

The exponential growth of invasive species denialism

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Abstract Since the 1990s, there have appeared numerous articles in scholarly journals and the popular press that deny the risks posed by non-native species and claim that the field of invasion biology is biased, uninformative and pseudoscientific. Unlike normal scientific debates, which are evidence based, this discourse typically uses rhetorical arguments to disregard, misrepresent or reject evidence in attempt to cast doubt on the scientific consensus that species introductions pose significant risks to biodiversity and ecosystems; thus, it is similar to the denialism that has affected climate science and medical science. Invasive species denialism, like science denialism in general, is typically expressed in forums where it avoids expert peer review. Denialist articles have increased exponentially over the past three decades, most notably in the mainstream popular press. This burgeoning phenomenon could impede development and implementation of policies designed to safeguard against invasive species spread and impact.

Keywords Invasion biology · Science denialism · Post-truth · Temporal trend · Science communication

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Introduction

Over the past 50 years, ecology has been an arena for vigorous scientific debates concerning, *inter alia*, the importance of competition in structuring natural communities, the efficacy of single large versus several small nature reserves, niche-based versus neutral models of biodiversity, and the need for null models in ecological studies. These debates are based on facts presented and evaluated in peer-reviewed journals. In the subdiscipline of ecology concerned with biological invasions, however, mainstream views are being increasingly challenged through a different form of discourse: more ideological than scientific, based on contrasting values rather than on facts, and expressed largely through popular media. It involves laypeople, scholars in the social sciences and humanities, and a small minority of ecologists who downplay or deny the risks posed by non-native species. These contrarians assert that non-native species present no real threat to biodiversity (or ecosystems) and are no more likely than natives to cause environmental damage (e.g. Sagoff 2005; Pearce 2015a, b), despite peer-reviewed research that shows otherwise (Salo et al. 2007; Simberloff et al. 2012; Paolucci et al. 2013; Ricciardi et al. 2013; Hassan and Ricciardi 2014). Many of them claim that the field of invasion biology is biased, uninformative, pseudo-scientific, and a hindrance to conservation (Davis and Thompson 2002; Theodoropoulos 2003; Davis et al. 2011;

Thompson 2014; Pearce 2015a, b) and, therefore, should be abandoned (see references cited in Simberloff and Vitule 2014).

These claims are almost always made outside the lens of scientific peer review, occasionally appearing in opinion articles of scholarly journals, but much more frequently in books, magazines, news media, and internet blogs. Russell and Blackburn (2017) likened this discourse to science denialism because it typically disregards, misrepresents or rejects evidence in attempt to manufacture doubt on research concerning biological invasions—as has occurred with climate science and medical science (Oreskes and Conway 2010; Lewandowsky et al. 2013). Citing some recent examples, Russell and Blackburn (2017) suggested there has been a rise of ‘invasive species denialism’ but did not demonstrate a trend. In rebuttal, Crowley et al. (2017) argued that, although some people do disbelieve or disregard the evidence presented, “this does not necessarily equate with widespread (or rising) denialism towards invasive species.”

Here, we show that invasive species denialism is indeed rising (Fig. 1). We identified 77 articles published from 1994 to 2016 in scholarly journals and mainstream media (newspapers, online news sites,

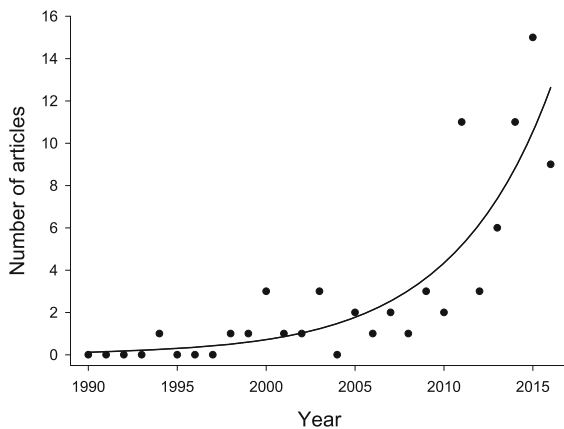


Fig. 1 Annual number of published articles (journal papers, radio and video broadcasts, news and magazine articles, books) that promote invasive species denialism—defined here as ignoring or denying scientific facts and making claims that have already been refuted in the peer-reviewed literature. Articles published between 1990 and 2016, inclusive, were searched through Web of Science, Google Scholar, and Google News archives using *invasive species*, *non-native species*, and *alien species* as search terms. Exponential curve fitted by nonlinear regression: $y = e^{0.18x - 2.10}$, where x is the number of years since 1990 ($R^2 = 0.745$, $P < 0.0001$)

radio, online video, magazines, books) that express denialism in whole or in part, including where it is presented as being equivalent to evidence-based scientific views (see Supplementary Material). We limited our search to these mainstream outlets and omitted articles from internet blogs (apart from those linked to media organizations), even though they are major purveyors of science denialism (Lewandowsky et al. 2013) and there exist various websites devoted to attacking invasion biology (e.g. *milliontrees.me*; *friendsofphragmites.com*; *dtheo.org*). Our search focused primarily on English-language articles and western news media. For these reasons, our quantification certainly underestimates the frequency and extent of the phenomenon. Nevertheless, an exponential trend is evident (Fig. 1).

Characteristics of invasive species denialism

Science denialism has been defined as the use of rhetorical arguments to give the appearance of legitimate debate where there is none, with the ultimate goal of casting doubt on scientific consensus (Diethelm and McKee 2009). Crowley et al. (2017) claimed that Russell and Blackburn (2017) unfairly equate ‘honest disagreement’ with denialism and, moreover, that there is no scientific consensus about biological invasions. On the contrary, as indicated in research literature spanning over three decades, the collective judgement of a vast majority of invasion biologists is that the biogeographic origin and evolutionary relationships of a species are relevant to its invasion success and environmental impact, and that non-native species introductions pose significant risks to biodiversity and ecosystems. This consensus and the evidence on which it is based continue to be denied (see Simberloff 2011; Richardson and Ricciardi 2013; Simberloff 2015a, b).

As did Russell and Blackburn (2017), we distinguish between genuine scientific debate and denialism; the former uses evidence (from experiments, systematic observations, or new analyses of data) to challenge models, whereas denialism rejects scientific evidence. A fundamental characteristic of denialism is repetition of claims that have already been refuted in the scientific arena. People promulgating these claims typically make their assertions in forums where they can avoid expert peer review and impugn the

credibility of the science or even the integrity of its researchers. Exemplifying these tactics are several contrarians who have insinuated that invasion biology is afflicted with a bias arising from xenophobia and latent racism (e.g. Theodoropoulos 2003; Raffles 2011; Winograd 2013; Thompson 2014; but see Simberloff 2003). Furthermore, they accuse researchers of stoking alarmism for financial gain (Pearce 2015a; Thompson 2014) and of working in collusion with major pesticide companies (Theodoropoulos 2003; Cockburn 2015). Misrepresentation of motivations and ethics is a common characteristic of science denialism, as has been witnessed in campaigns against climate change and public health policies. For example, pro-tobacco groups highlight the fact that Hitler supported anti-smoking campaigns (Diethelm and McKee 2009). Allusions to Nazi Germany have likewise been used to attack invasion biology (Theodoropoulos 2003; Thompson 2014). Thompson (2014) compared attempts at distinguishing native and non-native species to separating humans by skin colour in apartheid South Africa or by Jewishness in Nazi Germany; he emphasized that Hitler advocated for gardens to be planted only with native species.

A comprehensive example is an opinion piece printed in *New Scientist* by journalist Fred Pearce in which he attempted to cast doubt on evidence that invasions play a significant role in native biodiversity loss (Pearce 2015b). In this polemic, Pearce attacked a highly-cited 2005 paper by ecologists Miguel Clavero and Emili García-Berthou, who examined the International Union for the Conservation of Nature (IUCN) Red List database and found that invasive species were implicated in over 50% of the animal extinction cases for which a cause was known. After referring disparagingly to their paper's length ("just four paragraphs long"), Pearce insinuated improper professional conduct by claiming that, upon request, the authors could not provide him with details of their analysis or notes on which species they had included in their study—a charge he repeats in a book that was published the same year (Pearce 2015a). In a response letter, Clavero and García-Berthou (2015) countered that in October 2013 (2 years before the publication of Pearce's opinion piece) they had sent him supplementary information that included a complete taxonomic list of extinct species and the recorded causes of extinction from the IUCN database, which is freely available online. Pearce's apparently false charge was

later omitted from an updated online version of his *New Scientist* article. It should also be noted that in their 2005 paper, Clavero and García-Berthou cited several previous statistical studies that indicate that invasive species are important causes of extinction of birds, fishes, and mammals. Such studies continue to be published (e.g. Clavero et al. 2009; Doherty et al. 2016) and include a recent comprehensive analysis of the IUCN database that supports Clavero and García-Berthou's original findings and goes further to conclude that alien species are the most common threat associated with vertebrate extinctions overall (Bellard et al. 2016). These studies have been dismissed or ignored by Pearce and other contrarians, including Thompson (2014), who asserted that "the data can show whatever we want them to show, provided we choose them right"—a common refrain of those who deny climate science.

What is fueling the rise?

Invasive species denialism has grown in spite of burgeoning evidence demonstrating the significant role of invasions in biodiversity loss, food web disruption, altered ecosystem function, and human health risk (e.g. Mazza et al. 2013; Ricciardi et al. 2013; Bradshaw et al. 2016; Paine et al. 2017). This trend may be fueled by a range of motivations, such as those of free-market ideologues opposed to ecologists' calls for increased regulation on transportation and trade in living organisms (e.g. Bailey 2000). Denialism could also stem from distrust of scientific institutions in a post-truth society (Lewandowsky et al. 2013) or from conflicting values and perceptions of nature (Simberloff 2012; Estévez et al. 2013). Another motivation, for some, might be a desire to attain increased visibility; a contrarian message can facilitate exposure in the popular press as well as in some scholarly journals (Duffy 2013). Regardless of the cause, this extreme form of dissent is not evidence-based and therefore does not constitute a scientific controversy. Within academia, it is most often expressed by social scientists and philosophers, and far less by natural scientists; only 6% (5/77) of the articles we identified were published in natural science journals.

Invasive species denialism is lent credence by science reporters who present contrarian assertions

alongside those of mainstream ecologists in a false equivalence (“balanced reporting”), as has been observed for other environmental issues (Boykoff & Boykoff 2004). This “he said/she said framework of modern journalism”, according to Oreskes and Conway (2010), ignores the reality of the scientific process: “We [the media] think that if someone disagrees, we should give that someone due consideration. We think it’s only fair. What we don’t understand is that in many cases, that person has already received due consideration in the halls of science” (Oreskes and Conway 2010, p. 169).

Conclusion

In raising this issue, it is not our intention to stifle scientific dissent. Contrarians are free to offer evidence in the scientific arena. Denialism occupies an extreme end of a continuum of skepticism and should not be confused with vigorous fact-based debates expressed in the invasion biology literature concerning, for example, the extent to which invasions may be ‘passengers’ rather than drivers of environmental change, the risks of assisted colonization and rewilding, and the safety of biological control. By contrast, rejecting decades of research as ‘biased’ science is not honest debate. A credible challenge to a thriving scientific discipline requires more than opinion articles and manufactured controversies in the media.

In an era of rapid global change, invasion biology’s relevance to biosecurity, conservation, and ecosystem management is indisputable and increasing (Meyerson and Reaser 2003; Walther et al. 2009; Paini et al. 2017; Ricciardi et al. 2017), yet we anticipate that invasive species denialism will continue to have a voice in mainstream media outlets that mistakenly treat it as indicating a scientific controversy. The resulting manufactured doubt could have real consequences. A recent expert evaluation of emerging global issues affecting the science and management of invasive species (Ricciardi et al. 2017) concluded that growing denialism in the public sphere could impede development and implementation of policies designed to prevent, control, or mitigate invasive species spread and impact. Effective management of invasive species and other environmental problems requires community consensus—which is dependent on public perceptions, motivations and values, and how scientific

evidence is communicated (Shine and Doody 2011). Therefore, invasion biologists must convey their findings more pervasively and persuasively to the general public, using all media tools available.

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Supplementary Material. Articles identified as containing invasive species denialism. Rebuttals to the most common denialist claims can be found in Richardson and Ricciardi (2013); see references therein for information on invasive species impacts.

Year	Author(s)	Reference	URL
1994	Michael Pollan	Against Nativism. New York Times, May 15, 1994.	http://www.nytimes.com/1994/05/15/magazine/against-nativism.html?pagewanted=all
1998	J.H. Peretti	Nativism and nature: rethinking biological invasion. <i>Environmental Values</i> 7: 183–192.	
1999	Mark Sagoff	What's wrong with invasive species? <i>Philosophy & Public Policy Quarterly</i> 19(4): 17–23.	
2000	Ronald Bailey	Bio-Invaders. Reason.com (digital magazine). Aug/Sept 2000.	http://reason.com/archives/2000/08/01/bio-invaders
2000	Ronald Bailey	Preaching ecological xenophobia. <i>National Post (Canada)</i> , August 3, 2000.	
2000	Mark Sagoff	Why exotic species are not as bad as we fear. <i>Chronicle of Higher Education</i> , June 23, 2000.	http://www.chronicle.com/article/Why-Exotic-Species-Are-Not-as/2045
2001	Banu Subramaniam	The aliens have landed! Reflections on the rhetoric of biological invasions. <i>Meridians</i> 2(1): 26–40.	
2002	Mark A. Davis & Ken Thompson	"Newcomers" invade the field of invasion ecology: question the field's future. <i>Bulletin of the Ecological Society of America</i> 83: 196–197.	
2003	Severin Carrell	Top naturalist accuses "wildlife fascists". <i>Independent (UK)</i> , July 5, 2003.	http://www.independent.co.uk/environment/top-naturalist-accuses-wildlife-fascists-94935.html
2003	David Green	Naturalist in "ecological fascist" claim. <i>East Anglian Daily Times (UK)</i> , February 24, 2010.	http://www.eadt.co.uk/news/naturalist_in_ecological_fascist_claim_1_60610
2003	David Theodoropoulos	<i>Invasion Biology: Critique of a Pseudoscience</i> , Avvar Books, Blythe, California.	
2005	Mark Sagoff	Do non-native species threaten the natural environment? <i>Journal of Agricultural and Environmental Ethics</i> 18(3):215-236	
2005	Alan Burdick	The truth about invasive species: how to stop worrying and learn to love ecological intruders. <i>Discover (magazine)</i> , May 1, 2005.	http://discovermagazine.com/2005/may/cover

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2009	Louise Gray	'Eco-xenophobia' on the rise warns conservationist. The Telegraph (UK), September 19, 2009.	http://www.telegraph.co.uk/news/earth/earthnews/6206139/Eco-xenophobia-on-the-rise-warns-conservationist.html
2009	Mark A. Davis	Immigrant species aren't all bad. New Scientist, 23 Sept 2009.	https://www.newscientist.com/article/mg20327275-900-immigrant-species-arent-all-bad/
2010	Timothy Lee Scott	Invasive Plant Medicine: The Ecological Benefits and Healing Abilities of Invasives. Healing Arts Press, Rochester.	
2010	C. Lévêque, J.-C. Mounolou, A. Pavé, C. Schmidt-Lainé	À propos des introductions d'espèces. Études rurales 2010/1 (185): 219 – 234.	
2011	Davis et al	Don't judge species on their origins. Nature 474: 153–154.	
2011	Mark Davis	Do native birds care whether their berries are native or exotic? BioScience 61: 501–502.	
2011	Emma Marris	The Rambunctious Garden: Saving Nature in a Post-Wild World. Bloomsbury, New York.	
2011	Bryan Walsh	In a globalized world, are invasive species a thing of the past? Time, June 14, 2011.	http://content.time.com/time/health/article/0,8599,2077582,00.html
2011	Brandom Keim	Ecologists: time to end invasive-species persecution. Wired (magazine), June 8, 2011.	https://www.wired.com/2011/06/species-persecution/

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2011	Hugh Raffles	Mother Nature's melting pot. New York Times, April 3, 2011.	http://www.nytimes.com/2011/04/03/opinion/03Raffles.html
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2012	Mark Davis	Harm is in the eye of the beholder. Earth Island Journal, Winter 2012.	www.earthisland.org/journal/index.php/eij/article/davis/
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2013	Carissa Wyant	Biological xenophobia threatens environmental diversity. MintPressNews, June 24, 2013.	http://www.mintpressnews.com/biological-xenophobia-threatens-environmental-diversity/164186/
2013	Sydney R. Singer	Invasive species agenda promotes racism. Hawaii Reporter, March 7, 2014.	http://www.hawaiireporter.com/invasive-species-agenda-promotes-racism/123
2013	Nathan J. Winograd	Biological Xenophobia: The environmental movement's war on Nature. Huffington Post: The Blog, June 6, 2013.	http://www.huffingtonpost.com/nathan-j-winograd/biological-xenophobia-the_b_3385265.html
2013	Bill Chameides	The case for invasive species. Huffington Post: The Blog, October 11, 2013.	http://www.huffingtonpost.com/bill-chameides/the-case-for-invasive-spe_b_4084391.html

2014	Ken Thompson (interviewed by Joy Cardin)	Invasive Species: Do we worry too much? Wisconsin Public Radio: Joy Cardin Show, September 18, 2014.	http://www.wpr.org/listen/647121
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2014	John Briggs	Invasions, adaptive radiations, and the generation of biodiversity. Environmental Skeptics and Critics 3(1): 8–16.	
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2014	Banu Subramaniam	The aliens in our midst: managing our ecosystems. In: Controversies in Science and Technology: From Sustainability to Surveillance. (D.L. Kleinman and J. Handelsman eds.), Oxford Univ. Press.	
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