Biol Invasions (2016) 18:1599–1609
DOI 10.1007/s10530-016-1104-7

ORIGINAL PAPER

Knowledge, perceptions and willingness to control designated invasive tree species in urban household gardens in South Africa

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Received: 16 July 2015 / Accepted: 29 February 2016 / Published online: 10 March 2016
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Abstract Many biological invasions result in negative impacts on the environment and human livelihoods, but simultaneously some also provide benefits that are valued differently by various stakeholders. To inform policy and management of invasive species it is important to assess landowners' and broader society's knowledge and perceptions of invasive species, something which is lacking in many contexts, especially in urban settings. In this study we interviewed 153 householders living in a medium-sized South African town who had declared invasive alien trees in their gardens. Less than half of the respondents could identify the invasive tree on their property and only one-third knew that it was an invasive alien species. There was a positive association between income and education levels with exposure to media about invasive alien species and respondents' ability to identify the species and name any other invasive alien tree species. Knowledge levels were unequal across species. Amongst those who knew the tree was an invasive alien species, reasons why they retained it in their gardens included that it would be costly or too much effort to remove, they liked the tree, that it was not causing any harm and that the property was rented and so its removal was not their responsibility. However, the majority of people (83 %) were willing to have it removed from their garden if done for free by appropriate agencies, which is promising for compliance with new regulations on invasive species implemented at the end of 2014 in South Africa. The results also highlight the need for targeted and appropriate education and awareness programs amongst urban householders on invasive alien species, relevant legislation and their obligations.

Keywords Declared species · Garden · Invasive tree · Removal · Urban

Introduction

In past centuries the movement of humans around the globe has led to purposeful and accidental introductions of non-native species into new locations outside of their natural habitats (Mack 2003; Kull et al. 2011). This has resulted in biological invasions which are now a major driver of global change, causing a variety of ecological, economic and social impacts (Pimental et al. 2000; Jeschke et al. 2014). However, many of these introduced, or alien, invasive species are used and valued by humans for agriculture, agroforestry, forestry, subsistence and horticulture, thereby often causing conflicts of interest around their use and management (Shackleton et al. 2007; Dickie et al.

Electronic supplementary material The online version of this article (doi:10.1007/s10530-016-1104-7) contains supplementary material, which is available to authorized users.

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2014; Shackleton et al. 2014; van Wilgen and Richardson 2014). Consequently, management of these invasions needs to be informed by knowledge of species attributes and their use (Robertson et al. 2003), whilst being flexible, adaptive and context specific (Shackleton et al. 2007; van Wilgen and Richardson 2014).

Most research on biological invasions has been approached from ecological or economics perspectives, which are insufficient when faced with conflict of interest situations (Warner and Kinslow 2011). Research and understanding on the social dimensions of and attitudes towards invasive species are still relatively undeveloped (McNeely 2011; García-Llorente et al. 2008, 2011; Shackleton et al. 2015). Understanding peoples' levels of knowledge and perceptions of invasive species and the role of invasive species in livelihoods is important to comprehend the felt and perceived costs and benefits surrounding any conflicts of interest and thereby guide policy frameworks and management options (Shackleton et al. 2007; Verbrugge et al. 2013; Shackleton et al. 2015). Policy frameworks need to be sufficiently comprehensive and robust, yet flexible to include and account for the multiple settings, perspectives and types of conflicts of interest. Some authors have assessed the perceptions of rural land owners or environmental managers regarding their knowledge of invasive alien species (IAS) and the threats they pose (e.g. Bardsley and Edward-Jones 2006; Andreu et al. 2009; Kapler et al. 2012), but research into the knowledge, perceptions and motivations of the urban dwellers is scarce (Verbrugge et al. 2013; Shackleton et al. 2015).

With respect to settings, most research and understandings on invasion dynamics, impacts and control is conducted in rural and conservation areas, due to the more obvious negative ecological impacts on ecosystem services such as water yield, grazing production, pollination, biodiversity and recreational enjoyment (Holmes et al. 2009). In contrast, the framing of debates and policies around IAS in urban settings has received scant attention. This is surprising because, firstly, the majority of currently invasive plant species arose from horticulture practiced most widely in urban settings (Richardson and Rejmánek 2011) and continue to be major sources and pathways of invasion into agricultural and natural lands (Reichard and White 2001; Marco et al. 2010; Donaldson et al. 2014). In addition, many urban IAS have long-range dispersal mechanisms and can be the sources of new invasions into rural areas. For example, *Solanum mauritianum* is dispersed widely by birds (Jordaan et al. 2011), whilst *Ailanthus altissima* can be dispersed by water, with streams from urban areas carrying propagules into downstream rural environments leading to the establishment of new invasions (Säumel and Kowarik 2010). Secondly, conflict over management or removal of invasive alien trees appears to be most prevalent in urban or near-urban areas (Dickie et al. 2014). Urban forestry and urban ecology studies have long noted the propensity for urban settings to have high numbers of non-native species as a consequence of deliberate introductions and spontaneous invasions into disturbed or unmanaged urban spaces (McConnachie et al. 2008; Kowarik 2011; Moro and Castro 2015). Indeed, urban settings pose very different contexts because of (1) the small scale of land management units (gardens, parks, roadsides, corporate grounds, vacant lots) (2) a fine-scale mosaic of different tenure systems in close proximity resulting in multiple owners or decision-makers of what species are planted, retained or 'controlled' and (3) a great variety of alien, and at times invasive, species planted for largely aesthetic purposes (Dolan et al. 2011). It is also possible that urban dwellers have less experience and knowledge of IAS because they are less reliant on the immediate use of their surrounding natural environment for their primary means of a living. Consequently, understandings of urban IAS will be beneficial for awareness and management of IAS in both urban and rural areas.

Being a mega-diverse country South Africa has a long history of attempting to limit the ecological impacts of biological invasions (van Wilgen et al. 2012; van Wilgen and Wannenburgh 2016). This includes legislation regarding IAS management, the backbone of which is the Conservation of Agricultural Resources Act (CARA) (Act 43 of 1983), which listed 193 species, classified into three groups based on invasiveness and potential impacts and subsequently what actions need to be taken for their control or elimination (see Table 1 for more explanation). Similar categorisations have also been adopted in Australia and Japan (Australian Weeds Committee 2012; Ohsawa and Osawa 2014). This Act was further streamlined and empowered under the National Environmental Management of Biodiversity Act (NEMBA) (Act 10 of 2004) which has the same

categories. New regulations were recently (August 2014) promulgated under NEMBA, which seek to further regulate the distribution, propagation, planting and sale of 138 IAS (Department of Environmental Affairs 2014). Under these new NEMBA regulations all property owners are obliged to list any of the designated IAS present and remove them before sale of the property. If declared IAS are not removed, the purchaser of the property can require that the cost of IAS removal be subtracted from the property selling price. Similar legislation regarding IAS is also present in Australia and the United States. Such efforts align with the obligations of signatory countries to the Convention on Biodiversity to produce policies to manage and mitigate the negative impacts of biological invasions.

This long history of IAS management in South Africa has been backed by substantive and world renowned IAS control programmes, most notably the "Working for Water" programme (Buch and Dixon 2009; van Wilgen et al. 2012; van Wilgen and Wannenburgh 2016). Linked to this programme has been substantial media exposure of the ecological impacts of IAS, especially in relation to reduced water yields, which is of national importance in a semi-arid country such as South Africa. The 'scourge' of IAS and the efforts of the Working for Water programme feature regularly in newspapers, environmental magazines and on television, and they appear in part of the national school curriculum. It is therefore expected that, in general, South African citizens should be well informed on the impacts of IAS in South Africa.

Within the context of the above, this paper reports on findings from a research project to ascertain: (1) the reasons why some urban households have declared invasive tree species within their gardens, (2) whether householders would be willing to remove the invasive tree from their garden, (3) urban residents' knowledge of invasive species and (4) if respondent profile was correlated with levels of knowledge about IAS and willingness to have them removed.

Study area

Grahamstown (33°18′S; 26°33′E) is a medium-sized town in the Eastern Cape province of South Africa, with a population of approximately 70,000 people. It is the administrative centre of the Makana local municipality. Having been founded as a military base during the colonial frontier wars of the early 1800s, it is now a well-known educational centre, with a university and numerous private and state schools. Grahamstown is located at an altitude of 650 m.a.s.l and has a moderate climate with an average seasonal temperature ranging from 9.8 to 23.1 °C. The hottest months are December to March and the coldest months are June and July (Climatedata.eu 2013). It receives, on average, 669 mm of rainfall annually (State of the Environment in South Africa 2007), with bimodal peaks in October–November and again in March–April, largely as frontal rain showers. The city is situated within a region of high biodiversity as it lies in the convergence zone of four major biomes, namely, fynbos, grassland, thicket and karoo (Mucina and Rutherford 2006). At the local scale, the natural vegetation is grassy fynbos and grasslands on the hill tops, with dense woody thicket in the valleys (Mucina and Rutherford 2006).

Approximately 42 % of the adult population have only primary schooling or less, and 11 % have a school leaving certificate or higher (Makana IDP 2011). The level of unemployment is 34 %, which is higher than that of the province or country as a whole. Of those who are employed (32.1 %), 19 % hold elementary occupations, while 17 % are professionals (Makana IDP 2011). Almost one-quarter (23 %) of households subsist on a cash income below the national poverty line. Mean housing density varies from 4.3 ha^{-1} in the more affluent western suburbs to 32.3 ha^{-1} in the newly constructed low-cost state housing areas (reserved for the indigent) in the east (McConnachie and Shackleton 2010).

Methods

Data collection consisted of two phases. The first was to identify a sample of households in Grahamstown that had one or more declared invasive trees in their garden. The second was to then interview a willing adult respondent within these households. Location of households was achieved via drive-by surveys noting the street name and house number for properties that had visible invasive trees. The data cannot be used to assess prevalence of invasive trees because at most households it was impossible to see into the whole property. Up to six roads were sampled per eleven

randomly selected suburbs of the city across the socioeconomic spectrum. A sample of 150 households was sought, and the final number of households interviewed was 153.

Each house noted as having an invasive alien tree was subsequently visited and permission sought to interview the household head or any other adult member about the invasive tree on their property and IAS more broadly. The questionnaire had two sections (see online "Appendix"). The first contained questions covering subjects such as (1) could they identify the IAS tree in their garden, without us mentioning that it was an IAS, (2) how the tree was established (present before they occupied the house, planted or wildling), (3) did they know if it was indigenous or alien, (4) did they know it was a nationally declared invasive alien species in terms of South African legislation, (5) if they did, why did they retain it and would they be willing to have it removed for free, (5) if they did not know it was a declared weed, having now learnt it was, would they be willing to have it removed, (6) could they name any other declared IAS tree and did they know any threats posed by IAS. Care was taken not to lead the respondent, and during the initial questions we made no mention of the selected tree being an IAS. All questions pertained to the specific IAS tree as recorded during the drive-by survey, even if other IAS were noticed once on the property. The second section captured the respondent's demographic profile, such as age, gender, level of education, years in the town, membership of an environmental society, ownership or renting of the property and who was mostly responsible for working in the garden. Lastly, permission was sought to measure the diameter at breast height (dbh) of the noted invasive tree.

Nominal answers were classified and provided numerical codes prior to analysis and treated as continuous variables. Differences in response frequencies between species were examined by means of Chi squared tests. Potential correlations between respondents' demographic characteristics and knowledge of invasive tress (could identify the invasive tree species, could name another invasive tree species) were examined via a principal components analysis (PCA) with all variables scaled to between 0 and one against the highest value. The characteristics of respondents willing or unwilling to have the IAS removed were compared via *t* tests, as were those who had planted the IAS relative to those who had not planted it.

Results

Demographics of the sample population

The respondents' age ranged from 22 to 85 years, with a mean of 44 ± 15 years. Both genders were adequately represented, with 49 % females and 51 % males. The number of years of formal education varied between 1 and 22, with an average of 12 ± 4. Seven percent of the respondents stated that they were members of an environmental society or organisation. Self-rating of environmental awareness on a five points scale (1 having no environmental awareness and 5 being highly aware) averaged 2.5 ± 1.2.

Identification and knowledge of invasive trees

Just under half of the respondents (43.6 %) could successfully identify the invasive tree asked about in their garden. Irrespective of whether they knew the name, 51.6 % thought that the invasive tree in their garden was indigenous, 32.3 % stated that it was not indigenous and the remainder (16.1 %) did not know. Not unsurprisingly, therefore, more than three-quarters of the respondents (76.6 %) did not know that the species under discussion was a nationally designated invasive tree species. The prevalence of knowledge of whether or not the species under question was an invasive differed between species (Table 1). For *Acacia mearnsii* and *Jacaranda mimosifolia*, the majority of respondents knew that they were declared invaders, whereas for *Cestrum laevigatum*, *Melia azedarach*, *Schinus molle* and *S. mauritianum* the significant majority were unaware of the species' status as a declared invasive.

Those respondents who knew that the tree in their garden was an invader were more likely (70 %) to be able to name another invasive plant than those respondents who did not ($\chi^2 = 49.5$; $p < 0.0001$). Similarly, those who did not know that their tree was an invasive were relatively unlikely (11.2 %) to be able to name another invasive plant. Overall, 75.8 % of respondents could not name another invasive plant. Nineteen different IAS species were mentioned, with the three most common being *A. mearnsii*, *Eucalyptus* species and *Lantana camara* (Table 2).

Table 1 Proportion of respondents who knew the IAS species in their garden was a declared IAS

Species	South African IAS category[a]	Proportion who knew it was an IAS (%)		Chi square	*p*
		Yes	No		
Acacia mearnsii	2	83.3	16.7	43.5	<0.0001
Cestrum laevigatum	1	4.5	95.5	81.0	<0.0001
Jacaranda mimosifolia	3	78.3	21.7	31.4	<0.0001
Melia azedarach	3	16.8	83.2	43.6	<0.0001
Schinus molle	3	0	100.0	100.0	<0.0001
Solanum mauritianum	1	16.2	83.8	46.2	<0.0001
Others (6 species)		25.0	75.0	25.0	<0.0001
Total		23.4	76.6	64.6	<0.0001

[a] IAS category (1 = species may not be propagated, distributed, sold or grown and they must be removed wherever they occur. 2 = may be permitted under controlled, managed conditions in certain areas, but all individuals outside the designated areas must be removed, including domestic gardens. 3 = cannot be propagated, sold or planted without special permits, but need not be removed unless within 30 m of the 50 year flood-line)

Establishment of invasive trees in gardens

Of the total number of invasive trees recorded (220), 58.8 % of respondents stated that the tree was already there when they first moved to that property, whereas 41.2 % identified that the IAS had established after their occupation of the house. The dbh of the sampled trees ranged between 23 and 262 mm (mean dbh = 98.4 ± 40.2 mm), indicating a wide range of probable establishment dates. Of this latter group, over half (56.5 %) said that they had planted the tree, with the remainder stating that it had self-seeded in their garden. The primary mode of propagation differed between species. *M. azedarach* and *S. molle* were usually planted (71 and 83 %, respectively) rather than self-seeded, *C. laevigatum* establishment was equal between the two modes and the remainder were largely self-seeded, with *A. mearnsii* and *Senna didymobotrya* 100 % self-seeded and *S. mauritianum* 75 %. There were no significant differences in the profile of respondents (age, gender, education, income, level of environmental awareness, reading of materials) who had planted the IAS in their garden relative to those who had not planted it.

Reasons for retaining invasive trees in gardens

Fifteen different reasons were provided for retaining the invasive tree in the garden of those respondents who knew that the species was a declared invader (Fig. 1). Some of the respondents who were well aware of their tree's invasive status had tried to remove it but it was regrowing or they said that the effort or expense of removing it was too high and therefore a reason for inactivity. On the other hand, many respondents listed attributes that they liked about the invasive tree in their garden and did not wish to remove it. Such reasons included its beauty or shade, that it attracts birds or insects, that they have cherished memories associated with that specific tree, that it screens their property from the street, or that it has a tree house or climbing structures in it. With respect to *J. mimosifolia*, several responded that it was only a Category 3 alien species in terms of the South African regulations and therefore there was no obligation to remove it. The joint fourth-most common reason for retaining the tree was that respondents felt it was not causing any harm.

Although some respondents retained invasive trees in their gardens for perceived benefits, the majority (82.6 %) of all respondents were willing to have the tree removed if the municipality or the Working for Water programme provided the service free of charge. Most of those unwilling to have it removed were the ones who had motivated the retention of the tree on the basis of what they deemed as desirable attributes. A few mentioned that they would be willing to have it removed, but that the removing agency should provide them with a replacement tree for their garden. Those who were unwilling to have the IAS removed were significantly older ($t = 2.99$; $p < 0.005$) than those who were (53 ± 16 and 42 ± 15 years, respectively)

Table 2 Additional tree species mentioned by respondents as an IAS (other than the species in their own garden)

Species	South African IAS category	Rank	% of respondents mentioning
Acacia mearnsii	2	1	22.5
Eucalyptus species	2	2	19.7
Lantana camara	1	3	15.5
Pinus species	2/3	4	9.9
Jacaranda mimosifolia	3	5	4.2
Solanum mauritianum	1	5	4.2
Others (*Acacia longifolia* (1), *A. saligna* (2), *Cereus jamacaru* (1), *Grevillea robusta* (3), *Hakea sp.*(1), *Ligustrum sp.*(3), *Melia azedarach* (3), *Morus sp.* (3), *Opuntia aurantiaca* (1) *Opuntia ficus-indica* (1) *Schinus molle* (3), *Sesbania punicea* (1)			<4 %
Unable to name an additional invasive tree plant			75.8

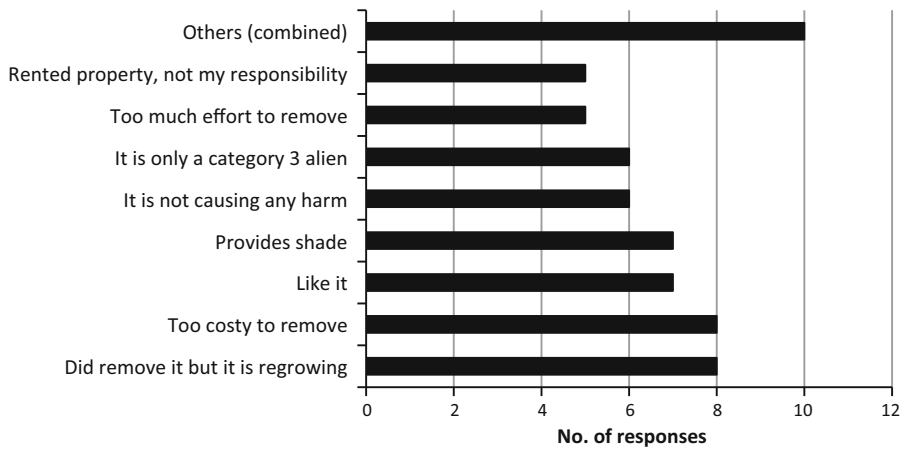

Fig. 1 Reasons why respondents retained tree IAS in their gardens. (*Note* in South Africa, category 3 alien species need not be removed, but cannot be planted)

and had a significantly higher ($t = 2.03$; $p < 0.05$) self-rating of their own environmental awareness (2.9 ± 1.3 and 2.3 ± 1.1, respectively). There were no significant differences between the two groups in other personal attributes such as gender, education, income or exposure to IAS media.

Drivers of knowledge of invasive trees and perceived threats they pose

The PCA indicated that there was a positive association between levels of education, exposure to news sources about invasives and income bracket and the ability to identify the invasive species in the garden as well as list other invasive species (Fig. 2). There was little influence of respondent gender or their self-ranking of their environmental awareness and their ability to identify the species or mention any other invasive species.

Only one-third (35.9 %) of respondents were able list one or more potential threats posed by tree invaders. Sixteen different potential threats were mentioned across all respondents, with a mean of 1.6 ± 0.71 per respondent (range 1–4). Most of the sixteen threats were mentioned by only one or two respondents, and only three threats were mentioned by five or more respondents. These were that invasive trees use large volumes of water (74.5 %), they displace or disrupt indigenous species (49.1 %) and they spread very fast and encroach land (9.1 %).

Discussion

These results show that the respondents had a poor knowledge of invasive trees and their associated potential threats, which is similar to many other regions of the world (Colton and Alpert 1998; Daab

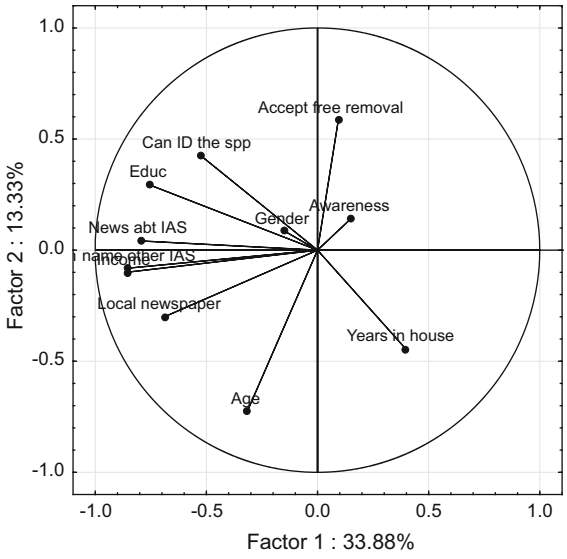

Fig. 2 Principal components analysis plot of relationships between respondent characteristics and willing to accept free removal of IAS from their garden and knowledge of IAS (ability to identify the IAS species and name other IAS species)

and Flint 2010; Verbrugge et al. 2013). Knowledge and understanding relating to invasive species and other environmental issues by the public is important when it comes to policy and management implementation, and a lack of understanding can hinder, delay or even derail effective implementation of management practices due to the supply of benefits or intrinsic value of some IAS (Warner and Kinslow 2011; Dickie et al. 2014). It is therefore important that scientists and implementing agencies have a sound understanding of residents' knowledge and perceptions of IAS, but also to comprehend the underlying drivers of such perceptions and knowledge (Warner and Kinslow 2011; Crall et al. 2012).

Less than half the respondents could identify the invasive tree in their garden, only one-third knew that it was not indigenous, and only one-quarter of those knew it was a declared tree invader in terms of South African legislation. These figures are lower than expected given the high media coverage of impacts and control of IAS in South Africa, and lower than awareness and knowledge amongst farmers and rural communities (Shackleton et al. 2015). This is most likely because the direct impacts of IAS on the livelihoods of urban residents are less obvious to them and less than those experienced by rural land managers and owners. Low awareness and knowledge of IAS amongst the general public is not unique to our sample. For example, Colton and Alpert (1998) reported that knowledge of IAS was low amongst a sample of 206 general visitors to a research facility in California (USA), with most of the respondents equating IAS with weeds, which were a nuisance rather than a significant biological or economic threat. Daab and Flint (2010) found that over 85 % of respondents in Colorado had heard of invasive alien species, but when asked about IAS specific to the respondent's area the proportion dropped to between 34 and 62 %. Similarly, Verbrugge et al. (2013), in a sample of 398 respondents along a rural–urban gradient in the Netherlands, found that 80 % were familiar with the term non-native (not necessarily invasive), but only 52 % of them could actually name a non-indigenous species and only 42 % could name any non-native species control programmes. Moreover, low levels of knowledge of specific species amongst urban populations is not unique to alien species, with several studies showing generally low levels of species level knowledge across a wide range of taxonomic groups (e.g. Randler et al. 2007; Shwartz et al. 2014; Voight and Wurster 2015).

These low levels of knowledge may have one or more underlying reasons. Firstly, it may be that there is insufficient media coverage of, or other forms of information on, IAS and their impacts. Secondly, it may be that there is sufficient media coverage or information but that it is inappropriately packaged or targeted and so poorly received. Lastly, it may be that the public receive the media messages but do not translate them as being applicable to their own personal space (they see the problem of IAS as something 'out there'; on farms, roadsides, degraded lands). Differentiating these would require an in-depth analysis of IAS in the media in South Africa. There is significant media coverage of IAS impacts and control in South Africa, discrediting the first hypothesis. Daab and Flint (2010) reported that general awareness of IAS was significantly correlated with exposure to relevant communications from government agencies and media articles in newspapers. Our results show that exposure to media was positively related to knowledge of IAS, both of which were in turn positively related to education levels and household income. This suggests that perhaps different types of media and a range of languages and formats of the core messages may be required to target members of the

public with lower education levels (bearing in mind that 42 % of Grahamstown's population have only a few years of basic education). For example, what proportion of media coverage about IAS is in the home language of the local residents in this part of South Africa? Having knowledge on invasives has been seen to be important in increasing support for their management (García-Llorente et al. 2011; Verbrugge et al. 2013). In addition the possibility of how the message is conveyed might be flawed and militaristic metaphors might make people lose interest; the topic of "marketing"/conveying the issue and educating the public needs further research and attention (Larson et al. 2005; Warner and Kinslow 2011; Crall et al. 2012). Lack of understanding of layperson perceptions and knowledge can hinder IAS management programs and lead to wasted resources (Warner and Kinslow 2011).

Whilst the overall level of knowledge of declared IAS was low, it was not uniform across different species, with some species being better known than others. We speculate that *A. mearnsii, Eucalyptus* spp. and *L. camara* were more well-known because they have high impacts and therefore are ranked highly in terms of research and control (Robertson et al. 2003) and consequently receive greater media coverage in South Africa. Similar disparities on the level of knowledge around IAS were reported by Ohsawa and Osawa (2014) in Japan. They also demonstrated that legislative listing of specific IAS prompted increased research, eradication programmes, and media exposure. This implies that as the new NEMBA regulations become more widely known in South Africa, knowledge amongst the lay public about common or key IAS should increase as long as media coverage continues.

Invasive species are transported and become established through various pathways and vectors (Wilson et al. 2009). Amongst our respondents, more than one-fifth reported they had planted the invasive tree, with an additional 58 % stating it was already established when they moved in (of which a similar proportion were probably planted by previous occupants). Most of these planted invasive trees have desirable horticultural traits, such as being fast growing, providing good shade and are aesthetically pleasing, and included species such as *C. laevigatum, J. mimosifolia, M. azedarach* and *S. molle*. This was expected as more than 60 % of invasive trees and shrubs globally are a consequence of the horticulture industry (Richardson and Rejmánek 2011). However, many countries now have active engagement with plant nurseries and distributors to limit the propagation and sale of listed invasives for that country, including in South Africa (e.g. Burt et al. 2007; Coats et al. 2011). Nonetheless, several invasive trees commonly established in peoples' gardens unintentionally through bird dispersed seeds, including *C. laevigatum* and *S. mauritianum*. Thus, nursery-based control strategies alone will be ineffective and there is need for complementary, enhanced engagement with the broader public.

Once the listed invasive trees were established in gardens most respondents did not remove them for various economic, aesthetic and policy related reasons. Additionally, many lacked knowledge on IAS and their impacts and perceived that the invasive trees were not causing any harm, once again questioning the nature and adequacy of information distributed to the public. The escape of IAS from urban gardens is a common pathway for invasion into agricultural, natural and rangeland areas (Alston and Richardson 2006), as well as other lands and properties within an urban landscape (le Maitre et al. 2004). It was noteworthy, however, that 83 % of respondents were willing to let appropriate agencies remove the declared invasive trees in their garden (13 % who knew it was an IAS had already tried unsuccessfully to remove it), which is promising with regard to the new NEMBA policy and programmes to promote removal of IAS from domestic gardens. This is similar to the 86 % of respondents in favour of control of non-native species in the Netherlands (Verbrugge et al. 2013), although support for control varied according to species. These values are on average 10 % higher than in reports from other studies in South Africa (Shackleton et al. 2015). Daab and Flint (2010) reported that 58 % of their respondents had taken actions to remove IAS, but the highest action was against herbaceous species, and there were general concerns about the cost or time to remove other IAS. Given that most of the respondents were not initially aware that they had an IAS, this high proportion also bodes well for the potential effects of any comprehensive information campaigns.

Although the considerable majority of respondents were willing to have the IAS tree removed from their property, 17 % remained unwilling, which is probably sufficient to continue to pose an invasion risk to surrounding landscapes and neighbouring properties. The economic implications of not removing invasive

species when selling properties (under NEMBA) might provide some incentive or compulsion for some of these to remove IAS from their gardens whilst they are still small and more manageable. Respondent age had a negative association with willingness to remove the invasive tree, which may be a reflection of their longer attachment to a specific tree or sense of place on a specific property and its appearance. Counter-intuitively respondents with higher self-rating of their own environmental awareness were less likely to support removal of the IAS than respondents with lower self-ratings. This illustrates what Cook et al. (2011) describe as the "complex relationship between environmental values and ecologically friendly landscaping values". This is echoed for example, by findings of more ecologically aware households at times using more water or chemicals on their gardens than less ecologically aware respondents (Robbins and Birkenholtz 2003; Cook et al. 2011).

A further consideration for any information programmes or campaigns would be to consider the benefits that urban residents obtain from IAS, which lead to some maintaining them, even if they know that they are invasive. The most common reasons were that the IAS provided shade, had beautiful flowers and that it attracts birds or insects. All these benefits can also be provided by many different indigenous tree species across the various bioclimatic regions of the country. Thus nurseries and local government agencies could profile indigenous species with similar traits for replacing specific IAS so that residents obtained the same benefits that are currently provided by the IAS. The Botanical Society of South Africa has long had a campaign to encourage the cultivation of indigenous flora as replacements for exotic ones, albeit not targeted specifically at IAS.

As a relatively novel piece of work internationally, these findings point to the need to address a number of research questions to develop a more comprehensive understanding of IAS in urban settings, especially those under private tenure. As understanding develops it will allow for informed design of appropriate campaigns, strategies and policies to limit the negative impacts of IAS at local and broader scales. First, we see a need for more detailed understanding of the motivations that particular households have for maintaining specific IAS even when they know it is an IAS, and whether the benefits in which they are interested can be easily substituted by indigenous species? Secondly, is the attraction to or maintenance of specific IAS species related to their relative abundance in the local environment or more socially mediated? Thirdly, what sort of information and awareness campaigns are required to optimise success amongst populations with low literacy and formal education? And fourthly, how do urban residents perceive the disservices associated with IAS, as well as are they different to rural dwellers, and if so why?

In conclusion, this study shows that knowledge of IAS in an urban population in South Africa is limited, and is higher amongst people with higher education and exposure to media on IAS. This limited knowledge is likely to underpin the observed general absence of efforts by urban citizens to remove declared IAS from their gardens, because most were willing to have the IAS removed upon learning of its IAS status. This limited knowledge is likely to hinder uptake of the new NEMBA regulations for IAS control in urban areas of South Africa, requiring that they be accompanied by appropriate and targeted awareness raising campaigns, or that implementation will rest on consultants or state officials. Any awareness campaigns must be appropriately targeted and take cognisance of the low levels of education and literacy amongst large sectors of the South African population and multiple home languages.

Acknowledgments This work was funded by the National Research Foundation of South Africa under the rated researchers incentive grant to CS, for which we are grateful. We also thank and acknowledge the land owners who happily responded to our questions.

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