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A review of volunteers' motivations to monitor and control invasive alien species

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Abstract

People make an important contribution to the study and management of biological invasions, as many monitoring and control projects rely heavily on volunteer assistance. Understanding the reasons why people participate in such projects is critical for successful recruitment and retention of volunteers. We used a meta-synthesis approach to extract, analyze and synthesize the available information from 28 selected studies investigating motivations of volunteers to engage in monitoring and control of invasive alien species (IAS). Our findings show how motivations fit three broad themes, reflecting environmental concerns, social motivations, and personal reasons. An important outcome of this study is the description of motivations that are unique to the IAS context: supporting IAS management, protecting native species and habitats, and livelihood/food/income protection or opportunities. In addition, our study reflects on important methodological choices for investigating volunteer motivations as well as ethical issues that may arise in practice. We conclude with a set of recommendations for project design and future research on volunteer motivations in IAS contexts, emphasizing the importance of collaboration with social scientists.

Keywords
Biological invasions, biodiversity monitoring, citizen science, perceptions, public engagement, social dimensions

Introduction

Public involvement in the monitoring and control of invasive alien species (IAS) contributes to both increased scientific understanding and effective management of biological invasions in multiple ways (Hester and Cacho 2017; Roy et al. 2018, Larson et al. 2020a; Pawson et al. 2020; Price-Jones et al. 2022). Species occurrence data collected by volunteers can improve our understanding of IAS distributions and inform modeling of species range expansion (Brown et al. 2008; Bois et al. 2011; Gallo and Waitt 2011; Crall et al. 2015; Grason et al. 2018; César de Sá et al. 2019; Giovos et al. 2019; Lehtiniemi et al. 2020). People can also play an important role in the early detection of IAS (Looney et al. 2016; Carnegie and Nahrung 2019; Epanchin-Niell et al. 2021). For example, in New Zealand, 63% of detections of new pest incursions were attributed to the general public (Bleach 2018 in Epanchin-Niell et al. 2021), while in the United States, the general public and private owners of nurseries and farms detected 27% of new alien pests found between 2010 and 2018, including a large number of species with high economic or environmental impact (Epanchin-Niell et al. 2021). People can also play active roles in the capture, control and removal of IAS (Bryce et al. 2011; Kobori et al. 2016; Marchante and Marchante 2016; Dechoum et al. 2019; Jubase et al. 2021). Additional benefits of engaging people in IAS projects include increased public awareness of IAS (Jordan et al. 2011), potentially resulting in the prevention of new introductions (Azevedo-Santos et al. 2015), changed behavior which can reduce the spread of IAS (Cole et al. 2016, 2019), and wider acceptance and support of IAS control and eradication (Larson et al. 2016; Novoa et al. 2017; Dunn et al. 2018, 2021; Bailey et al. 2020; Phillips et al. 2021).

Understanding volunteer motivations is critical for effective volunteer recruitment, retention, and the long-term sustainability of volunteer-driven projects (Wright et al. 2015; Cardoso et al. 2017; Veeckman et al. 2019; Rüfenacht et al. 2021). Different theories have been proposed to explain why people spend time and effort on volunteer tasks (see West and Pateman 2016 for a recent synthesis). Such motivations may be intrinsic, meaning that a person finds fulfillment in the volunteer work itself (e.g. through learning or altruistic concerns), or extrinsic when it offers external rewards (e.g. increased job prospects) (Finkelstein 2009). Previous research in the field of social psychology notes that "acts of volunteerism that appear to be quite similar on the surface may reflect markedly different underlying motivational processes" (Clary et al. 1998, p. 1517) and posits that motivations of individuals may be derived from a person's values (i.e. finding it important to help others), the drive for understanding and knowledge (i.e. wanting to learn), building and maintaining social connections and capital (i.e. strengthening relationships or sense of community), career perspectives (i.e. gaining career-related experience), self-protection (i.e. reducing negative feelings),

or personal development (e.g. growing or developing psychologically) (Clary et al. 1998; Clary and Snyder 1999; Omoto and Packard 2016).

Research on environmental volunteering, including volunteer motivations, gained traction in the last two decades, especially in countries with a long tradition in people's involvement in biodiversity monitoring, such as the United Kingdom, the Netherlands, Australia and the United States (Measham and Barnett 2008; Geoghegan et al. 2016; Merenlender et al. 2016; Ganzevoort 2021), or countries with a long history of managing IAS, such as South Africa (Shackleton et al. 2019; Jubase et al. 2021). Previous studies have empirically tested and classified different motivations in an environmental context (Bruyere and Rappe 2007; Measham and Barnett 2008; Larson et al. 2020b). For example, Measham and Barnett (2008) present a set of six broad motivations underpinning environmental volunteering (i.e. contributing to community, social interaction, personal development, learning about the environment, a general ethic of care for the environment, and attachment to a particular place or species) and five different modes through which volunteering is manifested (i.e. activism, education, monitoring, restoration, and promoting sustainable living). Large scale surveys among environmental volunteers have shown that they can have multiple reasons for participating, and that motivations vary by socio-demographic attributes and the type and extent of participant involvement (Ganzevoort and van den Born 2020; Larson et al. 2020b).

One environmental area in which participation of volunteers is increasing relates to biological invasions (Johnson et al. 2020; Price-Jones et al. 2022). The ability to purposefully design projects for monitoring and controlling IAS in which the public is involved requires knowledge of the motivations of individuals to participate in such initiatives (Hobbs and White 2012; Roy et al. 2018; Pocock et al. 2020; Encarnação et al. 2021). While a number of studies have synthesized research on perceptions of IAS (Kapitza et al. 2019; Shackleton et al. 2019; Cordeiro et al. 2020), we do not know of any research which does this relating to volunteer motivations. To fill this gap, our primary objective was to synthesize existing knowledge about the diverse motivations of volunteers who participate in IAS monitoring (e.g. citizen science initiatives) and control projects (i.e. hands-on activities to manage IAS). Although these two types of activities are different, they are closely linked as monitoring or observing IAS often contributes to decisions about management actions. This connection is sometimes very clear, for example in early detection and rapid response (de Groot et al. 2020), but there are also more implicit ways in which monitoring data informs decision-making in IAS management and science (Groom et al. 2019). In this paper, we simply refer to 'IAS projects', including both monitoring and control activities, but as motivations may differ for the two, we emphasize important differences when they arise.

To achieve our objective, we used a meta-synthesis approach to extract, analyze and synthesize the available information about volunteer motivations from relevant scientific and grey literature. This approach is useful for analyzing a relatively small number of studies on a selected topic (Hoon 2013) and is increasingly applied in the context of environmental and other interdisciplinary studies (Carlson and Palmer 2016; Garavan et al. 2019).

Although initially our synthesis focused on documenting and better understanding the diversity in volunteer motivations, while conducting our meta-synthesis, we further identified important methodological and practical implications of study and project design. First, we found large differences in how and to what extent studies investigated motivations, ranging from very limited quantitative reports to in-depth qualitative inquiries. This led us to document the different approaches and methodologies that were used for measuring volunteer motivations and to what extent they were reported in the articles. Second, we also paid close attention to ethical and practical dilemmas reported in the studies. At the end of the paper, we provide a number of recommendations for (i) designing projects that consider the diverse motivations of participants to maximize recruitment and retention, and (ii) future research on volunteer motivations in IAS contexts.

Methods

Bibliographic analysis

We searched for relevant publications using multiple databases and sources for peer-reviewed and grey literature. A bibliographic search was conducted using both Web of Science (WoS) on February 10, 2021 and SCOPUS on March 5, 2021. The search string captured three main topics (i.e. motivations, citizen science and volunteering, and invasive alien species) and we included multiple synonyms for each topic: (motivation* OR engag* OR incentive*) AND ("citizen science" OR volunteer* OR community) AND ("invasive species" OR "alien species" OR "exotic species" OR "non-native" OR "nonnative" OR "non-indigenous" OR invas*). We used the filtering options of the databases to exclude publications from other fields (e.g. healthcare, physics). This search resulted in a list of 267 bibliographic references in WoS and 302 in SCOPUS. Next, we scrutinized the title and abstract and, if needed, the full text of the articles, to further exclude articles that did not relate to IAS or did not contain any information pertaining to volunteer motivations to participate in IAS projects. Combining the searches from WoS and SCOPUS databases, we selected 18 relevant articles (of which six were found using SCOPUS, but not included in WoS).

Additionally, we conducted a search using the Google and Google Scholar search engines using (variations of) the same search string and reviewing the first 50 results, as relevant search results declined quickly and were not found in the last 30–50 results. This yielded three additional references. We also requested information from working group leaders of the EU Cooperation in Science and Technology (COST) Action AlienCSI (www.alien-csi.eu) via email, obtaining one additional unpublished dataset (Marchante et al., pers. comm.) and one recently published paper. Finally, we included five additional papers obtained via the snowball sampling strategy, i.e. by retrieving relevant papers from the reference lists of the selected papers.

Altogether, 28 sources were selected for inclusion in the meta-synthesis. Despite using different search strategies covering academic and non-academic literature, we did not find any grey literature sources. This may be a limitation of our search being in English only, as such reports are likely to be published in local languages.

Data analysis

Each of the selected papers was read in full by the first and last author who made extensive notes about the study context, methodologies and findings. First, we documented the specific context of each study using the questions and categories in Table 1. Second, we listed each phrase or text fragment referring to motivations (hereafter 'motivation statement') that was presented in the paper. A more detailed explanation of how we categorized these motivations is given below. Third, we collected detailed information about the methodology and/or approach that was used for measuring motivations using the questions and categories in Table 2. Finally, we systematically listed important findings or recommendations that linked motivations to the design and evaluation of IAS volunteer projects. These findings were grouped and summarized according to specific themes.

Table 1. Questions and categories used for describing study contexts.

Name	Question	Categories
Year	In which year was the paper published?	Free text
Country	In which country did the study take place?	Free text
Volunteer type	Which type of volunteers were involved in the project?	IAS project volunteers*, specific target audiences (e.g. landowner, hunter, divers, etc.), the general public, or other
Project type	What was the main aim of the project in which volunteers participated?	Control, detection/monitoring or other
Target species	What was the target species?	Free text
Target species group	To what species group does the species belong?	Bird, fish, insect, mammal, plant, reptile or other
Habitat type	Which habitats did the study cover?	Terrestrial, freshwater, marine, or island

* i.e. volunteers already involved in an ongoing IAS project

Table 2. Questions and categories used for describing study methodologies for measuring motivations.

Name	Question	Categories
Data collection	What was the main method used for data collection?	Questionnaires, interviews, both or other
Respondent number	How many respondents answered the question about motivations?	Free text (number)
Question type	What type of question was used to measure motivations?	Open, closed, both or other
Documentation	Did the study provide adequate information about the data collection method and questions (either in the main text or in an appendix)?	Yes or no

Classification of motivations for participating in IAS projects

We collated a list of 233 motivation statements retrieved from the 28 papers (See Suppl. material 1). The listed motivations were assigned to broader categories using iterative coding (c.f. Asah et al. 2014). The iterative coding process was both deductive (i.e. based on previously known motivation categories; Measham and Barnett 2008; Wright et al. 2015; West and Pateman 2016; Larson et al. 2020b) and inductive (i.e. by identifying and grouping motivations that did not resemble previously known motivations categories and assigning them to new categories). Visualization of the conceptual framework was done using open source diagrams.net software (https://www.diagrams.net/).

Some statements included multiple motivations, for example, when the participants expressed both an attachment to a particular place and a more general desire to help the environment, or a wish to contribute to science, while experiencing fun and enjoyment at the same time. In such cases, the motivation statement was assigned to multiple categories, thus resulting in a higher number of recorded motivations than the total number of recorded statements (264 vs. 233, respectively). While a number of motivation statements were assigned to preexisting motivation categories (e.g. contribution to science, helping the environment, social interaction, attachment to a particular place, or wanting to share existing knowledge with others), others required us to develop a new set of categories unique to volunteers participating in IAS projects.

To decrease subjective interpretations, the categorization was performed by a team of four researchers. The first author developed the initial categorization scheme and started the process of ascribing motivations to appropriate categories. Three of the co-authors joined the process of categorization by providing their own views on the appropriate categories, thus ensuring that the final result of the categorization was not influenced solely by the perspective of one author. Motivations which were categorized differently were discussed until consensus was reached.

Results and discussion

Study contexts

All papers included in the analysis (See Suppl. material 1) were published in the last ten years (2012–2021) except for one study (Krasny and Lee 2002). Most studies were conducted in Europe (n = 12) and North America (n = 9), with three conducted in Australia and one study each in South Africa, the Caribbean, Hawaii and the Canary Islands. Studies reporting on terrestrial ecosystems (n = 24) strongly outnumbered those related to marine environments (n = 4). Majority of the studies (n = 20) reported volunteer motivations for participating in control projects only, while six studies reported on monitoring projects and one each on the training of IAS monitoring and management planning. The projects often targeted a specific IAS and these were mostly plant (n =

11) and mammal (n = 5) species, or both (n = 1), while the remaining were focused on invasive fish (n = 3), birds (n = 3), reptiles (n = 2), insects and tree insect and fungal pest species (one study each). The one remaining study did not specify any IAS target group. The reviewed studies investigated the motivations of groups of volunteers committed to participating in IAS projects (n = 14), or specific target audiences (e.g. land-owners, hunters, divers, etc.; n = 11), while the remaining studies focused on the general public (n = 3) or the participants of a training program on invasive species (n = 1)

Motivations

Iterative categorization of the 233 motivation statements resulted in 15 different motivations affecting the participation of volunteers in IAS projects (Table 3). The conceptual framework presented in Fig. 1 shows how these motivations fit three broad themes, reflecting primarily (1) environmental concerns (i.e. supporting IAS management, helping the environment, and protecting native species and habitats), (2) social motivations (i.e. social interaction, community responsibility, and contribution to science), and, (3) personal reasons (i.e. learning something new, personal and career development, feeling of accomplishment, health and wellbeing, and enjoyment and fun). A number of motivations belong to more than one theme. For example, contact with nature and attachment to a particular place are motivations which include both a personal and an environmental aspect, while the desire to share existing knowledge and livelihood/food/income protection or opportunities are influenced by the social and personal aspect of motivations (Fig. 1).

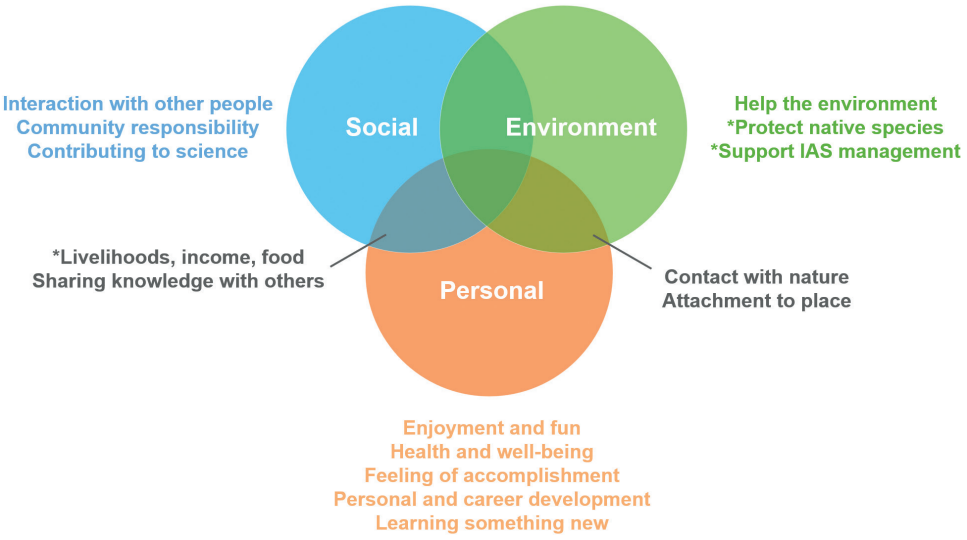

Figure 1. Conceptual framework for understanding volunteer motivations for participating in monitoring and control of invasive alien species along three main themes. Newly identified motivations unique to the IAS context (compared to existing literature) are marked with an asterisk.

Three motivations unique to the IAS context emerged during the analysis: 1) supporting IAS management (Environment theme), 2) protecting native species and habitats (Environment theme), and 3) livelihood/food/income protection or opportunities (Social/Personal theme). We describe these motivations in more detail in the section on "*Motivations specific to IAS context*". In addition, eleven motivations were described in previous literature (Clary and Snyder 1999; Measham and Barnett 2008; Finkelstein 2009; West and Pateman 2016; Larson et al. 2020b). Eight statements could not be categorized and were termed 'Other' (Table 3). Five of these statements were related to previous experience of participating in citizen science initiatives (Marchante et al. 2017; Garrard et al. 2020; Jubase et al. 2021; Phillips et al. 2021; Marchante et al. pers. comm.) which led people to take part in subsequent activities. The remaining three were fear of the species itself (Servia et al. 2020), "desire to preserve environmental aesthetics" (Jubase et al. 2021, p. 4), and cost, with participation in the project being "cheaper than a normal biology course or dive" (Cerrano et al. 2017, p. 316).

Motivations specific to IAS context

As stated above, three motivations unique to the IAS context emerged (Table 3). Supporting IAS management emerged as a leading motivation of volunteer participation (expressed through 30 statements in 20 papers, Table 3). This category groups motivations that start from an understanding of the harmfulness or alien status of IAS, leading to a desire to assist in their management/eradication. While some simply expressed a desire to remove the IAS "to aid conservation management" (Stien and Hausner 2018, p. 189) or for the "chance of keeping them [tree pests or diseases] at bay or eradicating them" (Pocock et al. 2020, p. 724), others recognized that IAS are not meant to be in the introduced area (e.g. "carp don't belong here and there are too many of them" in Atchison et al. (2017, p. 340)).

Ten papers outlined that participants were motivated primarily by the wish to protect native species and habitats in their surroundings (e.g. Harvey et al. 2016; Niemiec et al. 2016; Cerri et al. 2018; Crowley et al. 2018; Pagès et al. 2018, 2019; Dunn et al. 2021). This motivation reflects the close relationship, affection, and attachment people feel towards native species (e.g. red squirrels in Crowley et al. (2018); puffins in Pagès et al. (2018)) and habitats (e.g. native broadleaved woodlands in Crowley et al. (2018)), and consequently their desire to protect these from the impacts of IAS. Often respondents reported that they feel that native species are more valuable than alien species (Pagès et al. 2019) and that humans are responsible for the introduction of alien species, making it our moral duty to control them (Crowley et al. 2018). Similarly, the study of Jubase et al. (2021) also reports this motivation, expressed as a desire to preserve the unique native fynbos biome in South Africa.

Livelihood/food/income protection or opportunities refers to the protection or improvement of livelihoods and incomes in cases where IAS cause crop damages (e.g. Cerri et al. 2018; Saavedra and Medina 2020) or have a negative effect on business

Table 3. Motivations of volunteers participating in invasive alien species monitoring and management projects (categories unique/specific for IAS contexts are given in bold).

Theme	Motivation	Description	Examples	Reported In*:
Environment	**Supporting IAS management**	A desire to participate in IAS control and eradication	see Section "*Motivations specific to IAS context*"	[3], [4], [7], [8], [9], [10], [11], [12], [13], [14], [16], [17], [18], [19], [20], [21], [22], [23], [24], [26], [27], [28]
	Helping the environment	A desire to help the environment	"help nature" "protect the environment" "assist with conservation efforts"	[1], [3], [4], [5], [7], [9], [10], [11], [13], [14], [16], [17], [18], [19], [21], [22], [28]
	Protecting native species and habitats	A desire to protect native species and habitats	see Section "*Motivations specific to IAS context*"	[4], [6], [8], [9], [11], [12], [16], [20], [21], [22]
Environment/ Personal	Contact with nature	Opportunity to experience nature, being in close contact with the natural world, unique experiences in nature	"opportunity to work in close contact with the natural world" "opportunity to experience impressive nature"	[1], [2], [5], [10], [12], [16], [18], [21], [22], [23], [28]
	Attachment to a particular place	Feeling of attachment to local places	"personal attachment to local places" "taking care of favourite dive sites"	[1], [5], [9], [22]
Personal	Learning something new	A general interest in acquiring new knowledge	"to learn more about the environment/IAS" "learning something new"	[1], [2], [4], [5], [7], [10], [12], [13], [14], [18], [21], [28]
	Personal/career development	Interest in acquiring new skills; education, or career progression	"learning job skills" / "skill development" "gaining additional field experience" "use of novel technologies"	[1], [2], [4], [5], [7], [10], [14], [17], [18], [21], [22]
	Enjoyment/fun	Expressions of positive emotions like enjoyment and fun	"thrill seeking" "exciting experience"	[1], [2], [3], [4], [5], [12], [13], [15], [16], [23], [28]
	Health and wellbeing	References to mental and physical health	"to get out of the house" "to get exercise" "a good form of relaxation"	[1], [2], [9], [13], [21], [22], [28]
	Feeling of accomplishment	Feelings of pride, satisfaction and doing something that is meaningful	"to show that I can make a difference" "I feel I'm doing it right and I am proud"	[1], [2], [5], [12], [18], [19]
Personal/Social	**Livelihood/food/ income protection or opportunities**	References to protecting or improving livelihoods and incomes	see Section "*Motivations specific to IAS context*"	[2], [3], [4], [6], [8], [11], [19], [20], [22], [25], [27], [28]
	Wanting to share existing knowledge	Wish to share existing knowledge with others	"to let children/ grandchildren know the sea" "to teach others about invasive species"	[2], [3], [5], [13], [14], [18]

Theme	Motivation	Description	Examples	Reported In*:
Social	Contribution to science	Wish to contribute to or take part in scientific research	"because data can be useful for science" "participation in exciting discoveries"	[5], [15], [17], [18]
	Community responsibility	Feeling a sense of responsibility / duty of care / giving something back to the community	"for the future generations" "showing that one can make a difference" "moral duty to manage the consequences"	[1], [2], [3], [4], [5], [6], [8], [12], [13], [16], [18], [19], [21], [22], [24]
	Social interaction	Spending time with friends, family, or like-minded people	"spending time with friends/family" "being with people that share interests" "a sense of belonging to a group"	[1], [2], [4], [5], [9], [12], [13], [14], [18], [21], [22], [28]

* The numbers in brackets refer to the number in the List of studies used in the analysis, provided in Suppl. material 1.

profitability and property value (e.g. Marshall et al. 2016; Pagès et al. 2019). This motivation also includes IAS as a new source of food or income (e.g. Carballo-Cárdenas and Tobi 2016; Atchison et al. 2017), where local communities have recognized the potential of either eating a particular IAS, or by selling products and services related to the target IAS (e.g. lionfish in Carballo-Cárdenas and Tobi (2016)).

Observed differences in motivations

Our meta-synthesis indicated some minor (and expected) differences in motivations between volunteers participating in either detection/monitoring or control projects. Participants in control projects did not report being motivated by 'contributing to science', while participants in detection/monitoring projects did not report 'protecting native species/habitats' or 'health and wellbeing' as motivations. However, these findings are based on a limited number of studies and most of these were linked to control projects. In order to provide more insights, we need comparative study designs measuring the types and strength of motivations in different kinds of projects.

We observed some interesting patterns of motivations for different target groups. Land-owners and local residents (Marshall et al. 2016; Niemiec et al. 2016; Saavedra and Medina 2020; Dunn et al. 2021) have a vested interest in their own neighborhoods or properties, are more locally oriented, and therefore motivated by the desire to protect their livelihood/food/income opportunities, develop social interactions with their neighbors and contribute to their community. Hunters (Stien and Hausner 2018) and divers (Carballo-Cárdenas and Tobi 2016; Cerrano et al. 2017) are often motivated by the opportunity for fun and enjoyment, outdoor recreation/sport, and contact with nature. Additionally, divers reported an attachment to a particular place (e.g. a preference for certain diving spots; Cerrano et al. 2017), a desire to contribute to science, share knowledge and develop personally/career-wise.

Pagès et al. (2019) observed differences in motivations within groups of project volunteers controlling the same IAS, ranging from helping nature to protecting private

property, or seeing the IAS as threatening to their recreational activities. They also found differences in motivations between groups of volunteers controlling different target IAS (i.e. grey squirrel vs. Himalayan balsam). The most notable difference was that while supporting IAS management was seen as the leading motivation in the group of volunteers controlling Himalayan balsam, those tasked with killing invasive grey squirrels saw it as a disincentive for participation, rather than motivation (a more detailed discussion on the ethical problems of killing animals is made in the section on "*Ethical and practical dilemmas*"). In other studies, the participants taking part in the control of invasive mammals (e.g. squirrels; Crowley et al. 2018; Dunn et al. 2021) and reptiles (e.g. Burmese pythons; Harvey et al. 2016) were motivated to protect native species and habitats.

Methodologies and approaches used for measuring motivations

The majority of the studies (n = 17) used online or paper questionnaires for data collection, five studies conducted interviews, three studies used both questionnaires and interviews, and two were based on participant observations. Generally, the questionnaires included closed questions (e.g. multiple choice, ranking). Interestingly, very few of the questionnaire studies draw upon existing typologies from social science literature (the exception being Asah and Blahna 2012; Asah et al. 2014 who adopt a functionalist perspective), pointing to an obvious research gap as well as a lack of scholarly exchange between disciplines. Interviews with open questions gathering qualitative data provided more novel insights, which informed our section on 'new motivations' in the section *"Motivations specific to IAS context"*. Less than half of the studies (n = 12) provided a copy of their questionnaire as supplementary material, or adequately explained their methods in the text. Our synthesis approach did not answer questions of relative importance of motivations, or directly compare outcomes from different studies. This was difficult due to the great diversity in methods used to measure motivations, lack of reporting on methodological procedures and outcomes, and large differences in target groups and sample sizes.

Initial and sustained motivation: changes over time

A number of studies, mainly related to IAS control, investigated temporal dimensions of motivations, by measuring them at several points in time. For example, in their study of volunteers in urban conservation via invasive plant control, Asah and Blahna (2012) found that social and personal benefits were better predictors of the frequency of participation than more often reported environmental-related reasons. In a similar vein, Carballo-Cárdenas and Tobi (2016) reported that participant motivations shifted from collective reasoning (i.e. to help the environment) to individualistic reasoning, including promoting commercial and recreational harvesting of lionfish. In this case, sustained interest was thus mainly driven by self-interest. This confirms findings from previous research that self-reported motivations (often measured at the start of a project) are not necessarily influential motivations that predict the duration of the engagement (Ryan et al. 2001).

Pagès et al. (2018) studied volunteers' initial and sustained motivations by surveying and interviewing prospective, new, returning, experienced and inactive volunteers in invasive plant management on islands. They found that motivations changed from identifiable functional reasons to start volunteering (i.e. personal goals/circumstances and project aims) to more complex attachments to the place and group over time. Similar was observed by Jubase et al. (2021), who have shown that in 43% of volunteers a difference was observed between the initial reasoning for getting involved in IAS management and the motivations to remain involved in these activities. This implies that experiences during volunteer activities influence motivations, however, this change in motivation can be both positive and negative. Creating unique experiences for participants, e.g. by visiting places which are otherwise off limits can be an incentive to participate and can also result in a greater sense of responsibility for the volunteer or better relations between volunteers, stakeholders and management authorities based on trust (Cerrano et al. 2017; Pagès et al. 2018).

Another study noted that the perceptions of control feasibility can shift initially optimistic views to more nuanced, realistic or even pessimistic perspectives on the effectiveness of IAS control (Pagès et al. 2019). This, in turn, can affect volunteer retention, as participants may become disengaged over time, doubting or questioning the value of what they are doing (Atchison et al 2017). One way of dealing with this specific issue is to design the project in such a way that volunteers can see tangible results and feel like they are making a difference, e.g. by first clearing a field of weeds mechanically before bringing in volunteers to remove the last remaining plants (Pagès et al. 2019) or observing the recovery of indigenous vegetation (Jubase et al. 2021). Early detection of species is a rare event which may also reduce motivation to participate in monitoring (Pocock et al. 2020). In such cases, it is important to carefully communicate about the species' detectability to foster realistic expectations and avoid backlash where people's participation results in reduced concern about IAS because they cannot find it (Falk et al. 2016; Harvey et al. 2016).

Ethical and practical dilemmas

Motivations of project organizers and volunteers can differ substantially, leading to practical and ethical dilemmas. Pocock et al. (2020) give some clear examples from the context of early detection of tree pests and diseases and how this may affect motivations of participants to join or stay engaged in citizen science projects. One dilemma is that local communities can be disproportionately affected by actions following detection of pests and diseases as negative impacts, while the benefits of these actions are more likely gained at a larger scale. People may stop reporting due to concerns about the impacts of eradication measures, both due to the method used (e.g. killing, pesticides) or their outcome (e.g. felling trees or restricting access, sometimes resulting in a loss of income). Thus, in contrast to their expectation of helping the environment (e.g. to save trees), participants' efforts in reporting may lead to unintended consequences (e.g. as saving trees involves felling some of them). Similarly, Pagès et al. (2019) point to the potential failure in reconciling multiple goals of participation (e.g. gathering

more data vs. empowering people) and warn that an overemphasis on conservation and cost-effectiveness criteria can fail to address local communities' concerns.

Another issue is that volunteers may be regarded as an answer to labor shortages and escalating costs. Some of the studies reported that detecting and monitoring species in marine environments is relatively expensive. Engaging volunteers can reduce costs for working hours and equipment, but resources can also be a constraint for volunteers to participate (Carballo-Cárdenas and Tobi 2016). In general, citizen science and volunteering should not be regarded as free labor of any kind, as it may actually result in higher associated costs for stakeholders or organizations (e.g. due to the high workload in confirming observations, communication or training of volunteers).

Awareness of volunteer perceptions is especially important when their activities involve or contribute to the killing of animals. Studies report that this can be an emotional burden on people, especially with charismatic invasive animal species such as grey squirrels or Asian carp (Atchison et al. 2017; Crowley et al. 2018; Dunn et al. 2021). Killing invasive animals brings combined ethical and practical constraints. For example, even in large scale invasive animal control projects (involving hundreds of thousands of animals being killed, e.g. Bonnet et al. 2021), the majority of volunteers may not have access to the most humane methods of dispatch, forcing them to rely on a blow to the head or to drowning the target animals (e.g. Crowley et al. 2018). Olszańska et al. (2016) have shown that such methods received lower support or were even opposed by the public, making it vitally important to communicate, promote and make the most humane methods for killing the target IAS more accessible, as they are often either not known or not practiced by a broader audience (e.g. Atchison et al. 2017). The discourse of ethics should not be confined solely to methods used for killing animals. Rather, it also needs to consider the potentially negative impacts on the wellbeing (both health and safety) of volunteers and the social implications (e.g. being regarded as animal killers) for people who volunteer in such eradication campaigns.

A final dilemma concerns the decision to reward volunteers or not. Several studies report on the risk of crowding out intrinsic motivations if authorities promote personal benefits such as financial rewards (Stien and Hausner 2018; Garrard et al. 2020). On the other hand, it may promote inclusiveness by enabling participation of diverse volunteers that could have financial barriers (Pateman et al. 2021). The examples we found were linked to (semi)professional hunters receiving a reward per animal. As a rule, the other volunteer activities were unpaid, even though it is important to highlight that reimbursements can be important in enabling volunteer participation.

Recommendations for future research

Our synthesis revealed that studies of volunteer motivations in IAS contexts are often pragmatic without making reference to theoretical frameworks. Inadequate reporting of methods was another issue. Our findings also point towards the importance of considering situation-specific drivers and temporal changes when measuring motivations. In addition to scoring or ranking motivations, it is thus also important to test whether such self-reported motivations actually influence behaviors and whether they change

over time. Such longitudinal and explanatory studies remain scarce within the context of volunteer projects and require more attention. Differences in motivations between and within specific volunteer groups highlight the need to understand the target group of volunteers. This would ensure better success in their recruitment and retention throughout volunteer projects. Our recommendations for future research are to:

- Design survey methods that build upon previous research on motivations, behavior and knowledge from different research disciplines (e.g. Clary and Snyder 1999; Wilson 2000; Omoto and Packard 2016).
- Include demographic information in the study for possible segmentation of the sample into different groups with different motivations, e.g. nationality, gender, age, income, level of education, ethnicity, disability status and employment status.
- Comply with transparency and FAIR data policies, e.g. publish questionnaires used, results and other relevant methodological information as standard practice.
- Use comparative study designs for measuring the types and strengths of motivations in different kinds of projects or comparing between different groups.
- Test whether self-reported motivations align with observed behavior and whether these change over time (longitudinal and explanatory studies).

Recommendations for designing future volunteer projects

Most papers provided concrete recommendations for designing projects that consider the diverse motivations of participants to maximize their recruitment and retention (See Suppl. material 3). For example, it is important to be inclusive of diverse groups of people and tailor tasks or roles to their interests and capabilities (MacLeod and Scott 2021; Pateman et al. 2021). To this end, providing clear information on what is required from the volunteers, how much time would they need to invest and what support they can expect from the project is important. Also, projects should consider active recruitment strategies based on information from potential participants regarding their preferences for reporting data or contributing to IAS management. Some concrete recommendations for designing IAS volunteer projects based on the information reviewed in our work (See Suppl. material 3) and our personal experiences are:

1. Document and report participant demographics (age, gender, participant profile, etc.) to monitor diversity in citizen science, evaluate engagement and devise strategies to improve inclusiveness.
2. Consider whether volunteers can have a larger role in co-designing or collaboratively developing the project. Asking (potential) volunteers about their needs and wishes before and during a project enables the targeting of specific audiences and adapting to their needs.
3. Organize activities that provide volunteers with unique opportunities, exciting experiences, and fun and enjoyment.

4. Visit locations where (potential) volunteers can see and experience the negative impacts of IAS first-hand. Such an experience can trigger a desire to help or to continue volunteer activities.

5. In case of control projects, clearly state the management objectives of projects to avoid disillusionment.

6. Carefully consider ethical, legal and financial aspects around the involvement of volunteers, particularly in control projects. Provide adequate support to volunteer work that involves high risk activities (e.g. insurance).

7. If possible, partner up with existing projects and initiatives to ease volunteer recruitment and avoid 'competition' between projects.

8. Promote long-term projects that allow for continuity and for "knowing and recognizing the brand".

9. Promote collaboration between different stakeholders, e.g. between the government and volunteer organizations.

10. Ensure that information about the programs is made more accessible (due to problems with internet access, and social media platform usage).

Conclusions

Knowledge of volunteer motivations is important for developing and improving project design, communication, and evaluation of IAS projects. Despite increasing public involvement in monitoring and control of IAS, our synthesis found that only a limited number of studies have investigated volunteer motivations to participate in such activities. Our conceptual framework identified 15 motivations of which three were unique to the IAS context: supporting IAS management, protecting native species and habitats, and livelihood/food/income protection or opportunities. This framework, including environmental, social and personal motivations, provides a clear starting point for developing survey instruments, though the selection and number of survey items will depend on the target audience. We encourage researchers and project managers to amplify their efforts in systematically gathering and reporting data on participant motivations in IAS projects, to allow for comparative studies and quantitative assessments of the importance of certain motivations. Collaboration with social scientists is strongly recommended to ensure the use of appropriate methodologies and consideration of relevant theoretical frameworks.

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Supplementary material 1

List of the studies used in the analysis

Authors: Ana A. Anđelković, Lori Lawson Handley, Elizabete Marchante, Tim Adriaens, Peter M.J. Brown, Elena Tricarico, Laura N.H. Verbrugge

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Supplementary material 2

Overview of the study characteristics and methodological approaches of the selected papers

Authors: Ana A. Anđelković, Lori Lawson Handley, Elizabete Marchante, Tim Adriaens, Peter M.J. Brown, Elena Tricarico, Laura N.H. Verbrugge

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Supplementary material 3

List of recommendations for designing projects to ensure maximum recruitment and volunteer retention extracted from the studies used in the analysis (for their full references, please see Suppl. material 1) and their link to our recommendations

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