


RESEARCH ARTICLE

Does origin determine environmental impacts? Not for bamboos

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Societal Impact Statement: Non-native species can cause considerable negative impacts in natural ecosystems. Such impacts often are directly due to the fact that these species occur in habitats where they did not evolve. We explored this for bamboos and found that, contrary to the situation in many other plant groups, biogeographic origin was not a strong predictor of the type and severity of environmental impacts caused. We argue that impacts from bamboos are a response to land transformation and disturbance of forest habitats by humans. Therefore, the threats posed by bamboos to highly disturbed forest systems should be the same wherever bamboos are present or planted, and management should adopt similar approaches.

Summary

- Negative environmental impacts can result from the human-mediated breakdown of biogeographic boundaries that historically shaped species distributions leading to rapid population expansions, that is, from biological invasions. However, the alteration of natural ecosystems by humans has created opportunities for both native and non-native species to become weedy. We assessed whether origin status (native or non-native) matters for the type and magnitude of environmental impacts caused by bamboos (Poaceae: Bambusoideae).
- We used a systematic global literature search and the International Union for Conservation of Nature's (IUCN) Environmental Impact Classification of Alien Taxa (EICAT) scheme as the basis for scoring impacts of bamboo species.
- We found that the type and severity of recorded impacts were similar in the native and non-native ranges of weedy bamboos, and that the habitats in which impacts are most often reported (i.e., temperate and tropical forests) were also the same.
- Origin was not a strong predictor of environmental impacts for bamboos. Rather, impacts are likely to be a response to human-mediated land transformation and disturbance of forests. Further research on the mechanisms whereby bamboos impact other species is needed to guide management strategies in their native ranges and as input to risk assessments for new introductions and plantings.

KEYWORDS

bamboos, biological invasions, forests, global review, impacts, native weeds

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1 | INTRODUCTION

Many non-native species profoundly alter communities they invade through competition, hybridisation, disease transmission and other mechanisms (Kumschick, Alba, Hufbauer, & Nentwig, 2011). Such impacts threaten the presence of native taxa, and have contributed to species extinctions (Bellard, Cassey, & Blackburn, 2016). The extent and magnitude of impacts of invasions are increasing globally, and methods for identifying and quantifying them more efficiently are urgently needed. The link between impact and biogeographical origin is, however, contentious. Non-native species are sometimes the drivers and at other times the result of global change (MacDougall & Turkington, 2005), and many plant species are agricultural and/or environmental weeds, even within their native ranges (Randall, 2017).

Some authors have suggested that further comparisons are needed for species that are weedy both in their native and non-native ranges to make progress in the field of invasion science (Hufbauer & Torchin, 2008). For example, identifying weedy native plants can be useful for management; and species that are prone to becoming weedy (i.e., expanding rapidly, encroaching or having transformative impacts) following disturbance are more likely to become problematic when introduced to similar habitats (Caley & Kuhnert, 2006; Davis et al., 2010). Moreover, controlling weedy natives and non-natives concurrently is often necessary to promote the rehabilitation of ecosystems. When weedy natives become dominant they often reduce populations of other native species (Yelenik, Stock, & Richardson, 2004). And, when management focuses on non-natives only, for example, through clearing, resultant disturbances often cause native communities to become dominated by other weedy or ruderal species.

Though native species can display weedy habits under specific conditions, there is general consensus that invasive non-native species have greater environmental impacts (Hassan & Ricciardi, 2014; Meiners, Steward, & Cadenasso, 2001; Paolucci, Macisaac, & Ricciardi, 2013; Simberloff, Souza, Nuñez, Barrios-Garcia, & Bunn, 2012; Taylor, Maxwell, Pauchard, Nuñez, & Rew, 2016). A 40-year study reviewing abandoned agricultural land found that invasions by non-native species had a stronger effect than native weeds on overall species richness (Meiners et al., 2001). This pattern is generally consistent for plants (Simberloff et al., 2012; Taylor et al., 2016) and animals (Hassan & Ricciardi, 2014; Paolucci et al., 2013). These findings suggest that origin status (i.e., native or non-native) influences the magnitude and type (i.e., mechanism) of environmental impacts that occur when a species becomes weedy and forms a dominant component of communities.

Bamboos (Poaceae: Bambusoideae) are an excellent group for exploring the relevance of biogeographic origin when considering impacts caused by weedy species. A growing number of studies have addressed the impacts of bamboos in both their native and non-native ranges for several reasons: (1) bamboos have an extensive distribution both naturally and because they have been widely redistributed around the world by humans (Canavan et al.,

2017); (2) bamboos are often dominant components of vegetation—a change in abundance can therefore have strong effects on community structure and functioning; (3) species that are known to have impacts are not always the same as those with capacity for rapid dispersal, that is, to become invasive (Canavan et al., 2017; Richardson, Pyšek, & Carlton, 2011); and (4) bamboos are perennial forest grasses and therefore have a unique interaction with trees compared to other grass groups (Soderstrom & Calderon, 1979). Forest systems are generally less studied in invasion science than other major habitat types, such as grasslands (Levine, Adler, & Yelenik, 2004), and they are considered to be generally inherently less susceptible to invasions by non-native species than most other habitats (Crawley, 1987; Von Holle, Delcourt, & Simberloff, 2003). Therefore, studying bamboos might provide insights into a facet of invasion science that has not received much attention (Martin, Canham, & Marks, 2009).

We reviewed the literature on the environmental impacts caused by invasion (i.e., the spread of non-native species) and expansion (i.e., the spread of weedy native species) of bamboos. We then used the International Union for Conservation of Nature's (IUCN) Environmental Impact Classification of Alien Taxa (EICAT) scheme (Blackburn et al., 2014; Hawkins et al., 2015) to score the impact type and magnitude in the native and non-native ranges. We expected to find greater impacts in the non-native range where bamboos might have fewer pressures controlling their populations, and that the types of impacts would be different for native and non-native species. We also tested whether the habitats where impacts are described are similar in native and non-native ranges.

2 | METHODS

2.1 | Species selection

Because bamboos are a large taxonomic group (c. 1600 spp.) we selected a subset of species for our literature search. Taxa were selected based on two criteria: (1) in line with previous impact assessment reviews (Kumschick, et al., 2015) we chose species that have been introduced to multiple regions (≥ 5 countries according to Canavan et al. (2017)); (2) as we were also interested in impacts within the native range, we used the Global Compendium of Weeds (GCW) database to identify all bamboo species for which terms associated with weediness (e.g., garden thug, native weed, etc.) have been applied in the literature (Randall, 2017). An additional general search was carried out using the term “bamboo” and other key terms.

To assess whether our method was suitable for capturing most of the literature on impacts of bamboos, we tested whether our selection criteria for taxa (by number of regions) was related to the amount of literature available (Figure S1). We searched (June 2017) for “Species name” in a general online search platform (Google) and in academic search platforms (Google Scholar + Web of Science), and we recorded the number of search results returned

for all bamboo species. We used a non-parametric (Kendall's τ) correlation to test whether the number of search results returned per species on each online platform (Google, Google Scholar and Web of Science) was related to the number of regions of introduction (country level). All analyses were performed in R v3.2.1 (R Core Team, 2015).

2.2 | Impact framework

The EICAT scheme, which has been adopted by the IUCN, offers a standardised tool for producing impact assessments. To date, studies using EICAT have been published on birds (Evans, Kumschick, & Blackburn, 2016), amphibians (Kumschick, Measey, et al., 2017; Kumschick, Vimercati, et al., 2017), molluscs (Kesner & Kumschick, 2018), and some mammals (Hagen & Kumschick, 2018), but not yet for plants. In assessing the impacts of bamboos, we followed the guidelines of Hawkins et al. (2015) including: (1) intensive literature search of selected taxa of interest; (2) filtering of relevant literature pertaining to impacts; (3) scoring of the type and magnitude of impacts from the literature; and (4) evaluation of the data quality of the literature scored.

We performed a systematic search of the peer-reviewed literature of our selected taxa using binomial species names on Google Scholar. Species were searched independently, and with additional key terms ("impacts" OR "invasive"). Results were filtered by relevant titles and abstracts of papers. For literature on bamboos in their native range, we only included references of impacts when the expansion or presence of the species was due to disturbance caused by human activities which has changed the "natural" and historical abundance and distribution in that region (e.g., logging of forests, agriculture fragmentation of the habitat, changes associated with climate change etc.). For all literature we noted the habitat type where impacts were recorded, where applicable. This was not an exhaustive search, but it is likely to have captured data for the vast majority of bamboo species for which impacts have been recorded.

2.3 | Scoring impacts and analyses

Impacts reported in the literature were evaluated and scored according to Hawkins et al. (2015). For each species, the magnitude of impacts were scored (Minimal Concern, Minor, Moderate, Major, Massive) across 12 categories of impact mechanisms. The literature was also evaluated to determine the quality of evidence (low, medium, and high; e.g., direct observational evidence of a given impact is high quality evidence; see Figure S2). Publications in which the origin status (native or non-native) was unknown were excluded. To test whether the distribution of references across different impact magnitudes was the same between the native and non-native ranges we used a Wilcoxon signed-rank test. To test whether the number of references by origin status was different across mechanism types, and also for habitat types, we used a two-way χ^2 test.

3 | RESULTS

3.1 | Species selection

135 bamboo taxa were systematically searched for impacts (Supplementary Dataset 1). The search represents all taxa that are likely to have recorded impacts in the literature (see Figure S1). The remaining bamboos that were not evaluated in this study are therefore classed as NE—Not Evaluated under the EICAT scheme (although some of these can be considered as NA—No Alien Population according to Canavan et al., 2017). Of the 135 taxa that were included in the study, we found 65 references which contained details on 20 species for which recorded environmental impacts could be scored using the EICAT scheme. The 115 species for which we could not find literature were classified as Data Deficient.

The number of references reporting impacts has increased over time, although this could be related to a general increase in online literature (Figure 1) and/or research interest in the group. Regarding the availability of literature for bamboo species, we find that the number of regions to which a species has been introduced is positively correlated with the number of online search results returned per species on Google ($\tau = 0.405$, $p < 0.001$), Google Scholar ($\tau = 0.384$, $p < 0.001$) and Web of Science ($\tau = 0.385$, $p < 0.001$; see Figure S1). This suggests that we have identified the majority of bamboo species for which impacts have been formally recorded, which is ~1% of all species.

3.2 | Scoring impacts using EICAT

3.2.1 | Species and regions

There was an equal representation of impacts reported in the native and non-native range of bamboos ($n = 31$ references for both groups), and an additional three references where the species origin was unknown (Supplementary Dataset S1). More species ($n = 13$) were associated with impacts in the native range than in the non-native range ($n = 9$). Almost half (32/65) of all impact references were for the species *Phyllostachys edulis*, for which there was near equal representation in native and non-native ranges (Table S1). The only other species that had impacts recorded in both the native and non-native ranges was *Bambusa tulda*.

3.2.2 | Mechanism of impact

Impacts of bamboos were associated with four mechanisms as defined by Hawkins et al (2015): competition, poisoning/toxicity, structural changes to an ecosystem, and chemical changes to an ecosystem (Figure 1a). The number of references for impacts across each mechanism was not significantly different between native and non-native ranges, χ^2 (4, $N = 62$) = 4.450, $p = 0.35$. The mechanism that most frequently led to impacts was competition, followed by

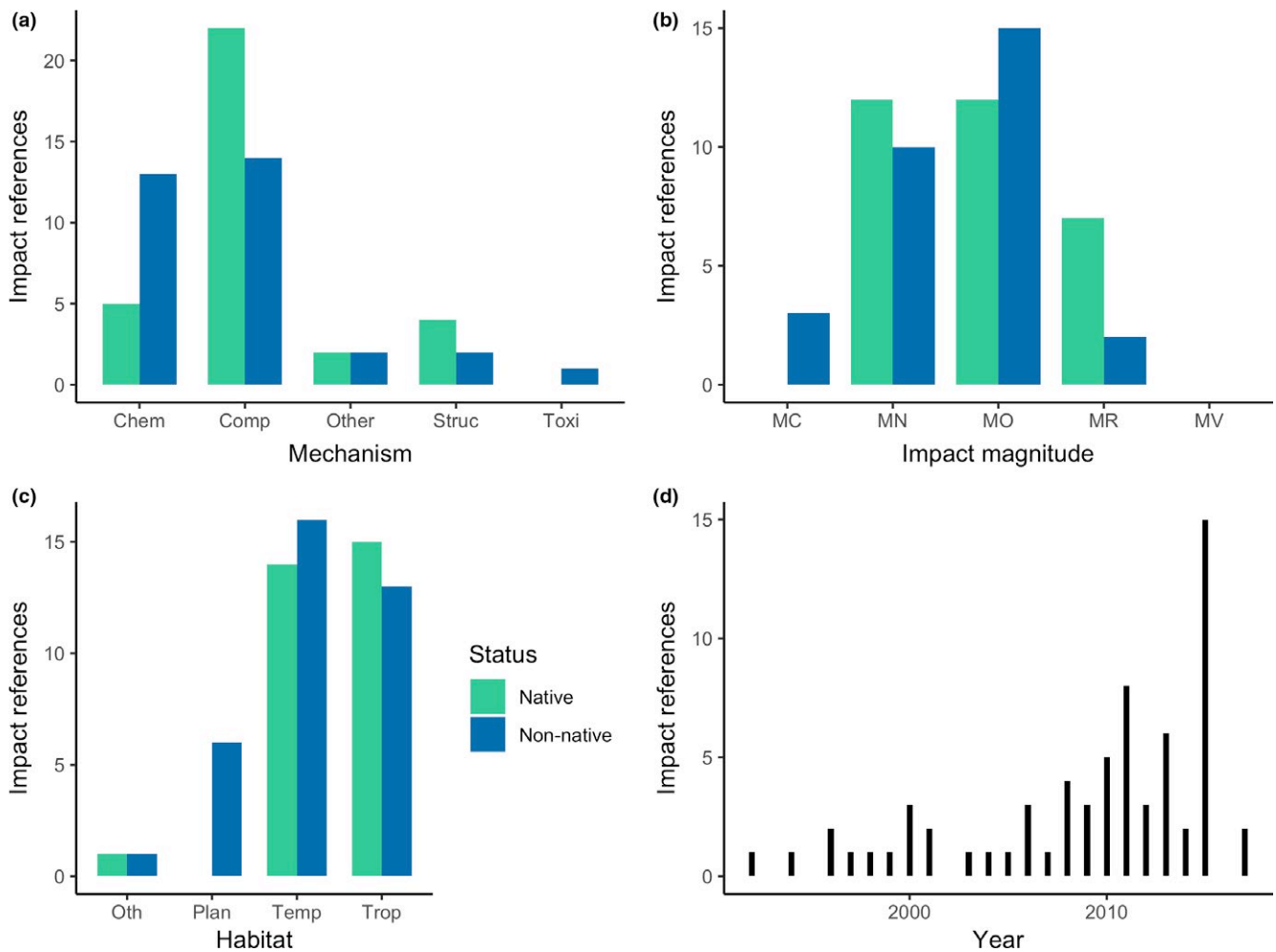


FIGURE 1 A comparison between impacts in the native and non-native ranges of bamboos using a systematic global literature search and a modified version of the International Union for Conservation of Nature's (IUCN's) Environmental Impact Classification of Alien Taxa (EICAT) scheme. Colours indicate the number of impact references reported in the non-native (dark blue) and native (light green) ranges for: (a) type of impact or mechanism (Chem - chemical changes to an ecosystem; Comp - competition; Other; Struc - structural changes to an ecosystem; Toxi - poisoning/toxicity); (b) impact magnitudes (MC - minimal concern; MN - minor; MO - moderate; MR - major; and MV - massive); and (c) habitat where the impact is occurring (Other; Plan - plantation; Temp - temperate forest; Trop - tropical forest) and (d) the number of impact references found online that address environmental impacts of bamboos by year of publication up to the end of 2017

chemical changes to an ecosystem (Figure 1a). We also found no significant difference ($W = 5$, $p = 1$) in the distribution of references across impact magnitudes between native and non-native ranges (Figure 1b).

3.2.3 | Habitat and distribution

Impacts were predominantly reported in tropical and temperate forests in both native and non-native ranges, and also in plantations (Figure 1c). There was no significant difference in the number of references for habitat type by origin status, χ^2 (3, $N = 65$) = 5.778, $p = 0.12$. We also found that impacts in the native range are mostly reported from regions with large native bamboo floras, specifically in Asia and South America (Figure 2). Impacts of non-native bamboos were also recorded in these regions, and in Central America, North America, and Africa.

4 | DISCUSSION

Contrary to our expectation, we found that biogeographic origin was not a clear indicator of the type or magnitude of environmental impacts caused by bamboos (Table 1). The high incidence of reported impacts in the native ranges of bamboos relative to the non-native range is unusual compared to what has been observed for other taxonomic groups (Kumschick et al., 2011). This may be partially explained by the historically high usage of bamboos by humans within their native ranges, which has undoubtedly altered their natural abundance and distribution, especially in Asia. In many cases, the exact native provenance of a species is disputed or unknown (e.g., *B. vulgaris*).

An example of a species with impacts in its native range is *P. edulis* (moso bamboo), a large temperate species that is the most commonly cultivated bamboo for timber in China. Although native,

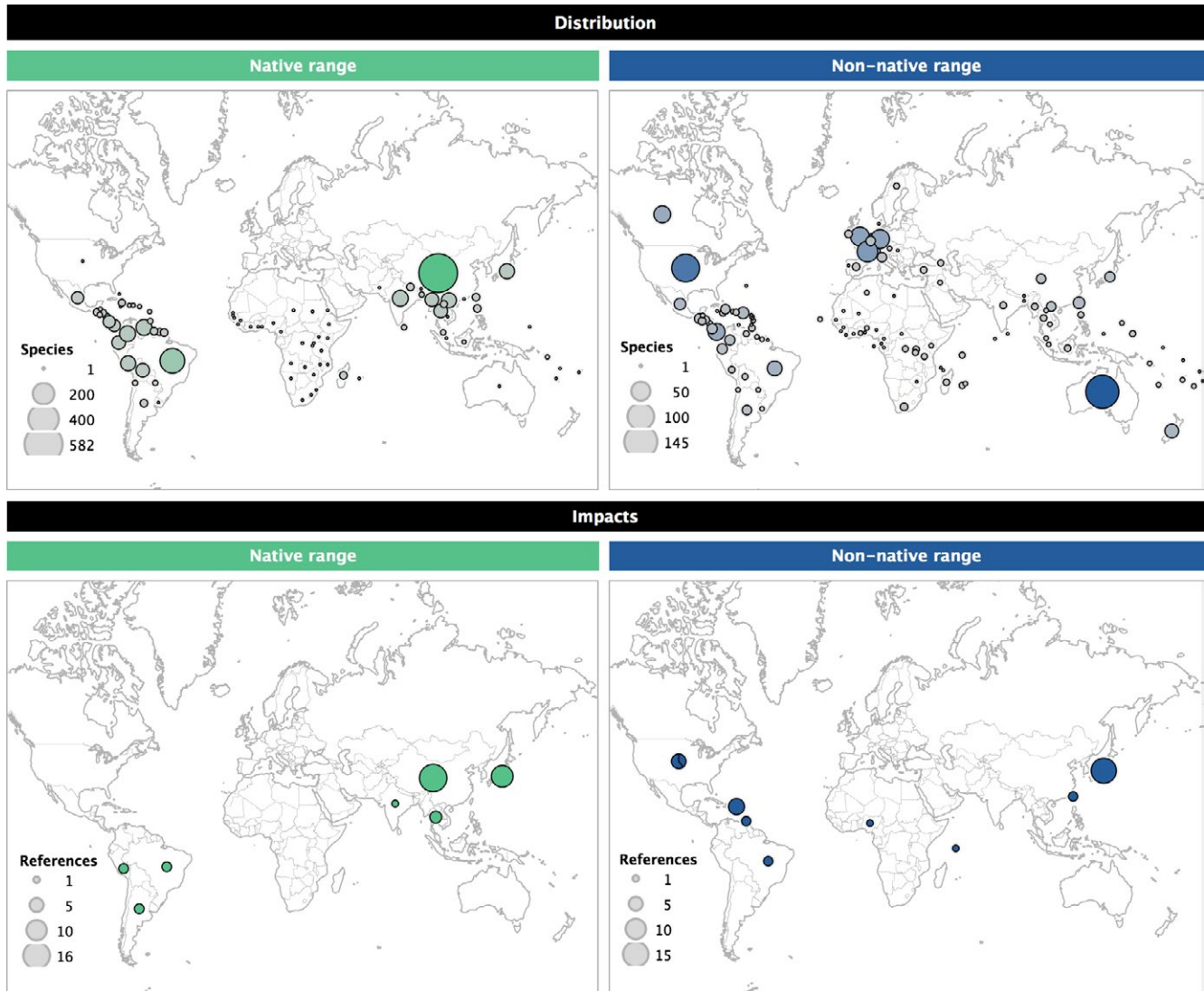


FIGURE 2 The geographic distribution and localities of reported impacts of native and non-native bamboos. Top: the native and non-native distribution of bamboo species (data retrieved from Canavan et al., 2017). Bottom: localities where impacts have been reported in the native and non-native ranges of bamboos based on a systematic global literature search using a modified version of the International Union for Conservation of Nature's (IUCN's) Environmental Impact Classification of Alien Taxa (EICAT) scheme. Circle size is proportional to the diversity of bamboos in a given country/region (top) and to the number of references (bottom). Note that species and references in Hawaii are grouped with the continental United States

this species has become increasingly problematic over the past few decades in China (Wang & Stapleton, 2008). This is in part because of the increased demand for bamboo products which has led to mixed-species forests (bamboos and trees) being converted to bamboo monocultures. Other indirect types of human influence such as climate change have also been reported to cause changes in bamboo abundance, facilitating impacts in their native range, for example, the spread of *P. edulis* forests to higher altitudes in the Tianmu Mountains in China (Song et al., 2013), and the expansion of native dwarf bamboo (*Sasa kurilensis*) into relatively undisturbed alpine snow-meadows in Japan (Kudo, Amagai, Hoshino, & Kaneko, 2011; Kudo, Kawai, Amagai, & Winkler, 2017).

In South America, several reports exist of native bamboos being problematic in Amazonian forests (Table 1). There is evidence that

pre-Columbian civilisations altered these forests to favour species that were of value to humans (Levis et al., 2017). Watling et al. (2017) investigated the impacts of humans over millennia and found that these cultures most likely took advantage of bamboo life cycles (e.g., entire senescence of populations following seeding) to deforest areas for agriculture. This could have had legacy effects on the contemporary distribution patterns of native bamboos in these regions.

Almost all examples of bamboos having impacts are in temperate and tropical forests, which we expected in the native range where bamboos occur naturally. However, this was also true for impacts in non-native ranges, which was unexpected for two reasons: (1) forests are generally considered to be less susceptible to plant invasions (although some authors have attributed this to study biases

TABLE 1 Selected examples of the three most common environmental impacts recorded for bamboos

Impact mechanisms	Region (status)	Examples
Competition	Argentina (native)	<i>Chusquea ramosissima</i> Lindm. quickly fills gaps following timber extraction from forests to dominate understories. Considered to be one of the most aggressive colonisers in the region, it suppresses the growth of emerging trees and saplings by filling available space and shading out light (Montti, Honaine, Osterrieth, & Ribeiro, 2009).
	South America (native)	The expansion of native bamboos (including <i>Guadua tagoara</i> (Nees) Kunth) is considered a major threat to the South American Atlantic Forest (Araujo, 2008; Lima, Rother, Muler, Lepsch, & Rodrigues, 2012). The dieback of trees from competition with bamboo is the most commonly reported impact. This leads to the simplification of plant composition, as the aboveground biomass of bamboo and tree mortality rate increase at the invasion front.
	China (native)	The expansion of <i>Phyllostachys edulis</i> (Carrière) J.Houz. (= <i>Phyllostachys pubescens</i> J.Houz.) in native forests in China is associated with changes to the spatial distribution of plant communities (Huang, Qi, Tao, Jiang, & Hao, 2009), declines in the diversity of birds (YangDu, Chen, & Liu, 2008), declines in forest-floor ants (Touyama et al., 1998), and increased microbial biomass and diversity in areas where <i>P. edulis</i> dominates compared to native broadleaf forests (Xu et al., 2015).
Other: indirect effects	Argentina (native)	Bamboo abundance has indirect effects on animal communities by changing their behaviour: the continued expansion of bamboo is thought to affect the dispersal of big seeds by mammals where big mammals had a preference for areas not dominated by native bamboo (Gallardo, Montti, & Bravo, 2008).
	Japan (native)	The expansion of dwarf bamboo (<i>Sasa</i> spp.) affects acorn seed dispersal by wood mice; fewer acorns are found in areas where <i>Sasa</i> dominated compared to where it had been removed (Iida, 2004).
	Seychelles (non-native)	Naturalised <i>Bambusa vulgaris</i> Schrad. was associated with changes to the density and foraging behaviour of the vulnerable giant millipede; areas not dominated by bamboo were preferred for foraging (Lawrence et al., 2013).
Chemical	China (native)	<i>Phyllostachys edulis</i> expansion is associated with changes to nutrient/pollutant fluxes in forest floors including: changes to C and N properties of the soil, although inconsistent patterns have been found depending on habitat type (Lin et al., 2014); changes to soil community structure (Chang & Chiu, 2015); lower soil nitrogen availability and slower cycling rates of nitrogen compared to secondary evergreen broadleaved forest, which is potentially contributing to soil degradation (Song et al., 2017).
	Japan (non-native)	<i>Phyllostachys edulis</i> invasions into Hinoki forests are associated with increased soil pH (Umemura and Takenaka, 2015). Higher silica content in bamboo litterfall was observed compared to other forest types in Japan, as well as higher silica concentrations in surface soils (Ikegami et al., 2014). This results in the accumulation of huge biogenic pools of silica on forest floors colonised by bamboo (Umemura & Takenaka, 2014). <i>Phyllostachys edulis</i> invasions into Hinoki forests are also associated with increased soil pH.

towards grasslands and scrublands (Martin et al., 2009)); and (2) bamboos have been extensively introduced and cultivated outside of forest systems, including highly transformed ecosystems and disturbed habitats (e.g., urban areas, agricultural land) that tend to be more vulnerable to plant invasions (D'Antonio & Meyerson, 2002). This might indicate that habitats of lesser ecological value (e.g., roadside verges, abandoned agricultural land etc.) have not been studied in as much detail to determine invasion impacts, or that bamboos just have greater potential for impacts in forests.

There are several possible reasons for this pattern. The bamboos found to have impacts have clear physiological adaptations that make them highly competitive in heterogeneous light environments, for example, the understory of forests. Also, bamboos are often dominant components of the vegetation where they occur which means that a change in their abundance can have a big effect on community structure and functioning. The dense underground clonal root

systems can further facilitate competitive expansion by storing and supplying energy for growth when needed, even when little light is available (Wang, Bai, Binkley, Zhou, & Fang, 2016). For example, bamboos overwhelm tree seedlings following canopy disturbances by quickly colonising available space and capturing light (Larpkern, Moe, & Totland, 2011). Bamboos can also produce large amounts of biomass in short periods of time, which can sustain dominance by suppressing the growth of neighbouring vegetation through the build-up of leaf litter. The lack of top-down regulation of bamboos through herbivory may also enhance their competitive ability.

When bamboos replace trees their distinct morphological and physiological traits often lead to changes in biogeochemical processes, that is, chemical changes to ecosystems (Chiwa, Onozawa, & Otsuki, 2010; Song et al., 2016; Wu, Jiang, & Wang, 2008). For example, the build-up of leaf litter leads to the accumulation of silica pools in the soil (Ikegami, Satake, Nagayama, & Inubushi, 2014), slower rates

of decomposition (O'Connor, Covich, Scatena, & Loope, 2000), and altered nutrient cycling (Song et al., 2016, 2015). The high density of roots and rhizomes can also lead to changes in hydrological processes (Shinohara & Otsuki, 2015), for example, increased surface runoff of rainwater (Ide et al., 2010). These impacts can alter biotic communities, changing the abundance and diversity of bacterial (Lin et al., 2013), ant (Touyama, Yamamoto, & Nakagoshi, 1998), and other microbial (Chang & Chiu, 2015) communities in the soil, as well as animal behaviour (Iida, 2004; Lawrence, Samways, Kelly, & Henwood, 2013).

The physical removal of bamboo biomass can reverse some impacts, especially by increasing tree recruitment rates (Larpkern et al., 2011). For example, the removal of dominant *P. edulis* over a seven-year period was associated with the passive restoration of plant species diversity (Bai et al., 2013). Moderate thinning of stands and clearing of dead biomass of native bamboos along riverbanks in Japan have led to increased biodiversity in riparian areas (Suzaki & Nakatsubo, 2001). Similarly, the removal of native dwarf bamboo species has led to the recovery of native species and increased diversity in alpine communities (Kudo et al., 2017). This shows that managing weeds and reducing their dominance can be an effective conservation tool in areas affected by bamboos (regardless of their status as native or non-native species). A better understanding of not just a species' native range but also its natural abundance within its range is needed when managing impacts.

Although this review covered most of the available studies of impacts caused by bamboos (cf. Figure S1), the sample size was small and likely subject to sampling bias (only 20 of the 135 bamboo taxa searched could be evaluated using the EICAT scheme). There was literature that we were unable to access, for example, articles published in local Chinese journals. More impact studies covering a greater diversity of bamboo species are needed to determine whether the findings of this study hold true for bamboos in general. The results nonetheless indicate that bamboos have the potential to cause major impacts in forest systems. We also note that there was a prevalence of impact studies involving *Phyllostachys* species, especially *P. edulis*. Species in this genus are "runners," that is, they send underground rhizomes to produce shoots several meters from parent plants. This growth form enables them to spread more rapidly than other species, such as those with a clumping growth form (Lieurance, Cooper, Young, Gordon, & Flory, 2018). The overrepresentation of this genus in studies reporting impacts in bamboos suggests that impacts are common and dramatic, and that further impacts are very likely in new areas where *Phyllostachys* species are introduced and planted.

Although our assessment was restricted to environmental impacts, weedy bamboos also have diverse socio-economic impacts in both their native and non-native ranges (Smith, Gomulkiewicz, & Mack, 2015). Most notable is the association between mass-seeding events of bamboos and famine (Nag, 1999; Singleton, Belmain, Brown, & Hardy, 2010). Prolific seeding leads to booms in populations of rodents and other small mammals which feed on the bamboo seeds (Numata, 1970). Once the seeds are depleted the rodents move to neighbouring agricultural land where they destroy food

stocks (Nag, 1999; Singleton et al., 2010). While not yet recorded from the introduced range as far as we know, such impacts have been identified as risks associated with widespread cultivation or invasions of bamboos (Smith et al., 2015).

We conclude that certain bamboo species are inherently weedy in that they can exploit human-mediated disturbances (e.g., timber extraction and logging) to increase in abundance and cause impacts, regardless of their biogeographic origin. To manage such impacts, we need to identify these species. The management of weedy native bamboos has been considered necessary to promote the regeneration of other species, particularly trees, and to prevent the formation of bamboo monocultures. If these same species were introduced to areas outside their native ranges, we would expect similar impacts to occur and that similar management would be needed. We predict that the species of bamboo that have impacts in the native range will be a threat if introduced to non-native ranges, especially forests. In addition, we hypothesise that the lack of a biogeographical signal for impact (as is evident for many other taxonomic groups), is due to the inherent competitive ability of bamboos, their response to disturbance, and a possible general lack of top-down regulation through herbivory. Further work to understanding these mechanisms and how they vary across other groups is needed to inform objective strategies to ensure the sustainable utilisation of bamboos. Finally, based on the findings here, we suggest that plant species that respond vigorously to disturbance and that do not have strong top-down population regulation might be expected to show less of a biogeographic signal for impact than other species.

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AUTHOR CONTRIBUTIONS

SC, JR UW, JLR and DMR conceived the idea. SC compiled and scored the data with help and advice from SK. SC led the writing of the manuscript with inputs from all co-authors.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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Article title:

Does origin determine environmental impacts? Not for bamboos

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The following Supporting Information is available for this article:

Fig. S1 The relationship between the number of regions to which a species has been introduced and the number of search results returned on the online platforms of (a) Google (b) Google Scholar and (c) Web of Science.

Fig. S2. Number of references reporting environmental impacts of bamboos in the native and alien range by magnitude or level of impact (Minimal Concern, Minor, Moderate, Major, Massive) grouped by scoring confidence (Hawkins et al., 2015).

Table S1. Number of environmental impact references reported in the native and non-native range per species of bamboo.

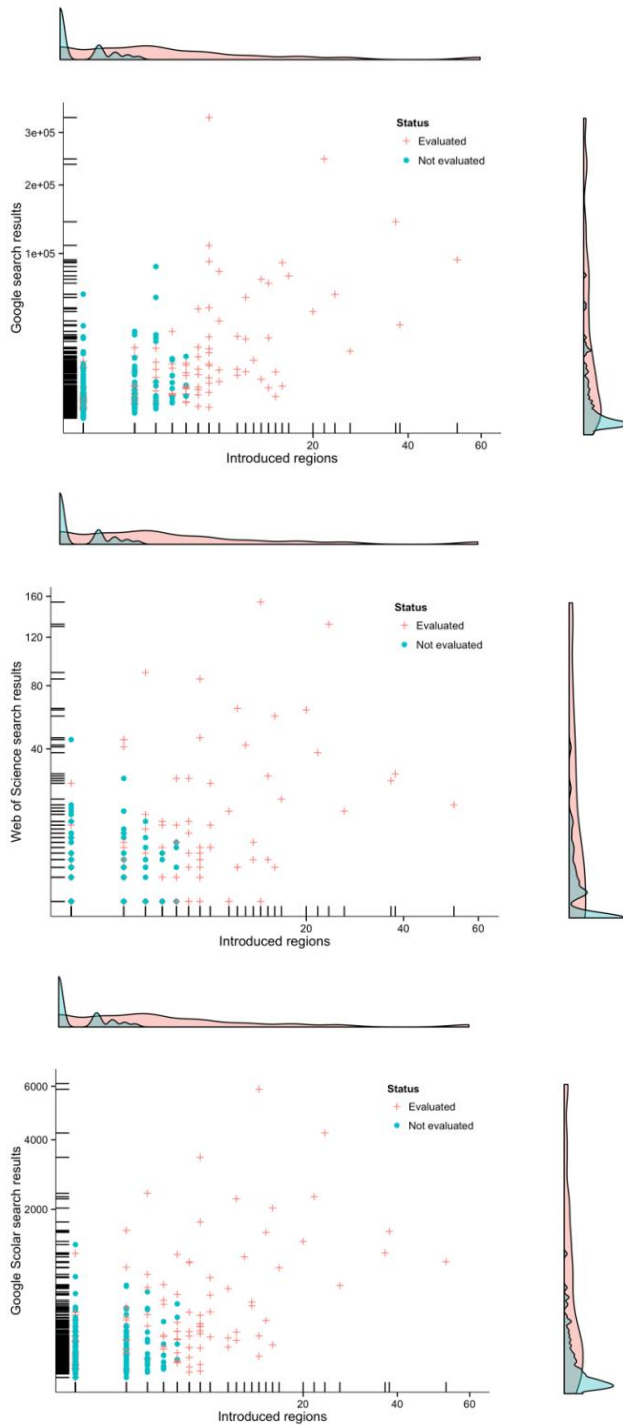


Fig. S1 The relationship between the number of regions to which a species has been introduced and the number of search results returned on the online platforms of (a) Google (b) Google Scholar and (c) Web of Science.

Occurrence points are separated by taxa that were evaluated (red crosses), either actively searched for or were found to have impacts in the general search, and those that were not evaluated (blue circles), they were not individually searched for or found to have impacts. Given the positive correlation between literature availability and introduced regions, it is likely the search found all bamboo species with recorded impacts.

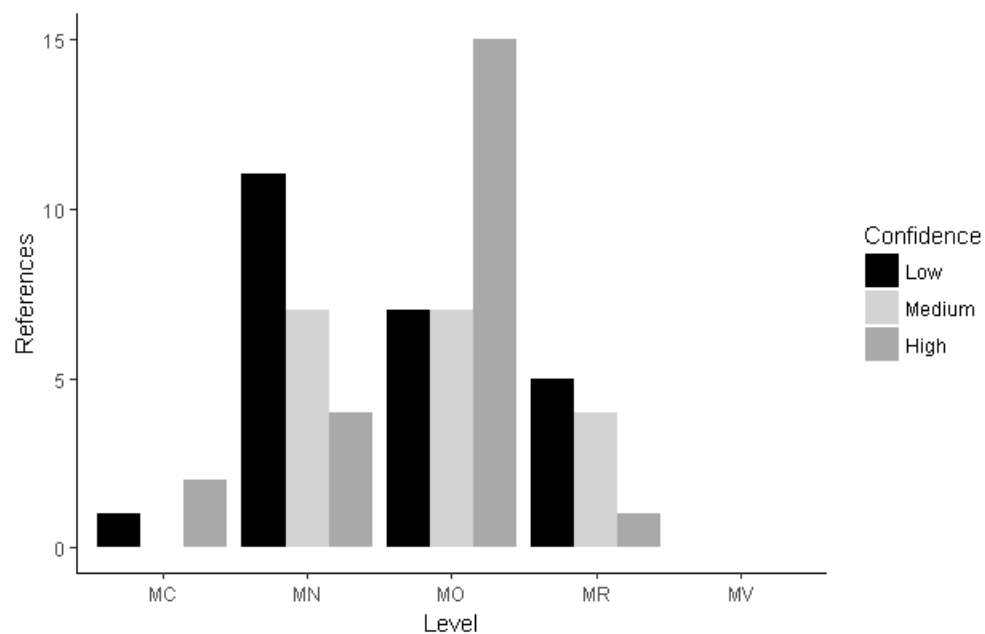


Fig S2. Number of references reporting environmental impacts of bamboos in the native and non-native range by magnitude or level of impact (Minimal Concern, Minor, Moderate, Major, Massive) grouped by scoring confidence (Hawkins et al., 2015).

Table S1. Number of environmental impact references reported in the native and alien range per species of bamboo.

Species	References	
	Non-native	Native
<i>Bambusa longispiculata</i>	1	
<i>Bambusa tulda</i>	1	1
<i>Bambusa tuldooides</i>	2	
<i>Bambusa vulgaris</i>	7	
<i>Cephalostachyum pergracile</i>		1
<i>Chusquea ramosissima</i>		2
<i>Dendrocalmus strictus</i>	1	
<i>Gigantochloa albociliata</i>		1
<i>Guadua sarcocarpa</i>		1
<i>Guadua tagoara</i>		2
<i>Guadua weberbaueri</i>		1
<i>Melocanna baccifera</i>		1
<i>Phyllostachys aurea</i>	1	
<i>Phyllostachys bambusoides</i>	3	
<i>Phyllostachys edulis</i>	16	16
<i>Phyllostachys nigra</i>	3	
<i>Phyllostachys sp.</i>	2	1
<i>Pleioblastus chino</i>		2
<i>Sasa chartacea</i>		1
<i>Sasa kurilensis</i>		1
<i>Sasa palmata</i>		1
<i>Sasa sp.</i>		1

Reference

HAWKINS, C. L., BACHER, S., ESSL, F., HULME, P. E., JESCHKE, J. M., KÜHN, I., KUMSCHICK, S., NENTWIG, W., PERGL, J., PYŠEK, P., RABITSCH, W., RICHARDSON, D. M., VILÀ, M., WILSON, J. R. U., GENOVESI, P. & BLACKBURN, T. M. 2015. Framework and guidelines for implementing the proposed IUCN Environmental Impact Classification for Alien Taxa (EICAT). *Diversity and Distributions*, 21, 1360-1363.