

What sorts of species
become 'invasive
aliens' in a world of
climatic change



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“ Invasive alien species have caused untold damage to natural ecosystems and human economies alike over the past few centuries. Globalization is accelerating the destruction, as expanding tourism and trade offer more and more opportunities for unwanted species to hitchhike to new homes. ” - Mr. H.

Zedan, Executive Secretary of the CBD, 6th meeting of COP of CBD, 2002 “ The concept of ‘ alien’ can be seen as irrational if we look back at the history of vegetation dispersal, survival and evolution and a time reference point is needed if we are to justify what is native and what is alien. - Trudgill, 2001: 681 There is a long history of concern about the impact of non-native species upon ‘ natural’ environments, as illustrated by the 1905 publication date of Dunn’s Alien Flora of Britain. The study of plant and animal invasions remains popular and has recently been described as one of the “ hottest current topics in ecology” (Sol, 2001 cited in Henderson, forthcoming). A number of different disciplines have contributed to the study of ‘ invasive aliens’. As such the terminology is frequently misused and confused, and will be therefore be defined at the outset (Richardson et al.

, 2000). The term ‘ invasive alien’ has two components; the first relates to the relative degree of success experienced by a species, whilst the second infers a description of the origin of the species (Henderson, forthcoming). The two components are not necessarily mutually causative, a species may be classified as an ‘ alien’ without being ‘ invasive’, or vice versa. Aliens (also known as exotics, non-natives or non-indigenous) may be defined as species ‘ that have been transported into a region by humans across a barrier that has apparently prevented natural dispersal’ (Alpert et al.

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, 2000). Invasives are 'naturalized plants [or animals] that produce reproductive offspring, often in very large numbers, at considerable distances from the parent plants [or site of introduction] and thus have the potential to spread over a considerable area' (Richardson et al. , 2000). It is also important at this stage to draw a distinction between the terms 'climatic change' and 'climate change'. In this essay the former will be used to refer to an ongoing natural process of change that has been in operation throughout Earth's history, and the latter to encapsulate more recent and anthropogenically-induced changes that are associated with elevated levels of greenhouse gases.

The majority of this essay will refer to invasive aliens in the context of climate change, although knowledge of plant and animal responses to past episodes of climatic change will also be used to inform the discussion. In this essay two different viewpoints will be used to tackle the question of which species become invasive aliens in a world of climatic change. Firstly, biogeographic theory upon the characteristics of invasive species will be applied to scenarios of global warming to outline some of the possible results of climate change upon invasive aliens. It will be argued the type of species that will become invasive aliens is largely dependent upon the local resonance of climate change processes and a variety of other factors (such as habitat disturbance), although life history characteristics of the invasive species will remain an important variable.

Secondly, by revealing the social construction of the term 'invasive alien', it will be suggested that our notion of what constitutes an alien needs re-examination in a world of climatic change. However, it is first necessary to <https://assignbuster.com/what-sorts-of-species-become-invasive-aliens-in-a-world-of-climatic-change/>

briefly outline the dimensions of the 'invasive alien' problem. There are four main stages of the invasion process, as illustrated by Figure 1. The human-mediated introduction of an alien species may be intentional or accidental. Many nuisance species have been established or naturalized for a considerable length of time before they become invasive (Myers ; Bazely, 2004). For plants, Richardson et al.

2000) have suggested that invasive species may be defined as those advancing by 100m over 50 years for taxa spreading by seeds and other propagules, and 6m over 3 years for taxa spreading by roots, rhizomes or creeping stems. In reality, the boundary between invasive and non-invasive is a somewhat arbitrary, though conceptually useful, break imposed upon a spectrum of species success. Invasiveness has also been conflated with the ecological or economic impact of a species (for example, see Biotech Resources, 1995-1998 and IUCN, 1999), although this interpretation is not necessarily helpful (Richardson et al. 2000). There are many benign invaders whose environmental or ecological impact is beyond practical detection, for example *Aira praecox*, *Myosotis strict* and *Velezia rigida* (ibid.

, 2000). Richardson et al. (2000) consider other terms, such as 'pest' or 'weed', to be more useful to refer to the 50-80% of invasive species that are deemed to be harmful. They also propose the use of the term 'transformer' for the 10% of invasive species that change the character, condition, form or nature of ecosystems over substantial areas. Williamson ; Fritter (1996) found that only 10% of UK plants pass through each stage of the colonization processes of introduction, establishment and invasion, an observation which

has become known as the 'tens rule'. The number of non-native species varies considerably between nations and regions.

For example, approximately 28% of plant species in Canada are estimated to be non-native and nearly 50% of vascular plants in New Zealand likewise (Heywood, 1989; Green, 2000). A recent survey by the Botanical Society of the British Isles counted 1402 recent introductions out of a total of 2,947 plant species in the UK (Preston et al. 2002). Well under 0.

1% species introduced to the UK have become pests (Crawley et al. , 1996).

Figure 1 Stages in the introduction, establishment and spread of a non-native species. (Adapted from Myers ; Bazely, 2004) Until recently, most research upon invasive species has tended to focus upon those with direct economic effects such as those which have affected crops or fisheries (Parker ; Reichard, 1998).

The economic impact of invasive species can be significant, for example, the estimated cost to the United States economy in 2001 was \$125 billion (Baker, 2001). Research into ecosystems containing alien species was often explicitly avoided in the past, as they were perceived as 'unnatural' and therefore unable to provide insight into 'real' ecological processes.

Consequently there is a lack of data upon alien plant abundance and a pronounced sampling bias against such species (Crawley et al. , 1996).

However, there has been increasing recognition of the negative impact that some invasive alien species can have upon key conservation priorities, including species richness, genetic variability and regional floristic compositions (see Groombridge et al.

1992, Wilcove et al. , 1998). Invasive alien species may directly affect biodiversity through predation, competition (e. g. shading out), hybridization, and by carrying pathogens or parasites (IUCN, 2004).

The issue has been popularised through the mass media as part of the wider sustainable development movement, and more specifically through the 1992 Rio Earth Summit (which saw the introduction of the Convention on Biodiversity), the UN Global Invasive Species Programme and a specialist group of the International Union for Conservation of Nature and Natural Resources (IUCN). Extinction rates in the current ' Biodiversity Crisis', or ' Sixth Extinction', are estimated to be 10 to 100 times greater than those of past extinction episodes (Lawton ; May, 1995). Invasive species are recognised as one of five main causes of this human-induced extinction, acting in conjunction with habitat destruction, habitat fragmentation, over-exploitation and secondary effects that can lead to cascading ' chains of extinction' (Diamond, 1989). For example, introduced species are a threat to approximately 20% of endangered mammal and bird species (MacDonald, 2003).

However, the threat of extinction is not uniform and certain habitat types are particularly endangered, such as grassland heaths and scrubs, oceanic islands and tropical forests (ibid. , 2003). A number of countries have developed, or are in the process of developing, strategies and legislation to deal with the problem of introduced species (Myers ; Bazely, 2004). On an international scale, Article 8h of the Convention on Biodiversity instils a three-pronged precautionary policy of prevention, eradication and containment. Preventative tools include the use of border controls and <https://assignbuster.com/what-sorts-of-species-become-invasive-aliens-in-a-world-of-climatic-change/>

quarantine measures, and the issuing of licenses prior to the first time introduction of a potentially invasive species.

Post-invasion action may be effected through chemical control (for example, using pesticides), mechanical control (the physical removal of invasive species), biological control (the introduction of a natural enemy-predator, parasite, or disease) and also through ecological control (the manipulation of environmental factors such as fire and water flow which can give native species a competitive edge). Understanding and predicting which species will become invasive aliens is therefore an important biogeographical issue with considerable political, economic and social ramifications. A wide range of species have the potential to become invasive aliens, they are not limited to species from a particular genera or region, although these may be contributory factors. In their native habitats, all species must have the potential to expand when rare or must otherwise drift towards extinction (Crawley et al. 1996). A considerable body of literature has developed concerning the invasion and colonization process, yet it remains difficult to predict which species will become invasive (Mooney ; Hobbs, 2000).

However, there are a number of life history traits which can influence evolution, adaptation, population growth and population dynamics and thereby contribute to whether a species will be able to outcompete natives or fill a vacant niche and subsequently become invasive (Myers ; Bazeley, 2004). Common life history characteristics of successful invasive species include short generation times and juvenile periods, large numbers of offspring, and vegetative reproduction and readily dispersed propagules in plants (MacDonald, 2003). In a comparative study of the phylogenetic traits of <https://assignbuster.com/what-sorts-of-species-become-invasive-aliens-in-a-world-of-climatic-change/>

native and alien vascular plants in the UK, Crawley et al. (1996) found that alien species tended to be taller, have larger seeds and were more likely to show protracted seed dormancy. Crawley et al. 1996) also distinguished several predictable patterns for the establishment of invasive alien plants; weeds in one country are likely to be weeds when introduced to another climatically matched country, the rate of establishment of alien plants will be proportional to the frequency and intensity of disturbance of the habitat, and that alien plants will grow bigger and have greater ecosystem impact than equivalent native plant species as a result of their release from their specialist pathogens.

However, competitive ability is not only determined by intrinsic factors but also by extrinsic biotic and abiotic variables, including the identity of competing species and environmental conditions (ibid. , 1996). The proportion of alien species differs considerably according to habitat, for example, alien species comprise 0. 8% of UK waste ground communities compared with less than 0. 1% in grass and heath land communities (ibid. , 1996).

Therefore, in many situations the traits which determine species invasiveness potential are highly contingent upon the local context and its associated processes. Whilst invasive species have been the subject of increasing popular and academic attention, few studies have related this problem to scenarios of global climate change (although see Dukes ; Mooney, 1999; Mooney ; Hobbs, 2000 for notable exceptions). Predictions of climatic change associated with anthropogenically-induced global warming are complex and contested, largely due to uncertainty about the magnitude <https://assignbuster.com/what-sorts-of-species-become-invasive-aliens-in-a-world-of-climatic-change/>

and direction of numerous feedback mechanisms that may be induced. As well as forecasting both positive and negative changes in temperature and precipitation according to locality, models have also suggested that elevated levels of atmospheric CO₂ and increased nitrogen deposition will be experienced (Dukes ; Mooney, 1999).

There are a number of possible interactions between alien species and climate change, for example, the severity of the impact of existing invasive species may be altered or formerly benign alien species may become invasive through a newly advantageous competitive trait (ibid. 1999). In the case of the former possibility there is evidence to suggest that 'invasive species share traits that will allow them to capitalize on the various elements of global change' (Dukes ; Mooney, 1999: 135). North American invasive species, such as cheatgrass (*Bromus tectorum*), kudzu (*Pueraria lobata*) and Japanese honeysuckle (*Lonicera japonica*), have been shown to respond positively to elevated CO₂ levels when grown individually or in monoculture (Smith et al.

, 1988; Sasek ; Strain, 1988, 1991 cited in Dukes ; Mooney, 1999). In diverse communities the results have been less clear cut and other factors, such as local resource availability, are also important in the determination of local species abundance (Dukes ; Mooney, 1999). Higher precipitation levels in arid and semiarid regions of North America could increase the dominance of invasive alien grasses. For example, Californian grassland communities residing upon serpentine soil are presently composed of native and endemic species with European annual grasses, such as soft chess, are confined to marginal, more fertile soil types.

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However increased levels of precipitation could give the European annuals a competitive advantage. Alien species can also set feedback mechanisms in process which facilitate their future establishment. In the Arizonan Sonora Desert it has been suggested that successive years of higher-than-normal rainfall have allowed populations of the introduced perennial, buffel-grass (*Cenchrus ciliaris*) to expand (Burgess et al. , 1991 cited in Dukes ; Mooney, 1999). The subsequent build up of non-native grass litter can increase fire frequency and thereby facilitate grass dominance (D'Antonio & Vitousek, 1992, cited in Dukes & Mooney, 1999). In northern California elevated temperatures may support the spread of the Argentine ant (*Linepithema humile*) to the detriment of native ant species, as the foraging time of the latter is limited by upper daily temperature limits (Human & Gordon, 1996).

In the UK, a modest climatic warming could lead to the replacement of native trees by species such as *Robinia pseudoacacia*, *Ailanthus altissimus* and *Quercus cerris* (Pysek et al. 1995). By contrast, a doubled-CO₂ climate scenario model for South Africa that accounted for both climate and soil suitability suggested range size decreases for five of the country's major plant invaders, including a 37% reduction in the area covered by the prickly pear (*Opuntia ficus-indica*) (Dukes ; Mooney, 1999). Therefore, whilst climate change is a global process many of its impacts in terms of invasive alien species will be regionally differentiated and played out at the local scale. Although it is difficult to predict which specific alien species will flourish as a result of climate change, it is likely that many of the aforementioned life history characteristics of invasive species will remain advantageous.

For example, rapid climate changes would favour species with short generation times that can quickly expand their ranges – a property common to many biological invaders (Dukes ; Mooney, 1999). Invaders tend to be 'generalist' species, having a wide environmental tolerance and large niche (MacDonald, 2003). This characteristic could permit alien invasives to withstand newly introduced climatic stresses that more specialised native species cannot (Dukes ; Mooney, 1999). The prevalence of early successional species may increase as a result of the climate-driven decline of late-successional species, a further characteristic of many invasives (ibid. 1999).

The tendency for aliens to be located close to human populations could also be a strong factor in promoting the spread of invasive species in a world of climatic change. For example, many non-invasive aliens are currently artificially supported in gardens; however, in the advent of climatic change it is possible that some could establish viable 'wild' populations, particularly as garden species tend to be relatively quick growing and low maintenance. The spread of such species could be facilitated by proximity to disturbed roadside habitats and the opportunity to migrate via 'hitch-hiking' on vehicles. In a world of climatic change and in terms of their life history characteristics, it is unlikely that the sort of species that become invasive aliens will change significantly, although existing aliens may find conditions sufficiently tipped in their balance that they can become invasive.

It is also likely that climatic change may contribute to the increased competitiveness of known and currently invasive alien species. However, it is important to remember that the sort of species that become invasive aliens in a world of climatic change is not only determined by species-specific

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traits, but also by local conditions and processes other than climatic change. The impact of climatic change is one of a number of mutually interacting processes of global change as illustrated by Box 1 below. The importance of other human impacts, such as habitat destruction and disturbance, upon enhancing the success of invasive species should not be underplayed (IUCN, 2004). Source: Dukes ; Mooney, 1999

The majority of the preceding discussion has taken the validity of the concept of an 'invasive alien' as a given. However, Trudgill (2001) has asserted that the notion of an 'invasive alien' needs to be seen as a product of 'semantics, western values and conceptualizations of nature' (Trudgill, 2001: 684).

Language used to describe invasive alien species in the popular press is certainly emotive, as evidenced by the recent discussion of the Red King crab (*Paralithodes camtschatica*): "Millions of giant Pacific crabs... are marching south along Norway's coast, devouring everything in their path. The monster crabs.

.. re proving so resilient that scientists fear they could end up as far south as Gibraltar. Energized by a mysterious population explosion a decade ago, whole armies of the crustaceans...

have already advanced about 400 miles along the roof of Europe, overwhelming the ports of northern Norway. They now number more than 10 million... leaving in their wake what one expert described as "an underwater desert".

" (Source: Telegraph, 28/02/2004) In contrast to invasive aliens, species

which expand into a new area by their own initiative are often warmly

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embraced as 'first sightings' (Trudgill, 2001). This was demonstrated by the enthusiastic response to a critically endangered slender-billed curlew at Druridge Bay in Northumberland in 1998 (BBC News, 2002). Certain types of species are much more likely to be perceived as 'bad' invasive aliens, and to be subsequently publicized as such. These include species which affect particularly prized natives, are visually unappealing, or have negative economic impacts.

Such 'bad' aliens include Japanese knotweed, the American mink, American grey squirrels, Ruddy ducks and the Mitten crab. However, many (less publicized) 'good' aliens provide the backbone of our agricultural economic systems or themselves have considerable cultural significance, for example, rabbits, poppies and the Sweet Chestnut (*Castanea sativa*). Much discussion of 'invasive aliens' rests upon the idea that humans are separate from, rather than a part of, nature. The very definition of an 'invasive alien' is centered upon the view that the human introduction of species is 'unnatural' and against the 'laws' of nature. Furthermore, we do not consider ourselves as invasive aliens as the human race settles new areas and dramatically alters existing habitats. Discussions of invasive alien species are often imbued with guilt about their introduction via human action, which is perceived to bring a species outside its 'natural' or 'god-given' range, and is thereby upsetting the pre-given 'balance' or 'stability' of a 'pristine' state (Trudgill, 2001).

Whilst the discourse of biodiversity suggests that species have a right to exist, the invasive species narrative implies that this right is only applicable in certain places and for defined population sizes (ibid. , 2001). Yet when we <https://assignbuster.com/what-sorts-of-species-become-invasive-aliens-in-a-world-of-climatic-change/>

consider the history of British flora, such notions of a permanent and stable ecological composition become problematic. The successive periods of ice advance and retreat during the Quaternary lead to the slow and continuous build up of what is currently considered to be 'British' flora (Godwin, 1975).

Paleoecological evidence has shown that it is impossible to scientifically pinpoint a date in geological history from which to infer what should (and should not) be counted as native. In the context of global climate change, a conceptualization of invasive aliens which is reliant upon relict ecological and arbitrary political boundaries will become unsuitable and unsustainable.

Migration is likely to be the key survival strategy for those species unable to tolerate environmental changes in their present habitat as a result of climate change (Huntley, 1995). In a world of climatic change, it is necessary to reassess the values behind our perception of what species will become 'invasive aliens'. Henderson (forthcoming) has taken the first step towards this goal, suggesting a more fluid and adaptable definition of 'alien' that is based upon the recent dispersal history of a species.

Indeed, in the context of rapid climate change, many potentially invasive alien (or native) species with slow migration rates may have to be actively introduced (or translocated) if we are to ensure their long term global survival. In conclusion, if we accept that the present conceptualization of an 'invasive alien' as valid, the sorts of species that are likely to become invasive aliens in a world of climatic change are not dissimilar to those which are invasive aliens today. Many life history traits that have been identified in current invasive aliens, such as short generation times, will remain

important, and many existing invasive aliens will be further advantaged by <https://assignbuster.com/what-sorts-of-species-become-invasive-aliens-in-a-world-of-climatic-change/>

climate change. However, it is important to emphasize that the factors controlling which species become invasive are not only intrinsic and climatic variables. Any prediction of which species will become invasive will also require careful consideration of local processes, including the identity of competing species and any human intervention through habitat disturbance and fragmentation.

However, in a world of climatic change which will involve range readjustment for some species to survive, any concept of an 'invasive alien' which rests upon political or relict ecological boundaries will need serious re-examination. Perhaps it is time to assess species in terms of their impact rather than their origin, and to move from perceiving species as having a rightful place to considering their potential ecological space.