definition, “real” nature	4.9	39.22	55.88	0.00	38.24	61.76
7. Plant cultivation is a part of nature	3.92	87.25	0.0882	5.71	50.00	44.12
	nr	Yes	No	nr	Yes	No
<i>Q3 IAS</i>						
1. As a citizen, are you aware of the IAS problem?	4.95	57.43	37.62	0.00	100	0.00
2. Do you have a general knowledge of IAS?	6.93	41.58	51.49	0.00	82.35	17.65
4. As a professional, are you concerned about the problem of invasive alien species?	8.91	65.35	25.74	32.35	67.65	0.00
5. Do you know the geographical origin of the plants that you sell? (for horticulture professionals)	7.92	69.31	22.77			
<i>Q4 Language and concept</i>						
4. Based on the CBD definition (given), do you feel concerned by the problem?	29.70	42.57	27.72	5.88	88.24	5.88
5. Do you think that any of the plants or seeds you sell fit within framework of the CBD definition?	22.77	18.81	44.55			
<i>Q5 Availability of information and information tools</i>						
1. Do you consider yourself adequately informed about the subject?	7.92	9.90	79.21	2.94	47.06	47.06
<i>Q7 Control and solutions</i>						
1. At this time, do you think you have the means to control the spread of IAS?	28.71	14.85	51.49	14.71	14.71	67.65
4. Do you think there should be government legislation addressing the IAS issue?	18.81	51.49	24.75	5.88	91.18	2.94
5. As a solution to the problem, should there be an information framework for [horticulture professionals (in the horticulture professionals survey)]/ [nature conservation professionals (in the nature reserve managers survey)]?	7.92	83.17	8.91	8.82	91.18	0.00
6. Do you think that a prohibition on the sale of exotic species will negatively affect your company? (for horticulture professionals)	0.00	5.94	94.06			
7. Do you think that failure to control IAS threatens nature and natural areas? (for nature reserve managers)				2.94	70.59	26.47
8. Do you think that efforts to control or eradicate IAS would seriously disrupt nature reserve visitation? (for nature reserve managers)				3.12	96.87	6.25
9. Do you think that the recreational function of nature reserves would be compromised by the control or eradication of IAS? (for nature reserve managers)				3.12	96.87	6.25

responded in the affirmative when asked ‘As a professional, do you feel concerned by the problem of invasive alien species?’ When asked if they would sell seeds which fit the CBD definition, 19% replied positively, 45% negatively, 23% did not answer and 13% did not know. Having read the CBD definition, over twice as many nature reserve managers (88%) expressed concern about the issue.

There was significant co-inertia ($P = 0.012$) between the ‘concept and language’ issues and the perception of nature when considering all respondents. Of particular interest was the fact that respondents who were not concerned by the IAS issue after reading the CBD definition, were the same individuals who agreed with Q.2.2 and Q.2.4 concerning nature representations. Moreover, individuals using a large number of concepts to describe the IAS problem also expressed disbelief in the capacity of future technological advancements to solve environmental problems.

Availability of Information and Information Tools (Q5)

The Monte-Carlo test revealed a significant difference ($P < 0.001$) in the response to Q5 between the two surveyed groups. While both horticulture professionals and nature reserve managers felt that lack of information was a significant impediment to dealing with the IAS issue, a much larger percentage (81%) of the former felt that they were inadequately informed about the subject and also that 79% of wholesalers did not have enough information. Seventy-two percent of horticulture professionals advocated better public education and 56% of the respondents believed that, at a minimum, professionals in the field needed better information; 25% were in favor of better information for both the general public and the horticulture professionals. A much lower percentage (47%) of nature reserve managers felt that they were inadequately informed, a reflection, perhaps, of the education and the training they need to adequately meet job requirements. However, despite the perceptions of their own abilities, 94% of the nature reserve managers were of the opinion that visitors to nature reserves were inadequately informed about IAS. Nature reserve managers were great advocates of enhanced public education (97%); 23% of reserve managers felt that it was important that workers and professionals within the field of nature conservation be informed, while 15% were in favor of enhanced education for both the public and nature conservation professionals.

There was significant ($P < 0.001$) co-inertia between the ‘information and information tools’ issues and the perception of the nature when considering all respondents from both of the surveyed groups. Respondents who considered themselves as sufficiently informed were also the ones who disagreed with statements Q.1.8 and Q.1.5 (that

humans or technology can help nature and/or solve environmental problem) and, to a lesser extent, with the statement that plant cultivation should be considered part of nature.

Dangers and Effects (Q6)

The Monte-Carlo test revealed a significant difference ($P < 0.001$) in the response to Q6 between the two groups. Ninety-four percent of nature reserve managers described the impacts of IAS compared to 71% of the horticulture professionals. Horticulture professionals described the impacts using 18 different concepts or categories while only 10 were used by reserve managers (see Appendix 2.4). Environmental impacts (on native flora and fauna, as well as ecosystems) were most frequently cited by both groups. Human health problems were also suggested but only horticulture professionals brought up the issue of economic impacts. Interestingly, three horticulture professionals asserted that dangers posed by IAS were neither threatening nor insurmountable. Fewer than 10% of both horticulture professionals and managers felt the problem was already out of control.

For horticulture professionals, the three main factors that influenced their perception of the damage caused by IAS were affecting their own properties (57%), management costs (43%) and description of the issue by the media (25%). Managers were mostly influenced by management costs (86%), though other elements (prejudice to property, opinions of other persons, cultural identification, subsistence utility and historical perception) were also influential (17% for each). The only factor that did not apparently impact the perceptions of reserve managers was the media.

Fifty percent of horticulture professionals did not respond when asked which species would become problematic in the next few years; only 12% of nature reserve managers did not respond to that question. Species mentioned by both groups were exotic plants or animals that are already highly problematic in Belgium (*Fallopia japonica*, *Heracleum mantegazzianum*, *Impatiens glandulifera*), species already described as problematic in neighboring countries and, frequently, aquatic species (plant or animals).

Responses to the question about control actions combined actions which should be taken (in the future) and actions already being taken by the horticulture professionals included in the survey. The survey indicated that the respondents were already aware of the known control methods and solutions (see Appendix 2.5), specifically: interdiction (23%) and limiting (6%) the sale of IAS, providing accurate information to customers (20%), and a variety of management practices and methods. Interestingly, only one person had personally searched for information, two were anticipating they would receive competent advice and one

asserted that it was the responsibility of competent individuals to act in the face of this problem. Most nature managers felt that the availability of accurate, up-to-date information was important (23%) and, in addition, described classical management methods that they felt could be applied to this issue. Only one person expressed the opinion that competent advice should be provided by someone else, and one individual proposed that the problem would work itself out over time, even without active, targeted actions. Analyses did not identify any significant co-inertia between the awareness and concern issues and the perception of nature.

Control and Solutions (Q7)

The Monte-Carlo analysis revealed a significant difference ($P < 0.001$) in the response to Q7 between the two surveyed groups. Only 15% of the horticulture professionals thought they had the skills and tools needed to control the spread of IAS; 51% felt they did not. The same percentage (52%) felt that the means for IAS control should come from a higher (responsibility and skill) level within the horticultural sector (29%), or from legal authorities at the regional (9%), national (57%) or European level (4%). Some respondents also gave suggestions for management methods such as prohibiting the sale (2%) or controlling the introduction of new species (2%), improved dispersal of information (4%), mechanical management methods (5%), and chemical products (6%). The majority of horticulture professionals (52%) agreed there should be legislation to address the IAS issue and 83% of the respondents were advocates of an information network for horticulture professionals. Providing customers with accurate information about the potential adverse impacts of IAS was supported by 60% of the horticulture professionals. Limiting the use of listed invasive plants was the second option most favored by horticulture professionals (44%), followed by controlling commercialization of exotic species (37%) and a more thorough review of ecological information before introduction (29.41%) (non-respondent rate = 6.86%). Only 6% of the horticulture professionals thought their business would be threatened if the sale of exotic species was prohibited.

Nature reserve managers also expressed that they do not have the means to control the spread of invasive species than do horticulture professionals. Only 15% said they had the necessary tools to control the spread of IAS, while 68% said they did not. Seventy percent (70%) of nature reserve managers were of the opinion that the means for controlling the spread of IAS should come from a higher authority within the conservation sector (12%) or a higher legal authority at the regional (40%), national (24%) or European level (8%). Of the surveyed nature reserve managers, 94% reacted positively to the question of whether there

should be legislation to address IAS. The same number of respondents (94%) thought a framework based on factual background information would be a positive step toward beneficial management of IAS. The willingness of nature reserve managers to accept one or more obligations in order to assist in addressing the IAS problem was high (80% of respondents). In particular, reserve managers expressed strong support for providing people with factual information (89% of respondents) and curbing the commercialization of exotic species (93% of respondents). Limiting use of the listed exotic species was supported by 51% of the reserve managers, while 67% agreed that up-front documentation of potential ecological impacts was needed before the sale of any new exotic species. There was over-whelming agreement among nature reserve managers that neither visits, nor the recreational function of nature reserves, would be hindered by IAS management (91%); 83% believed that natural areas are threatened without some kind of IAS control.

Commercialized Species

All horticulture professionals responding to our survey opted to complete the provided list of exotic species. All of them sold at least one exotic species on the list, although 45% had previously denied having sold an IAS as defined by the CBD (Q4.5). The availability of exotic species varied, as illustrated by the number of commercial establishments presenting them for sale (Fig. 2). In the 'Harmonia' database (Branquart 2008), species are placed on either a "black" or "watch" list of invasive species. Those on the black list are species for which the potential for environmental impact is high; watch list species are recognized as having a moderate environmental impact in the ISEA protocol, a simplified environmental impact assessment protocol used in Belgium (Branquart 2008). Six species in the database were sold by more than 50% of the respondents: *Buddleja davidii* and *Amelanchier lamarkii*, both on the watch list, and *Acer negundo*, *Mahonia aquifolium*, *Rhododendron ponticum* and *Cotoneaster horizontalis*, all on the black list.

Discussion

Information gathered in the present study indicated that, regardless of the target sector investigated, the descriptions recorded for the IAS issue properly cover the scientific definitions and knowledge. Current perceptions of IAS are therefore more a result of a lack of information than they are simply incorrect and/or inaccurate precepts. It is reasonable to suspect that the level of awareness identified in our survey is overestimated because of self-selection

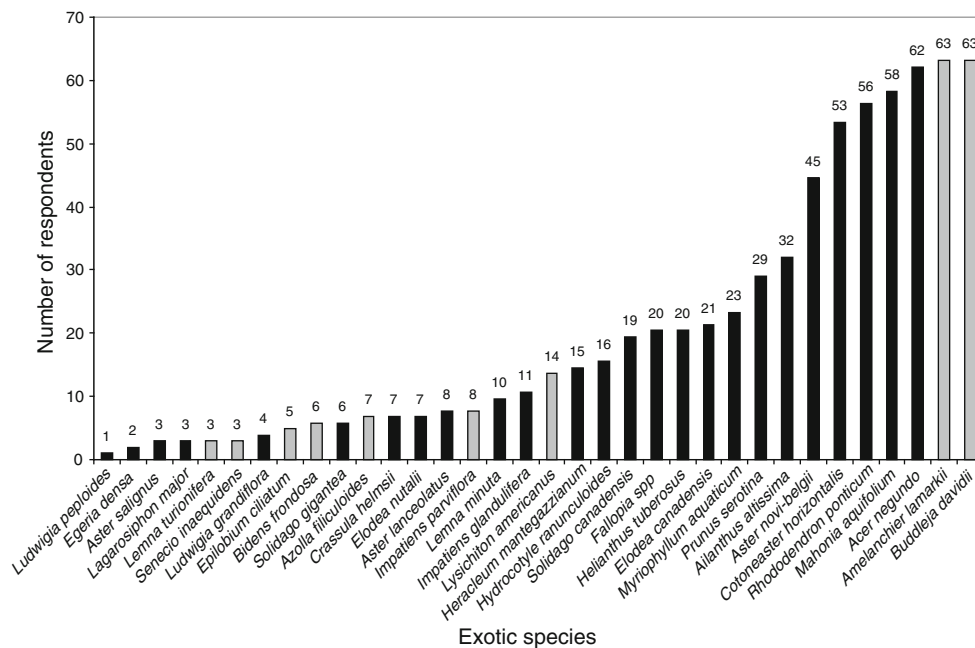


Fig. 2 Exotic species sold by respondent horticulture professionals. Black bars are used for those on the black list, and grey bars for those on the watch list, of invasive species in the *Harmonia* database (Branquart 2008)

among respondents. That is, people with a strong interest in the IAS issue are more likely to respond to the survey (Bremner and Park 2007). In fact, when designing this study it was thought, a priori, that nature reserve managers and horticulture professionals would be more concerned about the IAS issue than the general populace. While it is true that a difference of status between the investigated groups (i.e., gender, ages, educational standard, level of responsibility) may result in differences of Nature and IAS perception (Bremner and Park 2007), our purpose was here to consider the two groups independently from the individual characteristics. Further communication strategies will indeed focus on the groups as a whole, independently of their specific composition.

The human-nature relationships and nature representations of nature reserve managers were in contrast to those of horticulture professionals, resulting in some divergence relative to concern about the IAS issue. Respondents for which nature representation was ‘wilderness’ or ‘autonomy’ tended to consider themselves well informed about IAS, and did not believe humans or technology can solve environmental problems. The nature reserve managers tended more to have this kind of nature representation than the horticulture professionals.

Although all reserve managers identified themselves as being aware of the IAS issue, only 74% were able to adequately describe the important IAS issues. It is worth noting that surveyed individuals in this target group were composed of both professionals and volunteers working in the field of nature conservation and potentially dealing with IAS every

day. In contrast, only ca. 50% of horticulture professionals were aware of IAS and able to describe the species and issues of concern. Globally, nature reserve managers expressed more concern about the issue than did horticulture professionals, probably due to their involvement with a broad array of nature conservation issues and subjects. The lack of information was largely recognized by both target groups, with a general agreement of the importance of public education. The need to inform the different occupational sectors was only a priority for about half of the horticulture professionals and 23% of the reserve managers, while the need for parallel action on the part of both sectors, and the general public, appeared to be less important for both target groups. Nonetheless, the fact that <75% of respondents from either group (lower for the nursery sector) were unable to comfortably and competently describe the critical IAS issues suggests the need for a sector-specific informational framework. Efforts to raise awareness in both the general public and in the specialized audiences must include convenient didactical approaches appropriate for each.

Despite relatively low ability of respondents from both sectors to accurately state important IAS issues, the descriptions that were provided, on both the species and the issues, approached and reflected the concepts frequently used in the literature (Lockwood and others 2007; Pyšek 1995; Richardson and others 2000). Ideas most often articulated by nature reserve managers reflected their personal observations and concerns about potential IAS impacts. In general, they were able to precisely describe the environmental impacts on the fauna, flora and ecosystems,

but also recognized that their own perceptions were skewed by what they recognized as the management costs resulting from IAS. The responses obtained from horticulture professionals may reveal a lower level of understanding about IAS impacts, though the description they did provide were particularly accurate from the environmental point of view. It is worth noting that some horticulture professionals asserted that the dangers from IAS were relatively minor or not insuperable, which was counter to the opinions expressed by nature reserve managers.

Both sectors recognized that few options were available for the control and management of IAS in Belgium. There is a general opinion that professionals in multiple sectors, including legal authorities, should and are willing to increase their financial and informational support of tactics to solve, or hinder, the problem. Restrictions on plant movement would receive a lower level of acceptance in the horticulture sector compared to nature conservation, where most professionals are already convinced of the necessity of mandatory controls. However, we also identified significant support in all sectors for preventive measures. All suggested voluntary initiatives, such as better information, use limitation and factual ecological documentation related to exotic species, appeared to be welcome. These kinds of participatory measures are integrated into voluntary initiatives as codes of conduct to encourage self-regulation by the horticultural trade (Burt and others 2007; Heywood and Brunel 2008). Building awareness, collecting, managing and sharing information, strengthening national policy, legal and institutional frameworks, and prevention are among the main objectives established by the European Union (Genovesi and Shine 2004; Hulme 2007). As stated in the European strategy on IAS, voluntary instruments provide the baseline from which state and regional economic integration organizations within the European Community can develop policy, legal and management frameworks to address IAS issues (Hulme 2007). But *pre* and *post* assessment of this kind of voluntary environmental approach may be needed to accurately measure the effectiveness and efficiency of such programs (Alberini and Segerson 2002). This survey revealed a high level of willingness of respondents to take responsibility and educate themselves, their customers and the public. This was also observed in different areas of the United States (Gagliardi and Brand 2007; Harrington and others 2003; Peters and others 2006).

Initial introduction of exotic plants frequently occurs from a desire to use them as ornamental species (Dehnen-Schmutz and others 2007). Horticulture plays a role as a continuous source of propagules, fostering naturalization and expansion of exotic plant populations (Kowarik 2003; Mack and others 2000). In the present survey, we confirmed that, in Belgium, many recognized invasive plant species remain commercially available, among which nine

species (*Senecio inaequidens*, *Solidago gigantea*, *S. canadensis*, *Impatiens parviflora*, *I. glandulifera*, *Heracleum mantegazzianum*, *Fallopia* spp., *Prunus serotina* and *Cotoneaster horizontalis*) are targets of current or recent research projects in Belgium (Monty and others 2008, Piquera and others 2008; Tiébré and others 2007; Verheyen and others 2007). Some of these species were also chosen for pilot management studies in Belgium (De Bruyne and others 2007; Pieret and others 2008). Interestingly, the continued commercial availability of certain invasive species contradicts their answer to the previous survey question that asked whether horticulture professionals thought they were selling species that fit the CBD definition of invasive species. To this question, 45% of the respondents answered 'no', although they all sold at least one species recognized as invasive in Belgium. The majority of horticulture professionals (58%) was aware of the IAS issue and able to describe the characteristics of theoretical invasive species, but they were generally unable to identify invasive species among the species they sold. By using an anonymous questionnaire, we limited the power of the analyses in that we overviewed the sector in general, but we did not identify in this survey the perception, roles or willingness of the different sub-sectors, including garden contractor, wholesalers, suppliers, plant nursery workers, distributors or retailers. Direct questionnaires or telephone interviews stratifying the horticulture professionals across the different sub-sectors might have been more informative in that sense.

In a survey performed among commercial Minnesota (USA) horticulturists, Peters and others (2006) reported a willingness of horticulture professionals to take preventative actions against IAS by informing customers or by labeling plants. However, they admitted that competitive pressure from other nurseries that persist in selling popular, invasive species is likely to influence their own decision about whether or not to sell the plants themselves. In addition to the ignorance of the invasive status of species, this kind of behavior might explain the contradiction we observed in the present situation. Nevertheless, the competitive factors that apparently influence the commercial availability of invasive species indicate the necessity for regulatory measures. Interestingly, in our study we did not record any requests for information regarding the marketing of indigenous plants that could be alternates to IAS, yet identifying and promoting alternative species is an important approach in voluntary programs for the reduction in IAS sales (Baskin 2002; Gagliardi and Brand 2007). The horticulture business sector may feel unfairly targeted while trying to satisfy the public demand for non-native species. It is not surprising, therefore, that there are strong feelings among horticulturists that they should be included in any decisions that have the potential to affect the success

Appendix 1 continued

	Yes	No	No opinion	
Based on the CBD definition (<i>given</i>), do you feel concerned by the problem?				
Do you think that any of the plants or seeds you sell fit within framework of the CBD definition?				
<i>Q5 Availability of information and information tools</i>				
Do you consider yourself adequately informed about the subject?				
Do you think [wholesalers (in the horticulture professionals survey)] / [visitors to nature reserves (in the nature reserve managers survey)] are enough informed?				
Do you think it is necessary to raise public awareness in general or just for [those individuals involved in nature conservation (in the nature reserve managers survey)] / [horticulture professionals (in the horticulture professionals survey)]?				
<i>Q6 Dangers and effects</i>				
What are the dangers associated with the IAS problem?				
In this context, which element(s) influence(s) your perception of the damage?				
(1) My own property				
(2) Opinion of other persons				
(3) Description of the issue by the media				
(4) Management costs				
(5) Recreational function				
(6) Cultural identification				
(7) Subsistence utility				
(8) Historical perception				
What IAS do you perceive as being detrimental over the next few years?				
In relation to the previous question, what actions do you take to control the continued expansion of these species?				
<i>Q7 Control and solutions</i>				
At this time, do you think you have the means to control the spread of IAS?				
	Sectors	Higher authority	Both	No opinion
Do you think the tools and strategies for IAS control should come from a higher level of the [horticulture sector (in the horticulture professionals survey)]/[nature conservation agencies (in the nature reserve managers survey)] or from an even higher authority (e.g., government regulatory agency)? If yes to the latter, which authority?;				
	Yes	No	No opinion	
Do you think there should be government legislation addressing the IAS issue?				
As a solution to the problem, should there be a framework for [horticulture professionals (in the horticulture professionals survey)]/[nature conservation professionals (in the nature reserve managers survey)]?;				
Which obligations are you prepared to accept?				
(1) Information of the public				
(2) Limitation of use				
(3) Ecological file before the introduction of any new exotic species				
(4) Curb of commercialization				
(5) None				
Do you think that a prohibition on the sale of exotic species will negatively affect your company? (for horticulture professionals)				
Do you think that failure to control IAS threatens nature and natural areas ? (for nature reserve managers)				
Do you think that efforts to control or eradicate IAS would seriously disrupt nature reserve visitation? (for nature reserve managers)				
Do you think that the recreational function of nature reserves would be compromised by the control or eradication of IAS ?(for nature reserve managers)				

Appendix 2: List of concepts presented through open-ended questions**2.1 Concepts presented in answers to questions about IAS knowledge, number (*n*) and frequency of observation (%)**

	<i>n</i>	%
<i>Plant horticulture professionals</i>		
Examples	21	20.59
Expansion/colonization	14	13.73
Impact	11	10.78
Exotic/geographical origin	10	9.8
Nothing/don't know	9	8.82
Local/indigenous/autochthon	7	6.86
Dominating species	5	4.9
Introduction by man	5	4.9
Multiplication/reproduction/ proliferation	5	4.9
Control par man	4	3.92
Habitat/niche	3	2.94
Monitoring/eradication	3	2.94
Absence of predators	2	1.96
Disturb human activities	1	0.98
Accidental/deliberate introduction	1	0.98
Legal regulation	1	0.98
<i>Nature reserve managers</i>		
Nothing/don't know	13	38.24
Impact	13	38.24
Local/indigenous/autochthon	11	32.35
Exotic/geographical origin	8	23.53
Expansion/colonization	8	23.53
Habitat/niche	7	20.59
Dominating species	6	17.65
Introduction by man	6	17.65
Accidental/deliberate introduction	5	14.71
Absence of predators	5	14.71
Monitoring/eradication	5	14.71
Control par man	5	14.71
Multiplication/reproduction/proliferation	5	14.71
Disturb human activities	4	11.76
Legal regulation	4	11.76
Examples	3	8.82

2.2 Concepts presented in answers to questions about the characteristics of IAS, number (*n*) and frequency of observation (%)

	<i>n</i>	%
<i>Plant horticulture professionals</i>		
Nothing/don't know	9	8.82
Impact	8	7.84
Expansion/colonisation	8	7.84
Local/indigenous/autochthon	7	6.86
Multiplication/reproduction/ proliferation	6	5.88
Dominating species	5	4.90
Introduced by man	4	3.92
Exotic/geographical origin	4	3.92
Control par man	4	3.92
Absence of predators	3	2.94
Adaptation	2	1.96
Resistant to herbicides	2	1.96
Absence of competitors	2	1.96
Monitoring/eradication	2	1.96
Habitat/niche	1	0.98
Diversification of invaded habitats	1	0.98
Interest for insects	1	0.98
<i>Nature reserve managers</i>		
Impact	14	41.18
Nothing/don't know	12	35.29
Local/indigenous/autochthon	9	26.47
Expansion/colonisation	8	23.53
Dominating species	7	20.59
Introduction by man	6	17.65
Absence of predators	4	11.76
Habitat/niche	3	8.82
Monitoring/eradication	2	5.88
Control par man	2	5.88
Multiplication/reproduction/proliferation	2	5.88
Adaptation	1	2.94
Absence of competitors	1	2.94

2.3 Concepts presented in answers to questions about the characteristics of the issue of IAS, number (*n*) and frequency of observation (%)

	<i>n</i>	%
<i>Plant horticulture professionals</i>		
Nothing/don't know	44	43.14
Expansion/colonisation	24	23.53
Impact	23	22.55

Appendix 2.3 continued

	<i>n</i>	%
Local/indigenous/autochthon	20	19.61
Multiplication/reproduction/proliferation	9	8.82
Exotic/geographical origin	8	7.84
Control par man	8	7.84
Dominating species	8	7.84
Introduced by man	6	5.88
Monitoring/eradication	4	3.92
Absence of predators	4	3.92
Resistant to herbicides	3	2.94
Absence of competitors	3	2.94
Adaptation	2	1.96
Habitat/niche	1	0.98
Diversification of invaded habitats	1	0.98
Interest for insects	1	0.98
<i>Nature reserve managers</i>		
Local/indigenous/autochthon	19	55.88
Impact	16	47.06
Dominating species	8	23.53
Expansion/colonisation	7	20.59
Multiplication/reproduction/proliferation	7	20.59
Nothing/don't know	7	20.59
Introduced by man	6	17.65
Absence of competitors	3	8.82
Absence of predators	3	8.82
Habitat/niche Beauty/ornamental species	3	8.82
Adaptation	2	5.88
Exotic/geographical origin	2	5.88
Accidental/deliberate introduction	2	5.88
Resistant to herbicides	1	2.94

2.4 Concepts presented in answers to questions about the impacts of IAS, number (*n*) and frequency of observation (%)

	<i>n</i>	%
<i>Plant horticulture professionals</i>		
Nothing insuperable	1	0.98
Water outflow	1	0.98
Dangerous herbicides	1	0.98
Landscapes	2	1.96
Socio-cultural	2	2.94
Weak dangers	2	2.94
None	3	3.92
Economic impact	3	4.9
Phytosanitary impacts	3	4.9
Irreversible impacts	3	4.9

Appendix 2.4 continued

	<i>n</i>	%
Important progression	4	6.86
Impact on fauna	4	8.82
Out of control	5	9.8
Management difficulties	6	10.78
Impact on ecosystems	9	13.73
Health Impact	9	20.59
Do not know	10	9.8
Environmental impacts	44	43.14
Native flora/biodiversity	44	43.14
<i>Nature reserve managers</i>		
Environmental impacts	24	75.00
Native flora/biodiversity	27	75.00
Do not know	10	31.25
Impact on ecosystems	3	9.36
Health Impact	3	9.36
Out of control	2	6.24
Management difficulties	2	6.24
Irreversible impacts	1	3.12
Important progression	1	3.12
Impact on fauna	1	3.12

2.5 Actions taken to control the expansion of IAS, number (*n*) and frequency of observation (%)

	<i>n</i>	%
<i>Plant horticulture professionals</i>		
Sell of management tools	2	3.85
Eradication	4	7.69
Herbicide	4	7.69
Ecological management	3	5.77
Sell limitation	3	5.77
In expectation of competent advices	2	3.85
Monitoring	2	3.85
Precautionary principle	2	3.85
Early mowing	2	3.85
Herbicide spraying	2	3.85
Pulling out and fire destruction	2	3.85
To let and manage by competent persons	2	3.85
Hoeing	1	1.92
Substratum improvement	1	1.92
Personal search of information	1	1.92
<i>Nature reserve managers</i>		
Information	7	23.08
Eradication	7	19.23

Appendix 2.5 continued

	<i>n</i>	%
Early mowing	5	7.69
Pulling out and fire destruction	7	7.69
Monitoring	2	5.77
Sell limitation	4	5.77
Hoeing	1	3.85
In expectation of competent advices	1	3.85
Ecological management	1	3.85
Herbicide	1	3.85
To let the time work	1	3.85

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