

**Section:** Letters

**Title:** Invasive alien species: Denialism, disagreement, definitions and dialogue.

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**Authors:**

James C Russell<sup>1,2,\*</sup>; Tim M Blackburn<sup>3,4</sup>

**Affiliations:**

<sup>1</sup>School of Biological Sciences and Department of Statistics, University of Auckland, New Zealand @IsldJames

<sup>2</sup>Department of Preventive Veterinary Medicine and Animal Health, School of Veterinary Medicine, University of São Paulo, Brazil

<sup>3</sup>Centre for Biodiversity & Environment Research, Department of Genetics, Evolution & Environment, University College London, Gower Street, London WC1e 6BT, United Kingdom @TimBlackburn66

<sup>4</sup>Institute of Zoology, ZSL, Regent's Park, London NW1 4RY, United Kingdom

\* Correspondence: j.russell@auckland.ac.nz

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We recently suggested that recent elements of invasion biology discourse might be categorised as cases of more general science denialism [1]. We did not intend to be provocative, but welcome the opportunity this has presented for both ourselves and others [2,3,4,5] to reflect on their own science and values with respect to invasion biology and invasive alien species (IAS) management (Box 1).

That IAS are disproportionately implicated in extinctions since 1500AD [7,8] and are prevalent in current biodiversity threats [9] is supported by all the available evidence. Briggs [2] argues against this evidence, going so far as to suggest that IAS bring stability to ecosystems, when this is evidently not the case. His position is undermined by his evident confusion of all exotic (introduced, alien) species with the subset of those which are invasive (Box 1), and between the contemporary epidemic of biological invasions and historical (pre-human) species 'invasions' (colloquial use of the term), arguing that there is no material difference between these two groups. We do not disagree that natural species colonisations play a critical role in maintaining or increasing species richness, but the current spate of human-mediated invasions differ in rates, processes and mechanism compared to natural invasions [10,11]. Adaptive radiations are not offsetting the current rate of extinctions, by invasive species or indeed by any other global change threat.

Tassin and colleagues have all published critically on invasion biology in the past (references in [1]). We do not advocate that everyone questioning the evidence for negative impacts or

valuation of a non-native species as invasive should be labelled a denier, just as other scientists seeking precision in other topics where science denialism is present would not necessarily be so. Indeed, we explicitly distinguished between informed scepticism and denialism, and Tassin and colleagues may prefer to identify themselves in the former group. To reiterate our original point, science denialism occurs when “evidence is disregarded, or motivations are disingenuous”. Combining scientific fact and social values in the definition of IAS need not cause a ‘breakdown’ as Tassin and colleagues argue. Tools and processes exist to robustly manage expectations and policy where facts and values interact [12].

We do disagree with Tassin and colleagues’ argument that the threat of IAS is restricted to islands and freshwater systems, as once again evidence on this is to the contrary [9]. They also appear to confound the distinction of alien and benign from alien and invasive species (Box 1). We do not share their optimism that regional increases in species richness caused by species introductions offset the erosion of global species richness, nor their pessimism for the inevitability of these global change processes, when bold initiatives such as removing some IAS from an entire country are currently being supported [13]. The rapid rate of biological change projected from biological invasions and climate change are not “*inevitable and essential to the survival of species and maintenance of ecosystem services*” [3] but instead a key driver of the greatly elevated current rates of species extinction, and a likely cause of collapse of ecosystem services [14]. Nevertheless, we consider discourses such as this “*a vibrant and robust dialogue on the negative and potentially also any positive impacts of IAS*” [1].

In contrast, we found the response of Davis and Chew [4] was unnecessarily focused on attacking the discipline and scientists rather than the science itself. Their criticisms are familiar and have been well addressed elsewhere [15]. Rather than a last stand we find more reason than ever to be optimistic about invasion biology as a scientific discipline, and about the prospects for global action on the threat of IAS, with announcements such as the 2016 Honolulu Challenge<sup>1</sup>. The origin of a species is critical in determining the appropriate management response [13]. We urge academics such as Davis and Chew [4] to distinguish philosophical details from pragmatic necessities – is anyone really arguing against action towards preventing IAS impacts? We are glad that Davis and Chew acknowledge that nature is not dichotomous, such that invasive species with overwhelmingly negative impacts, and authors with extremely denialist views, are but one extreme of a long continuum.

Across the continuum of valuations of IAS, we agree with Crowley and colleagues [5] that “*disagreement about invasive species does not equate to denialism*”. Like Crowley and colleagues we advocate for “*good quality public, or indeed scientific, debate*”, as we (JCR) have argued elsewhere that scientific communication must be a two-way dialogue [6] and advocated for the use of tools such as social impact assessment (SIA) for enhancing IAS management [16]. Just as there exists scientific consensus on evolution, and on human-induced climate change, we believe it also exists on the negative impacts of invasive species,

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<sup>1</sup> <https://www.iucn.org/theme/species/our-work/invasive-species/honolulu-challenge-invasive-alien-species>

but that this consensus does not preclude debate on scientific uncertainty within each discipline (Box 1). However, negotiating the tensions of perceived consensus alongside scientific uncertainty are critical, especially in the public's eye [17]. Furthermore, denial must always be distinguished from disagreement (Box 1), as considering it only another type of disagreement plays in to a dialogue that denial statements are legitimised.

The typology of believers and deniers has been stark in other scientific arenas, and it is important that we learn from experiences such as in climate change politics and do not allow ourselves to become entrenched into such dichotomous typologies [17]. We maintain that invasive species denial is increasing, as the topic of IAS and their management becomes more mainstream, but like other scientists [2,4,5,6] we urge others to acknowledge the diverse values which can underlie IAS policy, and recognise that denialism is but one extreme of a long continuum.

#### Box 1: Definitions

In all science clarity of definitions is imperative, and invasion biology is no exception [6].

**Alien & Invasive:** These two terms are not synonymous, and should not be used or interpreted interchangeably. Alien species (often called exotic or introduced) are those whose presence in a region is attributable to human actions that have enabled them to overcome barriers to their natural dispersal. Alien species must have impacts on the recipient ecosystem simply by their presence (i.e. on the availability of space, food, water or other resources for other species), but their impacts can be positive and negative, often a combination of both, and potentially benign overall. By contrast, invasive species are generally taken to be that subset of alien species that are determined overall to have negative impacts. Not all alien species are invasive.

**Disagreement & Denial:** Disagreement can arise among scientists from scientific uncertainty or among stakeholders from different beliefs and values. In contrast denial, in the scientific sense, arises when scientific evidence is disregarded, or motivations are disingenuous.

Consensus on scientific paradigms can exist despite disagreement on interpretations of patterns and processes within.

**Invasion & Colonisation:** We can distinguish between biological invasions by alien species, which occur after a species is transported by humans outside its native range, and natural invasions, which are better referred to as colonisations, whereby a species expands its range to a new location under its own powers of dispersal.

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