ORIGINAL PAPER



Aliens in the nursery: assessing the attitudes of nursery managers to invasive species regulations

Kate Cronin D · Haylee Kaplan · Mirijam Gaertner · Ulrike M. Irlich · M. Timm Hoffman

Received: 15 May 2016/Accepted: 27 December 2016/Published online: 9 January 2017 © Springer International Publishing Switzerland 2017

Abstract The horticultural industry is recognised as a major pathway for the introduction and spread of invasive alien plants (IAPs). The Conservation of Agricultural Resources Act (CARA) of 1983 (Act No. 43 of 1983) listed and categorised invasive species with an aim to curb their spread. The more recently enacted Alien and Invasive Species Regulations under South Africa's National Environmental Management: Biodiversity Act (NEMBA) are intended, in part, to improve controls on the horticultural industry's role in the spread of IAPs. In order to assess, and enhance, the likely effectiveness of NEMBA, it is important to build an understanding of stakeholders' awareness and attitudes towards the control of IAPs and associated

Electronic supplementary material The online version of this article (doi:10.1007/s10530-016-1363-3) contains supplementary material, which is available to authorized users.

K. Cronin (🖂)

Department of Biological Sciences, Percy FitzPatrick Institute, University of Cape Town, Cape Town, South Africa e-mail: katecroninkc@gmail.com

H. Kaplan

Invasive Species Programme, South African National Biodiversity Institute, Kirstenbosch Research Centre, Claremont, South Africa

M. Gaertner · U. M. Irlich Department of Botany and Zoology, Centre for Invasion Biology, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa regulatory policies. A two-pronged approach-involving nursery manager interviews (n = 30) and plant stock audit assessments (n = 41)—was used to gauge the awareness, compliance and attitudes of nursery managers towards both the CARA and NEMBA invasive species regulations. Less than ten percent of audited nurseries were fully compliant with the NEMBA regulations, and over 50% were stocking IAPs that have been regulated for at least 13 years under CARA. This is despite high levels of awareness (70%) about the CARA regulations reported in the interviews. The majority (73.5%) of IAP species stocked in nurseries were NEMBA category 1b invaders such as Nerium oleander and Canna indica. These are widespread and well-established invaders that require compulsory control under NEMBA. Half of the managers were not aware that the NEMBA

M. Timm Hoffman

Plant Conservation Unit, Department of Biological Sciences, University of Cape Town, Cape Town, South Africa

M. Gaertner \cdot U. M. Irlich

Green Jobs Unit, Environmental Resource Management Department (ERMD), Westlake Conservation Office, Ou Kaapse Weg, Cape Town, South Africa

regulations had been promulgated, but most respondents nevertheless reported being enthusiastic about compliance. Several factors were quoted as constraints on compliance by the industry. These included a perceived lack of enforcement, weak communication from government, and the lack of inclusion of the industry in the regulatory process. Suggested interventions that could enhance the impact of IAP regulations will involve improving the user-friendliness of the regulations, and supplementing the current top-down approach to regulation with an inclusive partner-centred approach.

Keywords Compliance · Invasive species · Legislation · Ornamental horticulture · Perceptions

Introduction

Traditionally, research on the problem of biological invasions has largely been addressed from a narrow ecological perspective (García-Llorente et al. 2008; Sharp et al. 2011; Vanderhoeven et al. 2011). However, the human-mediated pathways by which invasive alien species arrive and spread within a region have attracted growing attention (Richardson et al. 2003; Le Maitre et al. 2004a; Humair et al. 2014). This literature has demonstrated that the drivers behind biological invasions have important social and economic components that should be factored in when developing management interventions. To be effective, interventions aimed at preventing the introduction and spread of invasive alien plants (IAPs) require a thorough understanding of the underlying social, economic and biological drivers of invasion.

The horticultural industry is recognised as one of the major pathways for the introduction and spread of IAPs around the world (Reichard and White 2001; Dehnen-Schmutz et al. 2007; Kinght et al. 2011). In South Africa, the horticultural industry represents a particularly important pathway, and the escape of ornamental plants from cultivation and gardens has resulted in some of the most extensive biological invasions in the country (Richardson et al. 2003). Fastgrowing and fragmented urban development increasingly brings gardens and exotic ornamentals into closer contact with ever-declining remnant patches of indigenous, often threatened, vegetation (Alston and Richardson 2006).

The South African government has identified the control of IAPs as a primary concern. By 2006, eleven national and provincial laws aimed at regulating the problems associated with IAPs had been enacted (Paterson 2006). Chief among these laws, until recently, was the Conservation of Agricultural Resources Act (CARA, Act No. 43 of 1983) which included provisions designed to manage the impact of IAPs on the agricultural sector (Badenhorst 2011). In 2001, amendments to CARA officially made it illegal to sell or propagate, for commercial purposes, any of the plants listed under the regulations (Wilson et al. 2013). Despite the fact that CARA was promulgated over three decades ago, IAPs continue to spread across South Africa, costing the country an estimated ZAR6.5 billion every year (de Lange and van Wilgen 2010; Wilson et al. 2013). By 2011 there had not been a single successful conviction under this legislation (Badenhorst 2011).

A number of potential reasons for the inefficacy of the CARA IAP regulations have been cited (Paterson 2006). These include a lack of public awareness about the problems caused by IAPs, the narrow primary focus of the legislation on the agricultural sector, a lack of enforcement, reliance on a 'command and control' approach where government seeks to change and regulate behaviour using financial penalties, the absence of specific, regionally-relevant measures, ineffective monitoring, and the inadequacy of sanctions for non-compliance.

In 2004, in an attempt to transform biodiversity conservation legislation and develop a more coherent legislative framework to regulate IAPs, the South African government enacted the *National Environmental Management: Biodiversity Act* (NEMBA) (Act No.10 of 2004). The Alien and Invasive Species Regulations, giving effect, in part, to the Act, were promulgated on 1 October 2014. The regulations list 559 invasive species (383 plants, 128 animals and 7 microbial species) which must be controlled and may not be imported, propagated, moved, or sold. Species are grouped into four categories, depending on whether the species requires compulsory control (Category 1a and 1b), permitting (Category 2) or containment (Category 3).

Some of the weaknesses in the CARA regulations have been addressed in NEMBA. For instance,

regional variation is accommodated, provision is made for monitoring compliance with the regulations, and the new sanctions for non-compliance are far more severe. However, aspects of this new legislation continue to include features that have been identified as constraints on the impact of CARA. Of particular concern is the continued over-reliance on regulations without adequate engagement with stakeholders.

The 'command and control' assumption that effective and sustainable change in human behaviour can be achieved through legislation, regulation and sanctions alone is increasingly regarded as problematic (Stern 2000a; Dobson 2007). Sustainable behaviour change, not requiring constant enforcement, is best achieved through promoting the intrinsic adoption of appropriate values (Dobson 2007; Grant 2008; Crompton et al. 2014). Change in behaviour based on a change in intrinsic values is generally associated with strategies that rely on education, communication, and involvement in order to build shared commitment to longer term objectives (Stern 2000a; Dobson 2007).

International experience indicates that legislative tools that rely on financial incentives and/or penalties for directing behaviour have a limited impact on effectively preventing the spread of IAPs (Paterson 2006; Humair et al. 2014). The longer-term behaviour change necessary to curbing invasions would require approaches that impact on motivation based on intrinsic beliefs and attitudes. Thus, in order to improve the effectiveness of South Africa's IAP regulations, it is important to build an understanding of stakeholders' attitudes towards and perceptions of IAP regulatory policies. Such an understanding of factors that influence levels of motivation for compliance is particularly useful in a situation where detailed monitoring and enforcement is difficult.

Previous attempts to gauge South African nursery managers' awareness, perceptions and attitudes towards the CARA regulations on invasive alien plants (Badenhorst 2011) revealed relatively high levels of compliance with and awareness of the relevant legislation. However, most nursery managers expressed deep frustration at the lack of enforcement and the lack of government support for compliance with CARA (Badenhorst 2011).

In order to gain insight into the possible response to the recently promulgated NEMBA regulations as well as the older CARA act, this study involved interviewing nursery managers and an analysis of plant stock audit data to address the following questions: (1) what is the current situation with regard to the stocking of NEMBA-listed and CARA-listed IAPs in nurseries; (2) what levels of awareness exist amongst nursery managers about IAPs and the CARA and NEMBA regulations; (3) what are the attitudes of nursery managers towards the regulations and the control of IAPs; and 4) what are the factors indicated by nursery managers that influence compliance?

This study will contribute to improved understanding of ways in which regulation of the spread of IAPs through the horticulture industry can be strengthened.

Methods

Study area

This study was conducted in the Cape Town Metropolitan Area, South Africa, a fast-growing urban centre located in a globally important biodiversity hotspot. The apposition of Cape Town's pristine indigenous vegetation and encroaching urban development means that the nursery industry in the metropole is a potentially important factor in the spread of IAPs across the urban edge.

Sample selection

A database of nurseries in the Cape Town Metropolitan Area was compiled using listings in the Yellow Pages telephone directory, the South African Nursery Association's (SANA) membership list, the results of a *Google* search and listings on gardening websites. A total of 58 nurseries were initially identified. These nurseries were then approached for participation in the two strands of the study: the nursery manager interviews and the stock audit assessments.

The plant stock audit data were collected independently by the South African Department of Environmental Affairs' (DEA) Biosecurity Unit. The DEA official responsible for the audit conducted stock inspections at 41 of the 58 nurseries.

To enable a comparison to be made between the audit data and the interviews, the interview sampling effort was focused on those nurseries that had been included in the DEA audit. Interviews were arranged with nursery managers until saturation of the sample population was reached. A total of 30 managers agreed to participate in interviews.

Data collection

The independent stock audit conducted by the DEA recorded inventories of IAPs sold at individual nurseries using the NEMBA Alien and Invasive Species Lists (2014) and the amended (2001) CARA Declared Weeds and Invader Plants list and included only species that are listed as invasive within the Western Cape Province. Listed species, for which legal sterile cultivars and hybrids exist, were only included in the inventories if they were positively identified as non-sterile forms. Inventories were collected prior to interviews with nursery managers.

In the nursery manager interviews, data were collected using a formal questionnaire (Online resource 1). Given that the present study deals with issues of compliance with regulations, and the likely suspicion with which nursery managers would view the research, care was taken during the process of arranging the interviews to build trust and understanding about the purpose of the research. Telephonic contact was made with managers to arrange interviews and to provide a brief background to the study. Nursery managers were informed of the independence of the research from government and were given an outline of the content of the interview and how it would be used, including assurances that strict confidentiality and anonymity would be preserved. It was explained that, although compliance with legislation would be explored, the focus was on the challenges faced by nurseries in complying.

Twenty-one nursery managers participated in faceto-face interviews and nine managers participated in telephone interviews. The questionnaire was pretested in two pilot interviews conducted with managers from nurseries that were not included in the DEA audit sample. The pilot interviews did not reveal any problems with the interview schedule and the questionnaire did not need to be altered, and so these two interviews were incorporated in the nursery manager survey analysis. However, given that the two nurseries were not audited during the stock assessment study, statistical analyses involving comparisons between interview and audit data excluded the pilot interview data.

Questionnaire design

The aim of the questionnaire was to draw quantitative and qualitative responses to assess the levels of awareness, compliance and attitudes of Cape Town nursery managers towards CARA as well as the newly published NEMBA regulations on IAPs. Both closedended and open-ended questions were included (Online resource 1).

The response format of the closed-ended questions involved five-point Likert scales allowing respondents to indicate their level of agreement with statements $(1 = \text{strongly agree}, 2 = \text{agree}, 3 = \text{neutral}, 4 = \text{dis$ $agree}, 5 = \text{strongly disagree})$. Other closed-ended questions involved 'yes/no' response formats and variations on the Likert scale.

The questionnaire consisted of four sections: (a) background information on nursery managers; (b) awareness about IAPs and associated regulations; (c) compliance; and (d) attitudes towards IAP regulations and factors that influence compliance.

Data analysis

Responses to open-ended questions were summarised by grouping major opinions or answer-types and recording the number of respondents that mentioned each. Response frequency for the open-ended and closed-ended questions was analysed in the programme Statistical Package for the Social Sciences version 22.0 (SPSS).

In order to identify the underlying factors that influence whether a nursery is compliant or not, a Multiple Correspondence Analysis (MCA) was conducted. MCA is useful in this case as it allows for the relationships between multiple categorical dependent variables to be explored (Abdi and Valentin 2007). Potential underlying categorical factors that were included in the analysis were; (1) Awareness of the recent promulgation of the NEMBA regulations; (2) Attitude towards the control of IAPs; (3) Belief in the ability of Government to enforce the regulations; (4) Perceived expense of compliance; and (5) Fear of breaking the law. Due to the limited sample size associated with the nursery manager interviews, fivepoint Likert scales were collapsed into three response levels so as to ensure sufficient data coverage in each category.

Two additional Multiple Correspondence Analyses were conducted to determine whether (1) trade association affiliated nurseries and non-trade association affiliated nurseries; and (2) small and large (defined by annual turnover) nurseries differ in terms of awareness, compliance and attitudes. All multivariate analyses excluded pilot interview data, and were computed using the R package FactoMineR (Husson et al. 2011).

Results

The influence of nursery characteristics on compliance, attitudes and awareness

Just over a quarter of the nursery managers interviewed in the study indicated that their nursery belonged to one or more horticultural trade associations. The majority of nurseries participating in the study were considered small businesses (with an annual turnover of less than ZAR1 million), of which only $\sim 17\%$ were members of a trade association.

(MCA) Multiple Correspondence Analysis revealed differences in enthusiasm for compliance and awareness of NEMBA regulations between small (with a turnover of less than ZAR1 million per annum) and large (with a turnover of more than ZAR1 million per annum) nurseries (Fig. 1). Question Q33 (enthusiasm for compliance) exerted the greatest influence on dimension 1 ($\eta^2 = 0.7$) as compared to other variables, and separated small and large nurseries along the first dimension. Small nurseries were more enthusiastic about complying with the NEMBA regulations, while large nurseries were dispassionate or neutral. The level of awareness about NEMBA (Q6), which contributed the largest proportion of the loading on dimension 2 ($\eta^2 = 0.7$), was higher for larger nurseries whereas small nurseries reported ignorance more often.

The MCA analysis which compared trade association nurseries with non-trade association nurseries (Fig. 2) revealed that the factor most strongly separating affiliated and non-affiliated nurseries was compliance, which is indicated by audit status (contributing the greatest proportion of loading to dimension 1, $\eta^2 = 0.5$). Affiliated nurseries were more strongly associated with compliance, whereas nonaffiliated nurseries appear to be linked to noncompliance.

Awareness about IAPs and associated regulations

Half of the nursery managers interviewed were unaware that new invasive alien species regulations, specifically NEMBA, had recently been enacted. Seventy percent of the respondents disagreed or strongly disagreed with the statement that government has provided sufficient information on what nursery managers need to do in order to comply with the new regulations. Only one nursery manager stated that he had received official notification from government about the promulgation of the NEMBA regulations.

Of those who were aware of the NEMBA regulations, two-thirds indicated that they had seen the NEMBA list of IAPs that had been published two months earlier. In contrast to the low levels of awareness about NEMBA, 70% of respondents could positively identify CARA as a set of regulations controlling the sale of listed IAPs by the nursery industry.

Almost all nursery managers (93.3%) agreed that it is important to control the spread of these plants, and could list at least two relevant ecological reasons to motivate their answers.

Audited compliance

The stock assessment based on the DEA's audit data revealed that only four out of the 41 audited nurseries in Cape Town were a hundred percent compliant with the NEMBA IAP regulations. All four of these nurseries participated in the nursery manager interviews, and three out of the four were members of trade-associations. Non-compliant nurseries (any nursery selling one or more listed IAPs) were found to be stocking up to seven NEMBA-listed IAP species, but on average, most of the audited nurseries stocked three listed species. The most commonly stocked invasive alien plants were non-sterile forms of category 3 invader Hedera helix, single petal invasive cultivars of category 1b invader Nerium oleander, category 1a invader Iris pseudacorus, and category 3 invader Hedera canariensis (Table 1).

The vast majority (73.5%) of IAP species found in nurseries were category 1b invaders, that is, species that are widespread and well-established invaders that



Fig. 1 Scatterplot of respondents (n = 28) along the first two components of a multiple correspondence analysis (MCA) using stock audit data and responses to Q3/Size ("What is your nursery's approximate annual turnover?"), to Q6 ("Are you aware that new invasive species regulations (NEMBA) have been enacted?"), Q17 ("Do you think it is important to control the spread of IAPs?"), and Q33 ("How do you feel about

complying with the new NEMBA regulations on IAPs?"). Nurseries with an annual turnover of less than R1 million were deemed small ('open' data points) and those with an annual turnover of greater than R1 million were deemed large ('closed' data points). Some respondents were not prepared to disclose information on the turnover of their nurseries ('opaque' data points)



Fig. 2 Scatterplot of respondents (n = 28) along the first two components of a multiple correspondence analysis (MCA) using stock audit data and responses to Q4/Affiliation ("Does your nursery belong to a trade or industry association?"), to Q6 ("Are you aware that new invasive species regulations (NEMBA) have been enacted?"), Q17 ("Do you think it is important to control

require compulsory control (Table 1). Less than half (44.1%) of the species are listed under the 2001 amendments to CARA. Four additional species are

the spread of IAPs?"), and Q33 ("How do you feel about complying with the new NEMBA regulations on IAPs?"). Nurseries that belong to one or more trade associations are represented by 'closed' data points, while nurseries that are not affiliated with a trade association are represented by 'open' data points

listed under CARA's Table X, a list of potentially invasive plants that do not require official regulation under CARA. Out of all the nurseries included in the
 Table 1 NEMBA-listed invasive alien plants stocked by nurseries in Cape Town. Category listings are restricted to Western Cape Province statuses. Asterisks indicate plants for which sterile hybrids or cultivars exist. Plants were only
 included in the inventory if they were identified as non-sterile forms. Species that have been assigned 'NA' are not listed under the CARA regulations. Data were obtained from the Department of Environmental Affairs

Species (common name in brackets)	CARA category	NEMBA category	No. of nurseries	Frequency (%)
Agave americana (Spreading century-plant)	NA	3	4	9.8
Alisma plantago-aquatica (Water alisma)	NA	1b	1	2.4
Alpinia zerumbet (Shell ginger lily)	NA	3	1	2.4
Ardisia crenata (Coralberry tree)	NA	1b	2	4.9
Bryophyllum proliferum (Green mother of millions)	NA	1b	1	2.4
Canna indica (Indian shot)*	1	1b	5	12.2
Catharanthus roseus (Madagascar periwinkle)*	NA	1b	1	2.4
Coreopsis lanceolata (Tickseed)*	Table X	1b	1	2.4
Echinopsis schickendantzii (Torch cactus)	1	1a	1	2.4
Egeria densa (Dense water weed)	1	1b	1	2.4
Eriobotrya japonica (Loquat)	3	1b	1	2.4
Hedera canariensis (Canary ivy)	Table X	3	6	14.6
Hedera helix (English ivy)*	Table X	3	18	43.9
Hedychium flavescens (Yellow ginger lily)	1	1b	4	9.8
Houttuynia cordata (Chameleon plant)	NA	3	1	2.4
Hylocereus undatus (Dragon fruit)	NA	2	1	2.4
Iris pseudacorus (Yellow flag)	NA	1a	6	14.6
Lantana montevidensis (Lantana)*	1	1b	5	12.2
Melaleuca quinquenervia (Bottle brush tree)	NA	1b	2	4.9
Myriophyllum spicatum (Spiked water-milfoil)	1	1b	1	2.4
Nephrolepis exaltata (Sword fern)*	1	1b	1	2.4
Nerium oleander (Oleander)*	1	1b	7	17.1
Opuntia ficus-indica (Mission prickly pear)	1	1b	1	2.4
Opuntia microdasys (Yellow bunny-ears)	NA	1b	3	7.3
Passiflora caerulea (Blue passion flower)	1	1b	4	9.8
Passiflora subpeltata (Granadina)	1	1b	1	2.4
Pontederia cordata (Pickerel weed)	3	1b	1	2.4
Psidium durbanensis (Durban guava)	3	1b	1	2.4
Pyracantha coccinea (Red firethorn)*	NA	1b	2	4.9
Sambucus nigra (European elder)	Table X	1b	2	4.9
Schinus terebinthifolius (Brazillian pepper tree)	3	3	1	2.4
Tradescantia fluminensis (Wandering Jew)	NA	1b	1	2.4
Tradescantia zebrina (Wandering Jew)	NA	1b	1	2.4
Vinca major (Greater periwinkle)*	NA	1b	4	9.8

audit, just over half (51.2%) stocked species that are listed in CARA.

Self-reported compliance

In contrast with the audited NEMBA compliance rate of 13.3%, most nursery managers (76.6%) perceived

the industry to be largely compliant. In a further apparent disparity with the level of non-compliance (51.2%) with CARA, 60% of the nursery managers reported that 70–100% of the nursery industry has been compliant with the CARA regulations in recent years. A cross comparison of the audit data against the interview data revealed that all of the managers who

claimed to have seen the NEMBA lists (see 'Awareness' section) were selling invasive alien plants in their nurseries, and only one of the nursery managers that reported having heard of the regulations was a hundred percent compliant.

Analysis of the results of the MCA which shows the potential underlying factors that influence whether a nursery is compliant or not (Fig. 3) revealed that Q31 (perceived expense of compliance), which contributed the largest proportion of loading on dimension 1 $(\eta^2 = 0.3)$, was the major factor separating compliant and non-compliant nurseries. Non-compliant nurseries were strongly associated with the perception that compliance is inexpensive, while compliant nurseries were more strongly associated with the perception that compliance is costly. Non-compliant nurseries were also more strongly associated with the perception that government is not able to enforce the NEMBA regulations (Q30), with the belief that it is important to control the spread of IAPs (Q17), and with a fear of breaking the law (Q36).

Attitudes

Several factors were perceived as barriers to compliance by nursery managers (Fig. 4). In response to questions which highlighted potential constraints on the effectiveness of NEMBA, 73.4% of respondents felt that government was not able to enforce the regulations. Just over 50% of nursery managers qualified their answers by explaining that to date their nursery stocks have never been audited by an official from the DEA.

One nursery manager flagged a number of issues that he considered "grey areas" that are likely to cause a certain amount of confusion. For example, he suggested "*Plant labelling is a big grey area. There is a lack of congruence between the names of plants on the NEMBA lists and the way the plants are labelled in nurseries*". Other quoted sources of confusion pertained to the exemption of certain sterile cultivars of which there is currently no official list available to sellers and the incongruity between the two concurrent sets of IAP regulations (NEMBA and CARA.)

The majority (63.6%) of nursery managers reported being enthusiastic about complying with NEMBA. When asked about factors that potentially incentivize compliance, 80% indicated that a sense of duty to protect the environment most influences their enthusiasm for complying with the regulations. The majority indicated that their motivation for compliance is not affected by pressure from compliant nurseries



the regulations"), Q31 (Statement: "Compliance is expensive"), and Q36 (Statement: "I do not want to incur a penalty for breaking the law"). Compliant nurseries are represented by 'closed' data points, while non-compliant nurseries are represented by 'open' data points





Fig. 4 Percentage of Cape Town nursery managers (n = 30) participating in structured interviews that agreed or strongly agreed that certain factors act as barriers to compliance with the NEMBA invasive alien plant regulations

(56.7%), trade associations (53.3%) or consumer demand for non-invasive plants (40%). Eighty percent of the sample agreed or strongly agreed that government should encourage self-regulation by the industry as a means of boosting levels of compliance.

Discussion

This study set out to probe the levels of awareness, compliance, and attitudes within the horticultural industry that may influence the effectiveness of South Africa's newly promulgated invasive species regulations. The study used a novel approach of linking independently collected audit data of nurseries with face-to-face or telephonic interviews with the managers of the audited nurseries.

A key finding of the study is that the majority of audited nurseries were not compliant with IAP regulations despite legislation prohibiting the sale of listed IAPs existing for over a decade. The continued pervasive stocking of IAPs that have been listed in the CARA regulations since 2001, and, in some cases, since 1983, indicates an entrenched pattern of noncompliance. This suggests that simply issuing further regulations is unlikely to be effective in curbing the horticultural industry's role in spreading IAPs.

The influence of awareness

Awareness of regulations is a necessary condition for basic compliance. Nurseries with the lowest levels of compliance were those that were not affiliated with trade-associations. These tended to be smaller nurseries with low turnover which also reported low levels of awareness about the recent promulgation of the NEMBA regulations. Low-levels of awareness were linked to a lack of effective communication from government. Although the study was conducted a few months after the promulgation of the NEMBA invasive species regulations, one might still have expected government to have communicated well in advance of issuing the regulations, especially given that they had been in draft form since 2004. In fact, the current study confirms previous research indicating that since the 2004 promulgation of NEMBA and the draft IAP lists, nurseries appear to have received little or no official communications from government about IAPs and successive versions of the regulations (Badenhorst 2011). An interview with an official from the DEA's Biosecurity Unit (DEA, pers comm) suggests that government's recent attempts to communicate with the industry are inadequate, and that its plans to raise awareness are long-overdue. South African Nursery Association (SANA) members were sent multiple emails inviting the public to comment on the draft NEMBA lists and on NEMBA's promulgation. The official indicated that the DEA only communicates with SANA members, and regards other non-affiliated nurseries (which make up the bulk, roughly 62%, of Cape Town's nursery industry) as, in the words of the official, 'lone rangers'. These non-affiliated nurseries do not receive any communications because government does not have an official database of nurseries. It is perhaps not surprising then that non-affiliated nurseries were more strongly associated with noncompliance than affiliated nurseries. Assuming trade associations can be relied on to communicate with their members, it is the non-affiliated nurseries that government might be expected to target directly in order to enhance the reach of the regulations. However, government acknowledges that even SANAaffiliated nursery managers may have been ignorant about the regulations because the NEMBA legislation was not sent out to members as it 'could not be reduced in a readable format to be less than 1 megabyte' (DEA, pers comm). As such, only links to the relevant government websites were sent out to a community that government acknowledges 'is not very computer literate'.

Government has indicated that it plans to launch an awareness-raising campaign aimed at familiarising nursery managers with the IAP regulations (DEA, pers comm). However, this awareness-raising approach may not have much success in promoting new, proenvironmental behaviour when undertaken in isolation (Stern 2000a, b). In order for pro-environmental campaigns to successfully bring about change, they need to be built on an understanding of the multiple variables that influence behaviour particularly the beliefs, attitudes and situational pressures that influence them (Stern 2000a, b; Reaser 2001).

The results of the study indicate that an initiative to increase awareness will not, on its own, ensure compliance or reduce the impact of the nursery industry as a vector for the spread of IAPs. Only one of the 50% of managers who reported that they had heard of the enactment of the new regulations was a hundred percent compliant with NEMBA and, in the case of the 30% of managers who had actually seen the regulations, none was NEMBA-compliant. In addition, the disparity between high levels of reported awareness of CARA, and low levels of compliance with this long-standing set of regulations, indicates an entrenched pattern of cognisant non-compliance. This therefore contradicts the common assumption that awareness is positively associated with support for IAP control initiatives (Le Maitre et al. 2004b). Indeed, there appear to be many factors, other than a lack of awareness, that influence non-compliant behaviour.

The influence of attitudes and beliefs

It has been argued that the cognitive foundation of attitudes is basic beliefs (Fulton et al. 1996; Ajzen 2001). In order to assess how nursery managers' behaviour may be influenced by their attitudes, it is useful to organise these attitudinal factors into an

analytical framework of beliefs. An individual's behavioural intentions are shaped by three factors: behavioural beliefs (beliefs about the consequences of a certain behaviour which determine attitudes towards that behaviour), normative beliefs (beliefs about the expectations of society which influence perceptions about social pressure to perform a certain behaviour), and control beliefs (beliefs about the presence of factors that may impede or facilitate the performance of particular behaviour which influence the perceived difficulty of performing it) (Ajzen 2002). An examination of the potential contribution of each type of belief towards compliant behaviour provides a basis for understanding the cognitive foundation underlying low levels of compliance amongst nursery managers (Table 2).

Implications for improvement

The key to improving the impact of the regulation of the horticultural industry's role in the spread of IAPs will be to address each of these multiple systemic factors that hinder compliant behaviour. However, it is also important to supplement a narrow regulatory approach by strengthening the partnership between government and the industry. The findings of the survey suggest that nursery managers do not feel that they are treated as partners in a joint initiative with government. It is increasingly recognised that the effectiveness and relevance of policy implementation is enhanced by public participation in the decisionmaking and management processes, particularly if active and detailed enforcement is not going to be effective (García-Llorente et al. 2008; Humair et al. 2014). This approach not only provides a basis for informed decision-making, improved relevance and ongoing improvement of policy formulation, but is also crucial for encouraging stakeholder support for management interventions (Barbier et al. 2013; Humair et al. 2014). Internationally, a growing number of invasive species management schemes are drawing on participatory approaches to regulate the horticultural industry. For example, in Australia, the nursery industry has collaborated with the government to jointly develop prohibited species lists and initiate public awareness campaigns (Niemiera and Von Holle 2009). This level of collaboration or legislative consultation has not been developed in South Africa (Wilson et al. 2013).

Table 2 Summary of the key attitudinal and awareness factors that interviewed nursery managers identified as barriers to their compliance with the NEMBA invasive alien plant regulations.

This is conceptualised within Ajzen's (2001, 2002) analytical framework of belief concepts. Suggested responses to the factors impacting on compliance are given

blems	
Develop self-regulation supported by legal enforcement	
Build positive consumer pressure through awareness- raising campaigns	
Facilitate mutual information exchanges between government and nursery industry stakeholders	

However, in 2002, a cooperative agreement between SANA, the National Department of Agriculture, and the Working for Water (WfW) programme (the DEA-led national agency responsible for managing IAP control) was formed (Foxcroft et al. 2008). Amongst other roles, the key aim of the Working for Water Nurseries Partnership Programme (WfW NPP) is to use public awareness campaigns and training programmes to enhance the levels of awareness amongst horticulturalists and the public about IAPs and relevant legislature (Wilson et al. 2013).

While the WfW NPP's efforts represent an important acknowledgement of the need to engage with the industry this appears to not yet have been achieved. Although the intention may have been to build a relationship between government and the horticultural industry, the partnership is only extended to SANAaffiliated nurseries. Given that the majority of nurseries are not members of SANA, this limits the scope of the initiative to a small proportion of the industry. However, the existing structures of the WfW NPP could be used to extend the scope and scale of the initiative to develop an inclusive working partnership and oversight system that could ensure contextually relevant mechanisms are developed and jointly implemented. It could also enable self-regulation to be used wherever possible, so that enforcement and sanctions need only be applied where self-regulation fails to ensure the effective control of IAPs.

The industry would be actively involved in the process of deciding how best to address each of the

challenges that they face in terms of compliance. A number of suggestions arising from the interviews are made in this regard (Table 2). In order to address the problems related to perceived poor communication, lack of support, and perceived lack of inclusion, the partnership could facilitate mutual information exchanges. This would allow nursery managers to stay informed about IAP issues and legislation, enable government to learn from the experience of nursery mangers, and enable collaborative decisions to be made about how to address the grey areas in the legislation. The partnership could also ensure positive compliance pressures by fostering greater public awareness and enhancing pro-environmental consumer pressure through collaborative consumer awareness-raising campaigns that could involve labelling of IAPs and the promotion of non-invasive alternatives. In order to tackle the perception that there are no repercussions for non-compliance, enforcement of the NEMBA regulations will need to be augmented, but only once enabling conditions for compliance have been established and without defaulting to a 'command and control' approach.

An inclusive approach to enforcement could involve encouraging the nursery industry to police itself. One way to enhance the effectiveness of selfregulation would be to create public awareness and a demand for environmentally responsible nurseries and to initiate a publically recognisable certification system for nurseries that are fully compliant with IAP regulations. Aside from fostering a sense of involvement in the regulatory process, and therefore of shared responsibility, this approach would also enhance efficiency by taking some of the pressure off the limited resources government has available for enforcement (Badenhorst 2011). In this regard, most recent international efforts designed to prevent the spread of IAPs centre on nurturing and promoting voluntary self-regulation of the horticultural industry (Baskin 2002; Reichard 2004; Burt et al. 2007). It is important to note that self-regulation may need to be complemented with formal legal enforcement to deal with individuals that resist self-regulation so that the industry's efforts are not undermined by those who continue to profit from non-compliance (Drew et al. 2010).

While there are clearly many inhibiting factors that will need to be addressed in order to improve the impact of regulation of the horticultural industry, it is encouraging to note that there are also a number of enabling factors that present positive opportunities for regulation. Some of the enabling conditions required for effective self-regulation (Dehnen-Schmutz and Touza 2008; Drew et al. 2010) appear to be in place. For instance, the expense of compliance is not widely reported to be an obstacle by nursery managers. In addition, there is evidence of widespread understanding of the problems that IAPs cause and reported support for the control of invasives. There is also a reportedly strong sense of duty to protect the environment. Indeed, the overwhelming majority of nursery managers indicated that levels of compliance would be boosted if government were to encourage a selfregulatory approach.

Conclusion

The results of this study have revealed that there is a deep-rooted pattern of non-compliance with IAP regulations in Cape Town's nursery industry. The limitations of a reliance on regulation alone have been compounded in this case by issues arising from the levels of awareness and attitudes of many nursery managers. A range of relatively concrete actions may be taken to strengthen the level of commitment and compliance of nursery managers. This could be done in two major ways. The first could be achieved in the short term and would involve strengthening the operational elements of regulation itself. This could

involve enhanced user-friendly communication with key role players, ensuring the list of approved sterile cultivars is publically available, agreeing with the nursery industry on standardised plant labelling, and improving the clarity of the regulations and their implications, including their relation to CARA. The second group of actions would be focused on supplementing the regulatory 'command and control' approach with a longer-term orientation to strengthening a partnership with the nursery industry and developing a common commitment to relevant values and goals. This would ultimately reduce the need for active enforcement by government officials. It is suggested that these two broad measures will provide a stronger basis for future successful control of IAPs in South Africa.

Acknowledgements The authors are grateful to the following people for their assistance and support: Katya Mauff for statistical assistance; Ariella Rink and Lukas Otto for assistance with data collection; Ana Novoa, Guy Preston and Kay Montgomery for advice and insight with the project design; and Ernita Van Wyk for useful comments on the manuscript. HK acknowledges support from the Working for Water (WfW) Programme of the South African Department of Environmental Affairs, through the South African National Biodiversity Institute Invasive Species Programme. Lastly, we thank the nursery managers who agreed to participate in this study and took the time to respond to the questionnaire.

Compliance with ethical standards

This research was approved by the University of Cape Town Faculty of Science's Research Ethics Committee (7 October 2014, FSREC 074).

Conflict of interest The authors declare that they have no conflict of interest.

Informed consent Prior to being interviewed, participants were provided with an informed consent letter, detailing the content of the interview, how the information would be used and assurances that strict confidentiality would be preserved.

References

- Abdi H, Valentin D (2007) Multiple correspondence analysis.
 In: Salkind N (ed) Encyclopedia of measurement and statistics. Sage, Thousand Oaks, pp 651–657
- Ajzen I (2001) Nature and operation of attitudes. Annu Rev Psychol 52(1):27–58
- Ajzen I (2002) Perceived behavioural control, self-efficacy, locus of control, and the theory of planned behaviour. J Appl Soc Psychol 32:1–20

- Alston KP, Richardson DM (2006) The roles of habitat features, disturbance, and distance from putative source populations in structuring alien plant invasions at the urban/wildland interface on the Cape Peninsula, South Africa. Biol Conserv 132(2):183–198
- Badenhorst AB (2011) An investigation into the compliance of selected nurseries and garden centres within Kwazulu-Natal Ethekwini and the Umsunduzi geographical regions, with the Conservation of Agricultural Resources Act 1983 (Act no. 43 of 1983) CARA and the National Environmental Management: Biodiversity Act 2004 (Act no. 10 of 2004) NEMBA. Dissertation, University of South Africa
- Barbier EG, Knowler D, Gwatipedza J, Reichard SH, Ransom-Hodges A (2013) Implementing polices to control invasive plant species. Bioscience 63:132–138
- Baskin Y (2002) The greening of horticulture: new codes of conduct aim to curb plant invasions. Bioscience 52(6):464–471
- Burt JW, Muir AA, Piovia-Scott J, Veblen KE, Chang AL, Grossman JD, Weiskel HW (2007) Preventing horticultural introductions of invasive plants: potential efficacy of voluntary initiatives. Biol Invasions 9(8):909–923
- Crompton T, Weinstein N, Sanderson B, Kasser T, Maio G, Henderson S (2014) No cause is an island: how people are influenced by values regardless of the cause. Common Cause Foundation, London
- de Lange WJ, van Wilgen BW (2010) An economic assessment of the contribution of biological control to the management of invasive alien plants and to the protection of ecosystem services in South Africa. Biol Invasions 12(12):4113–4124
- Dehnen-Schmutz K, Touza J (2008) Plant invasions and ornamental horticulture: pathway, propagule pressure and the legal framework. Floric Ornam Plant Biotechnol 5:15–21
- Dehnen-Schmutz K, Touza J, Perrings C, Williamson M (2007) The horticultural trade and ornamental plant invasions in Britain. Conserv Biol 21(1):224–231
- Dobson A (2007) Environmental citizenship: towards sustainable development. Sustain Dev 15(5):276–285
- Drew J, Anderson N, Andow D (2010) Conundrums of a complex vector for invasive species control: a detailed examination of the horticultural industry. Biol Invasion 12(8):2837–2851
- Foxcroft LC, Richardson DM, Wilson JR (2008) Ornamental plants as invasive aliens: problems and solutions in Kruger National Park, South Africa. Environ Manag 41(1):32–51
- Fulton DC, Manfredo MJ, Lipscomb J (1996) Wildlife value orientations: a conceptual and measurement approach. Hum Dimens Wildl 1(2):24–47
- García-Llorente M, Martín-López B, González JA, Alcorlo P, Montes C (2008) Social perceptions of the impacts and benefits of invasive alien species: implications for management. Biol Conserv 141(12):2969–2983
- Grant AM (2008) Does intrinsic motivation fuel the prosocial fire? Motivational synergy in predicting persistence, performance, and productivity. J Appl Psychol 93(1):48

- Humair F, Siegrist M, Kueffer C (2014) Working with the horticultural industry to limit invasion risks: the Swiss experience. EPPO Bull 44(2):232–238
- Husson F, Josse J, Lê S, Mazet J (2011) FactoMineR: multivariate exploratory data analysis and data mining with R. R package version 1.16
- Kinght T, Havens K, Vitt P (2011) Will the use of less fecund cultivars reduced the invasiveness of perennial plants. Bioscience 61(10):816–822
- Le Maitre DC, Mgidi TN, Schonegevel L, Nel J, Rouget M, Richardson DM, Midgley C (2004a) Plant invasions in South Africa, Lesotho and Swaziland: assessing the potential impacts of major and emerging plant invaders. CSIR Environmentek, Stellenbosch
- Le Maitre DC, Richardson DM, Chapman RA (2004b) Alien plant invasions in South Africa: driving forces and the human dimension: working for water. S Afr J Sci 100(1 & 2):103–110
- Niemiera AX, Von Holle B (2009) Invasive plant species and the ornamental horticulture industry. In: Management of invasive weeds, pp 167–187. Springer, Netherlands
- Paterson AR (2006) Clearing a path towards effective alien invasive control: the legal conundrum. Potchefstroom Electron Law J 9(1):1–56
- Reaser JK (2001) Invasive alien species prevention and control: the art and science of managing people. In: McNeely JA (ed) The great reshuffling: human dimensions of invasive alien species. IUCN, Cambridge, pp 5–20
- Reichard S (2004) Conflicting values and common goals: codes of conduct to reduce the threat of invasive species. Weed Technol 18:1503–1507
- Reichard SH, White P (2001) Horticulture as a pathway of invasive plant introductions in the United States. Bioscience 51(2):103–113
- Richardson DM, Cambray JA, Chapman RA, Dean WRJ, Griffiths CL, Le Maitre DC, Newton DJ, Winstanley TJ (2003) Vectors and pathways of biological invasions in South Africa: past, present and future. In: Ruiz G, Carlton J (eds) Invasive species. Vectors and management strategies. Island Press, Washington, pp 292–349
- Sharp RL, Larson LR, Green GT (2011) Factors influencing public preferences for invasive alien species management. Biol Conserv 144(8):2097–2104
- Stern PC (2000a) Psychology and the science of human-environment interactions. Am Psychol 55(5):523
- Stern PC (2000b) New environmental theories: toward a coherent theory of environmentally significant behaviour. J Soc Issues 56(3):407–424
- Vanderhoeven S, Piqueray J, Halford M, Nulens G, Vincke J, Mahy G (2011) Perception and understanding of invasive alien species issues by nature conservation and horticulture professionals in Belgium. Environ Manage 47(3):425–442
- Wilson JR, Ivey P, Manyama P, Nänni I (2013) A new national unit for invasive species detection, assessment and eradication planning. S Afr J Sci 109(5–6):1–13