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Socio-economic impact classification of alien taxa (SEICAT)

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Abstract

1. Many alien taxa are known to cause socio-economic impacts by affecting the different constituents of human well-being (security; material and non-material assets; health; social, spiritual and cultural relations; freedom of choice and action). Attempts to quantify socio-economic impacts in monetary terms are unlikely to provide a useful basis for evaluating and comparing impacts of alien taxa because

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they are notoriously difficult to measure and important aspects of human well-being are ignored.

2. Here, we propose a novel standardised method for classifying alien taxa in terms of the magnitude of their impacts on human well-being, based on the capability approach from welfare economics. The core characteristic of this approach is that it uses changes in peoples' activities as a common metric for evaluating impacts on well-being.
3. Impacts are assigned to one of five levels, from Minimal Concern to Massive, according to semi-quantitative scenarios that describe the severity of the impacts. Taxa are then classified according to the highest level of deleterious impact that they have been recorded to cause on any constituent of human well-being. The scheme also includes categories for taxa that are not evaluated, have no alien population, or are data deficient, and a method for assigning uncertainty to all the classifications. To demonstrate the utility of the system, we classified impacts of amphibians globally. These showed a variety of impacts on human well-being, with the cane toad (*Rhinella marina*) scoring Major impacts. For most species, however, no studies reporting impacts on human well-being were found, i.e. these species were data deficient.
4. The classification provides a consistent procedure for translating the broad range of measures and types of impact into ranked levels of socio-economic impact, assigns alien taxa on the basis of the best available evidence of their documented deleterious impacts, and is applicable across taxa and at a range of spatial scales. The system was designed to align closely with the Environmental Impact Classification for Alien Taxa (EICAT) and the Red List, both of which have been adopted by the International Union of Nature Conservation (IUCN), and could therefore be readily integrated into international practices and policies.

KEYWORDS

alien species, capability approach, human well-being, impacts, socio-economy

1 | INTRODUCTION

Biological invasions are a major driver of global change and can cause high costs to recipient environments and socio-economies (Bellard, Cassey, & Blackburn, 2016; MEA, 2005; Pimentel, Zuniga, & Morrison, 2005). However, the impacts caused by alien species vary markedly between species and contexts (Kumschick, Bacher, et al., 2015; Kumschick, Gaertner, et al., 2015; Pyšek et al., 2012; Ricciardi & Cohen, 2007), and there is substantial debate as to their severity and scale (Davis et al., 2011; Simberloff et al., 2011, 2013). A challenge for invasion science is to provide transparent and comparable measures of impact based on clear and explicit definitions (Hulme et al., 2013; Jeschke et al., 2014). What has largely been missing from the invasion science toolbox is a standard method for quantifying impacts using a common metric so that they can be compared across impact types, regions or species (Nentwig, Kühnel, & Bacher, 2010). Such a method is essential to ensure that the documentation of impacts of alien taxa

is objective, transparent and can underpin efforts to prioritise species for policy and management. In this context, prioritisation is defined as the process of ranking alien taxa for determining their relative impacts, both environmental and socio-economic, and implementing necessary management actions (McGeoch et al., 2016). As such, the adoption of this method may contribute to key global policy measures aimed at addressing the problems associated with biological invasions, such as the Convention on Biological Diversity's (CBD) Strategic Plan for Biodiversity 2020 and associated Aichi Target 9 for biological invasions (UNEP, 2011).

A pragmatic solution for comparing diverse environmental impacts was recently developed: the Environmental Impact Classification for Alien Taxa (EICAT) (Blackburn et al., 2014; Hawkins et al., 2015). EICAT translates impacts caused through a broad range of mechanisms into five ranked levels of impact from "Minimal Concern" to "Massive." As these are measured in the same metric (impact on native biodiversity from individuals to communities), the magnitude of different impacts

can be directly, consistently and transparently compared. EICAT is receiving increasing international support and has recently been adopted by the IUCN (<https://portals.iucn.org/congress/motion/014>; accessed 20 April 2017).

Environmental impact classification for alien taxa focuses on environmental impacts only. However, alien species are also known to have socio-economic impacts which should also be accounted for in any management decision (Crowley, Hinchliffe, & McDonald, 2017). This suggests the urgent need to develop a system to assess the full socio-economic impacts of alien taxa. Such a system may also help differentiate social and environmental impacts despite the obvious interconnections between humans and their environments (Crowley et al., 2017) and to address synergies and trade-offs between these impact types.

In Europe, more alien taxa are documented as causing socio-economic than ecological impacts, probably because the former are more readily perceived and are immediately reported by concerned people (Vilà et al., 2010). Although there is some correlation between environmental and socio-economic impacts across species (Kumschick, Bacher, et al., 2015), socio-economic impacts cannot reliably be inferred from their impact on the environment, e.g. the tiger mosquito (*Aedes albopictus*) probably has a relatively low impact on biodiversity, but clearly a very high impact on human health. However, no robust and unified solution is available for comparing socio-economic impacts among alien taxa. Most attempts to quantify and compare these involve utilitarian approaches of monetising their costs (Born, Rauschmayer, & Bräuer, 2005; Reinhardt, Herle, Bastiansen, & Streit, 2003; Zavaleta, 2000). This seems an obvious route for quantifying socio-economic impacts. Yet it is unlikely that monetising impacts will provide a useful basis for comparison because converting all impacts into monetary costs is difficult, if not impossible (Hoagland & Jin, 2006). For example, the most comprehensive attempt to quantify the costs of alien taxa in the European Union came up with a total estimate of 12.5 billion Euros/year (Kettunen et al., 2009). The authors were careful to emphasise that this is a minimum estimate because many species and impacts were excluded. Moreover, monetary estimates of socio-economic costs vary considerably depending on the accounting method used (Born et al., 2005). In particular, such values are often derived solely from management costs and research (Scalera, 2010). While costs associated with management can often be readily calculated (e.g. pesticide costs, human labour), they do not allow a straightforward assessment of a species' impacts before or without control, and they are highly context-dependent (e.g. wages may vary widely between different countries). Furthermore, socio-economic impacts of alien taxa can be more appropriately reduced by technology or adaptive behaviour in affluent countries as opposed to poor countries where alien taxa can, in extreme cases, lead to the collapse of socio-economic sectors, thereby causing irreversible societal changes. Utilitarian approaches have difficulties in capturing such context dependence. But more importantly, many aspects of human life that alien taxa could impact upon (e.g. health, security, culture) are usually not included when monetising impacts.

To capture the full socio-economic impacts of an alien taxon, dimensions that go beyond monetary costs must be considered (Turnhout, Waterton, Neves, & Buizer, 2013). This is why it seems most promising to concentrate on changes in peoples' well-being as described by how they are being impacted by changes in their environment (including the influence of alien taxa). It has been shown that human well-being is context-dependent and should not be assessed solely in terms of wealth (Diener & Seligman, 2004). Moreover, it depends to a large extent on peoples' position relative to their opportunities (capabilities) rather than on absolute values (Diener & Seligman, 2004). Pejchar and Mooney (2009) suggested that the most appropriate measure of socio-economic impact of alien taxa should take into account the number of people affected and the magnitude of the impact on their lives, i.e. on their well-being.

Previous attempts to unify socio-economic impacts in a comparable metric other than money (e.g. GISS: Nentwig et al., 2010; Harmonia+: D'hondt et al., 2015) are based on variable descriptions of different impact scenarios. This makes comparisons between categories of socio-economic impacts difficult. We propose a novel standardised system based on human well-being for classifying alien taxa in terms of their socio-economic impacts. This system aims to be a practical tool that can: (1) be used to identify the magnitude of socio-economic impacts of alien taxa; (2) considers the context dependency of impacts, thereby facilitating comparisons of impacts among regions and taxa; (3) facilitates predictions of potential future impacts of the species in the target region and elsewhere; and (4) aids in the prioritisation of alien taxa and relevant introduction pathways for management actions. The proposed Socio-Economic Impact Classification for Alien Taxa (SEICAT) has the same key properties as (and is thus complementary to) the EICAT scheme (Blackburn et al., 2014). Like EICAT, SEICAT focuses on deleterious impacts, and classifies species on the basis of the best available evidence of their most severe documented impacts in regions to which they have been introduced. The goal of SEICAT is not to weigh deleterious against beneficial impacts to determine the net value of an introduction of an alien taxon, but rather to highlight potential consequences. It provides a consistent procedure for translating the broad range of impact types and measures into ranked levels of socio-economic impact, and is applicable across taxa and at various spatial scales.

2 | THEORETICAL BACKGROUND AND THE NEED FOR A PRAGMATIC APPROACH

Many multidimensional indices of well-being have been developed, most of them for assessments of poverty (Decancq & Lugo, 2013). However, as far as we know, none specifically assess changes to human well-being via changes in the environment. Our framework is based on the capability approach to assess human well-being in welfare economics and social sciences (Robeyns, 2011; Sen, 1999). This approach has become a paradigm in human development policy. It has inspired, among other things, the creation of the human development index of the United Nations (Anand, 1994), and has been identified as

a promising approach for evaluating effects of environmental changes on society (Hicks et al., 2016).

The core characteristic of this approach is its focus on what people are able to do and to be in their life, i.e. on their general capabilities. Examples include peoples' opportunities to be educated, and their ability to move around and enjoy supportive social relationships (Robeyns, 2011). A person's set of capabilities is determined by environmental factors, economic settings, and social context (Figure 1a). Of the given opportunities (capabilities), people choose a set of activities to engage in (their realised activities) according to their personal and cultural preferences. The capabilities are strongly linked to peoples' well-being (Sen, 1999).

Alien taxa can influence peoples' capabilities and realised activities via changes in environmental factors, economic settings, or the social context (Figure 1b). Thereby, different constituents of human well-being may be affected: security; material and immaterial assets; health; and social, spiritual and cultural relations (Table 1; Narayan, Chambers, Shah, & Petesch, 2000, Pejchar & Mooney, 2009). These constituents are analogous to the impact mechanisms in EICAT (Blackburn et al., 2014). The overarching premise for all constituents is the freedom of choice and action, i.e. the opportunity to be able to achieve what a person values doing and being. For example, the introduction of a new crop into a region where many people are undernourished can enlarge the capabilities of people by improving their health and access to material assets; this enables them to invest more time into preferred activities. In contrast, introduction of crop pests generally reduces the capability set of people because people would have to spend more resources (material and immaterial assets, e.g. time, money) to compensate for the losses, switch to less preferred crops that are not attacked by the pest, causing losses which may prevent e.g. their ability to send children to school. Such impacts would be perceived as detrimental.

Moreover, an alien taxon can affect not only the whole set of potential activities directly, but can also influence the activities that are actually realised. For example, stinging alien animals (e.g. wasps, mosquitoes, jellyfish) can make areas unsuitable for outdoor activities by threatening human health (thereby reducing the capability set), but

they can also indirectly (by threatening human safety) reduce the frequency of outdoor activities at sites where there are no aliens because of the fear of getting stung (thereby reducing the realised activities within the available capability set).

3 | QUANTIFYING THE IMPACT OF ALIEN TAXA ON HUMAN WELL-BEING

In practice, we cannot measure the complete set of peoples' capabilities and how they have been changed by an alien taxon, because many opportunities are not realised and thus remain unrecognised. However, what is ultimately important for human well-being is how much the realised activities of people have changed (Robeyns, 2005). Focusing on the magnitude of changes in realised activities due to alien taxa facilitates the comparison of their impacts on well-being at various spatial scales and in societies with different backgrounds.

We define an activity as any human endeavour that is, or could be, affected in its entirety by an alien taxon. This includes agriculture, hunting, recreation, industry, tourism, and so on. Defining activities is critical to the use of SEICAT, and will inevitably be different across different regions. A relatively straightforward possible consideration is to choose activities according to the nature of the impact of an alien taxon such that all people in the focal region participating in the activity can be considered as being potentially affected. In some regions, agriculture might be a relatively minor activity, and so it can be considered as a single activity affected in its entirety by the alien taxon. In other regions it might be necessary to consider different types of agriculture (e.g. cereal, market vegetables, livestock) as separate activities. It should also be remembered that people engage in multiple activities at a time and through time.

Impact assessments should always refer to a well-defined area (focal region); this may be a country, continent or some other geographically restricted area in which the alien taxon occurs (Blackburn et al., 2014). Within this region, SEICAT users may choose to weigh activities differently to account for different values placed upon them by society. This can ensure that, for example, the total loss of an activity

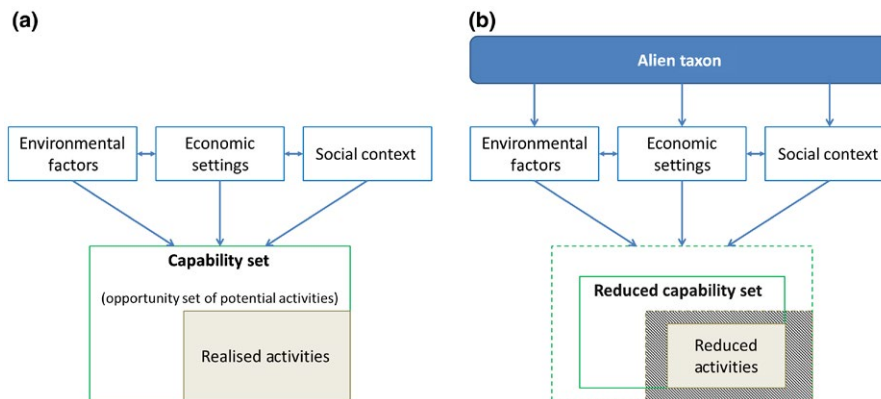


FIGURE 1 (a) A person's capability set depends on environmental factors, economic settings (goods & services), and the social context. From this set, people select the activities they want to achieve (realised activities). (b) Alien taxa can reduce peoples' opportunities via changes in environmental factors, economic settings or the social context. Socio-Economic Impact Classification for Alien Taxa (SEICAT) defines negative impacts as losses in realised activities attributable to an alien taxon (black hatched area)

TABLE 1 Constituents of human well-being and examples of their subcategories (after MEA, 2005). The overarching premise for all constituents is the freedom of choice and action, i.e. the opportunity to be able to achieve what a person values doing and being

Constituents of human well-being	Examples
Safety	Personal safety Secure resource access Security from disasters
Material and immaterial assets	Adequate livelihoods Sufficient nutritious food Shelter Access to goods
Health	Strength Feeling well Access to clean air and water
Social, spiritual and cultural relations	Social, spiritual and cultural practice Mutual respect Friendship

engaged in by very few people could be appropriately assessed against a less severe impact that affects many people. More details about these and other practical considerations involved in implementing SEICAT are described in the Supporting Information.

We define eight categories into which alien taxa can be classified according to the magnitude of changes in peoples' realised activities (Figure 2), detailed definitions of which are given in Table 2. This classification is analogous to the IUCN Red List and EICAT schemes (Blackburn et al., 2014; Hawkins et al., 2015; Mace et al., 2008). Five of the categories follow a sequential series of impact levels described by semi-quantitative scenarios. These were designed so that each step change in category reflects an increase in the order of magnitude of the particular impact; a new level of social organization is involved at each step. The remaining categories are not evaluated (NE; for taxa that have not yet been assessed), no alien population (NA; for taxa that have no known alien population), and data deficient (DD; alien taxa for which there is no information on impacts).

Alien taxa can have impacts on activities through effects on any of the constituents of human well-being (Table 1), similar to environmental impacts being potentially caused through several mechanisms in EICAT. During an assessment, all available evidence is gathered on socio-economic impacts of an alien taxon in its introduced range. For the final classification of the alien taxon, the highest deleterious impact level through any of the constituents of human well-being on an activity is reported.

4 | REPORTING

Since the proposed impact classification regards the whole socio-economic system as one entity determining human well-being, the

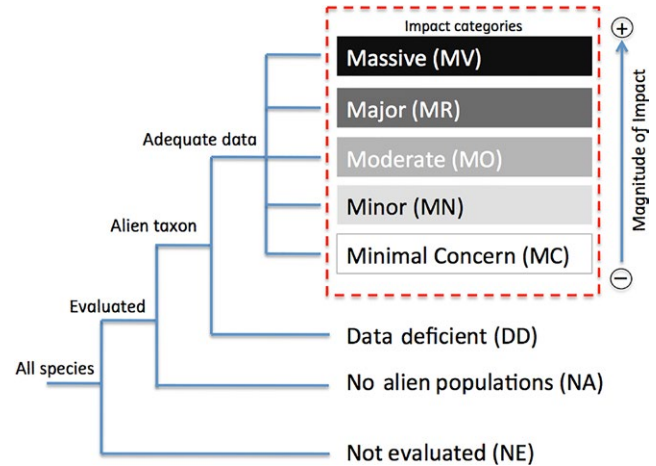


FIGURE 2 Socio-Economic Impact Classification of Alien Taxa (SEICAT) (after Blackburn et al., 2014; Hawkins et al., 2015). Detailed descriptions of the classes are given in Table 2

maximum score found in any of the activities assessed is decisive for the final outcome (analogous to EICAT; Blackburn et al., 2014). It is, however, recommended that the magnitude of impacts on all activities affected by the alien taxon be reported to allow other ways of summarising the results, e.g. as systematic reviews, or frequency distribution of SEICAT scores. It should also be reported which constituents of well-being are affected by each impact. Furthermore, different activities might be of interest to different stakeholders involved in decisions made regarding the management of alien taxa. Since the (perceived) impact of a species can change over time (Strayer, Eviner, Jeschke, & Pace, 2006), we suggest reporting the current maximum impact score and the maximum score ever achieved in history (Hawkins et al., 2015). The latter is a proxy of the potential maximum impact the species can achieve. It should be noted that some alien taxa have positive impacts on human well-being and can increase peoples' capabilities which would become apparent through an increase in selected activities (e.g. Pienkowski, Williams, McLaren, Wilson, & Hockley, 2015). These positive impacts need to be taken into account when making management decisions, but are not scored in SEICAT. However, SEICAT could provide a framework for scoring such positive impacts on human well-being.

5 | PROPERTIES OF THE CLASSIFICATION

Socio-Economic Impact Classification for Alien Taxa provides a common metric for all detrimental effects caused by alien taxa on socio-economy. In contrast to other schemes that rely on monetary values, it assesses the entire spectrum of possible impacts on human well-being and social structures. SEICAT provides a process for translating the broad range of impact measures into ranked levels according to observed changes in peoples' activities. It therefore allows distinction between taxa with different magnitudes of impact and provides a framework for comparing

TABLE 2 Description of Socio-Economic Impact Classification of Alien Taxa (SEICAT) according to observed changes in peoples' activities

Impact classification	Description
Minimal concern (MC)	No deleterious impacts reported despite availability of relevant studies with regard to its impact on human well-being. Taxa that have been evaluated under the SEICAT process but for which impacts have not been assessed in any study should not be classified in this category, but rather should be classified as data deficient
Minor (MN)	Negative effect on peoples' well-being, such that the alien taxon makes it difficult for people to participate in their normal activities. Individual people in an activity suffer in at least one constituent of well-being (i.e. security; material and non-material assets; health; social, spiritual and cultural relations). Reductions of well-being can be detected through e.g. income loss, health problems, higher effort or expenses to participate in activities, increased difficulty in accessing goods, disruption of social activities, induction of fear, but no change in activity size is reported, i.e. the number of people participating in that activity remains the same
Moderate (MO)	Negative effects on well-being leading to changes in activity size, fewer people participating in an activity, but the activity is still carried out. Reductions in activity size can be due to various reasons, e.g. moving the activity to regions without the alien taxon or to other parts of the area less invaded by the alien taxon; partial abandonment of an activity without replacement by other activities; or switch to other activities while staying in the same area invaded by the alien taxon. Also, spatial displacement, abandonment or switch of activities does not increase human well-being compared to levels before the alien taxon invaded the region (no increase in opportunities due to the alien taxon)
Major (MR)	Local disappearance of an activity from all or part of the area invaded by the alien taxon. Collapse of the specific social activity, switch to other activities, or abandonment of activity without replacement, or emigration from region. Change is likely to be reversible within a decade after removal or control of the alien taxon. "Local disappearance" does not necessarily imply the disappearance of activities from the entire region assessed, but refers to the typical spatial scale over which social communities in the region are characterised (e.g. a human settlement)
Massive (MV)	Local disappearance of an activity from all or part of the area invaded by the alien taxon. Change is likely to be permanent and irreversible for at least a decade after removal of the alien taxon, due to fundamental structural changes of socio-economic community or environmental conditions ("regime shift")
Data deficient (DD)	There is no information to classify the taxon with respect to its impact, or insufficient time has elapsed since introduction for impacts to have become apparent

impacts among taxa, mechanisms, particular introduction/invasion events and regions. Analogous to EICAT, SEICAT can be used to flag species with high potential impacts. However, the context-dependency of impacts should be considered when transferring impacts from one region to another (see Supporting Information).

The classification is dynamic and should be based on the best available evidence. Hence, species can move between impact categories as new data become available, for example if the quality of evidence improves, socio-economic or environmental conditions change, an invasion proceeds or is successfully managed. The classification can handle the lack of knowledge on some components of well-being, because it uses the maximum known impact. It thus identifies knowledge gaps and helps focus research to improve impact classification over time (see Supporting Information). The SEICAT protocol can be applied to assess impacts at a range of spatial scales, allowing national, continental, and global categorisation of impacts. It can therefore inform national or global assessment schemes in which species are assigned to management lists depending on their impacts (see Supporting Information). Finally, SEICAT considers only impacts on human well-being, but in combination with EICAT it is possible to assess environmental and socio-economic impacts in concert, thus evaluating the complete spectrum of deleterious impacts of alien taxa.

6 | CONGRUENCY OF SEICAT AND EICAT

The properties of SEICAT align with those of EICAT, mostly due to their structural similarity. The assessment units in EICAT are the native species in the local communities, and the irreversible loss of a native species from the local community is regarded as a Massive environmental impact. Similarly, the assessment units in SEICAT are human activities. Consequently, the complete irreversible loss of an activity (e.g. cereal farming) caused by an alien taxon from a local social community (e.g. a human settlement) is considered as a Massive impact on human well-being. In EICAT, impacts accumulate through different impact mechanisms, whereas in SEICAT impacts accrue at the level of constituents of human well-being (Table 1). Combining the two classification schemes for a complete assessment of negative effects on the recipient systems can inform evidence-based listing processes (e.g. Kumschick, Blackburn, & Richardson, 2016). For example, alien taxa that score high in both schemes can be identified and prioritised for management actions. Also, different stakeholder groups might weigh environmental and socio-economic impacts differently allowing them to use different weights for EICAT and SEICAT scores according to their needs or beliefs. Both SEICAT and EICAT follow a similar approach to that used in the widely adopted Red Listing approach of the IUCN, which paves the way for integration with existing management and policy procedures.

7 | APPLICATION

To illustrate the applicability and usefulness of SEICAT, we assessed all alien amphibians globally (104 species; Measey et al., 2016). In addition, to the references found by Measey et al. (2016), we supplemented their literature search focussing only on socio-economic impacts. We used the scientific species name as a search term in databases such as Google Scholar, ISI Web of Knowledge and databases specific to amphibians and alien species, manually filtering through the sources identified by reading titles and (if applicable) abstracts. We then looked for references in the resulting sources until no further records of impact were found. Suitable data for socio-economic impacts was found in 20 articles/reports for 44 impacts involving 7 species (Table S1). Impacts covered almost all impact classes: the cane toad, *Rhinella marina*, was the only species scoring MR, affecting several constituents of human well-being but most importantly leading to abandonment of certain cultural practices in Aboriginal communities in Australia due to the loss of totem species (Van Dam, Walden, & Begg, 2002). However, these impacts were considered to be reversible after control of the toad and thus we currently did not classify these as MV. The Asian common toad, *Duttaphrynus melanostictus*, has been reported to have caused death of a child in Timor after eating a toad meal; however no further changes in social activities were reported (Trainor, 2009). This consequently resulted in a classification as MO (fewer people participating in activities). We acknowledge that the death caused by an alien taxon might lead to a change in the activities of other people, but such changes are rarely reported. A major reason for the lack of reporting is probably that impacts through e.g. food poisoning caused by eating toxic animals and plants can be easily avoided and are therefore not causes of major concern for human well-being in most regions despite their potentially severe consequences. This is in contrast to risks that cannot be directly controlled, e.g. exposure to allergenic pollen produced by an alien plant. Such less controllable risks can have much more far-reaching impacts on human well-being and affect larger parts of societies. Three species were classified as MN: the coqui frog, *Eleutherodactylus coqui*, is widely reported to have large socio-economic impacts due to noise pollution, but the only impact on human activities which was reported was a decline in property trade due to increased real-estate prices in affected areas in Hawaii (Kaiser & Burnett, 2006). Thus, houses are still being sold and traded, but the activity of property trade is not doing as well when the frog is present. Also, human health might be affected by the noise levels, but

reports were lacking. A congener of the coqui frog, *Eleutherodactylus planirostris*, affects the nursery trade as plant shipments need to be treated. However, no other effects on trade were reported, and the activity did not seem to be reduced, but was just more onerous (Olson, Beard, & Pitt, 2012). Various minor impacts were also reported for *Osteopilus septentrionalis* (Johnson, 2007; see Table S1). In the case of *Hyla meridionalis*, it was reported that they cause a “deafening noise” (assuming this is not meant literally), without mention of any impacts on e.g. human health or activities being negatively affected in any specific way (Cheylan, 1983); therefore, this was classified as MC. The African clawed frog, *Xenopus leavis*, was classified as data deficient (DD) because the only impact reports were from the native range where it can affect fisheries. A further 98 species for which no studies on their impacts were found were also classified as DD (Table S1), and all other amphibians had no record of alien populations and were consequently classified as NA (not listed).

Most classifications (with the exception of *E. coqui*) were of low confidence due to the nature of the reports, which were mainly based on anecdotal observations and statements from affected people, but better quality studies are lacking. It is expected that such reports currently constitute the main evidence of impacts on human well-being until more systematic socio-economic studies that focus on changes in human activities due to alien taxa are done. General guidelines on how to conduct such studies are available (Palmer-Fry et al., 2017; Woodhouse, de Lange, & Milner-Gulland, 2016) and we hope that the publication of SEICAT triggers research in this direction. However, even with low quality data and in the presence of large uncertainties, SEICAT allowed a clear, meaningful, and transparent ranking of the species, with the cane toad causing the highest impact on human well-being, followed by the Asian common toad (whose impacts can be largely avoided), while other amphibians caused only minor or negligible impacts.

Comparing SEICAT and EICAT scores for amphibians for which both classifications are available (Table 3) shows that the scores are identical in only one species and that in general there is no good correlation between both scores. In most species, the EICAT scores were higher than the SEICAT scores, indicating that amphibians might tend to have stronger impacts on the environment than on human well-being (assuming that EICAT and SEICAT classifications can be considered as equivalent). However, because some species have larger environmental impacts and others higher impacts on human well-being it is not possible to forecast socio-economic impact from environmental impacts accurately (a simple regression

TABLE 3 Socio-economic (this paper) and environmental impact (Kumschick et al., 2017) classification of alien amphibians

	SEICAT	Confidence	EICAT	Confidence
<i>Rhinella marina</i>	MR	Low	MR	High
<i>Duttaphrynus melanostictus</i>	MO	Low	MR	Low
<i>Eleutherodactylus coqui</i>	MN	High	MO	High
<i>Eleutherodactylus planirostris</i>	MN	Low	MC	Medium
<i>Hyla meridionalis</i>	MC	Low	MO	Low
<i>Osteopilus septentrionalis</i>	MN	Low	MO	Low

SEICAT, socio-economic impact classification of alien taxa; EICAT, environmental impact classification for alien taxa; MR, major; MO, moderate; MN, minor; MC, minimal concern.

model assuming no correlation between the two scores actually fits better than a model assuming a linear relationship). It is currently not well understood which species have high or low impacts and which are more likely to affect the environment or socio-economy, but classification systems such as SEICAT and EICAT could be used to link such patterns to traits to understand and forecast species with different types of impact.

8 | CONCLUSION AND OUTLOOK

Considerable progress has been made recently on the quantification and classification of environmental impacts of alien taxa (e.g. Blackburn et al., 2014; Hawkins et al., 2015; Kumschick, Bacher, et al., 2015; Kumschick, Gaertner, et al., 2015) but assessing their effects on human well-being remains a challenge. Possible exceptions are purely economic pests such as agricultural pests (Simberloff et al., 2013) or species affecting human health (Rabitsch, Essl, & Schindler, 2017). There is a general demand for socio-economic impacts to be included in the decision making process on the legal regulation of alien taxa in trade, e.g. under the new EU Regulation (1143/2014) on invasive alien species, when justification for prioritising species is needed. Additionally, changes in SEICAT assessments over time (similar to the Red List Index of Invasive Alien Species from the Biodiversity Indicators Partnership; <https://www.bipindicators.net/indicators/red-list-index/red-list-index-impacts-of-invasive-alien-species>) could be used for developing an indicator of trends in socio-economic impacts, which is of crucial importance to guide policy and management decisions (Latombe et al., 2017; Rabitsch et al., 2016). Furthermore, socio-economic analyses can engage the public in ways that information on environmental impacts does not (Genovesi, Carboneras, Vilà, & Walton, 2014; Simberloff et al., 2013), thereby clarifying the framing of alien species problems (Woodford et al., 2016).

The global assessment of socio-economic impacts of alien amphibians shows that it is possible to differentiate between alien species with different levels of impacts meaningfully, even in the presence of uncertainty. The assessment also reveals that many impact descriptions are of low quality leading to classifications with low certainty and that for some suspected impact mechanisms information is not reported (e.g. presumed health effects due to noise). Furthermore, for the majority of species, no socio-economic assessments were reported, and they have to be classified as DD for the moment. The current classification, although useful, is dynamic and should therefore be seen as a starting point; species' classifications might change in the future as more and better data become available. As is the case with other classifications (e.g. Red List, EICAT), SEICAT classifications should therefore be regularly revised and updated.

In summary, SEICAT can aid policy makers creating policies for alien taxa and allocating funds to prevention and control programmes (Scalera, 2010) as well as research activities (e.g. by identifying knowledge gaps, traits of species with high impacts etc.). Assessments can also be used as transparent and consistent indicators to raise awareness on alien taxa and to strengthen public support for policy measures (Smeets & Weterings, 1999).

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AUTHORS' CONTRIBUTIONS

S.B. and S.K. conceived the ideas and designed methodology, S.K. classified the amphibians, S.B. wrote the first draft of the paper, and all authors contributed to ideas and critically reviewed and edited the manuscript and gave final approval for publication.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

DATA ACCESSIBILITY

Data deposited in the Dryad Digital repository <http://datadryad.org/resource/doi:10.5061/dryad.4g622>. (Bacher et al., 2017).

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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Supporting Information 1 to “Socio-economic impact classification of alien taxa (SEICAT)” : Details of SEICAT application

Selection of activities

Not all activities are equally valued by people. This raises the questions how to select certain activities for analysis and how to weight activities. Following ideal theories of justice, one could argue that each and every activity is relevant and should count (Vallentyne 2005). However, considerations of justice call for discrimination between morally relevant and morally irrelevant activities (Pierik & Robeyns 2007). There is no universal solution how to do this, and different answers can be appropriate in different situations, depending on feasibility, data availability, practical relevance, and even parsimony. Thus, different activities are differently valued in different contexts. A first approach, often used in the socio-economic literature (Robeyns 2011), could be to discriminate activities that are essential to escape poverty. Poverty is understood as including not only deprivation of materially based well-being but rather a deprivation of opportunities (World Bank 2001).

Alternatively, one might want to consider weighting activities that sustain human life higher than others. For example, Maslow’s pyramid of needs (Maslow 1954) gives a hierarchy for levels of human needs ((i) physiological needs, (ii) safety needs, (iii) belongingness and love, (iv) esteem, (v) self-actualization) according to which each basal level needs to be met before individuals desire higher level needs. However, currently there is neither a generally accepted list of activities that contribute to avoid poverty nor a theoretically well-grounded method for weighting or aggregating (Robeyns 2011). A practical solution regarding the assessment of the importance of specific activities for a region could be to engage stakeholders. Activities could then be ranked according to their importance in a given region, e.g. based on the number of people participating in a specific activity (Pejchar & Mooney 2009).

For the assessment, activities need to be aggregated into categories that are meaningful in practice. Some activities might appear to be too specific and the number of people participating too small to

be of practical relevance for evaluating alien taxa impacts while others are too large to be impacted in their entirety by an alien taxon. There are no precise guidelines how to aggregate activities meaningfully. A relatively straightforward possibility that we applied for assessing amphibian impacts is to aggregate impacts according to the nature of the impact of an alien taxon such that all people in the focal region participating in the activity can be considered to be potentially affected. For example, for a pest that affects all cereals, specific activities (wheat, corn, rye farming) should be aggregated into the largest activity potentially affected as a whole. Thus, this pest should be assessed as affecting cereal farming but probably not all agricultural activities; farmers who do not cultivate cereals will probably not be affected by the alien taxon.

If this approach for aggregating activities leads to obvious imbalances in the importance of different activities for human well-being, then different weights could be assigned to these activities. These weights could be based on democratic assessments of the perceived importance of activities (Kumschick et al. 2012, Robeyns 2005b). In any case, weighting should be done with care, as minority activities could be disfavoured. In the absence of a well-justified weighting scheme and if there are no obvious imbalances without weighting activities, we use as a default for SEICAT that all activities affected by alien taxa are equal.

The impact of alien taxa that do not affect *specific* activities, but rather impede activities generally (e.g. by affecting human health) should be evaluated as impacting multiple activities. A pragmatic approach here is to not assess all possible activities (which can be a tedious task) but to limit the assessment to those activities that are particularly affected and are particularly important to human well-being. In the case when the impacts of an alien taxon result in the death of at least one person, the impacts are automatically classified as at least MO (fewer people participating in activities), but can be higher if they lead to activities being given up entirely in a region (not necessarily by more deaths, but e.g. by stopping activities to avoid the consequences of the impact of the alien).

However, if the consequences of the impacts can be easily avoided and no further changes in human activities are observed, the impacts should be classified as MO even though they led to human

deaths. For example, there are cases where people died by eating certain toxic aliens (plants, fish, toads etc.). While such cases are tragic for the people involved, they can often easily be avoided by not eating the alien. This is comparable to not eating toxic native berries or mushrooms, which are also not causes of major concern for human well-being in most regions, although their consumption can have severe consequences. By contrast, impacts that cannot be directly controlled, e.g. exposure to allergenic pollen produced by an alien plant can have much more far-reaching impacts on human well-being and can change activities of larger parts of societies. Consequently, such less-controllable impacts will probably be classified as MR or MV more often.

Alien taxa can have indirect impacts on human well-being, which might even exceed the direct impacts in magnitude, and their impacts can occur in regions other than the ones invaded by the alien taxon. This is for instance the case with some alien pathogens that can lead to the local breakdown of production, education and health systems due to peoples' fear of infection and the resulting stop in participating in social activities, as happened for example during the resurgence of Dengue fever in South-America at the end of the 20th century (Gubler 2002).

Lastly, it should be mentioned that, in practice, it can sometimes be difficult to unambiguously attribute a change in activities to a particular alien taxon if the causal relations are not well known (passenger-driver problem; e.g. MacDougall & Turkington 2005). However, this phenomenon is not specific to socio-economic impact, or the system described here, but applies generally.

Spatial and temporal scale of impact assessment

The spatial and temporal scale over which impacts are assessed can influence their perceived magnitude. This is particularly important for deciding whether activities disappear locally (criteria MR and MV). This problem applies also to environmental impacts and we propose addressing this in a similar way as suggested for EICAT (Hawkins et al. 2015). Often, the focal region (e.g. country, continent) is much larger than the spatial scale over which the alien taxon exerts its impacts and

assessing impacts at very large scales might underestimate their severity locally. By contrast, at very small spatial and temporal scales, a few individuals temporarily giving up an activity might lead to an overestimation of the impact when extrapolating to larger scales. It is therefore important that impacts of alien taxa are assessed at appropriate spatial and temporal scales, taking into account the habitats in which the alien taxon occurs and the typical spatial and temporal scales at which social communities in the region of interest can be characterised (e.g. a human settlement).

Small scale impacts should still be reported alongside the final classification to identify impacts that may be a cause for greater concern on larger scales in the future.

Dealing with limited data availability

SEICAT classification is possible in the absence of knowledge of a taxon's full impacts, as long as some impacts are reported. For taxa with well-established and widespread alien populations, there is likely to have been sufficient opportunity to gather data pertaining to the impacts of the alien taxa, so it is more likely that adequate data will be available to categorise such alien taxa. However for taxa with short alien population residence times, or invasions restricted to small areas, data evidencing socio-economic impacts may be limited, or restricted to impacts in one particular area. In some cases, there may be insufficient evidence to categorise a taxon with respect to its impacts, or the residence time may be too short for impacts to have become apparent. In these cases, information about impacts may be inferred from indirect observations, such as circumstantial evidence of impacts, or outcomes from mathematical models. However, inferred data are likely to provide a much lower level of confidence in the assessment (see next paragraph). Taxa assigned to one of the impact categories based on inferred data should be re-assessed when better observational or experimental data become available, to improve the confidence rating of the assessment. If there is inadequate information to classify a taxon with respect to its impact, the taxon should be listed as Data Deficient (DD).

Impacts of a taxon (both environmental and socio-economic) might not necessarily be related to its alien status and thus impacts can also arise in the native region. However, impacts are context dependent, thus it might not be easy to extrapolate them into new regions. This makes impacts from the native region not be the best predictors of impacts in the alien region. SEICAT can certainly be used to compare impact magnitudes between invaded and native ranges (for species where information is available on both), but we do not recommend using impacts from native ranges for classification of alien taxa because of the inherent contradiction. However, impacts from native ranges might still be reported, particularly if they deviate from those in the alien range or in case no other impacts are known.

Confidence

Confidence needs to be considered when classifying taxa in terms of the magnitude of their impacts (Leung et al. 2012; Kumschick et al. 2015a), and it is crucial to communicate this to policy makers and managers. We suggest considering confidence by following the procedure outlined for EICAT assessments (Blackburn et al. 2014; Hawkins et al. 2015) by categorising it into three levels—high, medium, and low confidence—based on approaches used by the Intergovernmental Panel on Climate Change (IPCC) (Table S2; Mastrandrea et al. 2010). The confidence score should capture the reliability of impact descriptions, i.e. how confident is the assessor that the description captures the “true” impact of the alien. The measure of relevance for impact descriptions (level of confidence) depends on the evidence observed rather than on the source (e.g. whether it was published in a peer-reviewed journal or data reported by a person during an interview). Even a fully-scientific, quantitative experimental study in a peer-reviewed journal does not necessarily describe impacts relevant for SEICAT classification. For example, studies on transmission of diseases by alien species often quantitatively describe the prevalence of human pathogens in aliens but rarely the transmission rates to humans or the resulting health impacts or changes in their activities. Thus, although they appear in peer-reviewed journals, the information given in them does not describe

sufficiently how people are affected in their well-being; impact classification would therefore be assigned a low confidence. By contrast, if people in an interview report that e.g. all the fisherman of their village had to give up their job due to an alien taxon and migrated to the cities, this would be directly relevant, transparent and pertinent information for SEICAT classification and would be assigned a high confidence.

For the classification, and in accordance with EICAT (Hawkins et al. 2015), we currently recommend to use the highest reported (current) impact regardless of its certainty. This follows the precautionary approach of the Rio Declaration and the Convention on Biological Diversity. A low confidence score on a high impact does not mean that a lower impact is more likely. Therefore, a reported high impact with low confidence should not be down-weighted in favour of a lower impact with higher confidence. However, an estimate of the degree of uncertainty is attached to all classifications, so that the degree of confidence in every classification is explicitly made clear.

Impact and management

People have various options to avoid, mitigate or compensate for impacts of alien species on their well-being. For example, in affluent regions many agricultural pest species are well controlled but would probably be devastating to crop production, and human well-being, if the current control measures ceased, or were devastating before such measures were available. In such cases it is debatable whether classification of such alien taxa as having major or massive impacts is justified because the alien species concerned do not currently have a severe impact on human well-being. This might be different for the same pest species in regions where control methods are not readily available or come at relatively high costs compared to the resources available to local people. Impacts of the same species can therefore vary across regions, depending on the inherent vulnerability of the region and the possibilities for management. For example, the silverleaf whitefly (*Bemisia tabaci*) is a globally widespread alien species that both directly consumes crops and acts as

a vector of crop diseases. An outbreak of whitefly in Uganda in the late 1980s was responsible for the rapid spread of the virus that causes Cassava Mosaic Disease (University of Greenwich 2004). This drastically reduced production of the staple cassava crop, leading to widespread food shortages and an estimated 3,000 human deaths. Economic hardships arising from crop losses forced villages and families to break apart as individuals looked for food and work. In a contrasting example, whitefly also became a serious agricultural pest in the United States during the late 1980s. A rapid response from government agencies and the private sector, however, saw the development and distribution of control technologies, including commercial pesticides. Although the impacts of this invader in the US were and continue to be large, there have been no recorded human deaths, and the impacts have not been broadly felt (Oliveira et al. 2001). We therefore generally recommend that impacts are best represented considering the locally applied compensation measures. In this case, *B. tabaci* in Uganda would be classified as MR or MV (depending on whether or not the impact to crops by the virus would be reversible after removal of the whitefly as vector) while in the US the species would be classified as MN (in the absence of reports of farmers giving up their activities due to the whitefly). At the global scale, *B. tabaci* would be classified as MR or MV (its highest impact anywhere) to indicate its potential risk.

Assessment at different spatial scales and across taxa

Assessment at different spatial scales and across taxa in SEICAT follows the principles outlined in Hawkins et al. (2015) for EICAT. Consequently, SEICAT classification can be applied across taxa, so that different taxa can be compared using a common currency in terms of their socio-economic impact. SEICAT can also be applied to impacts assessed at a range of spatial scales, from global to national or regional. As most taxa that are alien and have impacts somewhere have not been introduced to many of the locations where they could potentially thrive and have impacts, the vast majority of assessments will use 'focal region' data to generate a global level species assessment. This reflects the precautionary principle for alien impacts, which is important as there is evidence

that many alien taxa can have strong impacts in at least part of their invaded range, if distributed sufficiently widely. However, impact listings are likely to be context dependent: an alien impact that is observed in one area of the introduced range may not occur elsewhere, or may not be as important elsewhere. Therefore national or regional level assessments, which only take into account impacts which have occurred within a particular country or region, may differ markedly from global level assessments which are based on the highest level of impact recorded anywhere in the alien range of the taxon being assessed. Non-global assessments should therefore be clearly identified as such. They may still be based on data from focal regions outside the particular country or region of interest, however, in these cases the area(s) from which data on impacts are considered for these assessments should be clearly stated.

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Table S1. Detailed SEICAT scores for alien amphibians

(please see separate file “SI2 Table S1 SEICAT Application to Amphibians.xlsx”)

Table S2. Guidance regarding the use of the confidence rating (modified from Blackburn et al. 2014; Hawkins et al. 2015).

Confidence level	Examples
<p>High (approx. 90% chance of assessment being correct)</p>	<p>There is direct relevant observational evidence to support the assessment (including causality);</p> <p><i>and</i></p> <p>Impacts are recorded at the typical spatial scale over which social communities in the region of interest can be characterised;</p> <p><i>and</i></p> <p>There are reliable/good quality data sources on impacts of the taxa;</p> <p><i>and</i></p> <p>The interpretation of data/information is straightforward;</p> <p><i>and</i></p> <p>Data/information are not controversial or contradictory.</p>
<p>Medium (approx. 65-75% chance of assessment being correct)</p>	<p>There is some direct observational evidence to support the assessment, but some information is inferred;</p> <p><i>and/or</i></p> <p>Impacts are recorded at a spatial scale which may not be relevant to the scale over which social communities in the region of interest can be characterised, but rescaling of the data to relevant scales is considered reliable, or to embrace little uncertainty;</p> <p><i>and/or</i></p> <p>The interpretation of the data is to some extent ambiguous or contradictory.</p>
<p>Low (approx. 35% chance of assessment being correct)</p>	<p>There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence;</p> <p><i>and/or</i></p> <p>Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterised, and rescaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties.</p> <p><i>and/or</i></p> <p>Evidence is poor and difficult to interpret, e.g. because it is strongly ambiguous.</p> <p><i>and/or</i></p> <p>The information sources are considered to be of low quality or contain information that is unreliable.</p>

Heading	Explanation
Species name	Scientific (latin) name of species
Impact	Impact magnitude as in Bacher et al. (unpublished manuscript.):
Mechanism	Impact on at least one of the constituents of human well-being: Safety; Material and immaterial goods for good life; Health; Social, spiritual and
Activity	Activity as described in Bacher et al. (unpublished manuscript): see paper for details
Confidence	Confidence as described in Hawkins et al. (2015) see Appendix document:
Rationale for confidence	Short explanation why the confidence level was chosen according to
Citation from text	A copy of the exact text passage where the impact (and its magnitude) was described. It should be possible to assign the impact according to this
Full Reference	Full reference details of the citation for this specific impact and magnitude
Location	Location where the impact was studied. Mostly this is a country, in some cases more specific. It should also be indicated whether the impact was
Comments	free text

Species name	Impact	Constituents of well-being affected by the alien	Activity	Confidence	Rationale for confidence	Citation from text	Full Reference	Location	Comments
Rhinella marina	MR	social and cultural relationships	cultural practices	low	There is no direct observational evidence to support the assessment - report with no reference	With this being the case, their decline will, in turn, adversely affect Aboriginal communities that are semidependent on the availability of such species as a food supply. Furthermore, should a decline in species of particular importance occur, then a change in some of the cultural ceremonies and dances performed by Aboriginal communities in Kakadu National Park seems predictable, as occurred following cane toad invasion in the Borroloola area. Ceremonies were changed to ask the spirits to return to the local Aboriginal people the foods and totem species (eg freshwater crocodile) lost due to the cane toad invasion. However, it is important to note that with the subsequent return/recovery of some of those species (in particular goannas and snakes), it was expected that the ceremonies would revert to their original form.	Van Dam, R. Walden, D. and Begg, G, (2002) A preliminary risk assessment for cane toads in Kakadu National Park. Scientist Report 164, Supervising Scientist, Darwin NT [www document]. URL http://www.environment.gov.au/ssd/publications/ssr/164.html	Australia	
Rhinella marina	MR	material assets?	hunting of specific species	medium	There is some direct observational evidence to support the assessment, but some information is inferred - no hunting in indigenous community due to no species to harvest	Today the hunting of goannas and blue-tongues has not resumed because women maintain goanna numbers may be returning but the goannas themselves are too small and too few to harvest. Blue-tongue lizards remain invisible.	Seton KA and Bradley JJ (2004) When you have no law you are nothing: Cane toads, social consequences and management issues. The Acian Pacific Journal of Anthropology 5:205-228	Australia	
Rhinella marina	MR	social relations, spiritual	traditional practices	low	The information sources are considered to be of low quality or contain information that is unreliable. - person to person communication	The social and cultural consequences of this were twofold: families that were close in kin ceased to hunt together and, at the same time, intimate discussions of kin, country and general gossip were not being shared. Young girls and women were not being taught because this hunting activity had ceased with the cane toad's invasion. Hunting only became viable at the end of the dry season when the lagoons were dry and hibernating longnecked turtles could once again be accessed, which did allow continuity in some traditional practices.	Seton KA and Bradley JJ (2004) When you have no law you are nothing: Cane toads, social consequences and management issues. The Acian Pacific Journal of Anthropology 5:205-228	Australia	
Rhinella marina	MO	material assets	bush tucker	low	The information sources are considered to be of low quality or contain information that is unreliable. - interviews with people, but check for final score that several reports on the same!	Although it was not mentioned frequently at other locations, the concern surrounding bush tucker loss was acute in the Ngukurr community, where some community members have a high reliance on traditional foods as part of their diet: for example: "All we're worried about is those bush tucker, your goanna ... first they eat them [cane toads] and they ... maybe they're dying out" (Ngukurr community member)	Clark et al. 2009	Australia	
Rhinella marina	MO	social relations? noise disturb	enjoyment of the bush	low	The information sources are considered to be of low quality or contain information that is unreliable. - interviews with people - not known how exactly people are affected	Concern around impacts on lifestyle included the loss of enjoyment of the bush and the nuisance factor of having cane toads in public and private amenity areas. The impact on public and private amenities was mentioned most frequently in Cairns and Ngukurr, and attachment to bush lifestyle most frequently in Kununurra.	Clark et al. 2009	Australia	
Rhinella marina	MO	health	health, physical activity	low	The information sources are considered to be of low quality or contain information that is unreliable. - reports from people	The Committee received a great deal of evidence regarding the impacts of cane toads on Indigenous communities. The decline in numbers of bush tucker species such as goanna, water monitor, lizards, snakes and turtles would primarily affect the important and strong relationships Indigenous communities have with their country. Also affected would be levels of health with an increased reliance on bought store meat and reduced physical activity in the practice of hunting...People hardly go out hunting. They eat less bush meat and are depending on the shop for meat...we are frightened of the toads and we teach our children not to humbug with the cane toads. So you got to be with the children all the time	Sessional Committee on Environment and Sustainable Development 2003	Australia	
Rhinella marina	MO	material assets?	multiple	low	The information sources are considered to be of low quality or contain information that is unreliable. - perception of indigenous people	Initially people were afraid to drink water inhabited by cane toads because they thought it would contain their poison.	Seton KA and Bradley JJ (2004) When you have no law you are nothing: Cane toads, social consequences and management issues. The Acian Pacific Journal of Anthropology 5:205-226	Australia	
Rhinella marina	MO	material assets	hunting	low	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence; - pers. comm. that fewer native species to hunt	However, one of the most far-reaching consequences was the stress and depression among Yanyuwa women when their daily movement across country in search of normal target prey (such as goanna and bluetongue) led only to 'finding cane toad in their holes' (Ida Ninganga, pers. comm. 1999). A core group of senior women ceased hunting goanna and blue-tongue lizards because this primary economic activity was seen to lose its worth.	Seton KA and Bradley JJ (2004) When you have no law you are nothing: Cane toads, social consequences and management issues. The Acian Pacific Journal of Anthropology 5:205-227	Australia	

Rhinella marina	MN	social relations? noise disturb pet keeping		low	The information sources are considered to be of low quality or contain information that is unreliable. - interviews with people	However, despite the relative frequency of concern for pets, only one respondent mentioned a pet having been killed by eating a cane toad and many people mentioned that they had learned how to treat their pets when exposed to cane toad toxins.	Clark et al. 2009	Australia
Rhinella marina	MN	health	multiple	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - not known if pathogens are transmitted, but known that cane toads are hosts	The present study showed the importance of cane toads as reservoirs of Salmonella serovars that are emerging as causes for human disease in the Western hemisphere.	Drake et al. 2012	Grenada, West Indies
Rhinella marina	MN	health, disease transmission	being healthy	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - inferred from study - no direct link checked for leptospirae on B. marinus and humans infected	Bufo marinus can harbor pathogenic leptospirae, and it may be a significant source of the Autumnalis serogroup infections in the Caribbean.	Everard COR, Carrington D, Korver H and Everard JD (1988) Journal of Wildlife Diseases 24:334-338	Barbados
Rhinella marina	MN	material assets	bush tucker	low	The information sources are considered to be of low quality or contain information that is unreliable. - newspaper article with one persons opinion	Kimberley residents, particularly Aborigines, are concerned about the impact of cane toads on the future of their river country. The small Aboriginal settlement of Jarlmadangah Burru, half an hour's drive from Camballin, is very close to the Fitzroy River. "Our children want a goanna to eat - they don't want a cane toad to eat," said John Watson, an elder of the area's Nyikina and Mangala Aboriginal communities. "I don't like to see anything poisonous like that coming into the country, it sounds very dangerous. Kids could pick cane toads up and think they might be good eating, because they don't know about the poison in their back. "A lot of our people wouldn't know what a cane toad looks like. I'm concerned about the goannas and the things that we eat. It really hurts my feelings - we've got lovely country here. What else are the pastoralists going to bring in?" he told ABC Science Online.	Horstman, M. (2003) Cane toad invasion halted in Western Australia. ABC News in Science [www document]. URL http://www.abc.net.au/science/news/stories/s793049.htm	Australia
Rhinella marina	MN	health	multiple	medium	There is some direct observational evidence to support the assessment, but some information is inferred; - pers comm & lab study	However, incidences of intoxication clinically similar to cardiac glycoside poisoning have been reported	Leitch IM, Lim TH & Boura ALA 2000. Novel drugs from toad skins. RIRDC Publication 00/17, Rural Industries Research & Development Corporation, ACT.	China
Rhinella marina	MN	social relations, spiritual	pet keeping	high	There is direct relevant observational evidence to support the assessment; - clinical cases collected	The proliferation of the cane toad has had substantial detrimental effects on native wildlife, and as they extend into urban areas, the cane toad is becoming a common threat to domestic pets. Toxicity usually occurs when dogs ingest venom after biting or eating a toad. It is also possible for toads to squirt venom up to 2 metres.	Reeves MP (2004) A retrospective report of 90 dogs with suspected cane toad (Bufo marinus) toxicity. Australian Veterinary Journal 82: 608-611	Australia
Rhinella marina	MN	social relations, spiritual	pet keeping	high	There is direct relevant observational evidence to support the assessment; - clinical cases collected	Most (66) dogs were treated during the spring and summer. For 54 dogs, exposure to toads had been witnessed. For the remaining 40, toad intoxication was diagnosed on the basis of history and clinical signs. The most common clinical signs were neurologic abnormalities, hyperemic mucous membranes, ptialism, recumbency or collapse, tachypnea, and vomiting. The oral cavity was lavaged with tap water in all dogs. Fifty-two dogs were hospitalized for treatment.	Roberts et al. (2000) Bufo marinus intoxication in dogs: 94 cases (1997-1998) JAVMA 12: 1941-1944	Florida

Rhinella marina	MN	material assets	nursery trade	low	The information sources are considered to be of low quality or contain information that is unreliable. - reports from people	We have identified a number of problems with Cane toads in our nursery. The toad will burrow into seed trays and we lose quite a few seedlings because of this. The only alternative is to put the trays on a higher stand. Ponds and water features are not recommended if they are on ground level as they will foul the water. They do seem to notice the difference between water that is chlorinated and plain water. We have never had a cane toad fall into or are near our chlorinated water. They can climb the height of a bath tub but cannot get out. They will also fall into a trench and not be able to climb out. The ecology has changed in the nursery. We have noticed more ants and in the last couple of weeks dead rats and an increase in the animals eg...The effect of the toad on growers and nursery people is an extra cost in production. More problem insect gaining a foothold. Other animals that do not eat toads will inc-mase eg Bandicoots because the natural predators have taken a hammering since the toad appeared.	Sessional Committee on Environment and Sustainable Development 2003	Australia
Rhinella marina	MN	social relations, spiritual	rituals, cultural practice	low	The information sources are considered to be of low quality or contain information that is unreliable. - perception of indigenous people	Overall these practices and emotional responses are based on sensory perceptions : the call of cane toads is foreign and drowns out the sounds of familiar species, the stench of dead piles of cane toads and dead animals rotting after contact with toads means country is unhealthy, and the sight of cane toads in the homes of hunted species is distressing and alarming....For example, the cane toad in relation to religious life in the Borroloola region has been seen as an invasion by a creature with no Law;9 it has no song, no place to fit within existing structures. This is especially important as the use of ritual, song and body design (and the esoteric knowledge that underlies these actions) is a powerful way of affirming and sustaining relationships to country and kin for Yanyuwa people (see Bradley 1997a), and essential to both ecological and cultural maintenance. Practical actions (such as speech, lighting fires, speaking to Spirit Ancestors) are also important components of this maintenance.	Seton KA and Bradley JJ (2004) When you have no law you are nothing: Cane toads, social consequences and management issues. The Acian Pacific Journal of Anthropology 5:205-225	Australia
Rhinella marina	MN	material assets	health	low	The information sources are considered to be of low quality or contain information that is unreliable. - reports by people, no direct establishment of causality	The contamination of water by cane toad toxin has been noted on a number of occasions. During periods of breeding activity, larval and adult cane toads are frequently found dead in spawning ponds. They release toxin into the water, and the parotoid glands of adults are generally covered with the exuded viscous white toxin. In surveys and personal interviews, many people have reported poisoning of pets and poultry due to contamination of drinking water (van Beurden 1980), and some consider boreholes and water troughs as sources of drinking water that could be particularly vulnerable to contamination by cane toad toxin (K Boland, Tropical Water Solutions, pers comm) and large numbers of rotting toad carcasses (Freeland 1984).	Van Dam, R. Walden, D. and Begg, G. (2002) A preliminary risk assessment for cane toads in Kakadu National Park. Scientist Report 164, Supervising Scientist, Darwin NT [www document]. URL http://www.environment.gov.au/ssd/publications/ssr/164.html	Australia no access to van Beurden (1980) and Freeland (1984)
Rhinella marina	MN	health, disease transmission	multiple	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - potential mechanisms, unknown if the consequences occur in human societies	"Cane toads are known to feed on human faeces, and as a result they may harbour human strains of Salmonella and other bacteria. The eggs of human parasites are also spread via toad faeces. In areas where modern sanitation practices are lacking, the presence of large numbers of cane toads could represent a health hazard. Another health-related issue is the potential for substance abuse of the cane toad toxin, a habit forming practice that is established in northern Queensland and in countries such as Fiji."	Van Dam, R. Walden, D. and Begg, G. (2002) A preliminary risk assessment for cane toads in Kakadu National Park. Scientist Report 164, Supervising Scientist, Darwin NT [www document]. URL http://www.environment.gov.au/ssd/publications/ssr/164.html	Australia

Rhinella marina	MN	health, disease transmission	drug abuse	low	The information sources are considered to be of low quality or contain information that is unreliable. - pers comm	It seems reasonable to suggest that substance abuse (as documented in the video, Cane Toads — An Unnatural History, ABC 1987) could also be practised in the NT. In fact, the cane toad toxin is listed as a dangerous drug under Schedule 2 of the Drug Misuse Act in Queensland (ABC 1987). When cane toad toxin is extracted from the parotid glands and dried and smoked in a hand-rolled cigarette, the therapeutic/hallucinogenic effects are said to be sufficiently rewarding for the substance to become habit forming, as it has done in countries such as Fiji (S Choy, Qld DNR, pers comm). Furthermore, due to the long period of time that cane toads have been living in Queensland, there is anecdotal evidence to suggest that similar habits have been adopted by a number of people living in Cairns (S Choy, pers comm).	Van Dam, R. Walden, D. and Begg, G. (2002) A preliminary risk assessment for cane toads in Kakadu National Park. Scientist Report 164, Supervising Scientist, Darwin NT [www document]. URL http://www.environment.gov.au/ssd/publications/ssr/164.html	Fiji
Rhinella marina	MC	material assets	poultry farming	medium	There is some direct observational evidence to support the assessment, but some information is inferred; - study has shown poultry is not affected by cane toads, but myth continues to flourish	Although discredited by scientists in 1938, within 2 years of the toads' introduction to Australia, the myth continues to flourish. We conducted experimental trials to evaluate the vulnerability of chickens to toad-contaminated water, and to toad ingestion. No ill effects were seen, with one chicken consuming 45 small toads without falling ill. Thus, available evidence suggests that cane toads do not imperil domestic poultry.	Beckmann C & Shine R (2010) The power of myth: the (non) impact of invasive cane toads (Bufo marinus) on domestic chickens (Gallus gallus). Animal Production Science 50: 847-851	Northern Territory, Australia
Rhinella marina	MC	health, disease transmission	being healthy	low	Evidence is poor and difficult to interpret, e.g. because it is strongly ambiguous. - inferred from study - no direct link checked for salmonella on B. marinus and humans	do not mention Bufo in the text, but tested for salmonella and found in >60% of the animals	Haddock RL, Nocon FA, Santos EA and Taylor TG (1990)Guam Reservoirs and vehicles of salmonella infection on Guam. Environment International 16:11-16	Guam
Rhinella marina	MC	material assets	tourism	medium	There is some direct observational evidence to support the assessment, but some information is inferred; - personal comment by people who would be directly concerned about no observed impacts	"Queensland has contended with the cane toad for many decades with no noticeable effect on tourism".	Sessional Committee on Environment and Sustainable Development 2003	Queensland, Australia
Rhinella marina	MC	material assets	power generation or distribution	medium	There is some direct observational evidence to support the assessment, but some information is inferred; - reports from people who would be directly concerned about no observed impacts	From the Power and Water Corporation's submission the Committee noted that there are no significant issues associated with cane toads on power generation or distribution, or sewage reticulation and treatment.	Sessional Committee on Environment and Sustainable Development 2003	Australia
Rhinella marina	MC	material assets?	catfish fishery	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - lab experiment	Our laboratory trials confirmed that some catfish eat toad eggs and die; but most catfish avoided the eggs. Catfish readily consumed toad tadpoles at both early and late developmental stages, but without experiencing mortality; and soon learned not to consume this toxic new prey type. Conclusions and implications. Despite potential frequent episodes of mortality of small numbers of catfish during the wet season, the overall impacts of cane toads on the Lake Argyle fishery likely will be minimal.	Somaweera R, Crossland MR & Shine R (2011) Assessing the potential impact of invasive cane toads on a commercial freshwater fishery in tropical Australia. Wildlife Research 38: 380-385	Australia
Rhinella marina	MC	material assets	tourism	low	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence; - pers comm	In spite of the presence of large numbers of cane toads, the numbers of tourists visiting National Parks in Queensland have not declined (R Pidgeon, pers comm).	Van Dam, R. Walden, D. and Begg, G. (2002) A preliminary risk assessment for cane toads in Kakadu National Park. Scientist Report 164, Supervising Scientist, Darwin NT [www document]. URL http://www.environment.gov.au/ssd/publications/ssr/164.html	Australia
Duttaphrynus melanostictus	MO	health	multiple	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - clinical reports, but only of anecdotal cases	One 6 year old boy died after eating a Black-spined Toad in Ermera district during 2008, and many villagers have become sick after eating toads.	Trainer CR (2009) Survey of a population of black-spines toad Bufo melanostictus in Timor-Leste: confirming identity, distribution, abundance and impacts of an invasive and toxic toad. A Report by Charles Darwin University to AusAID under contract agreement NO. 52294	Timor-Leste

Duttaphrynus melanostictus	MN	material assets	chicken farming	low	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence; - unsupported reports	Impacts to agriculture are poorly known – livestock such as buffalo, cattle, pigs, goats and chickens do not appear to be affected by toads. Recently hatched chickens (chicks) do die after ingesting toad toxin typically from roadkilled toads.	Trainor CR (2009) Survey of a population of black-spines toad Bufo melanostictus in Timor-Leste: confirming identity, distribution, abundance and impacts of an invasive and toxic toad. A Report by Charles Darwin University to AusAID under contract agreement NO. 52294	Timor-Leste
Duttaphrynus melanostictus	MN	health, pollution	multiple	low	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence; - unsupported reports	It is also a nuisance because toads can enter wells, drown and rot, potentially polluting important water sources. Road-killed toads which rot and smell will also be a nuisance particularly during the wet season.	Trainor CR (2009) Survey of a population of black-spines toad Bufo melanostictus in Timor-Leste: confirming identity, distribution, abundance and impacts of an invasive and toxic toad. A Report by Charles Darwin University to AusAID under contract agreement NO. 52294	Timor-Leste
Duttaphrynus melanostictus	DD	health	health	medium	Impacts are recorded at a spatial scale which may not be relevant to the scale over which social communities in the region of interest can be characterized, but extrapolation or downscaling of the data to relevant scales is considered reliable, or to embrace little uncertainty; - direct observations, but not systematically at the relevant scale; report from native range	confirms toxicity of Bufo melanostictus: We describe two patients who developed severe illness after eating the skin and eggs of a toad, probably Bufo melanostictus Schneider, in southeastern Laos. One boy died, and one developed a digoxin toxicity-like syndrome with bradycardia and heart failure but survived. A telephone survey of 16 Lao provincial hospitals suggested that toad poisoning occurs in at least six provinces. That 93% of villagers in three villages in southeastern Laos were aware that toads are poisonous but that 51% had encountered patients with toad toxicity suggests that the potential gravity is not appreciated. These data indicate that toad poisoning may be underestimated and that education on the seriousness of toad toxins could be a useful public health measure.	Keomany S, Mayxay M, Souvannasing P, Vilayhong C, Stuart BL, Srour L and Newton PN (2007) Toad poisoning in Laos. Am. J. Trop. Med. Hyg. 77(5):.850–853	native range (Laos)
Eleutherodactylus coqui	MN	material assets, health	property market	high	There is direct relevant observational evidence to support the assessment; - quantitative study	The primary economic effect of the frog is noise pollution. The males' calls, which are individually between 80-90 dBA at 0.5 m, now extend from an hour before sunset until dawn. The Hawaii Department of Health sets the threshold for minimizing impacts to human health and welfare at only 70 dBA (Department of Health, Hawaii Revised Statutes Section 324F-1)... The presence of frogs, however, does have a significant negative impact on property values. For properties within 500 meters of a complaint, property values decline 0.16%, or about 1/3 as much as values decline from a 1% increase in mortgage rates (-0.45%). For properties within 800m but not within 500 meters, property values decline less severely, at 0.12%. This is about ¼ of the drop from a 1% increase in mortgage rates.	Kaiser BA & Burnett K (2006) Economic impacts of E. coqui frogs in Hawaii. Interdisciplinary Environmental Review 8	Hawaii
Eleutherodactylus coqui	MN	material assets	nursery industry	medium	There is some direct observational evidence to support the assessment, but some information is inferred; - inferred from study	A secondary economic effect with concentrated impacts on one important Hawaiian industry comes from losses to the nursery industry. The suspected entrance vector for the frog to Hawaii is in plant media transported in the nursery trade; regardless, many nurseries have frogs present now. Demand for frog-free certification is increasing among both local and off-island customers. Informal surveys of island nurseries indicate both that sales revenues are declining and costs are rising as nurseries try to accommodate the frog's presence....Protecting these open field nurseries from frog infestation and re-infestation thus is expected to be quite costly....Since agricultural lands are also included in the data, we consider the lower property values in the presence of frogs to reflect expected losses in profitability for floriculture and nursery products. With annual sales values of \$50.5 million in these commodities, a loss of 0.16% per annum results in another \$81,000 in losses per year for the county.	Kaiser BA & Burnett K (2006) Economic impacts of E. coqui frogs in Hawaii. Interdisciplinary Environmental Review 9	Hawaii
Eleutherodactylus planirostris	MN	material assets	nursery trade	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - impact not proven, but legal requirement	The greatest direct economic impacts of the invasions are to the nursery trade, which must treat infested shipments.	Olson CA, Beard KH, Pitt WC (2012) Biology and Impacts of Pacific Island Invasive Species. 8. Eleutherodactylus planirostris, the Greenhouse Frog (Anura: Eleutherodactylidae)* (2012). USDA National Wildlife Research Center - Staff Publications. Paper 1174	Hawaii

Eleutherodactylus planirostris	MN	social and cultural relationship	swimming in artificial s/w		There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence; - assumption, unpubl. data	In addition to economic impacts to agricultural industries, several resorts in Hawai'i have attempted to manage greenhouse frogs because they are found in swimming pools and irrigation boxes; large populations may similarly affect homeowners (W.C.P., unpubl. data).	Olson CA, Beard KH, Pitt WC (2012) Biology and Impacts of Pacific Island Invasive Species. 8. Eleutherodactylus planirostris, the Greenhouse Frog (Anura: Eleutherodactylidae)" (2012). USDA National Wildlife Research Center - Staff Publications. Paper 1175	Hawaii
Hyla meridionalis	MC	social relations?	noise disturb not defined	low	The information sources are considered to be of low quality or contain information that is unreliable. - subjective impression of noise pollution; true impact could be higher, but nothing more is described	"elle paraît manquer sur Port-Gros, car je n' ai pu entendre son cri, la nuit, à l' endroit le plus propice de l'île alors que sur le littoral, à la même époque, ces animaux faisaient un vacarme assourdissant (deafening noise). »	Cheyilan M (1983) Status actuel des reptiles et amphibiens de l'archipel des îles d'hyeres	Îles d'Hyères, France
Osteopilus septentrionalis	MN	social and cultural relationship	multiple, aesthetics	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - no data, just statements	As they feed, they defecate on the windows and walls, and their fecal deposits can become unsightly over time, especially if there are a lot of frogs in the area.	Johnson SA (2007) The Cuban treefrog (Osteopilus septentrionalis) in Florida. This document is WEC218, one of a series of the Department of Wildlife Ecology and Conservation, UF/IFAS Extension. First published May 2007. Revised August 2010. Revised September 2013. Please visit the EDIS website at http://edis.ifas.ufl.edu .	Florida
Osteopilus septentrionalis	MN	safety	multiple	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - no data, just statements	Furthermore, when a person enters or exits his or her home at night, Cuban Treefrogs that are waiting for an insect meal may be startled and as a result will occasionally jump onto people or into their homes through open doors. This can be a scary experience for a person who is afraid of frogs. There are numerous instances where unsuspecting people have opened the lid to their toilet only to find a bug-eyed Cuban Treefrog staring up at them (Figure 5).	Johnson SA (2007) The Cuban treefrog (Osteopilus septentrionalis) in Florida. This document is WEC218, one of a series of the Department of Wildlife Ecology and Conservation, UF/IFAS Extension. First published May 2007. Revised August 2010. Revised September 2013. Please visit the EDIS website at http://edis.ifas.ufl.edu .	Florida
Osteopilus septentrionalis	MN	material assets	multiple	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - no data, just statements	Cuban Treefrogs have also been responsible for clogging sink drains.	Johnson SA (2007) The Cuban treefrog (Osteopilus septentrionalis) in Florida. This document is WEC218, one of a series of the Department of Wildlife Ecology and Conservation, UF/IFAS Extension. First published May 2007. Revised August 2010. Revised September 2013. Please visit the EDIS website at http://edis.ifas.ufl.edu .	Florida
Osteopilus septentrionalis	MN	social and cultural relationship	wildlife enthusiasm	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - no data, just statements	Cuban Treefrogs may also be a nuisance to wildlife enthusiasts that set up nesting boxes to attract and benefit birds. Because Cuban Treefrogs prefer enclosed hiding spaces, they readily enter nest boxes erected for birds. Birds may be dissuaded from using nest boxes when they are invaded by Cuban Treefrogs (Figure 6), but research is needed to study how the presence of the invasive frogs affects bird use of nest boxes.	Johnson SA (2007) The Cuban treefrog (Osteopilus septentrionalis) in Florida. This document is WEC218, one of a series of the Department of Wildlife Ecology and Conservation, UF/IFAS Extension. First published May 2007. Revised August 2010. Revised September 2013. Please visit the EDIS website at http://edis.ifas.ufl.edu .	Florida
Osteopilus septentrionalis	MN	health	feeling well	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - no data, just statements	Although they are not nearly as toxic as Cane Toads (also known as the invasive Bufo toad), Cuban Treefrogs have a sticky skin secretion that is extremely irritating to the mucous membranes of people, such as the eyes and nose. The secretions cause a burning and itching sensation that can last for more than an hour. This can be especially problematic for people who suffer from asthma or allergies, in which case full recovery from the ill effects of the frog's skin secretions may take several hours.	Johnson SA (2007) The Cuban treefrog (Osteopilus septentrionalis) in Florida. This document is WEC218, one of a series of the Department of Wildlife Ecology and Conservation, UF/IFAS Extension. First published May 2007. Revised August 2010. Revised September 2013. Please visit the EDIS website at http://edis.ifas.ufl.edu .	Florida

Osteopilus septentrionalis	MN	social relations? noise disturb pet keeping	low	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - no data, just statements	There do not appear to be any documented deaths or serious injuries of pets from ingesting or attempting to eat a Cuban Treefrog. However, there are reports of excessive salivation and even seizures by pets that have tangled with these noxious frogs, so dogs and cats should be kept away from them.	Johnson SA (2007) The Cuban treefrog (<i>Osteopilus septentrionalis</i>) in Florida. This document is WEC218, one of a series of the Department of Wildlife Ecology and Conservation, UF/IFAS Extension. First published May 2007. Revised August 2010. Revised September 2013. Please visit the EDIS website at http://edis.ifas.ufl.edu .	Florida	
Osteopilus septentrionalis	MN	material assets	being connected to povlow	Impacts are recorded at a spatial scale which is unlikely to be relevant to the scale over which social communities in the region of interest can be characterized, and extrapolation or downscaling of the data to relevant scales is considered unreliable or to embrace significant uncertainties. - no data, just statements	Nonetheless, they are known to get into transformer boxes and electrical switches and occasionally cause short-circuits. This increases maintenance costs for electrical utility companies, and power to some customers in central Florida has been interrupted as a result of shortcircuits in disconnect switches caused by Cuban Treefrogs.	Johnson SA (2007) The Cuban treefrog (<i>Osteopilus septentrionalis</i>) in Florida. This document is WEC218, one of a series of the Department of Wildlife Ecology and Conservation, UF/IFAS Extension. First published May 2007. Revised August 2010. Revised September 2013. Please visit the EDIS website at http://edis.ifas.ufl.edu .	Florida	
Xenopus leavis	DD	material assets	fish culturing	medium	There is some direct observational evidence to support the assessment, but some information is inferred; - relies on other reports, impacts recorded from the native range	The importance of this species as a predator of fish fry and fingerlings and therefore as a threat to fish culture has not only been observed in recent investigations in Transkei (Nakani, 1979; Schoonbee et al. 1979) but also by other investigators in Africa (Ldey, 1890; Hey, 1945; FAO/EPTA Fish Culturist, 1956; Jubb, 1980).	Prinsloo JF, Schoonbee HJ & Nxiweni JG (1981) Some observations on biological and other control measures of the African clawed frog <i>Xenopus leavis</i> (Daudin) (Pipidae, Amphibia) in fish ponds in Transkei. Water SA 7: 88-96	native range

(Triturus) Lissotriton montand DD
 (Triturus) Lissotriton vulgaris DD
 Alytes obstetricans DD
 Ambystoma (tremblayi) laterale DD
 Ambystoma tigrinum DD
 Amietophrynus gutturalis DD
 Amietophrynus regularis DD
 Anaxyrus americanus DD
 Aneides vagrans DD
 Bombina bombina DD
 Bombina orientalis DD
 Bombina variegata DD
 Bufo bufo DD
 Bufo gargarizans DD
 Bufo japonicus DD
 Bufo jimi DD
 Bufo mauritanicus DD
 Dendrobates auratus DD
 Desmognathus fuscus DD
 Desmognathus quadramacule DD
 Discoglossus pictus DD
 Duttaphrynus dhufarensis DD
 Eleutherodactylus antillensis DD
 Eleutherodactylus cystignatho DD
 Eleutherodactylus johnstonei DD
 Eleutherodactylus martinicens DD
 Euphyctis ehrenbergii DD
 Eurycea cirrigera DD
 Fejervarya cancrivora DD
 Fejervarya kawamurai DD
 Fejervarya limnocharis DD
 Fejervarya sakishimensis DD
 Gastrophryne carolinensis DD
 Glandirana rugosa DD
 Hoplobatrachus rugulosus (sy DD
 Hoplobatrachus tigerinus DD
 Hyla cinerea DD
 Hyla intermedia DD
 Hyla japonica DD
 Hyla squirella DD
 Hylarana guentheri DD
 Ichthyosaura alpestris DD
 Ingerophrynus biporcatus DD

Kaloula pulchra	DD
Limnodynastes dorsalis	DD
Limnodynastes tasmaniensis	DD
Lithobates berlandieri	DD
Lithobates catesbeianus	DD
Lithobates clamitans	DD
Lithobates grylio	DD
Lithobates pipiens	DD
Lithobates septentrionalis	DD
Lithobates sphenoccephala	DD
Litoria aurea	DD
Litoria cyclorhyncha	DD
Litoria ewingii	DD
Litoria fallax	DD
Litoria raniformis	DD
Microhyla ornata	DD
Microhyla pulchra	DD
Necturus maculosus	DD
Osteopilus septentrionalis	DD
Pelophylax bedriagae	DD
Pelophylax bergeri	DD
Pelophylax lessonae	DD
Pelophylax nigromaculatus	DD
Pelophylax perezii	DD
Pelophylax porosus	DD
Pelophylax ridibundus	DD
Pelophylax saharicus	DD
Physalaemus pustulosus	DD
Pipa carvalhoi	DD
Pipa parva	DD
Plethodon cinereus	DD
Plethodon jordani	DD
Plethodon shenandoah	DD
Pleurodema brachyops	DD
Polypedates leucomystax	DD
Polypedates megacephalus	DD
Pristimantis unistrigatus	DD
Proteus anguinus	DD
Pseudacris regilla	DD
Ptychadena mascareniensis	DD
Rana aurora	DD
Rana draytonii	DD
Rana sylvatica	DD
Rana temporaria	DD
Rhacophorus arboreus	DD
Rhacophorus viridis	DD
Scinax quinquefasciatus	DD
Scinax ruber	DD
Scinax x-signatus	DD
Speleomantes ambrosii	DD
Speleomantes italicus	DD
Speleomantes strinatii	DD
Strongylopus grayii	DD
Triturus carnifex	DD
Triturus marmoratus	DD