POLICY ARTICLE

Public support for invasive alien species eradication programs: insights from the Netherlands

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Over the last few decades, the number of invasive alien species (IAS) has increased worldwide. IAS can have negative impacts on biodiversity, human health, and the economy. For a number of reasons, IAS policies and management schemes that have been implemented have not been sufficient to tackle the problem. In this article, we focus on IAS eradication and a main obstacle to eradication, namely a lack of public support. By analyzing three specific cases of IAS eradication in the Netherlands (Indian house crow; Pallas's squirrel; and American bullfrog), we show how factors initially affecting public support for eradication interact with each other and influence the effectiveness of the measures that IAS eradication managers implement in order to achieve support for their eradication programs. Our analysis provides a better understanding of the manipulability of factors affecting public support. Finally, it reveals concrete measures that IAS managers can implement in order to gain public support. A lesson for IAS eradication managers is that they can effectively aim for support for eradication, even if low public support for eradication is to be expected in first instance. In addition, this article provides insight into practical measures that IAS eradication managers can implement.

Key words: biodiversity, governance, nature conservation, public policy

Implications for Practice

- Public support is important for effective invasive species eradication programs.
- Factors that influence the initial level of public support are: targeted species' characteristics, environmental values of stakeholders, knowledge about IAS, and eradication methods.
- Eradication managers can enhance support by the regular provision of information about eradication and tailoring eradication methods to the concerns of actors involved.

Introduction

Invasive alien species (IAS) are generally understood as non-native species that successfully occupy natural or seminatural ecosystems (Genovesi 2001). Over the last few decades, IAS have increased in numbers due to an intensification of international transport and climate change (Genovesi 2011). IAS are considered to be a major threat to biodiversity (Mack et al. 2000) but also pose risks to human health and the economy (Wittenberg & Cock 2001; McNeely 2009). There are therefore not only growing scientific concerns about IAS (e.g. Chown et al. 2012) but also governmental concerns. Globally, many governments have implemented IAS policies and management schemes, but so far they have not been sufficient to solve the problem (Olenin et al. 2011). In Europe, therefore, on 1 January 2015, a new Regulation 1143/2014 on IAS was brought into force which requires Member states to eradicate IAS as much as possible, if prevention has failed (European Commission 2014).

In this article, we focus on factors influencing public support for IAS eradication. Eradication programs are one of the options for IAS management and aim at elimination of the entire IAS population with methods such as mechanical control (e.g. cages) and chemical control (e.g. toxic baits) (Wittenberg & Cock 2001). Eradication is an option for managing IAS when it is no longer possible to prevent them entering or populating particular ecosystems (e.g. by monitoring of ballast water of vessels) (Moore et al. 2011). Eradication is also considered to be more effective and cost-efficient than control or containment of introduced IAS (Wittenberg & Cock 2001; Genovesi 2011). However, eradication has proven to be difficult and, when it fails, expensive (Myers et al. 2000; Genovesi 2001). A main constraint to eradication is the lack of public support (Myers et al. 2000; Bertolino & Genovesi 2003; Genovesi 2011). However, knowledge on factors positively influencing public support for IAS eradication is still lacking, and will therefore be further explored in this article. We will take the Netherlands as

a case study. In this country, the first IAS policy was implemented in 2007 (ANF 2007). Previous research has shown that in the Netherlands, eradication is sometimes not even considered when the amount of public support is expected to be low (à Campo & Runhaar 2010). We will analyze what measures are taken in practice in order to build public support, how effective these measures are, and what lessons we can draw from these practices for IAS eradication.

Theoretical Context

Public Support

Public support can relate to various aspects of policies and management (Dunlap et al. 2001). We define public support as the active or passive support of citizens and NGOs for an IAS eradication program, whereas the opposite of public support is active or passive opposition (cf. Van Zanten 2002). Unlike passive support or opposition, active support and opposition results in a certain action such as participating in eradication activities, or protesting or even bringing eradication managers to court (Bertolino & Genovesi 2003). Public support can be related to an eradication program in general or to specific aspects (e.g. granting access to private land; Myers et al. 2000). To measure the amount of public support, we used the method of Van Zanten (2002) and measured three components: point of view (whether the majority favors or opposes eradication), intensity of the expressed point of view, and power of support (ranging from active opposition to active support for eradication) (these components are explained in more detail in Appendix S1, Supporting Information).

Measures to Gain Public Support for IAS Eradication

The literature suggests two specific measures that IAS eradication managers can implement in order to gain support for their programs. First, communication of the program, its implementation, and its progress are found to contribute to trust in the program and to accountability, both of which are found to reduce the likelihood of public opposition (Larson et al. 2011). Second, involving the public in eradication activities (e.g. in terms of monitoring or species removal) contributes to the citizens' sense of ownership of the project, fostering public support (Wittenberg & Cock 2001).

The above measures are not always sufficient for building public support for eradication. Factors that also influence public support for IAS eradication, and that may mediate the influence of the above measures, include the targeted species, the environmental values of the people involved, the knowledge people have about the impacts of IAS, and the eradication methods used.

Regarding the *targeted species*, the eradication of appealing animals (mammals, birds especially, and pet species) is usually least supported (Genovesi 2001; Bremner & Park 2007; Verbrugge et al. 2013) and hence requires specific measures for building support. *Environmental values* encompass relatively stable and immutable basic beliefs about human interaction with nature. These values shape attitudes, which are more flexible and are predictors of behavior regarding IAS eradication (i.e. support or oppose). Discussions with the public about eradication goals and justification of the eradication methods to be used may be needed to avoid opposition (Wittenberg & Cock 2001). In particular, animal rights groups have frustrated eradication programs and frequent and positive discussions with these groups from the outset are considered necessary to avoid legal actions and delays (Perry & Perry 2008). If no agreement can be achieved through discussions, eradication programs could be modified to fit the various attitudes. Early stakeholder participation provides opportunities for discussion and incorporation of public attitudes in the design of the eradication program (Wittenberg & Cock 2001; Verbrugge et al. 2013). For a participative process to be effective, it is advisable to ensure transparency of the process, to give adequate information to the public, and to adequately consider and use the input gained (Genovesi 2001; Wittenberg & Cock 2001).

A lack of *knowledge* about the potential negative consequences of IAS will also result in low public support for eradication (Bremner & Park 2007; Verbrugge et al. 2013). Public support will be more likely when it is clear (or clarified) to the public what impact the species has on biodiversity and what benefits eradication will bring to native biodiversity (Mack et al. 2000; Bremner & Park 2007). Hence, eradication programs should contain information sharing (Larson et al. 2011), preferably species- and location-specific, freely available, and to-the-point (Verbrugge et al. 2013). The media can help to spread information (Wittenberg & Cock 2001), but can also foster opposition through sensationalization (Bremner & Park 2007).

The *methods used* also affect public support for IAS eradication (Bremner & Park 2007; Verbrugge et al. 2013). Eradication methods should be selected after consulting the public (Genovesi 2001). Chemical control options (e.g. poisoning) are least supported, mostly due to concerns about negative side effects on native species and humans (Mack et al. 2000; Bremner & Park 2007; Verbrugge et al. 2013). Mechanical control (e.g. trapping) is usually the most preferred option (Mack et al. 2000). Preference for methods depends on the targeted species (Verbrugge et al. 2013). An important issue is whether the method used also affects native species (Bomford & O'Brien 1995). Therefore, the side effects of selected eradication methods should be monitored and adjusted if necessary (Myers et al. 2000; Genovesi 2001; Simberloff 2008).

Methods

Embedded Case Studies

We analyzed three case studies for an in-depth understanding of eradication practices. Our cases included the Indian house crow (*Corvus splendens*) population in the city of Hoek van Holland, the Pallas's squirrel (*Callosciurus erythraeus*) population in the city of Weert, and the American bullfrog (*Lithobates catesbeianus*) population in the village of Baarlo. There are several reasons for this selection. First, these animals are vertebrates, which pose a "major threat to ecosystems" (Genovesi

2001, p 5), making their eradication important. Second, these cases vary regarding the degree to which these animals are (expected to be) appealing to the public and hence affect public support for eradication. The eradication of the house crow and the Pallas's squirrel was expected to be least supported by the public (cf. Bertolino & Genovesi 2003), whereas we expected that the American bullfrog would be a less appealing species. Third, sufficient information about these cases was available.

Data Collection

Data on the three case studies were collected regarding the eradication programs, a timeline of events, and the three elements of public support among involved citizens and NGOs (i.e. point of view, its intensity, and power of support). We relied on existing data. Newspaper articles were a main source of information. Articles were found in the online database Lexis Nexis Academic (http://academic.lexisnexis.nl). Search terms included the name of the species and the location of eradication. The websites of the actors involved (see Appendix S2) were also visited for useful data as we expected that these would contain the views and behavior of most relevant citizens and NGOs. The time period of data collection was April–June 2015. No articles or websites were excluded because their number was of an appropriate size to be processed. Information about the eradication programs was found in policy documents and gray literature. See Appendix S3 for further details.

Analysis and Determining Causality

The case study analysis consisted of: (1) reconstruction of a timeline of events including the IAS eradication process; (2) identification of the public involved (e.g. citizens, affected landowners, and NGOs); and (3) assessment of public support. We qualitatively assessed causal relationships between public support, measures implemented in order to achieve public support, and the factors that, according to the literature, affect public support. By varying one important factor—the level of appeal of the targeted species—we tried to tentatively assess the relative importance of measures taken and the factors affecting public support. Here, the comparative analysis of the three cases (see Table 1) helped us to qualitatively identify patterns. By constructing an open timeline of events for each of the three cases, we allowed for the exploration of factors other than those identified in the literature, that is rival explanations (Runhaar et al. 2006). In this way, we aimed to build "a logical chain of evidence" (Miles et al. 2014).

Results

Case Study I: The American Bullfrog

RAVON (a foundation monitoring and conducting research on amphibians with the aid of volunteers) announced the presence of bullfrogs in the village of Baarlo in a press report on 4 October 2010. It attracted a lot of regional and national media attention. The concise report provided information in a regional context and emphasized the need for eradication in order to avoid noise disturbance and to protect native amphibians, discussed what

steps had already been taken and what further actions were planned. One week later, an information evening was organized by RAVON and the municipality, during which residents of Baarlo were informed about the problem and the planned eradication process. Via door-to-door newspapers, regular newspapers, and a press report, residents were requested to report observations of bullfrogs to RAVON. The website of RAVON was referred to for more information. The website included similar information to the press report, but also a flyer with detailed pictures and descriptions of bullfrogs and native frogs. RAVON circulated 7,000 of these flyers.

Eventually RAVON received 35 reports of American bullfrogs and discovered that bullfrogs inhabited two ponds. At the first pond, the landowner fully cooperated and even helped to remove the bullfrogs. He knew his pond would be damaged severely, but believed protecting nature was more important. At the second pond, the landowner refused the eradication methods that had been used at the first pond. After 30 years of bullfrogs in his pond, he did not mind them anymore. After negotiations, it was agreed to either send captured bullfrogs to a university for research or tranquilize and kill them by means of a deadly injection. Also precautions were taken to avoid the unnecessary killing of pond animals. The eradication surprised residents, because bullfrogs had been in Baarlo for 20 years but there was no opposition. Residents complained about the noise disturbance and some had even tried to eradicate the bullfrogs themselves.

During a second information evening in May 2012, RAVON presented its research results and announced that the bullfrogs had been eliminated. Residents were asked to keep looking for bullfrogs to prevent new populations. All 35 people present were willing to cooperate and inspected the area dozens of times, but no more bullfrogs were found.

Case Study II: The Indian House Crow

In April 1994, two Indian house crows were reported in Hoek van Holland. SOVON (a bird research foundation) advised quick eradication. The responsible ministry commissioned a risk assessment but kept the outcome secret. "Stop invasieve exoten" (a platform aiming to combat IAS) forced publication in 2009 and then went to the press in order to urge the ministry to take measures. In March 2010, the ministry put the house crow on a list of species that are allowed to be eradicated. The province of Zuid-Holland was formally responsible for giving permission to any exterminator who volunteered to eradicate the house crows, but turned out to be indecisive in this case and did not respond to the media. In December 2011, the province finally gave the company Duke Faunabeheer permission to remove the house crows. The province stated in the press that eradication was necessary to prevent a plague and because the birds caused problems and could threaten native birds, cause noise disturbance, and damage crops and property in the future.

De Faunabescherming (an animal rights group) opposed this, stating that there was no proof the house crows would become a plague, or that they caused problems or posed risks. In December 2012, De Faunabescherming went to court to abort

Table 1. Comparison of the three case studies.

	American Bullfrog	*Indian House Crow*	*Pallas's Squirrel*
Measures to build public support			
Involve public from the outset	Yes	No	Yes
Adequate consideration and use of public input	Yes	No	Yes
Engage public in eradication activities	Yes	No	Yes
Monitor side effects of eradication methods and adjust if necessary	No	No	No
Communicate ethical and animal welfare concerns of selected eradication methods	Yes	No	Yes
Provide freely available, detailed, summarized, and species-specific information addressing negative effects of IAS and eradication benefits in a regional context	Yes	Yes, but only in newspapers	Yes
Cautious use of media	No	No	Yes
Transparency of the process	Yes	No	Yes
Communication of progress	Yes	No	Yes
Public support			
Point of view	Positive	Negative	Positive
Intensity	Moderately	Very high	Moderately
Power	Active support	Active opposition	Mixed
Amount of public support	High	Very low	Moderate

the eradication, which was approved. The eradication had to be stopped because the house crow was still listed as a protected species. The ministry of ANF then removed the house crow from that list, followed by other legal appeals by De Faunabescherming, but without success.

The eradication started in March 2014. Regarding the methods used, a few years earlier, in 2010, the ministry had said that the birds would be caught and sent to a zoo, a method also advised by Stop invasieve exoten. However, after nets and cages had appeared to be ineffective, it was decided to shoot the crows. Although two residents complained about the house crow, the shooting caused a lot of unrest among residents, especially when a native bird was shot. Duke Faunabeheer said this was "unfortunate." Residents stated that the house crow had never caused any problems and some residents decided to keep them safe in cages at a secret place. The Faunabescherming asked residents to show their disapproval of the eradication to the province via email, and many cooperated. According to the Faunabescherming, the province responded to these emails with a non-personal or detailed email. In June 2014, a petition signed by 1,700 residents was given to the Ministry of Internal Affairs to save the remaining house crows, but without result. In December 2014, Duke Faunabeheer announced that after the intervention the population had been reduced to four house crows.

Case Study III: The Pallas's Squirrel

In 1998, 10 Asian Pallas's squirrels escaped from a pet store and settled in a forest near Weert. In their risk assessment of the Pallas's squirrel, the Zoogdiervereniging (an organization researching and protecting native mammals) stated that the area provided a suitable climate and habitat for permanent settlement. To determine the population size, the Zoogdiervereniging carried out two inventories (in 2009 and in 2011), during which residents were asked directly and via flyers to report observations of the squirrels. The flyer provided brief but detailed information tailored to the local context, including illustrations and descriptions to help identify squirrels and emphasized the potential threat to "our native red squirrel." Forty people responded to the two calls. The Zoogdiervereniging estimated the population size at 50–110 squirrels. It was advised to act as soon as possible if eradication was the goal: as the population would grow, the feasibility of eradication was expected to decrease substantially.

In November 2011, the responsible ministry announced that the population would be shot the following spring. Stichting AAP (an animal rights group) opposed this and argued that this was another example of the government not responding to their calls to capture IAS, but favoring shooting as an easy way out. The ministry decided to negotiate with Stichting AAP. In December 2011, the ministry commissioned the Zoogdiervereniging to catch the squirrels. Prior to the eradication, stakeholders were involved and informed via the local media. In local newspaper articles, the Zoogdiervereniging clarified the reasons for eradication, to address the threat to native squirrels and damage to property and trees. Similar experiences from France and the Netherlands were mentioned as illustrations. Also, the Zoogdiervereniging reported the actual decline of native squirrels in Weert. On multiple occasions, residents were informed about the process and progress (e.g. via newspapers). The request to report observations of Pallas's squirrels was repeated via various media (e.g. local radio, free journals) and eventually resulted in 55 reports.

Cages that were considered animal-friendly were used for the welfare of the Pallas's squirrel and other species and in order to avoid public opposition. Captured squirrels were removed from the traps as fast as possible to minimize stress, then sterilized and brought to refuges. Although some residents complained about the squirrels because these had damaged their property (e.g. by chewing on plastic), they did not want the squirrels to be killed and therefore only accepted cages to be placed in

their gardens. However, some opposition was also observed; some residents refused to have cages in their garden and some cages were destroyed or stolen in the final months of eradication. Despite these few problems, the Zoogdiervereniging announced in April 2013 that 246 Pallas's squirrels had been captured and only a few remained. After years of absence, the presence of native squirrels was reported by residents again.

Comparative Analysis

Public Support and Measures Implemented to Gain Support. Table 1 provides an overview of measures taken in order to achieve support, and a tentative assessment of the amount of public support that the eradication programs had. Although the number of cases is low, there seems to be a correlation between the number of measures implemented and the degree of public support. During the eradications of the American bullfrog and the Pallas's squirrel, a relatively large number of measures were taken to build public support (7 and 8 out of 9, respectively). In these cases, a high and moderate degree of public support was found. Only one measure was taken during the eradication of the Indian house crow, and this did not receive much public support.

Influence of the Other Factors Affecting Public Support. In previous literature, we identified four factors that affect public support for IAS eradication: the targeted species, environmental values, knowledge, and the eradication methods employed. We will start with the first factor, which varies among cases. The lack of public support for the eradication of the house crow could be the consequence of not taking sufficient measures to build public support. However, this case study also supports the findings of Bremner and Park (2007) and Verbrugge et al. (2013) that eradication of birds is least supported by the public. Hence the targeted species seem to make a difference. Possibly, the lack of public support for eradication of the house crow was exacerbated by not taking sufficient measures. The shooting of a native bird caused a lot of indignation, which confirms that public opposition is very likely when non-target species are affected (Bomford & O'Brien 1995). More communication from the ministry to De Faunabescherming and citizens may have helped building some support. The eradications of the American bullfrog and the Pallas's squirrel are both good examples of what can potentially be accomplished when the project manager takes sufficient measures to build public support. In both cases citizens cooperated, and some even participated in eradication activities. Environmental values in terms of empathy for the IAS involved were present in all three cases. We doubt whether these values can be influenced. However, the cases showed that public support for eradication can be obtained even when there is empathy for the IAS at issue. All three cases showed that much depends on the eradication methods employed—another factor affecting public support. The media only seemed to play a role in the eradication of the Pallas's squirrel. In this case, public opposition during the final months of eradication could have been the consequence of attention to IAS in local media. The amount of public support for the eradication of the Pallas's squirrel can be called impressive, because mammals are

appealing and the eradication of the grey squirrel in Italy caused fierce public opposition (Bertolino & Genovesi 2003). This success illustrates that even when the targeted species is appealing, support can still be gained for the eradication program when sufficient support-building measures are taken.

Concluding Remarks

Limitations

This article was based on an embedded case study in one country. We therefore have to be modest in generalizing our conclusions. For instance, public support may manifest itself differently, and have a different weight, in other institutional contexts. There are three other limitations to our study. First, the degree of public support was primarily derived from newspaper articles. Some actors (e.g. those who are neutral or mildly positive toward eradication) may have been underrepresented in these articles. Second, the causality between taking measures to build public support, the degree of public support found in the three cases, and the influence of the other factors affecting public support for IAS eradication was only qualitatively assessed. A large-N study involving more cases and surveys among the public involved can help IAS managers to rank and select measures. At the same time, more in-depth case studies of other eradication programs concerning other species and/or different countries may reveal alternative rival explanations for public support for IAS eradication. Third and finally, we did not analyze the degree of freedom that IAS managers face when managing IAS—such as restrictions in time and financial resources (Wittenberg & Cock 2001) but perhaps also the urgency of eradication (cf. Roodenrijs et al. 2014). We encourage other researchers to address these limitations, in order to contribute to more effective IAS management policies.

Implications for IAS Eradication

Our analysis shows how complicated the issue of public support for IAS eradication is, but on the other hand also provides some practical points of application for eradication. One, it shows that even when initially public support for eradication seems to be low (which has deterred managers from initiating new IAS eradication programs in the past), public support can be built, as long as sufficient measures to build public support are taken. A logical starting point for eradication managers is to conduct a stakeholder analysis (Runhaar et al. 2006): which actors are potentially involved or interested in the eradication program, how do these actors relate to the species at issue, what values are involved, how intense are their viewpoints, and what means do these actors have at their disposal (alone or in coalition with other actors) to support or oppose (particular methods of) eradication? Two, this article provides insight into practical measures that IAS eradication managers can implement. These include the regular provision of information about the need for eradication and about eradication procedures and adjusting and tailoring eradication methods to the concerns of actors involved.

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Supporting Information

The following information may be found in the online version of this article:

Appendix S1. Indicators and scales for measuring public support.
Appendix S2. Explanation of actors involved in the cases.
Appendix S3. Introduction into the cases and full references.