# Invasive Alien Species (IAS): A Less Known Environmental Issue that needs urgent attention

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**Abstract:**Species are being introduced into new areas by human beings either intentionally or unintentionally. Such introductions have increased over the years in view of increase in economic activity, trade, travel, commerce etc. The introduction of species into new environments carries various risks as some of them may become invasive and pose serious threat to biodiversity, human health and economy. The possible mechanisms by which alien invasive species register their impact on ecosystems include alteration in hydrologic regimes, fire regimes, nutrient cycling, increased completion for resources, effects on the genetic variation of native populations via hybridization, and disruptions of mutualistic networks such as pollination and dispersal. Globally, control or eradication of these alien invasive species has proven extremely difficult. Hence there is an urgent need for the development of early warning systems and predicative framework that allows for identification of potentially invasive species either prior to their introduction or after their introduction in the non-native region. In addition lack of awareness and insufficient information on the alien invasive species and their impact, particularly in developing the countries, is proving a biggest obstacle in the effective control and management of these alien invasive species. This article is an attempt to review literature pertaining to consequences, risk assessment and control of biological invasion.

**Key words:** Alien species; biodiversity; competition; ecosystem; invasion.

## Alien species: What we know?

Alien species are, by definition, taxa that are introduced outside of their natural range either intentionally or unintentionally by human agency (IUCN 2000). Although only a small percentage of these alien species become invasive (10% rule), when they do so their impacts are immense, insidious and usually irreversible, and they may be as damaging to native species and ecosystems on a global scale as the loss and degradation of habitats (IUCN/SSG/ISSG 2000). For a species to become invasive, it has to overcome several barriers (Fig. 1).

From scientific point of view, a species introduced into a new area can either be beneficial, detrimental or neutral (Goodenough 2010). Negative effects on biodiversity are generally the main concern associated with biological invasions, but invasions also have serious implications for human well-being (Richardson et al. 2000). The possible benefits of alien species include: hosts for native species, pollinators and seed dispersers, ecosystem engineers and reduction of native predation pressure (Goodenough 2010). On the contrary, invasive alien species (IAS) often pose a significant threat to biodiversity (McGeoch et al. 2010, Seifu et al. 2017) and cause a significant damage to the economic value, diversity and function of invaded ecosystems (Mack et al. 2000; Pimentel et al. 2001).

It is now a well established fact that biological invasions contribute to biodiversity loss, ecosystem degradation, and impairment of ecosystem services. Worldwide researchers have found that neither all native species are threatened to the same degree nor all habitats are equally invaded (Lonsdale 1999). There

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are enough evidences which indicate that characteristics of a target community

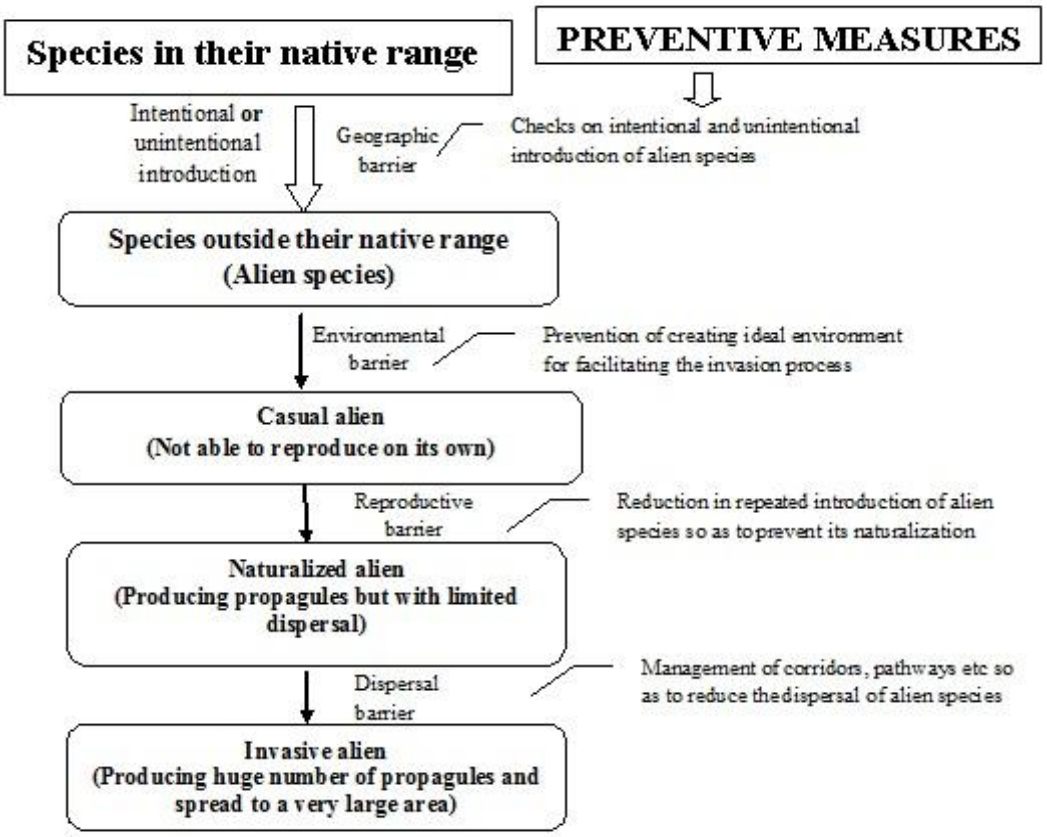



**Figure 1**

characteristics of the invader itself (invasiveness) (Drake and Williamson 1986; Rejmánek 1989; Ramakrishnan and Vitousek 1989; Lodge 1993). Habitat differences in the degree of invasion have been found to depend on alien species traits compared to native species, environmental and biotic characteristics of the recipient habitat, and the propagule pressure with which alien species are entering into the recipient habitat (Rejmánek et al. 2005). Further the impact of alien species on resident communities can get aggravated if one alien species facilitates the invasion of other species a process described as invasional meltdown by Simberloff and Von Holle (1999).

Recent advancement in global trade and commerce has increased the rate of biological invasion and has taken alien species to ever possible ranges (Hulme 2009). This has necessitated the need for studying the negative (invisibility) are as important, in determining the impact of alien species, as the effects of alien species on resident communities and functioning of invaded ecosystems (Williamson 1998, 2001; Parker et al. 1999; Byers et al. 2002; Simberloff et al. 2003) and understanding the mechanisms underlying these impacts (Levine et al. 2003). The increased rate of spread and the heavy ecological and economic damage, which is estimated at US$ 1.4 trillion per annum – close to 5% of GDP (GISP, 2009) and €12 billion per year for Europe (Kettunen et al. 2008), is also the rationale for the selection of 'Trends in Invasive Alien Species' as one of 22 Headline Indicators to measure progress towards the Convention on Biological Diversity's target of reducing the rate of loss of biodiversity by 2010.

**Lacunae, gaps, biases, and errors in understanding the impacts of invasion: Correct knowledge**

The problem of biological invasion, often considered as 'wicked problem' (Conklin 2005), has proven so complex that there is no single, easy or correct answer to management problems. The main issues which hamper the efficeient management of invasive species globally are:

i) Differences between developed and underdeveloped world with respect to knowledge about biological invasions (Nuñez and Pauchard 2010).
ii) Gaps in the availability of data, both in terms of taxonomies and geography (Pyšek et al. 2008).
iii) Lack of correct knowledge about invasion process and impact (Kulhanek et al. 2011).
iv) Poor understanding of differences in impact of invaders among different regions (Padilla, 2010; Thomsen et al. 2011).
v) Use of aggressive practices against invasive species and their possible impact on native species (Rinella et al. 2009).
vi) Poor understanding of the fact that not all aliens are bad like invasive insects can either be novel agricultural crop pests or disruptors of indigenous species assemblages.

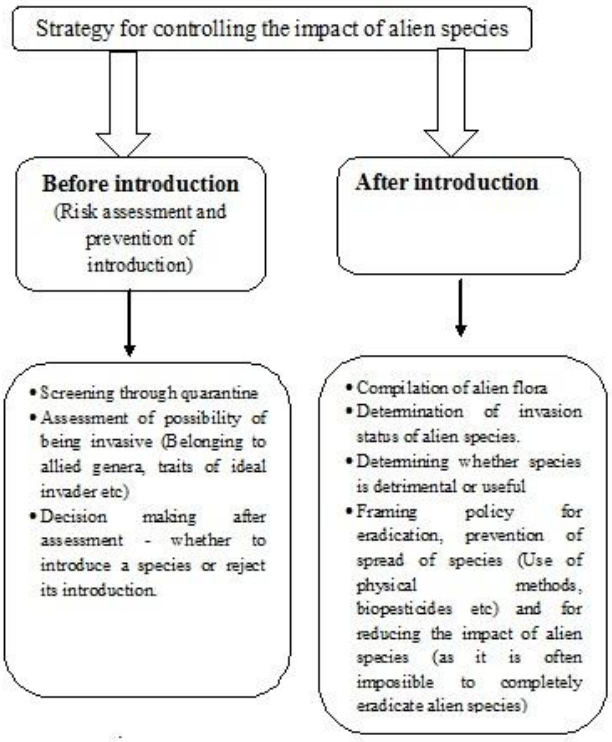
Probably it is our ignorance that the scientific evidence base for the impacts of many species perceived as among the worst invasive alien plants remains weak. As reported by Hulme et al. (2013) even the most ardent advocates of controlling alien plants acknowledge that only a fraction of naturalized species, perhaps as few as 10%, ultimately have a noticeable impact on natural ecosystems. Therefore, the first step in any programme directed at effective management of alien invasive species would involve removal of all the gaps in understanding process of biological invasion and possible impacts of invasion (Hulme et al. 2013).

**Framing policy: What is to be done? (Risk assessment and management of invasive species)**

In view of the multifaceted impact of invasion, the problem of plant invasion needs global coordination for its effective monitoring and management (McNeely et al. 2001; Simberloff et al. 2005; Panetta & Gooden, 2017). Globally, much of the progress has been made in management of invasive species but there is still scope for vast advancement. Among the activities that are receiving the most attention and that have the most promise for reducing problems are risk assessment, pathway and vector management, early detection, rapid response, and new approaches to mitigation and restoration (Pyšek and Richardson, 2010). Rejmánek (2000) highlights three fundamental management objectives for invasive alien species, namely, prevention/exclusion, early detection/rapid assessment, and control/containment/eradication, which in theory, might be very simple and straight forward to accomplish yet proves extremely difficult given the above mentioned problems.Risk assessment as the word suggests means predicting the potential adverse effects of exposure to hazardous agents or activities. Risk management is the process of identifying, evaluating, selecting, and implementing actions to reduce risk (The Presidential/Congressional Commission on Risk Assessment and Risk Management 1997). Assessment and reducing the possible risk of any action are two important components of safety and this job is itself proving a challenge so far as the alien invasive species are concerned. The main reason behind this is the fact that invasion patterns differ and as such numerous hypotheses have been proposed to explain it. Till date no single hypothesis can exclusively explain all invasion patterns.

There may be no sharp boundary between risk assessment and risk management in some analytic elements, e.g., the identification and evaluation of risk reduction measures, as these aspects are linked. Risk assessment for invasive

species is generally conducted to inform two classes of risk management decisions: (1) those regarding the introduction of potentially invasive nonindigenous species, their vectors, or conveyances prior to establishment (leading to decisions to authorize, prohibit, or permit activities under specified conditions), and (2) decisions regarding the allocation of scarce resources for the control of established invasive species, including rapid response to emerging threats. Framing policies about management of invasive species has proven a difficult job for all the reasons typically addressed by multi attribute decision analysis: uncertain outcomes, multiple and conflicting objectives, and many interested parties with differing views on both facts and values (Maguire 2004). Here we propose that management strategies for controlling alien species can be broadly grouped under two headings (Fig. 2):




**1. Before introduction (Early warning systems):** It includes checking both intentional as well as unintentional introduction. The best way to be safe from any enemy is to stay away from that enemy as much as possible. To prevent new plant invasions, there is an urgent need for the development of early warning systems to determine the likelihood of a given species becoming invasive and of methods to conduct rapid assessments of the status of invaders (Panetta &Scanlan, 1995; Sandlund et al., 1999; Groves et al., 2001; Wittenberg & Cock, 2001; Andow, 2003).

Preventive measures ideally consist of the prevention of entry of a species (Zamora et al., 1989; Westbrooks, 1991) for which invasive characteristics of the species under consideration needs to be understood. Now days, almost every country has quarantine board to screen materials imported or exported from the country. Living material should be properly screened so as to prevent introduction of any unwanted species. Even if a country has no other choice than to introduce a species so as to meet demands of growing population, prior investigation should be carried out so as to estimate the possible consequences of the required introduction (Risk assessment). In this regard knowledge of taxonomic belonging {Darwin's naturalization hypothesis (DNH) (1859); Mack, 1996; Rejmánek, 1996}, attributes of the species to be introduced {Baker (1965); Pyšek*et al*., (2004); Rejmánek*et al*., (2005)} whether species has attributes of an ideal invader} need to be taken into consideration in taking decisions. Keeping in view the challenges posed by alien species, numerous recommendations and guidelines for the implementation of quarantine of aquatic animals have been already made and precedents established (Davy and Graham 1979; Roberts 1981; Davy and Chouinard 1983; Rohovec 1983; Arthur 1987; Turner 1988; Grizel 1989; Langdon 1990; DeKinkelin and Hedrick 1991). Many countries, however, continue with limited, ineffectual or no quarantine when introducing aquatic animals which has put these nations at greater risk of invasion.

**2. After introduction:** It is management of introduced species once it has been introduced into a new range. It can be achieved by following:

*Compilation of alien flora.*Compilation of alien flora from phytogeographically distinct regions is of immediate relevance not only for better understanding the patterns of plant invasion but also for explicating the processes promoting invasion at local, regional or global scales (Khuroo et al. 2007).

*Recognition of invasion status of alien species (Whether casual, naturalized or invasive)*. This is likely to prove very useful sofar as the management of alien species is concerned. As an alien species has to overcome barriers to become invasive, our efforts of reducing the chances of an alien species overcoming these barriers is certainly going to play a pivotal role in eradication/management of alien species (Fig. 1).

*Framing policy for controlling alien species according to its invasion status*. Worldwide, federal and state transportation agencies have been working for years to implement numerous laws and policies aimed at effective vegetation management, promotion of native plants and wildflowers, and control of invasive species in the transportation corridors, both at national as well as international level. Much of these laws have been implemented mostly in developed countries and as such there is large gap between developed and underdeveloped countries sofar as management of alien species is concerned. Some of the landmark advancements in USA are Executive Memorandum on Beneficial Landscaping (1994), Executive Order 13112 on Invasive Species (1999), Noxious Weed Control and Eradication Act (2004) and the selection of 'Trends in Invasive Alien Species' as one of 22 Headline Indicators to measure progress towards the Convention on Biological Diversity's target of reducing the rate of loss of biodiversity by 2010.

*Dispersal of alien species*. Linear features in a landscape, such as rivers, canals, roads and railways are often viewed as habitat corridors that help direct the movement of organisms through less hospitable habitat, facilitating exchange between populations and thus population persistence (Van der Windt and Swart 2008). These corridor pathways need to be managed to in such a way that spatial spread of alien species is prevented (Hulme 2009).

*Use of eradication measures such as use of biopesticides, physical eradication etc*. Although eradication is often considered as a distasteful activity (Temple 1990) and an impossible goal (Bomford and O'Brien 1995) yet this eradication has also been successfully achieved e.g., the eradication of the coypu (*Myocastor coypus*) in the UK is one of the few successful programmes to be completed in Europe (Gosling and Baker 1989) and required extensive funding and specific legislation (Sheail 2003).

*Mitigation (actions that reduce the likelihood of invasions by reducing the invasiveness of species or the invasibility of ecosystems) and Restoration (the action of returning somethingto a previous stage).*Although above mentioned methods of invasive species management are very much the part of mitigation and restoration strategies, we propose that current approach of dealing with alien invasions must be a combination of theoretical and practical aspects. Dealing with invasive alien species is one of the key elements for ecosystem restoration (D'Antonio and Meyerson 2002) and as such many mitigation and restoration strategies have been suggested by ecologists (Gaertner et al. 2012; Perrings 2005).

## Conclusion

Currently there is enough literature available which suggests that alien species are often problematic than beneficial, as majority of alien species have been found to cause serious problems. This knowledge of ecological, genetic, and evolutionary perspectives on invasive species may be essential for developing practical solutions to the economic and environmental losses resulting from these species. Further understanding of mechanisms underlying the impact of alien species will greatly enhance the chance combating this issue of biological invasion. There are marked geographical and taxonomical biases in the study of invasions

and invasive species, but there have been major advances in the understanding of invasions for most taxonomic groups and major biomes in recent years. New technologies, notably molecular methods, remote sensing, and computers, must be employed to assemble accurate inventories, map and model distributions and the effect of interventions, and explore patterns of invasive species for their effective management.

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