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Between approval and disapproval: Citizens' views on the invasive tree *Ailanthus altissima* and its management

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Abstract

While cities are invasion hotspots, the view of urban residents on non-native species is critically understudied – an important knowledge gap since strategies on biological invasions could gain power by integrating human values, attitudes and perceptions. How citizens perceive the non-native tree *Ailanthus altissima* (tree of heaven) is unknown despite its abundance in many cities globally and its classification as invasive in many countries. In a quantitative survey with closed questions, we analysed (i) whether residents of Berlin, Germany knew the widespread species, (ii) how they perceived it in different urban situations, (iii) how they accepted different management strategies of it, and (iv) how the sociodemographic background of respondents predicted their preference and acceptability ratings.

In total, we surveyed 196 respondents. Most respondents recognized the tree in a photograph, but few provided its correct name. Citizens' preferences differed significantly among four urban contexts in which the species was shown, with prevailing approval for trees as a component of designed green spaces and less pronounced preferences for wild-grown trees in other urban spaces. When respondents were asked to indicate how the tree should be managed (three options), we found the most support for removal in problematic cases ('adaptive on-site' strategy); some support was found for the 'leave alone' strategy and least support for the 'complete removal' management strategy. Practitioners with expertise in urban landscaping were more critical of *Ailanthus* than laypeople. Ordinal logistic regression analyses showed that respondents with a 'close to nature' behaviour and attitude had a more positive view on *Ailanthus* and expressed more support for 'leave alone' management. Results demonstrate the importance of citizens' context dependent views about a widespread invasive species, spanning from approval to disapproval in

different situations. We conclude that urban management strategies concerning *Ailanthus* would gain support from citizens when combining multiple approaches: (i) to control the species in case of realized negative impacts; (ii) to prevent the invasion of the species in areas of conservation concern; and (iii) to develop novel approaches of integrating wild *Ailanthus* trees into urban green spaces. These insights could support management measures that need to be established due to the EU-Regulation on Invasive Alien Species.

Keywords
acceptance, biodiversity valuation, invasive alien plant species, management strategies, public perception, urban green spaces, weed control, wild vegetation, xenophobia

Introduction

Biological invasions fundamentally have a human dimension because non-native species are defined as those species that humans have introduced into areas beyond their natural range (Essl et al. 2018). Many invasion studies therefore illuminate the role of humans as the driving force of invasions and analyse, for example, the pathways of introduction, transport and release of non-native species (Thellung 1915; Kowarik 2003; Hulme 2009; Kueffer 2017). Another important facet of the intersection between humans and biological invasions, however, is clearly understudied: people's view on non-native species and related management policies (Sharp et al. 2011; Abrahams et al. 2019; Kapitza et al. 2019).

Strategies on the management of biological invasions, ranking high on local, national and international agendas (Essl et al. 2020; Pyšek et al. 2020), could gain power through increased integration of human values, attitudes and perceptions (Crowley et al. 2017; Shackleton et al. 2019a), as generally posited for conservation strategies (Manfredo et al. 2017). Considering the socio-ecological context in the complex scenarios of species' invasions and their potential management could help transfer approaches from broader to more local scales and vice versa, and enhance their acceptance and efficiency (Crowley et al. 2017; Woodford et al. 2018; Shackleton et al. 2019b). This is important because whether and how introduced species are managed is highly debated and often evokes disapproval in society, especially when it comes to charismatic species (Fischer and Young 2007; Selge et al. 2011; Verbrugge et al. 2013; Novoa et al. 2017; Höbart et al. 2020; Jarić et al. 2020).

Views on non-native species and their management starkly differ among and within groups of the public, scientists and different stakeholders (e.g., Fischer et al. 2014; Lindemann-Matthies 2016; Novoa et al. 2016; Heink et al. 2018; Luna et al. 2019; Cordeiro et al. 2020; Gbedomon et al. 2020). Thus, transparency of values, beliefs and attitudes that underlie the assessment of non-native species is required to make impact assessments and related strategies traceable (Estévez et al. 2015; Bartz and Kowarik 2019).

Preference studies on the species level are generally still scarce in the urban context (Botzat et al. 2016). Yet a small but increasing number of studies have explored the public's view, or that of different stakeholders, on non-native species, their impacts and

related management strategies, as recently reviewed by Kapitza et al. (2019) and Shackleton et al. (2019b). Most previous studies have been conducted in rural environments or on a country scale (e.g., Kowarik and Schepker 1998; Andreu et al. 2009; Selge et al. 2011; Sharp et al. 2011; Fischer et al. 2014; Crête et al. 2020), while urban studies are scarce (but see Verbrugge et al. 2013; Lindemann-Matthies 2016; Shackleton and Shackleton 2016; Potgieter et al. 2019a; Nguyen et al. 2020; Shackleton and Mograbi 2020). This leads to a surprising paradox: the human perspective on biological invasions is least understood for cities – places where both the human population and the number of introduced species reach their peak (Pyšek 1998; Kühn et al. 2004). Cities are introduction hubs of non-native species and can be invasion foci for adjacent landscapes, and non-native species can conflict with biodiversity conservation or ecosystem provisioning in cities (Gaertner et al. 2017; Shackleton et al. 2019b; Kowarik and Fischer 2021).

Non-native species can, however, also play a beneficial role in cities by supporting a wealth of urban ecosystem services (Dickie et al. 2014; Potgieter et al. 2017; Vaz et al. 2018; Shackleton et al. 2019b; Schlaepfer et al. 2020). Cultivated non-native plants are an important component of urban green infrastructure (Petřík et al. 2019; Schlaepfer et al. 2020), and sometimes grow under harsh urban conditions where there are few alternatives among native species (Sjöman et al. 2016). Planting and maintaining non-native species in parks and gardens directly reflect how people appreciate them for aesthetical and other reasons (Lindemann-Matthies 2016; Vaz et al. 2018). In parallel, non-native species contribute to regulating and cultural ecosystem services to the same extent as native species, as Schlaepfer et al. (2020) quantified for Geneva, Switzerland. Comprehensive assessments of non-native species in urban settings thus need to consider the benefits of these species for urban societies alongside the trade-offs with conservation risks or other disservices (van Wilgen 2012; Dickie et al. 2014; Potgieter et al. 2019b; Shackleton et al. 2020). This necessitates a combination of approaches from ecology and the social sciences (Crowley et al. 2017; Shackleton et al. 2019c).

As a contribution to such approaches, we analysed the view of citizens on the non-native tree *Ailanthus altissima* (tree of heaven, henceforth *Ailanthus*) in Berlin, Germany. Our model species has been classified as invasive in many countries because it can threaten biodiversity, for example, in dry grassland or rocky habitats (e.g. Pergl et al. 2016). *Ailanthus* has been designated by experts as one of "100 of the World's Worst Invasive Alien Species" (ISSG 2017), but is not among the worst invasive species in Europe according to the results of an impact scoring approach (Nentwig et al. 2018). Nevertheless, in 2019 the species has been included in the "List of Invasive Alien Species of Union Concern" (European Commission 2019). It thus falls under the "Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species [IAS]" (European Parliament 2014). As for all listed widespread invasive species at present, each member state of the European Union must develop and implement management measures for *Ailanthus*, which should be "appropriate to the specific circumstances" and "based on an analysis of costs and benefits" (European Commission 2019). The development and implementation of such measures not only require ecological knowledge, but also the inclusion of people's views on

the respective species and possible management strategies (Brundu 2017). Therefore, our study aimed at understanding the views of citizens on *Ailanthus* in Berlin.

Since its introduction from China to Europe around 1750, *Ailanthus* has been planted in many cities (Kowarik and Säumel 2007). These plantings were the source for often prolific wild (i.e., spontaneous) populations in cities and along transportation corridors outside cities (Kowarik and Säumel 2007; McAvoy et al. 2012; Casella and Vurro 2013; Kim 2016; Walker et al. 2017; Luigi Nimis et al. 2019; Paź-Dyderska et al. 2020). Some rural populations also exist in forest gaps (e.g. Knüsel et al. 2019; Lapin et al. 2019; Wagner et al. 2020), but these are usually less abundant in central Europe than urban populations. While there is little evidence of negative effects of *Ailanthus* on urban biodiversity, wild urban populations can be challenging due to the vigorous clonal growth and regeneration of the tree, necessitating increased efforts for maintaining green spaces, transportation corridors and built structures (Kowarik and Säumel 2007; Sladonia et al. 2017), including ancient monuments in southern Europe (Celesti Grapow and Ricotta 2020; Trotta et al. 2020).

The services and disservices that people gain from nature usually relate to societal values (Scholte et al. 2015). However, urban residents' views on non-native species such as *Ailanthus* in urban environments is largely unexplored. The few existing studies on citizens' views on non-native plants mostly refer to a species' identity, i.e. they explore respondents' preferences for a species as is (e.g. Verbrugge et al. 2013; Lindemann-Matthies 2016; Shackleton and Shackleton 2016; Potgieter et al. 2019a; Shackleton and Mograbi 2020), without differentiating for the spatial or functional context of a species within a city. Yet context matters when it comes to the specific invasion impacts and disservices of non-native species (Pyšek et al. 2012; Kumschick et al. 2015; Shackleton et al. 2019c). This leads to the challenge of differentiating impact assessments of non-native species for a range of environmental, spatial and functional settings (Bartz and Kowarik 2019).

We hypothesised that context dependence also matters for how urban residents view widespread invasive species, leading to different preferences of *Ailanthus* trees in different urban settings. In a quantitative survey with closed questions and photographic stimuli presenting the tree in different urban contexts, we assessed people's views on *Ailanthus* in relation to (a) the urban setting, (b) potential management strategies and (c) urban resident's sociodemographic backgrounds (i.e., gender, age, professional context; Fig. 1, Table 1).

Urban authorities are often confronted with the question of whether and how to manage *Ailanthus*. This question becomes even more important because management measures need to be implemented in the European Union according to the EU-legislation on invasive species (Brundu 2017). Hence, we asked for the acceptability of three management options (differing in their severity) of *Ailanthus* in the urban environment (Fig. 1, right below). Previous studies have shown that values attributed to non-native species, or support for different management strategies, can depend on a range of sociodemographic variables such as age and gender, the level of knowledge in the field of study, and respondents' nature relatedness (Garcia-Llorente et al. 2011; Selge

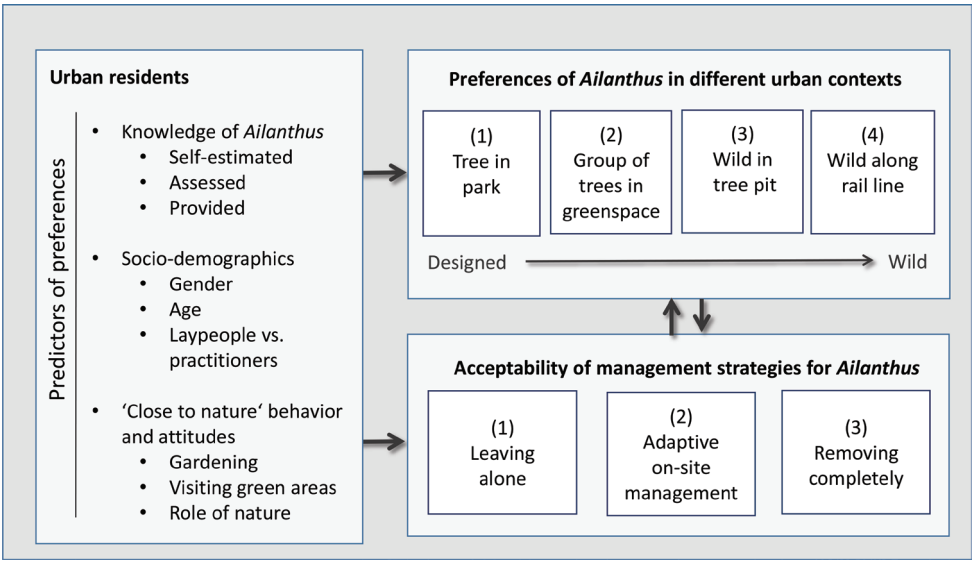

Figure 1. Approach of the study aiming to understand (i) respondents' preferences of *Ailanthus altissima* in different urban contexts (1–4, right on top); (ii) respondents' acceptability of different management strategies for *Ailanthus* (1–3, right, below), (iii) interactions between preference and acceptability (indicated by the two arrows), and (iv) characteristics of the respondents as predictors for preferences and acceptability (left part of the figure).

et al. 2011; Sharp et al. 2011; Lindemann-Matthies 2016; Shackleton and Shackleton 2016; Potgieter et al. 2019a). We thus included a set of sociodemographic variables and variables that assessed respondents' 'close to nature' behaviour and attitude as potential predictors of respondents' views on *Ailanthus* (Fig. 1, left). Since environmental preferences can differ between laypeople and those with professional expertise in the field (Bardsley and Edwards-Jones 2006; Hofmann et al. 2012; Gifford and Nilsson 2014; Shackleton et al. 2019a, b), we differentiated between two groups in our survey: respondents that had been randomly approached in Berlin's open spaces (henceforth laypeople) and vocational students with professional experience in urban landscaping, including green space management (henceforth practitioners).

In summary, we addressed the following research questions: (1) Do urban residents recognise *Ailanthus* and can they provide its name? (2) How do urban residents prefer *Ailanthus* in four urban contexts, which depict it specifically as either a cultivated or a wild-growing tree? (3) How do urban residents accept three strategies about managing *Ailanthus*, i.e. 'leave alone', 'adaptive on-site' or 'complete removal' management? (4) How do respondents' (i) knowledge (self-estimated, assessed and provided) of *Ailanthus*, (ii) 'close to nature' behaviour and attitude, and (iii) sociodemographic background (including their practitioner vs. layperson status) predict their preference of *Ailanthus* in different contexts (question 2) and their acceptance of management strategies (question 3)?

Table 1. Full list of predictor variables used to assess the context-dependent preferences and acceptability of management strategies for *Ailanthus*. The original wording and questions are given in a Suppl. material 1. For an overview on how the respondents' age and gender (g, h) are distributed in relation to professional context (i), see Table 2. For how the predictor variables relate to the response variables, see results in Tables 3, 4.

Predictor variable	Question/Explanations	Variable type
a) Self-estimated knowledge	Do you know this tree? (shown on a photograph)	Binary: 0 = no 1 = yes (NA = do not know)
b) Assessed knowledge	Do you know the name of the tree? (from the photograph)	Binary: 0 = no (person did not provide the correct colloquial or Latin name) 1 = yes (person provided the correct colloquial or Latin name) (NA = do not know)
c) Provided knowledge	Half of the respondents received the additional information: "This non-native tree of Chinese origin". This was only analysed for the acceptability of management strategies.	Binary: 0 = no 1 = yes
d) Gardening	Respondents gardening activity (e.g. in a garden, on the balcony, in a community garden)	Binary: 0 = no 1 = yes
e) Visit of urban green area	Frequency of visit of a public urban green area (e.g. park, forest, playground, cemetery, waterfront, etc.)	Categorical: 0 = never 1 = less than once a week 2 = once a week 3 = several times a week NA = do not know
f) Role of nature	Role of nature when visiting a public urban green area	Categorical: 0 = not 1 = a little 2 = moderately 3 = quite a bit 4 = very
g) Age	Respondents' age	Categorical: 1 = younger than 30 years 2 = between 30 and 60 years 3 = older than 60 years
h) Gender	Respondents' gender	Categorical: 1 = male 2 = female 3 = diverse
i) Professional context	Whether respondents were practitioners or randomly approached citizens which were passing-by in a green space or public square	Binary: 1 = practitioners 2 = laypeople

Methods

Study region

Berlin is Germany's capital and largest city, with 3.7 million inhabitants within a total area of 891.1 km^2. The climate is temperate, with an annual average temperature of 9.9 °C and a mean annual precipitation of 576 mm, with increasing periods of heat and drought in the observation period of 1981–2010 (Cubasch and Kadow 2011).

Berlin represents a metropolitan region, as today's Berlin is a result of the unification of several cities and other settlements in 1920. The resulting polycentric urban structure includes manifold remnants of the natural landscape and the preindustrial cultural landscape, which are located between individual settlement cores and at their peripheries. In addition to designed green spaces within the built areas, a new type of urban nature emerged from the natural revegetation of vacant land after the Second World War (WW II) and has been partly integrated into Berlin's green infrastructure (von der Lippe et al. 2020). About 59% of Berlin's surface is dominated by built-up areas and streets, while green and blue spaces cover 41% of the area (SDUDH 2016).

Model species

Ailanthus has been cultivated as an ornamental species in Berlin since the 1780s. Today, Berlin's tree database reports 3,004 *Ailanthus* trees along streets and in public green spaces (SDUDH 2020). In addition, there is a large, but unknown quantity of cultivated and wild trees in the same or other land-uses types. *Ailanthus* is a dioecious species, with female trees producing large quantities of seeds that are spread by wind as the primary dispersal vector (Kowarik and Säumel 2008; Wickert et al. 2017). In the post-war period since 1945, cultivated female trees serving as propagule sources, in combination with the high availability of open sites, facilitated the onset of invasion processes in Berlin and other cities subjected to destruction during WW II (Kowarik and Böcker 1984). At the beginning of the 1980s, *Ailanthus* was already a common wild tree in Berlin, mostly in built-up areas, in green spaces and along urban transportation corridors (Kowarik and Böcker 1984). Today, the populations have become more prolific in many parts of the city (Seitz et al. 2012), but are largely absent in near-natural ecosystems (Kowarik et al. 2013). In some urban sites, successional processes resulted in a novel forest type dominated by *Ailanthus*, but much less frequently than emerging forests with other dominant species (Kowarik et al. 2019). Wild populations in green spaces are often abundant due to adjacent seed sources and clonal offspring. The colonization of urban transportation corridors (road verges, tree pits, rail lines) is facilitated by secondary wind dispersal (Kowarik and von der Lippe 2011) and traffic (von der Lippe et al. 2013). Despite the abundance of *Ailanthus* in Berlin, no conflicts with biodiversity conservation have been reported thus far (unpublished data). Nevertheless, many spontaneous populations are managed in open urban spaces, likely due to conflicts with aesthetical values or for practical reasons, e.g. when blocking the view at roadsides.

Study design and field survey

In line with our research questions, we developed a quantitative study approach that combined theory from ecology and the social sciences (i.e. knowledge, context, sociodemographic data; Shackleton et al. 2019c). We devised a questionnaire with embedded photographic stimuli of *Ailanthus* in different urban situations. The questionnaire was pre-tested prior to the field survey with $N_{pre} = 10$, which led to a few adjustments

in the phrasing of the sociodemographic questions to improve the general understanding. There were no institutional requirements for ethical clearance and the survey was undertaken in accordance with the General Data Protection Regulation (GDPR) of the European Union.

In the field survey in 2019 (i.e., before the COVID-19 pandemic), we included both laypeople and practitioners in the field of urban gardening and landscaping. As practitioners, we approached students of the "Peter-Lenné-Schule", the Berlin vocational school for training in the field of urban gardening and landscaping. This is usually a type of secondary school with students switching regularly between their practical education partner (often a private company), where they gain hands-on experience, and the school, where they learn the theoretical background for their field of expertise. This type of school also offers courses to professionals in extra-occupational training programs wishing to further their expertise or earn a professional degree. During summer 2019 we first interviewed 96 students who were being trained in the field of urban landscape gardening. Of these, 14% had already completed vocational training before starting school. About two thirds of the surveyed students (63%) said that they had already worked in the public sector of landscape gardening, which strongly relates to green space management. Due to their practical work experience and specific educational background, we assumed that this group had more experience with management challenges regarding *Ailanthus* than the group of randomly interviewed people that we approached as laypeople. The survey was undertaken with the students in the classroom either at the beginning or end of their lesson. The questionnaires were handed out to the students with the request not to communicate among themselves. The time limit for answering the questionnaire was ten minutes.

Second, we performed standardized, structured interviews with randomly approached people in public spaces that we expected to be laypeople. Each interview lasted between five and ten minutes and included the same survey instrument and stimuli used in the practitioner group. To achieve a broad distribution in the Berlin population, several places in Berlin and different times of the day (from early mornings to evenings) and days of the week (both weekdays and weekends) were selected for the surveys of passers-by. The selected places included urban green spaces (57.4%) and public spaces and city plazas (42.6%) in different districts of Berlin (Alice-Salomon-Platz, Kienbergpark, Hildegard-Knef-Platz, Mariannenplatz, Tempelhofer Feld, Rüdesheimer Platz, Wittenbergplatz, Treptower Park). Areas with high tourist activity were largely avoided to focus on Berlin citizens.

Questionnaire and stimuli

The questionnaire was composed of three parts and included photographic stimuli that depicted *Ailanthus* in different urban contexts (Fig. 2; the original master version is provided as Suppl. material 1). The first part of the questionnaire assessed respondents' knowledge of *Ailanthus* in two ways since valuations of non-native species can be modu-

Figure 2. Photographic stimuli depicting *Ailanthus altissima* in different urban contexts in Berlin **A** as a single tree in a park **B** a group of trees in a green space along a road **C** a wild tree in tree pit, and **D** wild trees along an urban rail line. The urban settings thus show a gradient from designed to wild settings.

lated by familiarity with the species (Sharp et al. 2011; Luna et al. 2019). Respondents were first asked whether they recognize the tree (self-estimated knowledge) and second if they were able to provide its correct colloquial or botanical name (assessed knowledge).

The second part of the questionnaire assessed respondents' preferences for *Ailanthus* in four urban contexts by asking "How do you like the tree in this situation?" using a five-point Likert scale (1, [like] not at all – 5, [like] completely) and showing different photographic scenes (Fig. 2). Likewise, in this part of the questionnaire we assessed on the same five-point scale how respondents accepted three different management options that represent major approaches in managing non-native plant species (Sharp et al. 2011; i.e. 'leave alone', 'adaptive on-site' and 'complete removal' management). These strategies were addressed by using easily accessible wording by asking: "how should this tree be handled in Berlin?", with the answers "let it grow everywhere" ('leave alone' management), "remove it only if problems exist" ('adaptive on-site' management), and "remove it everywhere" ('complete removal' management).

In the third part of the questionnaire we assessed the sociodemographic background of the respondents (Table 1) since sociodemographic variables (i.e. age and

gender; Shackleton 2019c) are often related to the acceptability of management measures. Further, 'close to nature' behaviour and attitude (gardening, visits to urban green areas and role of nature) are important factors, when it comes to how people value urban biodiversity in different urban situations (Fischer et al. 2018).

To test whether respondents' preference ratings for different management strategies were motivated by xenophobia we used two versions of the question on management strategies. In the first version we asked: "how should this tree be handled in Berlin?" The second version provided additional information (i.e. provided knowledge) by changing "this tree" to "this non-native tree from China". We expected that interviewees with a xenophobic worldview would prefer the 'complete removal' strategy significantly more than other respondents after they had gained the information on the tree's non-native status in Germany due to its Chinese origin.

Five different photographs of *Ailanthus* were used as photographic stimuli in the questionnaire. In the first part, the photograph showed a single and mature tree within a typical background (i.e. urban street, in front of an apartment building) to ask participants whether they recognize the species (self-estimated knowledge) and could provide its name (assessed knowledge). In the second part, four photographs were used to assess the preferences of *Ailanthus* in four ubiquitous urban situations, which span a gradient from intensively designed green spaces to situations in which *Ailanthus* thrives as a wild tree outside of green spaces (Fig. 2). The first of these showed *Ailanthus* as a mature, cultivated tree in a traditional urban park. The second photograph showed a group of tall trees representing a small patch of a likely wild-grown emerging forest that had been incorporated into a traditionally managed green space along an urban street. The third depicted *Ailanthus* as a young, wild tree associated with a fenced cultivated tree in a streetscape. The last photograph showed a group of young, wild-grown trees along an urban rail line. All photographic stimuli represented situations at human eye level and field of vision with similar light conditions and flat topographic structures without aspects that might bias vegetation evaluations such as humans, animals, litter, or open water.

Statistical analyses

We fitted ordinal logistic models using the 'polr' command from the MASS package in R version 4.0.2 (R Core Team 2020). Our response variables were context-dependent preferences for the *Ailanthus* in four urban contexts and acceptability of three management strategies as illustrated in Fig. 1. For each candidate model (i.e. four for preferences and three for management strategies), we included the following explanatory variables separately as fixed effects (see Table 1 for details): the first set of models included (a) different forms of knowledge (self-estimated knowledge, assessed knowledge, provided knowledge (the latter only for acceptability of management strategies)) as explanatory variables; the second set of models included (b) 'close to nature' behaviour and attitude (gardening, visits to urban green areas and role of nature) as

explanatory variables; the last set of models included (c) three sociodemographic variables (age, gender and professional context) as explanatory variables.

To take into account that gender and professional context or age and professional context potentially interact in their effect on responses towards *Ailanthus*, we tested interaction terms between age, gender and professional context. In detail, we used responses towards *Ailanthus* (i.e. preferences or acceptability) as response variables and interaction terms between age, gender and professional context as explanatory variables. There were no significant interactions between these variables, i.e. no indication of a relationship between 'age', 'gender' or 'level of expertise' and the response variables. Therefore, we included each variable separately as fixed variables in the final models.

Results

In total, we surveyed 197 participants of which 101 were laypeople and 96 were practitioners. Most respondents were male (58%, while 40% were female and 2% diverse or did not mention their gender; hence too few in numbers for the statistical analysis), younger (48% of the respondents were under 30 years, while 30% were between 30 and 60 and 19% were above 60 years old; 3% did not mention their age) and born in Germany (88% of respondents, while the remaining participants were born outside Germany or did not mention their place of birth).

Age, class and gender distribution were different among laypeople and practitioners (Table 2). The number of younger people (< 30 years old) was higher in the practitioner compared to the laypeople group. Congruently, there were more people aged 30 years or older in the laypeople group compared to the practitioner group (x-squared = 72.8, df = 2, $p < 0.001$). Similarly, gender was not equally distributed. There were more males and fewer females in the practitioner group compared to the laypeople group (x-squared = 29.5, df = 2, $p < 0.001$). Since there was no indication of an interaction between gender, age and professional background (i.e. calculating interaction terms in our models), we considered age, gender and professional background separately in our further analyses.

Knowledge of *Ailanthus*

Overall, 83% of the respondents mentioned that they recognised *Ailanthus* when they saw it on the photograph (i.e. self-estimated knowledge). However, only 26% mentioned its correct colloquial or botanical name (i.e. assessed knowledge). Comparing the self-estimated knowledge between practitioners and laypeople, we found that practitioners (mean = 0.92, SD ± 0.28) mentioned significantly more often than laypeople (mean = 0.73, SD ± 0.45) that they would recognise the tree on the photograph ($p < 0.01$). In relation to assessed knowledge, practitioners (mean = 0.45, SD ± 0.50) also provided significantly more often the correct name of *Ailanthus* compared to laypeople (mean = 0.03, SD ± 0.16) ($p < 0.001$).

Table 2. Number of practitioners and laypeople distributed across age and gender categories.

	Practitioners	Laypeople
Age		
< 30 years (Category 1)	72	22
30–60 years (Category 2)	18	42
>60 years (Category 3)	0	37
Gender		
Male	73	42
Female	20	59
Diverse	2	0

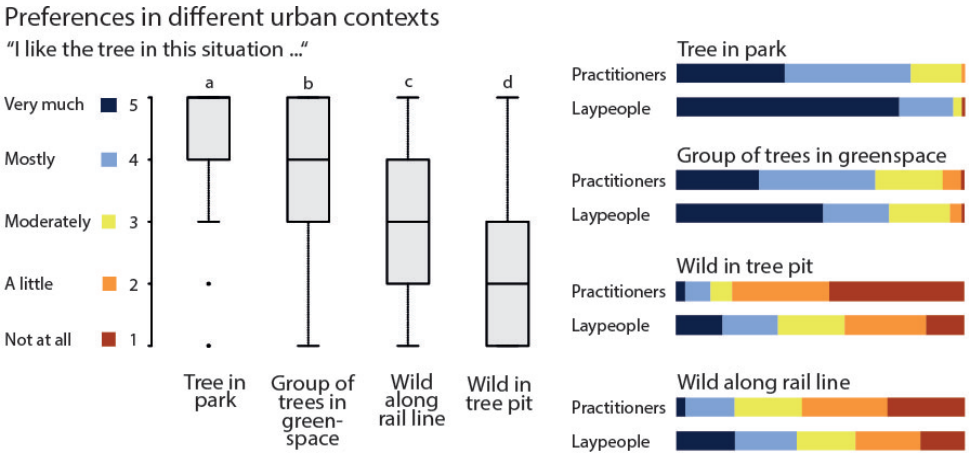

Figure 3. On the left, overall preference ratings of respondents for *Ailanthus altissima* in four different urban contexts (see Fig. 2). Different letters indicate significant differences (Tukeys HSD $p < 0.001$ for a to c, a to d, b to c and b to d, $p < 0.01$ for a to b and $p < 0.05$ for c to d). On the right, preferences are differentiated between practitioners and laypeople.

Preferences of *Ailanthus* in different urban contexts and predictors for these preferences

Overall, respondents reported a broad range of preferences for the photographs showing *Ailanthus* in different urban contexts (Fig. 3). Most respondents preferred the cultivated, mature tree in the urban park (mean = 4.5, SD = 0.7), followed by the group of trees in the green space along the road (mean = 4.1, SD = 1.0). The responses to the photographs showing younger, wild populations were less positive. On average, respondents liked the wild trees along the rail line to some extent (mean = 2.8, SD = 1.3) and the wild *Ailanthus* in the tree pit the least (mean = 2.4, SD = 1.3). These preferences for *Ailanthus* significantly differed between the contexts depicted in the photographs (ANOVA, F (3, 770) = 150.7, $p < 0.001$). In detail, *Ailanthus* was significantly more preferred in situations showing tall trees in the two green spaces (park, along urban street) compared to the scenarios depicting young, wild trees along the rail line and in the tree pit (Tukeys HSD, $p < 0.001$). Further,

Table 3. Predictors of respondents' preferences of *Ailanthus* in different urban contexts. Parameter estimates are derived from ordinal logistic regression. Significance levels shown in bold and with asterix for * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Tree in park	Group of trees in green space	Wild in tree pit	Wild along rail line
	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)
a) Knowledge				
Self-estimated knowledge	-0.25 (0.47)	0.02 (0.45)	0.01 (0.41)	0.43 (0.41)
Assessed knowledge	**-0.69 (0.35)***	-0.50 (0.33)	**-0.79 (0.34)***	-0.53 (0.33)
b) 'Close to nature' behaviour and attitude				
Gardening	-0.24 (0.34)	0.05 (0.30)	-0.51 (0.31)	0.15 (0.30)
Visiting green areas	-0.01 (0.18)	0.06 (0.17)	0.23 (0.18)	0.06 (0.16)
Role of nature	**0.97 (0.22)*****	0.33 (0.21)	**1.01 (0.23)*****	**0.89 (0.22)*****
c) Sociodemographic variables				
Laypeople (compared to practitioners)	**1.99 (0.45)****	**0.88 (0.37)***	**1.33 (0.37)*****	0.68 (0.35)
Age (compared to <30 years)				
Between 30 and 60 years	-0.55 (0.42)	-0.75 (0.36)	**1.00 (0.35)****	0.54 (0.34)
Older than 60 years	-0.78 (0.58)	-0.59 (0.46)	-0.03 (0.43)	0.09 (0.43)
Gender				
Female (compared to male)	**0.71 (0.34)***	0.27 (0.30)	0.65 (0.29)	0.06 (0.29)

preferences also differed within these contexts, with a higher preference for the single mature tree in the urban park than the group of mature trees in the green space along the road (Tukeys HSD, $p < 0.01$). The wild trees along the rail lines were significantly more preferred than the wild tree in the tree pit (generally the least preferred context) (Tukeys HSD, $p < 0.05$).

Overall, a wide range of preferences also existed for the practitioners and laypeople for photographs depicting *Ailanthus* in various urban contexts (Fig. 3, bar charts at the right). In our models, professional context, role of nature, assessed knowledge, gender and age had some predictive potential on respondents' preferences of *Ailanthus* in the four urban contexts (Table 3). First, laypeople preferred *Ailanthus* in three out of the four contexts (i.e. except rail lines) significantly more compared to practitioners. Second, respondents for which nature plays a large role when they visit urban green areas, also preferred *Ailanthus* in three out of the four contexts (i.e. except 'group of trees in green space') significantly more than other respondents. Third, assessed knowledge was a negative significant predictor for preferences of *Ailanthus* in urban parks and in tree pits. Last, as for gender and age, female respondents preferred seeing *Ailanthus* in urban parks significantly more than male respondents and respondents between 30–60 years preferred seeing wild grown *Ailanthus* in tree pits significantly more than younger respondents (under 30 years old).

Acceptability of management strategies for *Ailanthus* and predictors for this acceptability

Respondents' support of management strategies significantly differed between the three suggested strategies (ANOVA, $F(2, 558) = 205.1$, $p < 0.001$; Fig. 4). The 'adaptive on-site' management strategy yielded the most support (mean = 4.0, SD = 1.2) and was

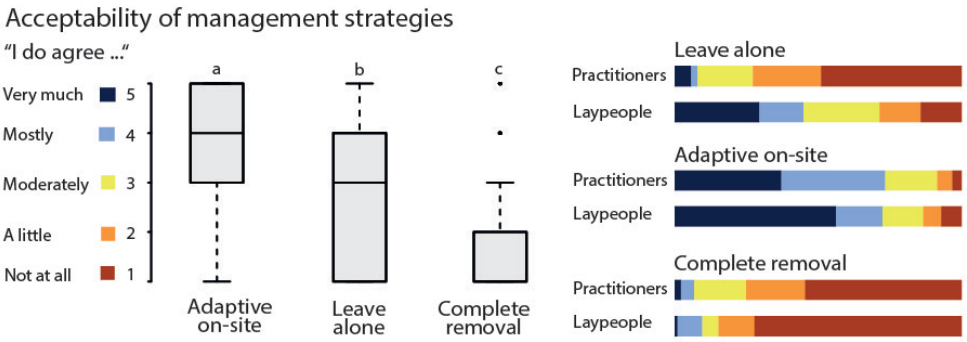

Figure 4. On the left, acceptability of three management strategies on *Ailanthus*. Significant differences shown by letters (Tukeys HSD $p < 0.001$ for a to b and c as well as b to c). On the right, preferences are differentiated between practitioners and laypeople

Table 4. Predictors of respondents' acceptability of management strategies for *Ailanthus*. Parameter estimates are derived from ordinal logistic regression. Significance level shown at shown in bold and with asterix for * p < 0.05, ** p < 0.01, *** p < 0.001.

	Leave alone	Adaptive on-site	Complete removal
	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)
Knowledge			
Self-estimated knowledge	**-0.83 (0.42)***	0.10 (0.43)	0.16 (0.53)
Assessed knowledge	**-1.07 (0.37)****	-0.53 (0.35)	0.62 (0.41)
Provided knowledge	-0.04 (0.33)	-0.34 (0.32)	0.12 (0.38)
'Close to nature' behaviour and attitude			
Gardening	-0.15 (0.31)	-0.50 (0.31)	-0.23 (0.35)
Visiting green areas	-0.18 (0.17)	-0.01 (0.17)	0.01 (0.19)
Role of nature	**0.76 (0.22)*****	0.25 (0.20)	**-0.64 (0.23)****
Sociodemographic variables			
Laypeople (compared to practitioners)	**1.38 (0.37)*****	**1.23 (0.39)****	**-1.29 (0.43)****
Age (compared to <30 years)			
Between 30 and 60 years	0.10 (0.35)	**-0.81 (0.37)***	0.09 (0.41)
Older than 60 years	**0.91 (0.45)***	**-1.40 (0.49)****	-0.39 (0.63)
Gender			
Female (compared to male)	0.55 (0.30)	-0.22 (0.30)	0.15 (0.36)

significantly more accepted than the other two management strategies (Tukeys HSD, p < 0.001). Respondents moderately agreed with the 'leave alone' management strategy (mean = 2.7, SD = 1.5), which involves renouncing management. The 'complete removal' management strategy gained the least support and was on average rejected (mean = 1.5, SD = 0.9) (Fig. 4).

Professional context, role of nature, age, self-estimated knowledge and assessed knowledge had predictive potential on the acceptability of the three management strategies (Table 4). First, laypeople accepted the most severe management strategy, 'complete removal', significantly less than practitioners, while they accepted the re-

maining two management strategies, 'leave alone' and 'adaptive on-site' management, significantly more than practitioners (Fig. 4, bar charts at the right). Second, respondents for which nature plays a large role when they visit urban green areas accepted the 'complete removal' strategy significantly less and the 'leave alone' strategy significantly more than other respondents. Additionally, self-estimated and assessed knowledge had negative predictive potential on the 'leave alone' management strategy while provided knowledge on the non-native status of *Ailanthus* had no predictive potential on any management strategy. As for age, older people (above 60 years old) significantly preferred the 'leave alone' strategy more than younger respondents. Respondents between 30 and 60 and those older than 60 years accepted 'adaptive on-site' management strategy significantly less than younger respondents. Gender had no predictive potential on any of the three management strategies.

Discussion

How citizens view widespread invasive species in different urban settings is largely unknown. We thus investigated (i) urban residents' preferences on the invasive tree species *Ailanthus altissima*, shown as a cultivated or wild tree in multiple urban situations in Berlin, (ii) which management strategies respondents considered acceptable towards *Ailanthus*, and (iii) how respondents' sociodemographic background and 'close to nature' behaviour and attitude predicted their preference ratings. Major insights of our quantitative survey were:

(1) It is not the identity of an invasive species alone that matters for urban residents' preferences, but the context in which it thrives. The respondents' view of *Ailanthus* was diverse, with significant differences between each of the urban contexts in which the species was shown. Citizens' view on a widespread invasive species is thus clearly context dependent.

(2) Respondents expressed the most support for adaptive on-site management of Ailanthus, some support for leaving it alone, and the least support for complete removal. This suggests that most respondents in our study generally accept *Ailanthus* as part of the urban environment and at the same time support management efforts in specific problematic situations.

(3) The views on Ailanthus and adequate management strategies depended on respondents' sociodemographic backgrounds and their 'close to nature' behaviour and attitude. Practitioners were more critical about *Ailanthus* than laypeople. Respondents with a 'close to nature' behaviour and attitude had a more positive view on *Ailanthus* than others and expressed more support for leaving it alone on urban sites. This indicates that biophilia in urban societies can also cover widespread invasive species. These insights have important implications for environmental policies and management plans on *Ailanthus* in urban regions.

Preferences of *Ailanthus* depend on the urban context

Approval or disapproval of non-native plants depend on people's general value system, which usually varies within different groups of society (Estéban et al. 2015; Shackleton et al. 2018), and largely differ for different species considered (e.g. Lindemann-Matthies 2016). These differences may be related to the fact that both positive and negative impacts may be attributed to different, or even the same species (e.g., Potgieter et al. 2019a; Shackleton and Mograbi 2020). As a consequence, a considerable amount of respondents in previous studies have been shown to tolerate some invasive non-native plant species in cities (Potgieter et al. 2019a). Yet previous studies largely explored residents' views in regard to the species itself, i.e. to species identity, and thus yielded insights into general approval or disapproval of urban residents for a given species. Our study goes one step further by assessing how respondents' preferences for the same species depend on different urban contexts, spanning from intentionally planted to wild *Ailanthus* trees. The significantly different preference ratings on each of the four shown situations reveal: peoples' views on a widespread invasive species not only depend on its identity and related features – such as beauty (Lindemann-Matthies 2016), charisma (Jarić et al. 2020), or usefulness (Shackleton and Mograbi 2020) – but also on the context in which it thrives. Citizens in Berlin thus tolerate, or even appreciate, cultivated or wild *Ailanthus* in some contexts while disapproving of it in others.

The respondents clearly liked *Ailanthus* in the two settings that showed tall *Ailanthus* trees in green spaces, but significantly less in the two wild settings with younger individuals (Fig. 3). This major difference can be explained with the presence, or absence of "cues to care" (Nassauer 1995), an important issue in landscape perception or preferences (Li and Nassauer 2020). The highest preferences for green space settings can be related to three mechanisms that underlie the significance of "cues to care" for landscape preferences (Li and Nassauer 2020), i.e. (i) *immediate recognisability*: the tall trees are easily recognizable as elements of traditional green spaces; (ii) *human presence or intention*: the size of the trees and their association with traditionally designed green spaces indicate that they are intended green space components; (iii) *cultural traditions or social norms*: both the individual tree and the group of trees are traditional design elements of English landscape gardens and their ubiquitous urban equivalents. Our study thus indicates that *Ailanthus* trees are broadly accepted by urban residents when integrated into traditional urban green spaces. However, in this regard also the downside of displaying various urban contexts (wild to designed) has to be considered: our photographs were not standardized with regard to environmental settings such as an even blue sky, small-scale urban infrastructures such as benches or fences, light settings or green space management (e.g., manicured lawns) that could have potentially biased the preference ratings.

The photos showing wild *Ailanthus* plants received significantly less favourable ratings than the contexts with mature trees in green spaces. This may be due to the recognisability of wild populations as unintended elements in urban open spaces. They represent wilderness components resulting from, and clearly indicating, the functioning of unmanaged, natural processes in designed environments (Kowarik 2018). In

this way, the wild context does not match the deeply rooted cultural traditions in maintaining neat open spaces. Wild, near-natural vegetation is still more highly valued by people that assign nature-related values to such scenarios in an urban green space context (Lampinen et al. 2021).

Yet the ratings of the wild scenes were not consistently negative. About 53% of the respondents liked the wild rail line situation "very much", "mostly", or "to some extent" opposed to 46%, which liked it "little" or "not at all" (Fig. 3). Thus, about half of the respondents shared a rather positive view on these wild populations. This share is similar to that of "wildness enthusiasts", opposed to people preferring highly maintained green spaces, in a study on preferences for wild vs. maintained roadside vegetation in Berlin (Weber et al. 2014). Respondents' preference ratings for the wild *Ailanthus* along the rail line could indicate a change in cultural values, leading to an increased valuation of wild urban nature. Indeed, the integration of wild urban nature is a current topic in urban development and design (Kühn 2006; Del Tredici 2010; McKinney et al. 2018; Hwang and Yue 2019), with Berlin being a forerunner in this area. Since the late 1980s, new types of wild urban nature such as naturally re-vegetated vacant land have been integrated into the city's green system (Lachmund 2013; Kowarik 2018, 2019). Respondents from Berlin could thus be more familiar with components of wild urban nature than people from other cities. Previous studies on landscape preferences revealed considerable support for wild urban vegetation (e.g. Weber et al. 2014; Fischer et al. 2018; Bonthoux et al. 2019; Hwang et al. 2019; Li et al. 2019). The survey at hand indicates that a widespread invasive tree species can receive a very high level of acceptance when integrated into green spaces, while respondents' view on wild *Ailanthus* trees is less favourable, but not consistently negative.

Preference ratings also differed significantly among the two wild situations, with less support for the tree pit context than the rail line (Fig. 3). The former could easily be read as a situation in which wild *Ailanthus* could conflict with an intended element of the green infrastructure: the carefully fenced young street tree. Respondents could have expected negative effects on the planted tree due to competition from the wild tree. Alternatively, but not mutually exclusive, the wild tree in the tree pit situation could be perceived as an indicator of neglect in a traditionally highly controlled urban environment. In contrast, the scene with the wild *Ailanthus* along the rail line might be read as re-vegetation of a harsh urban site, which might be associated with beneficial environmental effects but without competition with other species.

Broad acceptance of adaptive on-site management

Wild populations of *Ailanthus* may challenge the traditional aesthetic ideal of tidy open spaces and the required technical efforts to maintain urban green spaces, transportation corridors or built structures (Kowarik and Säumel 2007; Sladonia et al. 2017). Due to the high abundance of *Ailanthus* in Berlin, respondents were likely aware of the non-native species and related problems. Surprisingly, 31 of the 138 respondents that knew *Ailanthus* before (based on 'self-estimated' knowledge)–and generally 51 of all 197 respondents-were in favour (i.e. ratings '4' and '5') of the 'leave alone' manage-

ment strategy and only a minority of respondents (ca. 8%) supported the 'complete removal' of *Ailanthus* (Fig. 4). Since we did not ask respondents about perceived threats due to *Ailanthus*, missing knowledge about possibly associated problems could also explain the support for the 'leave alone' strategy.

A broad majority of respondents, however, supported the 'adaptive on-site' management strategy, and thus seemingly agreed to action if problems are evident in specific cases. This adds evidence to previous studies that also revealed the most support for an intermediate position between doing nothing and completely removing widespread invasive species (Sharp et al. 2011). A study from Austria, for example, found broad support for invasive species management, but less support for the use of lethal measures or herbicides (Höbart et al. 2020). In a study from Cape Town, South Africa, respondents broadly supported control measures, but the majority did not recognize a high management priority (Potgieter et al. 2019a). The clear support for 'adaptive on-site' management in our study corresponds well with the respondents' preferences for *Ailanthus* since these clearly depended on the urban context. Most respondents seemed to tolerate, or even appreciate *Ailanthus* in some situations, while disapproving of it in others. Overall, our study thus indicates a lack of support for a total ban (or removal) of *Ailanthus* in Berlin, but a high level of acceptance for problem-oriented management. Which kind of problems would justify the application of on-site management from the respondents' view or how the specific context relates to the approval or disapproval of management strategies should be analysed by a follow-up study.

What explains people's views on *Ailanthus*?

Our survey shed light on urban residents' views on *Ailanthus* as a widespread invasive tree species in Berlin, including the tree itself in different urban contexts and potential management strategies. We could not ask about the motivation behind respondents' preference ratings and acceptability due to the required brevity in interviews in the field. However, we related sociodemographic background and 'close to nature' behaviour and attitude of the respondents to their preference ratings and the acceptability of management strategies, which allowed us to describe these relationships in some detail.

Role of knowledge

As expected, practitioners were generally more critical towards *Ailanthus* than laypeople, with less favourable preference ratings in the urban contexts (except the rail line situation) and a higher support for the 'complete removal' strategy. This is in line with other studies revealing that respondents with a formal training in environmental issues are more aware of invasion risks and support more aggressive management strategies like attempt eradication (Luna et al. 2019; Cordeiro et al. 2020; Nguyen et al. 2020). Practitioners in our study were likely aware of management problems related to *Ailanthus* due to their experience in urban landscaping and green space maintenance.

However, a considerable share of practitioners also expressed positive ratings on the urban contexts and on the less strict management strategies (Figs 3, 4). Despite

clearly pronounced differences between laypeople and practitioners, the expert view on *Ailanthus* in cultivated and wild urban settings was not uniformly negative. This indicates that practitioners might not only be aware of risks, but also of some environmental benefits that can be supported by both cultivated and wild *Ailanthus* trees in urban environments (Kowarik and Säumel 2007; Sladonia et al. 2017; see below).

Since an enhanced level of knowledge was related to a higher sensitivity towards invasive species in other studies (e.g. Sharp et al. 2011; Shackleton and Shackleton 2016), we analysed how different levels of knowledge on *Ailanthus* related to respondents' preference ratings. The self-estimated knowledge, indicated by interviewees' response on recognizing the species, was not related to any preference rating in the four urban contexts. However, respondents that assigned the correct name to *Ailanthus* ('assessed knowledge') expressed less favourable ratings on two of the four urban scenes: the individual mature tree in the park and the young, wild tree in the tree pit. Both, self-estimated and assessed knowledge were negatively related to preferences on the 'leave alone' strategy. This indicates that people who had shared some knowledge on *Ailanthus* (analogously the practitioners in the practitioners-laypeople comparison) were less willing to let it grow without any intervention. Interestingly, 'provided knowledge' did not show any effect on the acceptability of management strategies. While other studies have shown the effect of information on the acceptability of management strategies (Ford et al. 2009) or landscape preferences (Straka et al. 2016), it is likely that illustrating the non-native status of the tree in Berlin by including information about its Chinese origin was not enough information for a shift of the acceptability of management strategies in this study.

Age and 'close to nature' behaviour and attitude

Preference ratings for the urban scenes were only weakly and inconsistently related to age and gender. However, older people (> 60 years) were significantly more willing to accept *Ailanthus* than younger people. In other studies, though, older respondents tended to perceive invasive plants more negatively than younger people (Potgieter et al. 2019a; Nguyen et al. 2020). These contrasting results may depend on the identity of the addressed species, on respondents' familiarity with it or on the urban settings in which the species grows.

Respondents' nature-related activities such as visiting green spaces, which were important predictors of preference ratings in other studies (Fischer et al. 2018), were not significantly related to any of the outcomes. However, respondents who said that nature plays an important role when visiting green spaces liked three of the four urban contexts significantly more than other respondents. Consistently, this close to nature attitude was positively related to the 'leave alone' strategy, and negatively to the 'complete removal' strategy. In a study from Cape Town, respondents with a higher level of environmental awareness were more likely to perceive non-native species as beneficial, but were also more supportive than others of control measures to protect biodiversity (Potgieter et al. 2019a). Our results suggest that *Ailanthus* is less likely to be perceived as a threat to biodiversity in Berlin.

Our study indicates that the biophilic view that exists in urban societies (Wilson 1984; Beatley 2010) can also cover widespread invasive species despite apparent challenges such as an increased demand for maintenance. This conclusion is also supported by the highest acceptance of the 'adaptive on-site' management strategy, as this approach explicitly excludes general measures against the species independently from the situation in which it thrives.

Missing indication of xenophobia

Environmental preferences not only rely on knowledge about the addressed issue but also on values and beliefs (Ives and Kendal 2014). We tested here whether respondents' preference ratings for different management strategies regarding a widespread invasive tree species were underlain by xenophobia, a controversial issue in invasion studies (Richardson and Ricciardi 2013). We expected that interviewees with a xenophobic worldview would prefer the 'complete removal' strategy significantly more than other respondents after they had gained the information on the non-native status and Chinese origin of *Ailanthus*. This approach seemed appropriate since we did not otherwise inform the interviewees about the origin or invasive status of *Ailanthus*, or associated problems, to avoid a bias in the preference ratings due to a priori information.

The lack of differences between the answers to the two versions of the question indicates that preference ratings were primarily related to respondents' views on *Ailanthus* – independently from their knowledge of its non-native status or origin. Alternatively, the absence of differences might reflect that the additional information did not increase respondents' knowledge, if they were previously aware of its non-native status. This explanation, however, is not supported by the gap between the self-estimated and assessed knowledge: 83% of all participants reported recognizing the tree, but only 26% knew its correct name. This indicates that a large majority of respondents did not have deeper information about *Ailanthus*, such as its non-native status, although they were likely familiar with the tree due to its abundance in Berlin for about 40 years (Kowarik and Böcker 1984). This supports the interpretation of our results as an indication of lacking xenophobia in respondents' views on *Ailanthus*.

Implications

Our results have implications for the implementation of management measures on *Ailanthus*, which have to be established according to Article 19 of the EU Regulation on invasive alien species (European Parliament 2014). Brundu (2017) highlighted the need of considering human values in the design and implementation of such measures. He also identified a lack of more detailed studies on the views of different stakeholders on *Ailanthus* in cities, although the inclusion of such views is essential for the success of management measures. Our study revealed that citizens' views on *Ailanthus* were context dependent, partially related to the background of respondents, and ranged from approval to disapproval. These results thus do not support the assumption that "*Ailanthus* invasions

are generally perceived as a problem in the habitats and land uses where *Ailanthus* stands are established and costly control intervention are often occurring" (Brundu 2017). Even in Berlin, as an *Ailanthus* hotspot, urban residents did not generally perceive this species as a problem. Consistently, respondents clearly supported the 'adaptive on-site' strategy.

Controlling *Ailanthus* only when concrete, on-site problems exist seems to be an appropriate strategy for cities like Berlin. *Ailanthus* largely spreads in the vicinity of female seed trees (Paź-Dyderska et al. 2020). It should thus not be assumed that *all* urban trees (both male and female) are a *general* threat to areas or species of conservation concern that are usually located in the urban fringe or surroundings of cities. Risks may emerge, however, when female trees are close to conservation areas or as a result of exceptional seed dispersal over very long distances. In such cases, the removal of female trees can be useful, for which a suite of control measures is available (Brundu 2017). These control approaches can also be used when *Ailanthus* becomes a nuisance in urban open spaces. However, this often requires long-term maintenance, as individual trees and clonal populations can regenerate vegetatively very well (Kowarik and Säumel 2007). Moreover, individual methods such as the application of herbicides or pathogenic fungi are not permitted everywhere, including Berlin.

Our results indicate that a management plan of *Ailanthus* could meet acceptance under the condition that the included measures are tailored to manage specific situations (e.g. removal from nature reserves and the management of propagule sources in the vicinity of susceptible habitats of conservation concern). However, the considerable share of respondents that preferred a general hands-off strategy indicate how important communication strategies are to justify management approaches and to explain their implementation.

Another implication is on the integration of *Ailanthus* in urban greening. Given the abundance of cultivated and wild trees in Berlin, as well as in many cities, a complete removal of the species is not realistic due to its regeneration potential and would not receive support from residents as indicated by our study. Management plans should thus focus on counteracting or preventing evidenced conflicts at the local scale and prevent invasions of habitats of conservation concern. According to the EU Regulation on invasive alien species, such measures should also "be proportionate to the impact on the environment and appropriate to the specific circumstances of the Member States, [and] be based on an analysis of costs and benefits" (European Parliament 2014).

The classic challenge here is to balance the negative and positive effects that can be associated with invasive species (van Wilgen 2012; Potgieter et al. 2019b; Shackleton et al. 2020; Brundu et al. 2020; Vimercati et al. 2020). Indeed, a range of services and disservices have been reported for urban *Ailanthus* trees (Kowarik and Säumel 2007; Sladonia et al. 2017): *Ailanthus* is well adapted to climate warming, and thus to the urban heat island (Roloff et al. 2019); it further supports a range of regulating ecosystem services, which have been quantified for some cities (e.g., air pollution removal, storm water management, carbon sequestration; Kim et al. 2015; Kim 2016; Riley et al. 2018; Arrington 2020). Our study adds the insight that both cultivated and wild trees can support cultural ecosystem services in cities as indicated by the considerable share of positive preference ratings for some urban contexts.

This leads to the conclusion that urban management plans on *Ailanthus* should combine three aims: (i) to perform on-site management in case of evidenced problems; (ii) to prevent the invasion of susceptible habitats of conservation concern and contain urban populations when feasible; and (iii) to develop and test novel approaches of integrating wild *Ailanthus* trees deliberately into the urban green infrastructure – if risks for conservation areas can be excluded. We thus argue for multidirectional management approaches towards *Ailanthus* in urban regions.

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Supplementary material 1

Original questionnaire in German language

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Data type: questionnaire

Explanation note: This version shows the master version, from which 4 subversions were generated: (a) without the explanation on the tree's origin, (b) with the explanation on the tree's origin, (c) with the explanation on the tree's origin and an additional question on practitioner's working environment, (d) without the explanation on the tree's origin and an additional question on practitioner's working environment.

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