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## Metaphors in Invasion Biology: Implications for Risk Assessment and Management of Non-Native Species

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### ABSTRACT

Metaphors for describing the introduction, impacts, and management of non-native species are numerous and often quite outspoken (e.g. invasional meltdown and explosive growth). Policy-makers have adopted increasingly disputed metaphorical terms from scientific discourse. We performed a critical analysis of the use of strong metaphors in reporting scientific findings to policy-makers. Our analysis shows that perceptions of harm, invasiveness or nativeness are dynamic and inevitably display multiple narratives in science, policy or management. Improving our awareness of multiple expert and stakeholder narratives that exist in the context of non-native species management, as well as metaphorical alternatives, is critical.

### Introduction

Non-native species are generally described as species introduced by humans, either intentionally or unintentionally, in areas outside their natural geographical range (Simberloff, 2013). Invasion biology is a relatively young scientific discipline which studies the causes, effects, and management of non-native species introductions (Carlton, 1999; Williamson, 1996). In the past years, a vigorous and polarized debate on the terminology in this particular field has emerged. In the vocabulary describing risks of (potentially) invasive non-native species, the metaphors in place are remarkably strong (at least for academic genres) and sometimes quite consciously chosen and used. Consider, for example, the term ‘invasional meltdown’ employed by Simberloff (2006) in the journal *Biological Invasions*. Such wordings do not merely describe ecological phenomena, but also give voice to an attitude of commitment and create a sense of urgency. It has been argued that the use of such terms reinforces militaristic thought patterns with regard to invasive species management, while the parallels in wording with immigration policy have led to accusations of xenophobia (Larson, 2005; O’Brien, 2006). Furthermore, the distinction between native and non-native species has received criticism from various academic disciplines, such as geography, biology, and philosophy, notably because of the lack of objective criteria and spatiotemporal references for defining what is ‘native’ and ‘non-native’ (Warren, 2007; Webber & Scott, 2012; Woods &

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Moriarty, 2001). It has come to a point where critics are advocating for the 'end of invasion biology' based on its perceived xenophobic stance, the ambiguity of definitions, and lack of foundation as such (Valéry, Fritz, & Lefeuvre, 2013). Several authors have proposed a more objective approach and neutral terminology to describe invasive species (Brown & Sax, 2004; Colautti & MacIsaac, 2004). In response to these proposals, others claim that this mode of non-action of scientists is inconsistent with their conservation values (Larson, 2007; Young & Larson, 2011) or may even hamper the development of ecological knowledge which benefits from a wealth of terms and meanings (Hodges, 2008).

Debates among scientists also evolve around the evidence for ecological impacts of biological invasions on biodiversity. Global indicators of biological invasions show significant impacts on IUCN Red List species driven by invasive non-native species (McGeoch et al., 2010). Ecologists involved in research on biological invasions stress the valuable outcomes of invasion biology in predicting and managing disrupting and costly biological invasions (Blondel, Hoffmann, & Courchamp, 2013; Richardson & Ricciardi, 2013; Simberloff & Vitule, 2013). However, others claim that extinction events are marginal and they therefore question whether current biological invasions are any different from the past (e.g. Sax & Gaines, 2008; Zimmer, 2008).

The urgent need to counteract the impact of non-native invasive species recently has been formally admitted by the European Commission (EC) and the European Parliament in the EU regulation on the prevention and management of the introduction and spread of invasive alien species (European Commission, 2014). With the adoption of a legal framework based upon the concepts of nativeness and invasiveness, the quandaries of invasion biology have entered (if not 'permeated') the realm of environmental policy as well. While the debate so far has mainly focused on the use of metaphors in scholarly discourse, less attention has been given to the impact of current vocabularies in the policy domain. It is here that the debate has a broader relevance, as it may create ambiguities and uneasiness when it comes to implementing research findings into policy (Shaw, Wilson, & Richardson, 2010; Young & Larson, 2011). It has been argued that the use of value-laden, ambiguous terms endangers the credibility of policy (Warren, 2007) as well as the consistency of the decision making process (Hulme, 2012).

While building on the literature on metaphors and value judgment in science, we will critically reflect on the implications of metaphorical language use for effective risk management of invasive non-native species. We use two important pillars of invasive species policy as examples of what we will introduce as 'strong metaphors'. The first is related to the 'nativeness' metaphor and addresses the issue of developing different standards for native and non-native species. The second one deals with the use of ecological impact assessment to distinguish between invasive and non-invasive species ('invasiveness' metaphor). We conclude by listing some key challenges for responsible metaphor management in invasive species risk assessment and management.

## A Critical Analysis of Biological Invasion Metaphors

Scientists often play an active role in the emergence of specific metaphors when scientific insights are presented in public and policy arenas (e.g. Zwart, 2010). The question whether and to what extent scientists must make value judgments or consciously use strong images when presenting their findings to policy has a long history (Rudner, 1953; Steele, 2012). In

a general sense, language as such is metaphoric, and a non-metaphoric, neutral language is a fictitious entity (Lakoff & Johnson, 1980). Metaphors play an essential role in establishing links between the science and public domain (Kuhn, 1979). However, they can also create or generate particular viewpoints from which decisions are made. According to Schön (1979), such 'generative' metaphors necessitate a cautious approach as they may quickly point to solutions but fail to represent an objective characterization of the problem at hand. An analysis of metaphors can provide a means of accessing and understanding conceptual frameworks and the social context in which they have been formed and used (Allan, 2007; Raymond et al., 2013). Such an analysis of metaphors requires a recollection of its sources and implications within and outside the scientific discourse (c.f. Mitchell, 1995) and plays a major role in answering poignant questions such as: how does the choice of words affect the way one studies invasive species, or the way they are perceived or managed?

We use the term 'strong metaphors' for particular phrases that function as carriers of value commitments, invoking a 'call for action', and creating a polarized setting for policy deliberations. This extends upon the work of Black (1979), who defined strong metaphors as those that are salient, focused, and forceful (or 'emphatic') while also having far-reaching responses and implications (or 'resonant'). The native versus non-native and invasive versus non-invasive categorizations will be used as key examples of strong metaphors in our paper, as they clearly represent diametrically opposed extremes and allow for specific framing of issues in a practical context (see also Keulartz & Van der Weele, 2008).

### Perspectives on Responsible Metaphor Management

Two relevant perspectives on the use of metaphors in invasion biology were developed by Larson (2011) and Hattingh (2001, 2011). According to Larson (2011), ecologists often have the tendency to overlook the value-dimension of the terms they use (p. ix), and invasion biology is presented as a rather extreme example. Although as a biologist Larson (2011) understands the concerns about invasive species, he is nonetheless critical about how these species have been 'vilified' in scientific discourse (p. 162). His basic contention is that, in the case of invasive biology, the metaphors used by scientists have often contributed to a climate of fear (p. 162). Rather than trying to rid ecology of metaphors and value-laden language, however, Larson (2011) argues that we should become more aware of this dimension, so that we can make responsible metaphoric choices both from a scientific and from a societal and policy point of view.

Hattingh (2001, 2011) argues that conceptual oppositions frequently used in the debate on invasive species (such as native versus non-native, natural versus unnatural, and pristine versus disrupted) quickly lose their meaning in a postmodern society that is characterized by globalization and mobility. In policy debates, as well as in science, multiple narratives are interacting with one another and Hattingh (2001) argues that we cannot escape the narrative dimension of these concepts. Rather than opting for one particular (allegedly 'neutral') interpretation, we should be aware of the strengths and weaknesses or relative value of the various terminologies available, and be open to alternative narratives that might be more effective in articulating concerns about non-native species in the policy or public realm. In other words, we can no longer afford to base our decisions for species management on particular vocabularies and leave the responsibility for developing and choosing this vocabulary to others. Both scientists and policy-makers have to become consciously involved in

how conceptual and linguistic disputes affect the way we study and manage invasive species, and whether we can live with its assumptions, implications, and consequences.

### Strong Metaphors in Policy Frameworks

At global, European, and national levels, governmental organizations and institutions have adopted tools and frameworks for assessing risks of non-native species (McGeoch et al., 2010). The outcomes of these procedures form the basis for management decisions, for example, by allowing prioritization and ranking of species in terms of invasiveness or by linking invasion stage to feasible interventions. The native versus non-native dichotomy is an important distinction in these policies, although not necessarily with similar implications. In Europe, decisions are usually based on the assumption that non-native species will not cause harm *unless* sufficient evidence indicates otherwise, while on other continents, the opposite principle 'guilty until proven innocent' is applied (Dahlstrom, Hewitt, & Campbell, 2011). But what are the motivations and underlying assumptions that support this particular focus on a species' nativeness?

To discriminate between native and non-native species is not without reason, as non-native species are more likely to become a pest (Paolucci, Maclsaac, & Ricciardi, 2013), due to factors such as high dispersal ability and broad tolerance ranges, absence of natural enemies and the unpredictable nature of their population development and spread (Richardson, Pysek, Simberloff, Rejmanek, & Mader, 2008). Therefore, to a certain extent, it seems reasonable to develop targeted risk assessment tools and policies. Moreover, the number of introductions of non-native species has increased tremendously over the past decades (Leuven et al., 2009; Liebhold, Brockhoff, Garrett, Parke, & Britton, 2012) and in a number of cases, immediate action seems warranted in order to forego severe ecological or socio-economic impacts (European Commission, 2014; Pejchar & Mooney, 2009).

Another aspect which acts as a selective bias to managing introduced species is our role as humans in the 'unnatural' spread and introduction of species. Because of the devastating impact that humans have (had) on nature, we feel responsible for actions which facilitate the spread of non-native species and want to correct our mistakes and interference by means of prevention, eradication, and control. The fact that non-native species are sometimes addressed as *biopollution* serves as a good example (Elliott, 2003; Panov et al., 2009). Both arguments, species' harmfulness and human responsibility for its spread, are key arguments in shaping both ecologists and lay public perceptions of non-native species (Selge, Fischer, & van der Wal, 2011).

Assuming that the native versus non-native dichotomy is a feasible one, and that non-native species indeed are potentially more likely to become invasive than native ones, the following step is to look further into the criteria for categorizing a species as invasive. The main criteria in ecological impact assessments to assess the risk of invasiveness of non-native species address adverse impacts of newcomers on native species communities (through predation, habitat modification, competition for food or habitat, parasitism, transition of disease vectors, or hybridization) and changes in ecosystem functioning and ecosystem services (Roy et al., 2014). These criteria also form the basis for the EU regulation (e.g. for listing of invasive non-native species of EU concern), and reflect societal values relating to nature or biodiversity. Protecting native species can be substantiated by the desire to preserve biodiversity, to protect certain ecosystems, and to counter the ongoing biotic

homogenization of the world. On a smaller scale, keeping out non-native species may be needed to protect scarce and vulnerable ecosystems that society values because they are relatively natural and authentic (Hettinger, 2001; Throop, 2000). In all these lines of argumentation, we must be aware of the fact that we frame a particular situation in terms of a particular narrative, which allows us to focus attention on the management perspective.

## Complexities in Ecological Impact Assessment

Ecological impact criteria, which function as operational guidelines to distinguish between invasive and not invasive, do not always incorporate clear, 'objective,' or noncontroversial definitions and quantifiable effect measures. The effectiveness and usefulness of risk assessment procedures have been questioned by Hulme (2012), who states that many lack consistent hazard identification and that risk assessors should be trained to limit cognitive biases.

One of the problems of using strong dichotomous metaphors of the invasive–non-invasive type is that the complexities and uncertainties of risk assessment procedures tend to be ignored (Roy et al., 2014; Verbrugge, Leuven, & Van der Velde, 2010). The assuring and definite tone of risk classifications sharply contrasts with the many uncertainties and complexities in the risk assessment processes (Liu, Sheppard, Kriticos, & Cook, 2011; McGeoch, Spear, Kleynhans, & Marais, 2012) and with the variability in risk classifications between countries (Verbrugge, Van der Velde, Hendriks, Verreycken, & Leuven, 2012). Risk protocols in force are of qualitative or semi-quantitative nature, translating qualitative data into numbers (Leung et al., 2012). Lack of data is a common problem and risk assessments often rely on expert judgments and anecdotal knowledge (Bayliss, Wilcox, Stewart, & Randall, 2012). Moreover, language can be considered as a source of uncertainty itself (Carey & Burgman, 2008). For example, in an assessment of predation impacts of bird species, experts have to state whether there is a decline of *several* or *many* native species (Strubbe, Chiron, & Shwartz, 2011).

From the point of view of 'responsible metaphor management,' the key objective should not be to eradicate subjectivity altogether, but rather to make it visible and open to debate. An important question for instance is: '*how can we distinguish between changing and damaging ecosystems?*' (Hulme, 2012). Whereas 'change' is objective and neutral, up to a certain point, the term damage entails an assessment and may depend on value judgements. A proposal to make subjective value judgments in ecological assessments more explicit has been made by Colautti and Richardson (2009). They argue that we should distinguish between motivational and methodological questions. An example of a methodological question is: '*What affects the rate of population growth in introduced species and does it differ from natives?*' Such a question, they argue, should be answered as objectively as possible, based on the data at hand. Interpretations among experts may differ, and a certain level of subjectivity and flexibility, referred to as 'methodological subjectivity,' may be involved. These questions should be distinguished from motivational ones, however, which are related to societal impact in terms of biodiversity, ecosystem management, and human welfare, for example: '*Why should we be concerned about invasive species and what constitutes a negative impact?*' Besides interpretations of the available data, such questions tend to involve value judgments as well. This type of subjectivity they refer to as 'motivational subjectivity.' It is much less constrained by established scientific methods than methodological subjectivity and therefore allows for much more flexibility among experts.

Colautti and Richardson (2009) argue that, in order to clarify the confusion, both types of subjectivity should be clearly distinguished but, in practice, risk assessment procedures will involve both. Scientists will have to deal with 'methodological subjectivity', but they also have to make value judgments based on the available data and within the boundaries set by the risk analysis framework. To the extent that impact assessment not only involves methodological issues, but also motivational ones, scientists are called upon to play a double role, as the responsibility for evaluating ecological impact will be based on a mixture of scientific evidence and societal values.

### Context-Dependence of Nativeness and Invasiveness

In his reading of metaphors, Black (1979) draws attention to the fact that the same metaphorical statement may have different and even partially conflicting readings, depending on the audience. The terms 'non-native species' and 'invasive species' have different meanings for scientists from different disciplines, such as ecologists and landscape scientists (Crees & Turvey, 2015; Humair, Edwards, Siegrist, & Kueffer, 2014). A case study in Norway has shown that labelling plants as non-native and invasive ('black listed') or as native and protected ('red listed') is problematic in landscape planning, due to the ambiguous and value-laden temporal thresholds that inform these categorizations (Qvenild, 2013). In this nature development project, conservationists and landscape architects had different opinions of what counts as wanted and unwanted nature, resulting in conflict (Qvenild, 2013). This example clearly shows that labelling a species as invasive is by no means a neutral exercise leading to clear-cut decisions in management (or 'a license to kill') as other stakeholder groups may focus on different aspects, such as favorable species' characteristics for planting or, in the case of animals, welfare of individual species. Boonman-Berson, Turnhout, and van Tatenhove (2014) looked at different conceptions of space in the categorization of invasive species in science, policy, and management, and identified that scientists use ecological spaces, such as biogeographical regions, to assess whether a species belongs to, or is invasive in, a certain area. This is in contrast to policy spaces, such as countries or states, and the demand for data about ecological, societal, and economic damage that are required in decision-making processes.

The policy perspective creates a number of difficulties for invasive species management. On a geographical level, countries differ in (political) history, cultural identity, and previous encounters with non-native species which may lead to variability in risk perception and eradication policies. For example, cultural differences as well as differences in the interpretation of available data may affect the consistency of risk classifications (Verreycken, Geeraerts, Duvivier, & Belpaire, 2010). Also, biological invasions may create situations in which a species is regarded as invasive and therefore subject to eradication in one region and regarded as 'endangered' and therefore subject to protection elsewhere in the world (Marchetti & Engstrom, 2016).

It is important to realize that our narratives concerning invasive species are not only sensitive to place but to time as well (see Crowley's example (2014) of the growing numbers of dromedary camels in the Australian desert, which are set 'out of time' and 'out of place'). Categorizations of species as invasive may catch up with the present time in which species that were previously introduced are now perceived a pest. For instance, in the nineteenth century, introduced plants were perceived positively at first, as migrating and adventurous

'cosmopolitans,' then negatively, as a 'weed,' followed again by a positive attitude towards all common, 'close to home' species, regardless of their origin (Dresen, 2011). Until the risks of non-native species became apparent, plant forms were regarded as 'common heritage of mankind' (Heywood, 2006). It may also work in the opposite direction. Recent examples of changing perceptions are those concerning the tamarisk (Stromberg, Chew, Nagler, & Glenn, 2009), the American jack-knife (Dekker & Beukema, 2012), and the zebra mussel (Leuven et al., 2009; Waajen, Van Bruggen, Pires, Lengkeek, & Lürling, 2016), species for which positive effects are now increasingly recognized. It is difficult to predict our future relations to introduced species. When taking a long-term view, one may argue that the appreciation of non-native species is likely to increase because they are experienced as part of the local flora and fauna by future generations who will grow up surrounded by them (Genovart, Tavecchia, Enseñat, & Laiolo, 2013).

### Role and Impact of Metaphors in the Species Management Arena

The importance of incorporating societal views in invasive species management is increasingly recognized in terms of preventing new introductions (for example by codes of conduct; Verbrugge, Leuven, van Valkenburg, & van den Born, 2014), early warning using citizen science (Adriaens et al., 2015), and public support for control or eradication (Genovesi, & Bertolini, 2001). Numerous examples exist of invasive species management actions that have been fiercely debated in society and communication appears to play a pivotal role in the process. On the one hand, a lack of communication dramatically decreased eradication success of a small population of Indian house crows (*Corvus splendens*) introduced by shipping to the Netherlands (Verbrugge, 2014, p. 133). On the other hand, intensive and targeted communication efforts have been regarded as important success factors in the eradication of the Pallas' squirrel (*Callosciurus erythraeus*) in the Netherlands and Flanders (pers. comm. M. La Haye and T. Adriaens).

A relevant question concerns the role of metaphors in shaping public perceptions of non-native species and support for invasive species management. To our knowledge, this topic is largely unexplored in science and we can only refer to one study addressing the effects of using specific 'frames' in communication on public willingness to take action against two invasive plant species (Hart & Larson, 2014). The particular frames were linked to the driver versus passenger model to describe the mechanism that explains invasive species' spread and impact; they can either be regarded as the causes (or 'drivers') of environmental change or as 'passengers' that spread in response to changing environment (Didham, Tylianakis, Hutchison, Ewers, & Gemmell, 2005; MacDougall & Turkington, 2005). The experimental design study found that the 'driver' frame, compared to the 'passenger' frame, increased perception of risk to humans and the environment, both of which contributed to willingness to take action. However, the same 'driver' frame also decreased personal causal responsibility, showing the importance of communicating human responsibility for introduction (Hart & Larson, 2014).

The lack of further empirical evidence, or other examples, stresses the need for more studies on metaphorical language in the public domain. The media are an important source of information for the general public. Content analyses of media sources, such as newspapers and the internet, can provide more insights in how the media frame the issue of non-native species. Specific elements such as metaphors, arguments, problem setting, and emphasis

can be identified to find out how frames in popular media may differ from science, policy, and other public domains.

## Concluding Remarks

The terminology concerning biological invasions employs a diverse range of metaphors, such as invasional meltdown, biopollution, and the driver-passenger model. The fact that non-native species are also referred to as neobiota, alien, foreign, exotic, introduced, or non-indigenous species reflects that alternative wordings exist to describe this phenomenon. However, the metaphors used in risk assessment of invasive species, both in the academic literature and in the policy arena, tend to be relatively strong. While these may be employed to create a sense of urgency in view of the serious damage which biological invasions may inflict on ecosystems, they may also give rise to biased accounts. Based on the principles of 'responsible metaphor management' we argue that the acknowledgment of value choices is of major importance for the implementation of effective policy which is, in fact, determined by numerous factors such as the consistency and efficiency of proposed measures, public support, and communicative efforts. In the case of invasive species, managers must decide on the basis of complex ecological, socioeconomic, and ethical arguments. Indeed, one might refer to it as a 'wicked problem' (Rittel & Webber, 1973) which involves many types of experts and stakeholders holding different values and perspectives.

One difficult challenge in 'responsible metaphor management' in the policy arena is that policies often frame non-native species in a national context, while natural systems, such as rivers and mountains, tend to cross (artificial) institutional boundaries. Especially in Europe, the use of bioregions may provide more accurate predictions and a more solid base for prevention and eradication programs. However, besides political and institutional bottlenecks, language and metaphors may play a role here as well. Every country has its own (historically and culturally) set of metaphors, conveying particular values and norms. Efforts towards harmonization on the level of transnational bioregions not only means creating more uniformity and consistency on the level of policy and legislation, but also entails conscious deliberations on the language, key terms, and metaphors employed. The existence of multiple narratives on invasive species in a particular area, for example, Europe, has to be acknowledged and their various strengths and weaknesses have to be assessed before a comprehensive 'bioregion' approach can be established.

A complicating factor is that policy-makers are increasingly confronted with changing ecosystems and here lies a second challenge for responsible metaphor management. Ongoing and often irreversible changes to ecosystems make traditional restoration and conservation norms based on historical references difficult to uphold (Hobbs, Higgs, & Harris, 2009). If a non-native species has successfully established in a certain region, this inevitably conflicts with flora or fauna compositions based on historical references. Climate change, shifts in land use, and other consequences of human activities further complicate our relation with the environment. We propose that better insights into visions of nature (Van den Born, Lenders, De Groot, & Huijsman, 2001) will help to evaluate non-native species policy in terms of values attributed to nature by institutions, professionals, and the public.

Multiple narratives also play a role within the science domain. We have identified a tension between the uncertainties in the risk assessment process and the presence of 'strong' metaphors that fill (or conceal) the gap between the questionability of the 'facts' and the often

rather outspoken recommendations for intervention. Naturally, we encourage ongoing efforts to develop more accurate risk assessments. However, even if uncertainties can be reduced, the outputs have to be interpreted and presented in accessible language, often resulting in recommendations for action. Increased awareness and transparency of the value judgments that play a role in ecological risk assessment, for example, when using expert judgment or interpreting data, is needed to improve our understanding of the decisions that are made based on this information.

Finally, full recognition of 'narrative' flexibility and responsibility can only be achieved by incorporating societal voices in the decision making process. Early involvement of stakeholders is not only important to inform policy about the opinions present in society, but it may encourage mutual understanding and reduce chances of conflict. A broader decision making framework incorporating multiple stakeholders' perspectives and possible positive (ecological) effects of non-native species will be better equipped to do so. Also, more research is needed regarding the choice of metaphors in the public domain and in identifying how frames in popular media may differ from science, policy, and other public perspectives.

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