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REVIEW

Tall-statured grasses: a useful functional group for invasion science

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Abstract Species in the grass family (Poaceae) have caused some of the most damaging invasions in natural ecosystems, but plants in this family are also among the most widely used by humans. Therefore, it is important to be able to predict their likelihood of naturalisation and impact. We explore whether plant height is of particular importance in determining naturalisation success and impact in Poaceae by comparing naturalisation of tall-statured grasses (TSGs; defined as grass species that maintain a self-supporting height of 2 m or greater) to non-TSGs using the Global Naturalised Alien Flora database. We review the competitive traits of TSGs and collate risk assessments conducted on TSGs. Of the c. 11,000 grass species globally, 929 qualify (c. 8.6%) as TSGs. 80.6% of TSGs are woody bamboos, with the remaining species scattered among 21 tribes in seven subfamilies. When all grass species were analysed, TSGs and non-TSGs did not differ significantly in the probability of naturalisation. However, when we analysed woody bamboos separately from the other grasses,

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the percentage of TSGs that have naturalised was 2–4 times greater than that of non-TSGs for both bamboos and non-bamboo groups. Our analyses suggest that woody bamboos should be analysed separately from other TSGs when considering naturalisation; within the $\geq$ 2 m height class they do not naturalise at the same rate as other TSGs. Rapid growth rate and the capacity to accumulate biomass (a function of height) give many TSGs a competitive advantage and allow them to form monospecific stands, accumulate dense and deep litter mats, reduce light availability at ground level, and alter fire and nutrient-cycling regimes, thereby driving rapid ecosystem transformation. While the height distribution in grasses is continuous (i.e. no obvious break is evident in heights), the 2 m designation for TSGs defines an important functional group in grasses that can improve predictive modelling for management and biosecurity.

Keywords *Arundo* · Bamboos · Biological invasions · Height · Invasive species · *Miscanthus* · *Phragmites* · Plant functional groups · Poaceae · Risk assessment

Introduction

A useful approach in studying alien plant invasions has been to identify broad patterns and correlates of invasiveness and impacts, such as functional groups, and to use these to provide generalisations for management (Vilà and Pujadas 2001; Colautti et al. 2006; Pyšek and Richardson 2008; Novoa et al. 2015). Functional groups are sets of organisms that share attributes that confer similar morphological, physical, behavioural, biochemical or environmental responses to ecosystem processes (Lavorel et al. 1997; Pérez-Harguindeguy et al. 2016; Garnier et al. 2017). Functional groups can be used to identify species that respond similarly to environmental pressures and are therefore useful for predicting and managing impacts of alien species (Lavorel et al. 1997; Díaz and Cabido 1997).

Plant height is considered a key trait for ecological strategies (Grime et al. 1988; Westoby et al. 2002; Garnier and Navas 2012), and according to Tilman's (1982) resource competition theory, resource exploitation is proportional to individual biomass, with larger individuals exploiting a disproportionate amount of resources (DeMalach et al. 2016). Many studies have recognised the benefits of increased height for initial colonisation by alien plants, as it is associated with better light capture and competitive ability (Pyšek et al. 2012; Moodley et al. 2013; Gallagher et al. 2015). Among plants, invasions by tall-statured grasses (hereafter TSGs; Fig. 1) are particularly noted for their ability to dominate plant communities and alter ecosystem

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functioning (Meyerson et al. 1999; Lambert et al. 2010; Saltonstall et al. 2010). Recent studies have reviewed sub-groups of tall grasses such as invasive grasses that dominate aquatic ecosystems, and have argued that they are functionally similar and have generalizable impacts related to their competitive nature [e.g. Lambert et al. (2010) refer to "large-statured invasive grasses"].

More broadly, tall-statured grasses are potentially an important functional group in invasion science because (1) established populations of TSGs can cause significant negative ecological impacts (Pagad 2016; Canavan et al. 2017b); (2) large height and biomass contribute to specific environmental impacts, e.g. reduction in light availability, changes to fire regimes, and alteration of nutrient cycles (D'Antonio and Vitousek 1992; Meyerson et al. 1999; Brooks et al. 2004; Smith et al. 2013; Gaertner et al. 2014; Visser et al. 2016); (3) TSGs occur in grasslands, riparian areas and estuaries, as well as tropical and temperate forests, yet the abiotic and biotic impacts are often similar across ecosystems; (4) TSGs are increasingly cultivated for commercial purposes such as bioenergy production and phytoremediation and therefore present new risks (Mislevy and Fluck 1992; Czakó et al. 2005; Heaton et al. 2008; Jakob and Zhou 2009; Mirza et al. 2010; Chen et al. 2015); and (5) TSGs are often dominant components of the vegetation in their native ranges, providing biotic resistance to invasion (including against alien TSGs) (Sheley and James 2010). However, TSGs have not been fully explored as a distinct functional group until now.

Here, we review the usefulness of the TSG functional group for invasion science. We produce a preliminary list of TSGs, and test whether there is a quantitative pattern in the naturalisation of grasses comparing TSGs with non-TSG grasses, for all grasses, only woody bamboo grasses, and all grasses other than woody bamboos. We identify which TSGs have been subject to risk assessments. We also discuss the invasion-science literature associated with TSGs, focussing on how competitive traits associated with increased height can affect the colonisation, invasion, and environmental impacts of alien grasses.

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Methods

Defining and creating a list of tall-statured grasses

Height in grasses (defined here as average inflorescence height, as per Kew's GrassBase; http://www.kew.org/data/grasses-db.html) varies across three orders of magnitude (2 cm–20 m; see Fig. 2). Efforts to classify vegetation into different height categories include Küchler (1949) and Dansereau (1951) who proposed that "tall herbaceous plants", including grasses, should have an average minimum height of 2 m; Edwards (1983) proposed four height categories for grasses, with tall grasses being 1 m and greater than 2 m to be the largest height category; Lambert et al. (2010) considered "large-statured invasive grasses" to be greater than 1.5 m in height. There are clearly important correlates between height and ecological processes, such as competition for light, e.g. light reduction to the soil surface decreases dramatically from 2 m down (Meyerson et al. 1999). However, previously proposed height classifications lack a clear ecological justification for their categories, and instead have been developed for practical purposes such as for vegetation inventories, descriptions and surveys (Edwards 1983). We propose 2 m as an ecologically relevant height threshold amongst grasses, and define TSGs as species that are $\geq$ 2 m. Grasses that maintain a height of $\geq$ 2 m experience a trade-off between other functional traits. Typical features associated with taller grasses include lignified culms, high growth rates, and abundant biomass (Table 1). For these reasons, and the common prior use of 2 m as the cut-off, we generated a preliminary list of "tall-statured grasses".

We extracted data on inflorescence height for all grass species from Kew's GrassBase. Our list of species was cleaned, updated and corrected; non-bamboo grasses were checked for synonyms using

Kew's World Checklist of Selected Plant Families (http://apps.kew.org/wcsp/qsearch.do) and bamboo species were checked using the International Network for Bamboo and Rattan's (INBAR) global checklist (Vorontsova et al. 2016). Species that do not maintain their height independently (i.e. those listed as 'climbing', 'scandent-', 'rambling', 'prostrate', 'liana' and or 'leaning' [on other vegetation]) were removed from the list of TSGs, and were considered non-TSGs along with shorter species.

Incidence and extent of naturalisation

If increased height is advantageous for colonisation, we expected that TSGs would have higher rates of naturalisation compared to shorter grasses (i.e. non-TSGs). To test for this, we calculated whether: (1) TSGs are more likely to be naturalised in at least one region of the world (what we refer to as 'incidence of naturalisation'); and (2) for naturalised species, TSGs are more globally widespread outside their native range (which we refer to as 'extent of naturalization'; see e.g. Razanajatovo et al. (2016)). Data from the Global Naturalised Alien Flora (GloNAF) database were used for both analyses. The database covers 843 non-overlapping regions (countries, federal states, islands) covering around 83% of the Earth's land surface.

The effect of stature on the probability of a grass species becoming naturalised could simply mean that

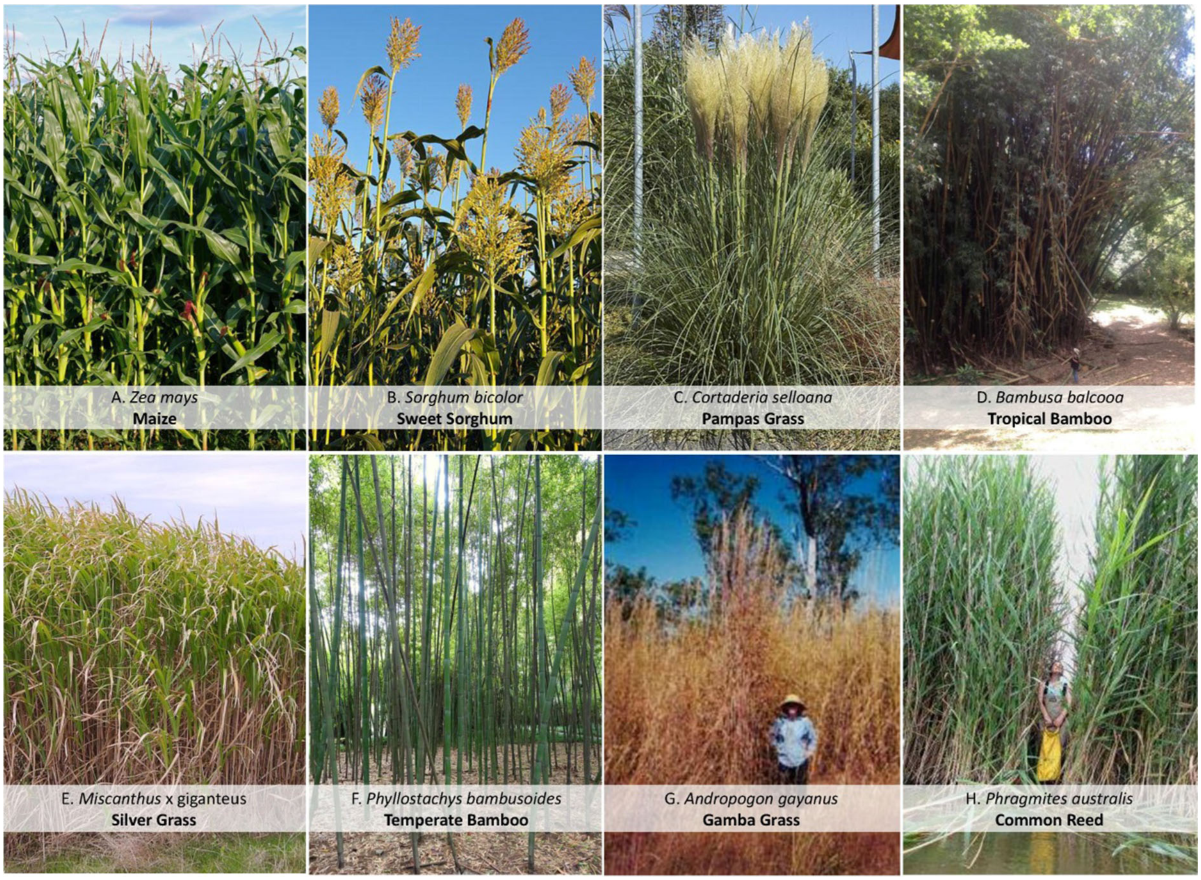

Fig. 1 Tall-statured grasses (TSGs) come in a variety of forms and occur in a range of different ecosystems (e.g. temperate forests, dry grasslands to tropical wetlands). They are useful to humans for food (**a** and **b**), ornamental horticulture (**c** and **d**), for biofuels (**e** and **f**) and other uses (**g** and **h**). Several TSGs are associated with environmental impacts in invaded ranges due to their ability to form monospecific communities that exclude other vegetation types (**d**, **f**, **g** and **h**). Photographs: Wikimedia Commons (A: Christian Fischer (CC BY-SA 3.0 & CC0); B: Wouter Hagens (CC BY-SA 3.0); E: Bgabrielle (CC-BY-SA-3.0); F: Daderot (CC0)) and other sources (C: Kijktuinen Nunspeet -http://www.kijktuinen.nl); D: Susan Canavan; G: retrieved from Rossiter-Rachor et al. 2009; H: Michigan Technological University)

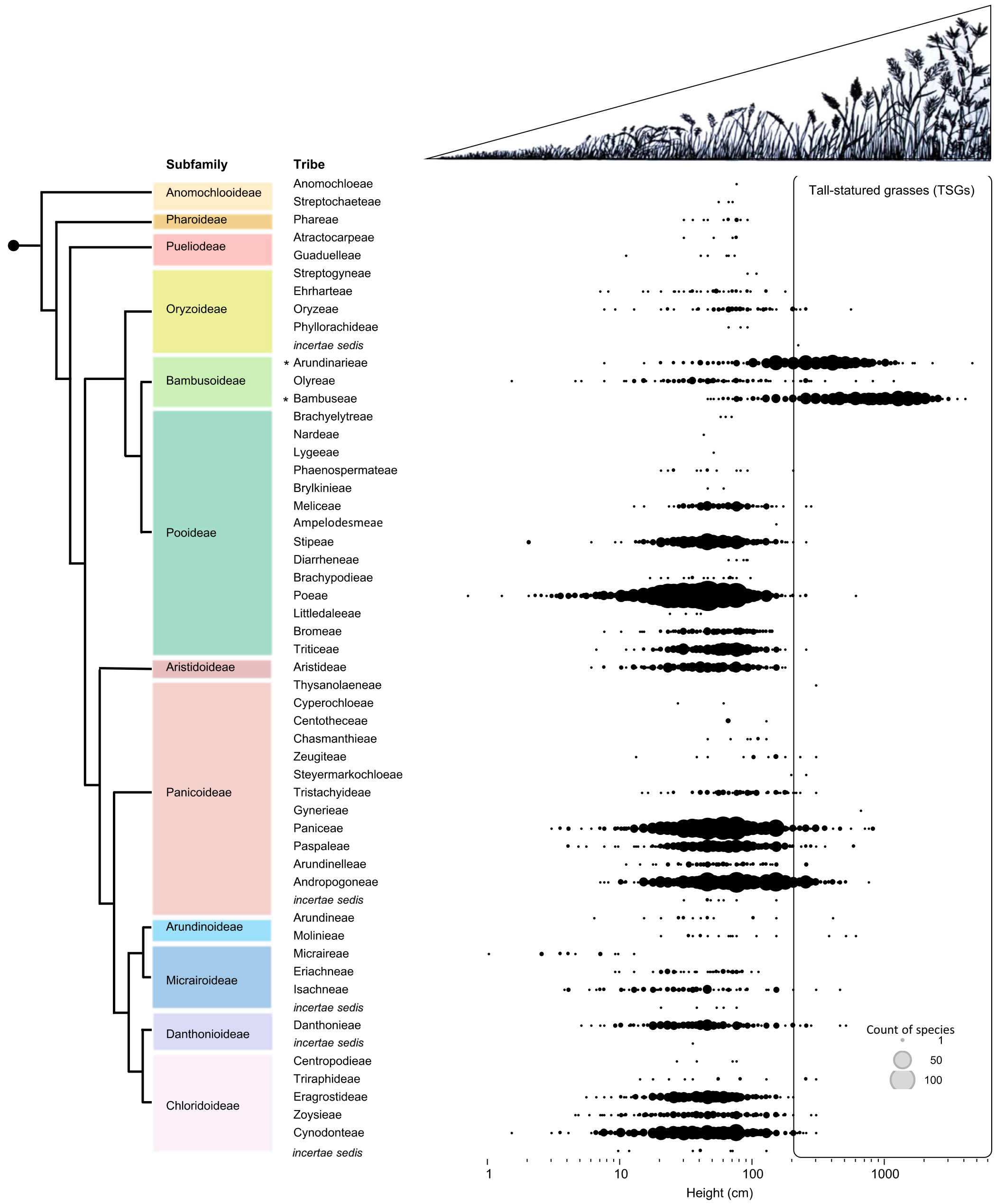

Fig. 2 Height distribution of grass species in subfamilies and tribes as per Soreng (2015)'s classification of Poaceae. Species within the black-outlined box have average bloom (inflorescence) heights of ≥ 2 m. Note that not all of these taxa are defined in this paper as tall-statured grasses (TSGs) as some taxa do not maintain their height independently (e.g. climbing species). The area of the black circles is proportional to the number of species. Data were retrieved from Kew's GrassBase (http://www.kew.org/data/grasses-db.html) for 10,818 species. Species that are unplaced in a tribe are shown as *incertae sedis* for that subfamily. Woody bamboos (tribes Arundinarieae and Bambuseae) are marked with an asterisk. Figure generated using Tableau V 10.0

TSGs are more likely to be traded because of their ornamental value. To test for this, we used data on the plant trade sourced from Dave's Garden Plant Files (http://davesgarden.com/guides/pf), arguably the most comprehensive global database of garden plants. While it would have been ideal to use quantitative sale

Table 1 Typical features of tall-statured grasses (TSGs) that confer a high likelihood of causing widespread invasions and severe environmental impact

	Features typical of TSGs	Implications for invasiveness/ impact	Examples
1. Biomass production	Statured architecture	High light capture, so likely to outcompete shorter vegetation	*Miscanthus sinensis* (Tang et al. 1990); *Phragmites australis* (Meyerson et al. 2000)
	Fast growth rates	Can outcompete neighbouring species	Bamboos (Montti et al. 2014)
2. Biomass accumulation	Leaf litter build-up	Suppress growth of neighbouring plants	*Cortaderia jubata* (Lambrinos 2000); *Cortaderia selloana* (Domènech et al. 2006); *Miscanthus* × *giganteus* (Amougou et al. 2012); *Phragmites australis* (Haslam 2010; Holdredge and Bertness 2011)
	Chemically distinct leaf litter	Reduced decomposition	*Bambusa* spp. (O'Connor et al. 2000); *Phragmites australis* (Meyerson et al. 2000)
		Alter nutrient cycling	*Cortaderia selloana* (Domènech et al. 2006); *Phragmites australis* (Meyerson et al. 2000); *Phyllostachys edulis* (Song et al. 2017)
	Production of large quantities of highly flammable aboveground biomass	Alter the frequency and intensity of fires	*Arundo donax* (Herrera and Dudley 2003; McWilliams 2004; Lambert et al. 2010; Coffman et al. 2010); *Andropogon gayanus* (Rossiter et al. 2003); *Andropogon virginicus*, *Hyparrhenia rufa*, *Melinis minutiflora*, *Schizachyrium condensatum* (Brooks et al. 2004); bamboo (Jaiswal et al. 2002); *Cortaderia selloana* (Bossard et al. 2000)
3. Dual reproductive modes	Tall plants with seeds held high up	Long range dispersal of seeds	*Cortaderia selloana* (Drewitz and DiTomaso 2004); Generally in plants (Thompson et al. 1995); specifically for grasses (Linder et al. 2018)
	Dense root systems	Crowd out other vegetation	*Phragmites australis* (Meyerson 2000)
	Clonal networks leading to greater resource acquisition	Ability to survive high stress environments	*Gynerium sagittatum* (de Kroon and Kalliola 1995); clonal plants in general (Stueffer et al. 1996; van Kleunen and Stuefer 1999)
	Clonal networks leading to colonisation by juvenile ramets into low resource patches are supported by older ones	Ability to colonise stressful environments	*Phyllostachys edulis* (Wang et al. 2016)
	High belowground allocation/storage of resources	Ability to survive disturbance and regenerate quickly, out-competing neighbouring vegetation	*Dendrocalamus strictus* (Singh and Singh 1999); *Miscanthus* spp. (Amougou et al. 2011)
4. Anthropogenic interest	Use as biofuel	Increased dissemination, propagule pressure, often in large stands in climatically suitable areas close to the natural environment	*Arundo donax* (Cosentino et al. 2006); *Miscanthus* × *giganteus* (Schnitzler and Essl 2015); *Miscanthus sinensis* (Flory et al. 2012)
	Use in ornamental horticulture (particularly landscaping)	Increased dissemination, propagule pressure, and multiple foci for potential invasions	*Arundo donax*, *Cortaderia selloana*, *Cenchrus purpureus* (Foxcroft et al. 2008); *Cortaderia selloana* (Okada et al. 2007); bamboo (Canavan et al. 2017b); *Miscanthus sinensis* (Dougherty 2013)

and trade data from Dave's Garden as a proxy of propagule pressure, such data were only available for a small subset of species. We therefore confined the analyses to whether or not a species was present in Dave's Garden Plant Files.

When exploring the raw data, it was clear that the vast majority of TSGs were woody bamboos (tribes: Bambuseae and Arundinarieae; Fig. 2). Also, the percentage of TSGs that naturalised was greater than that of non-TSGs for woody bamboos and other grasses (i.e. non-bamboos and non-woody bamboos), although this pattern was not found when pooling all grasses together (a result of inequities in the proportions of the taxa which were TSGs; see Online Resource 4). For this reason, we conducted the remaining analyses on naturalisation incidence and extent (described below) separately for the set of woody bamboos and for the set of other grasses.

To assess whether naturalisation incidence was higher in TSGs than non-TSGs, we ran generalised linear mixed-effects models with a binomial error distribution (logistic regression), separately for woody bamboos and for other grasses, using the 'lme4' R package (Bates et al. 2015). The response variable was status (presence or absence) in the GloNAF database and the predictor variables were whether a species is a TSG or non-TSG, and whether a species was traded or not (as inferred from presence or absence in Dave's Garden Plant Files). To account for phylogenetic non-independence of the species, we included genus (in the case of woody bamboos) and genus nested within tribe (in the case of other grasses) as random factor(s). This also provided an opportunity to test whether the 2 m cut-off was appropriate. We ran similar models with height (standardised to a mean of 0 and standard deviation of 1) as a continuous explanatory variable instead of stature as a binary variable (TSG or non-TSG).

To analyse extent of naturalisation (i.e. number of regions in the GloNAF database) we ran generalised linear mixed-effects models with a negative binomial error distribution, due to high incidence of zeros, separately for woody bamboos and for other grasses, using the 'glmmADMB' R package (Fournier et al. 2012). We used the same predictor variables and random factors as in the analysis of naturalisation incidence. Finally, we looked at the global geographic pattern of numbers of naturalised TSGs and of the proportion of TSGs among all naturalised grass species.

Reviewing future risks

To explore the threats of TSGs introduced to new regions, we reviewed risk assessments that have been completed in different parts of the world for our list of TSGs (See Online Resource 2 for details). We did this by searching (from May to July 2016) for primary literature and fact sheets on Scopus, ISI Web of Science and Google Scholar using the specific names of the TSG species/"tall grass" AND "risk assessment"/"risk analysis" as keywords. We collated all the risks assessments and then summarised the species for which assessments have been reported.

Results

TSG species

From the lists extracted from Kew's GrassBase, we removed 18 species that did not have names matching the World Checklist of Selected Plant Families or INBAR's global 2016 checklist, four unplaced species were kept in the list, and synonyms (n = 79) were updated accordingly to reflect current nomenclature. Of the remaining 10,818 grass species for which height data were available, 1136 species reach heights of 2 m or more, although 207 of these do not maintain their height independently and were classified as non-TSGs. This left 929 species (8.6% of grass species) as TSGs for subsequent analysis (See Online Resource 1 for a complete list of species).

Among TSGs, the vast majority (80.6%) are woody bamboos (tribes Arundinarieae and Bambuseae). The remaining 180 species of TSGs come from 21 tribes in 7 subfamilies (Fig. 2), many of which are important reed species, such as Burma reed (*Neyraudia reynaudiana*; Triraphideae), common reed (*Phragmites australis*; Molinieae), and giant reed (*Arundo donax*; Arundineae). Other TSGs include popular horticultural and biofuel species such as pampas grass (*Cortaderia* spp.; Danthonieae) and silver grass (*Miscanthus sinensis*; Andropogoneae). The TSG group also contains important food crops, in particular maize (*Zea mays*; Andropogoneae), pearl millet (*Cenchrus americanus* = *Pennisetum glaucum*; Paniceae), sorghum (*Sorghum bicolor*; Andropogoneae), and sugarcane (*Saccharum* spp.; Andropogoneae) (Fischer et al. 2014). With the exception of woody bamboos, TSGs are outliers in their respective tribes in terms of height, although the height distribution of all tribes appears to be roughly unimodal (Fig. 2).

Incidence and extent of naturalisation

The GloNAF database lists 1226 species in the grass family. We found overall a similar percentage of naturalised species among TSGs and among non-TSGs using the 2 m threshold, with 11.4 and 11.3% of species naturalised, respectively (Fig. 3). However, when considering woody bamboos alone, the percentage of naturalised TSGs is more than three times that of non-TSG bamboos, with 7.6 and 2.0% of species, respectively (Fisher's exact test: odds ratio = 4.1, 95% confidence interval of 1.9–9.9, $p < 0.001$). This is also the case among all other grasses (i.e. excluding woody bamboos), with 27.2 and 11.7%, respectively (Fisher's exact test: odds ratio = 2.8, 95% confidence interval of 2.0–4.0, $p < 0.001$). The lack of contrast overall between TSGs and non-TSGs is because most TSGs are woody bamboos but fewer woody bamboos than other grasses have naturalised (Online Resource 4).

Among both woody bamboos and other grasses, species that are traded for ornamental horticulture have naturalised more often than non-horticultural species. Of the 1233 grass species listed in Dave's Garden Plant Files, 53.4% are naturalised, while only 5.9% of the other 9585 grass species have naturalised. When the presence of a species in Dave's Garden Plant Files was accounted for in the analysis, tall stature had a significant, positive effect on naturalisation incidence of other grasses (Table 2a). This was not the case for woody bamboos. However, when a similar model was run with height as a continuous variable height had a significant, positive effect on naturalisation incidence for both woody bamboos and other tall grasses (Table 2a).

Of the subset of 1226 grass species (of all tribes) that have naturalised somewhere, 384 species have naturalised in only one region, whereas some species (e.g. *Eleusine indica,* a non-TSG) have naturalised in 309 regions according to the GloNAF database. On average, when considering grasses together, TSGs and non-TSGs have naturalised in similar numbers of regions (Online Resource 4; Wilcoxon test: W = 56,274, $p = 0.368$). When considering woody bamboos alone, and accounting for the strong positive effect of presence in the horticultural trade, the extent of naturalisation was still significantly positively associated with tall stature (Table 2b). Indeed, woody bamboo TSGs have naturalised in up to 101 regions (e.g. *Bambusa vulgaris* being the most widespread species) whereas the 8 non-TSG woody bamboos have naturalised in at most five regions (Online Resource 1). However, this effect of stature on naturalisation extent was not found for other grasses.

The regions with the highest number of recorded naturalised alien grasses (irrespective of whether they are a TSG or not) are the southern United States, tropical South America, Hawaii, parts of tropical Africa, Madagascar, Indonesia and New Zealand (Fig. 4a, Table 3). However, the pattern is strikingly different when using the proportion of TSGs among all naturalised grasses (in part because species richness is affected by differences in sizes of the regions). This relative measure identifies a marked hot spot of TSGs in tropical Africa (especially islands in the Western Indian Ocean), where the proportions in most countries range between 30–70% and even more (Fig. 4b). The Caribbean is a second hotspot (Fig. 4b).

Reviewing risks

We found 127 risk assessments that have been completed for 64 TSG species. Of these, 55 assessments (43%) on 23 species had an outcome indicating a high risk of invasion or recommended that further introductions should be rejected in the region evaluated (Table 4; See Online Resource 3 for full list). More than a third (38%) of the risk assessments were conducted on 32 woody bamboo species (all of which are TSGs). However, woody bamboos generally received lower risk scores than other TSGs, with only three risk assessments scoring high risk for two species, and five assessments called for an introduction to be rejected on five species.

The most widely used risk assessment scheme was the Hawaiian Weed Risk Assessment (H-WRA), which has been applied in 60 assessments, followed by the Australian Weed Risk Assessment (A-WRA) with nine assessments. Another 16 variant risk assessment frameworks were used. The following species had the greatest number of completed risk assessments: *Arundo donax* (12), *Miscanthus sinensis* (8), *Cortaderia jubata* (7), *Sorghum bicolor* (7) and *Cortaderia selloana* (7). Based on the results of the risk assessments, the species with a high potential to

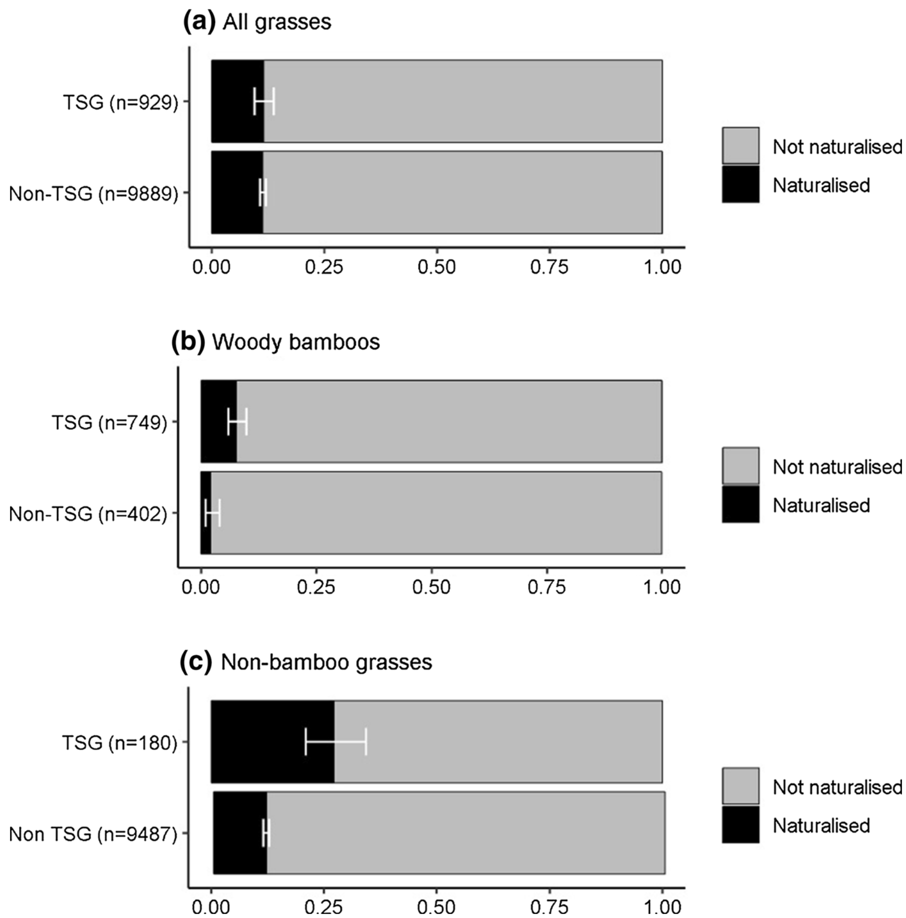

Fig. 3 The proportion of grass species that have naturalised globally, by height group, for **a** all grasses, **b** woody bamboos only and **c** all grasses excluding woody bamboos. Data were retrieved from the GloNAF database [see van Kleunen et al. (2015)]. The proportion of tall-statured grasses (TSGs; those that are 2 m in height or greater) and non-TSGs (less than 2 m in height) that have naturalised vary between woody bamboos and other grasses. The white bars indicate 95% confidence intervals. There is a very large number of tall-statured non-naturalised bamboos. See Online Resource 4 for the raw data

cause negative impacts were *Arundo donax*, *Cortaderia jubata*, *Echinochloa pyramidalis* and *Phragmites australis* (Table 4).

Several intended uses for TSGs were identified as generating heightened risk due to the massive propagule pressure associated with such usage: of the risk assessments completed, 37% were for the introduction of ornamental horticulture and food crops species and 28% for biofuels and bioenergy purposes. The purpose of introduction was unspecified in 42% of assessments (see Online Resource 3 for more details).

Discussion

Tall-statured grass (TSG) groups with high impact

Woody bamboos (tribes Arundinarieae and Bambuseae) are among the tallest grasses and make up the majority of TSG species (Fig. 2). They have some of the most varied uses of any plant group and are widely used in agroforestry, medicine, food, fodder, ornamentation and, more recently, phytoremediation and bioenergy, and for these reasons they have been distributed and cultivated around the world (Soderstrom and Calderon 1979; Farrelly 1984; Liese and Köhl 2015; Canavan et al. 2017b). According to Canavan et al. (2017b), at least 232 (14%) of all 1662 bamboo species have been introduced beyond their native range. However, only 12 species are recorded as invasive (i.e. spreading), fewer than other grass tribes and less than other TSGs. Although they have been widely introduced, bamboos have lower invasion rates but have high levels of environmental impacts in disturbed forests, both in the native and alien range (O'Connor et al. 2000; Teixeira and Oatham 2001; Lima et al. 2012; Xu et al. 2014; Rother et al. 2016; Canavan et al. 2018a). This is attributed to the high competitive ability of certain bamboo species and their capacity to rapidly colonise open space in disturbed

Table 2 The influence of plant stature and garden use status on global naturalisation of woody bamboos and other grasses. Plant height was analysed both as a factor (i.e. tall-statured grass (TSG) of stature $\geq$ 2m vs. non-TSGs) and as a continuous variable (results shown in italics). Garden-use status was binary (presence/absence in Dave's Garden Plant Files database; http://davesgarden.com/guides/pf). Global naturalisation was measured as (a) naturalisation incidence outside the native range (expressed as being naturalised in at least one region, yes or no), and (b) naturalisation extent (number of regions where the species is recorded as naturalised). To assess whether naturalisation incidence or naturalisation extent related to stature and to the presence in Dave's Garden database, we ran generalised linear mixed-effects models with a binomial error distribution or a negative binomial error distribution, respectively. To account for phylogenetic non-independence of the species, we included genus (for woody bamboos) or genus nested within tribe (for other grasses) as random factor(s). For naturalisation incidence, we ran similar models with height (standardised to a mean of 0 and standard deviation of 1) as a continuous explanatory variable instead of stature, the results are shown in italics. Note that woody bamboos refers to species within the Bambuseae and Arundinarieae tribe, and non-bamboo grasses include all other species in the family Poaceae

Explanatory variable	Woody bamboos (n = 1162)				Other grasses (n = 9674)			
	Estimate	SE	z	*p*	Estimate	SE	z	*p*
(a) Global naturalisation incidence (yes/no)								
Intercept	− 5.365	0.533	− 10.06	< 0.001	− 3.026	0.181	− 16.74	< 0.001
	− 5.101	*0.422*	*− 12.087*	*< 0.001*	*− 3.023*	*0.187*	*− 16.15*	*< 0.001*
Stature (TSG/non-TSG)	0.4803	0.470	1.021	0.307	0.931	0.242	3.85	< 0.001
Height (continuous)	*0.431*	*0.143*	*3.021*	*0.0025*	*0.159*	*0.036*	*4.37*	*< 0.001*
Recorded in Dave's Garden (yes/no)	3.843	0.428	8.979	< 0.001	3.204	0.092	34.99	< 0.001
	3.839	*0.427*	*8.983*	*< 0.001*	*3.188*	*0.092*	*34.79*	*< 0.001*
Random factors	SD				SD			
Genus	0.6864				0.9504			
	0.6854				*0.9491*			
Tribe	not applicable				0.5826			
					0.6278			

Explanatory variable	Woody bamboos (n = 67)				Other grasses (n = 1162)			
	Estimate	SE	z	*p*	Estimate	SE	z	*p*
(b) Global naturalisation extent (number of regions where naturalised)								
Intercept	− 0.612	0.751	− 0.81	0.415	1.583	0.142	11.13	< 0.001
Stature (TSG/non-TSG)	1.139	0.511	2.23	0.026	− 0.147	0.242	− 0.61	0.54
Recorded in Dave's Garden (yes/no)	1.340	0.655	2.05	0.041	1.518	0.080	18.92	< 0.001
Random factors	SD				SD			
Genus	0.3947				0.7103			
Tribe	not applicable				0.4037			

forest canopies and take advantage of available light and resources. Due to their large size and robust stature, they often alter biotic and abiotic processes and compete with trees. The competitive interaction between bamboos and trees is unusual compared to species in other grass tribes. Tall bamboos are usually not perceived as 'invasive' given their low spread rates, but they should receive closer scrutiny with regard to their potentially large impacts on community structure and ecosystem functioning (Canavan et al. 2018a). Recognising the dominance of bamboos and managing their biomass is an integral part of landscape management in many forest ecosystems (Suzaki and Nakatsubo 2001; Larpkern et al. 2011; Bai et al. 2013).

Large reeds form another important subgroup within TSGs and are often the dominant vegetation in riparian, lake and coastal ecosystems. Some of the most notorious invasive plants are reed TSGs

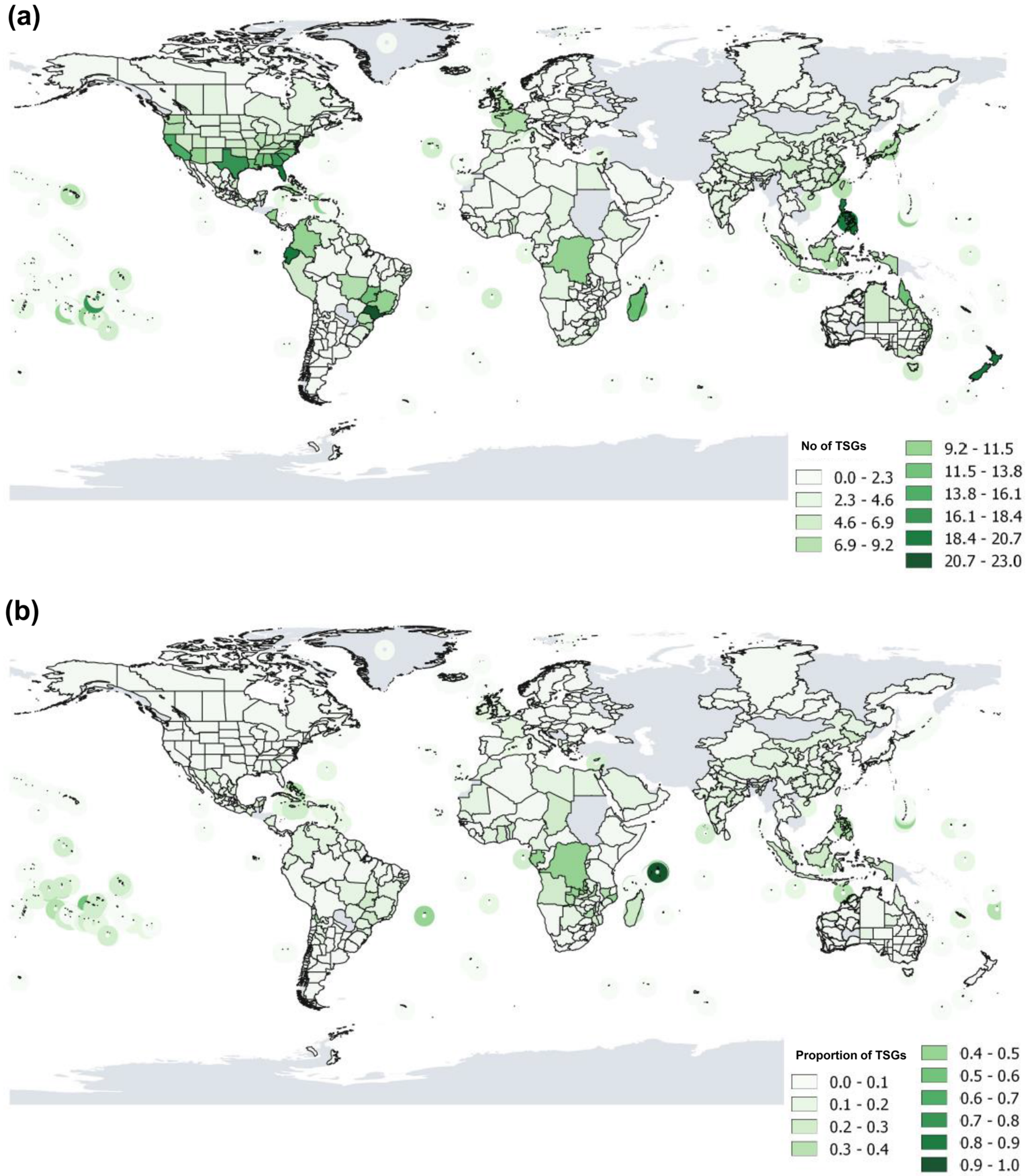

Fig. 4 **a** Numbers of naturalised tall-statured grass species (TSGs) and **b** their proportions among all naturalised grass species (**b**) in 843 GloNAF regions of the world (see van Kleunen et al. (2015) for description of regions and data acquisition). Darker colours indicate a greater number of naturalised TSGs or that naturalised TSGs represent a greater proportion of all naturalised grasses, respectively. Regions in grey are missing data

Table 3 The twenty most widely distributed tall-statured grass species ranked according to the total number of regions in which they are naturalised. Height is in terms of the maximum inflorescence height. The broad continental regions (as per the Biodiversity Information Standards TDWG classification (see van Kleunen et al. (2015)) from which the grass is native are indicated with an asterisk, note species are often native and naturalised in a single TDWG region as there are many GloNAF regions per TDWG region

Taxon	Height (cm)	Tribe	Occurrence in regions (number of GloNAF regions)								
			Total	Africa	Asia (temperate)	Asia (tropical)	Australia	Europe	North America	Pacific Islands	South America
Arundo donax	400	Arundineae	220	26	12*	33*	33	7	46	15	48
Cenchrus purpureus	350	Paniceae	175	38*	11	37	13	0	23	20	33
Sorghum bicolor	350	Andropogoneae	147	12*	2	5	34	8	57	9	20
Cenchrus americanus	225	Paniceae	132	19*	33	33	9	0	21	6	11
Zea mays	250	Andropogoneae	120	18	0	2	2	6	52*	14	26*
Saccharum officinarum	450	Andropogoneae	113	23	0	2*	5	0	18	34	31
Bambusa vulgaris	1750	Bambuseae	101	23	0	10*	4	0	11	25	28
Phragmites australis	375	Arundineae	94	1*	0*	3*	3*	0*	85*	0	2*
Cortaderia selloana	200	Danthonieae	66	6	1	1	16	15	20	7	0*
Sorghum almum	260	Andropogoneae	63	0	33	1	19	0	10	0	0*
Zea mexicana	300	Andropogoneae	41	1	33	2	0	0	4*	0	1*
Phyllostachys aurea	500	Arundinarieae	39	1	0*	1	7	2	15	1	12
Chrysopogon zizanioides	225	Andropogoneae	35	6	6	3*	0	0	2	13	5
Sorghum arundinaceum	215	Andropogoneae	33	10	0*	0	14	0	0	6	3
Olyra latifolia	230	Olyreae	30	30*	0	0	0	0	0*	0	0*
Schizostachyum glaucifolium	650	Bambuseae	28	0	0	0	0	0	0	28*	0
†*Pseudosasa japonica*	400	Arundinarieae	27	5	0	0	1	9	11	0	1
Cortaderia jubata	225	Danthonieae	24	8	0	0	7	0	4	1	4*
Bambusa multiplex	300	Bambuseae	23	2	8*	1	1	0	3	4	4
Saccharum ravennae	275	Andropogoneae	22	0*	0*	1*	0	0*	21	0	0

†*Pseudosasa japonica* originated from cultivation. Source of data: GloNAF (van Kleunen et al. 2015)

Table 4 Risk assessments completed for tall-statured grass species

Species	Common name	RAs	Reg	Accept	LR	IR	HR	Reject	EF	Other
Andropogon bicornis L.	West Indian foxtail grass	1	1				1			
Andropogon gayanus Kunth	Gamba grass	1	1					1		
Arundo donax L.	Giant reed	12	9				2	7		1
Bambusa bambos (L.) Voss	Thorny bamboo	1	1						1	
Bambusa chungii McClure	Emperor's blue bamboo	1	1		1					
Bambusa glaucophylla Widjaja	Malay dwarf bamboo	1	1		1					
Bambusa lako Widjaja	Timor black bamboo	2	1		1				1	
Bambusa multiplex (Lour.) Raeusch. ex Schult.	Chinese dwarf bamboo	3	2	1				1	1	
Bambusa oldhamii Munro	Oldhamii bamboo	2	1	1					1	
Bambusa oliveriana Gamble	Bush bamboo	1	1		1					
Bambusa pervariabilis McClure	Puntingpole bamboo	1	1		1					
Bambusa textilis McClure	Weaver's bamboo	1	1		1					
Bambusa tuldoides Munro	Buddha Belly bamboo	1	1						1	
Bambusa vulgaris Schrad.	Common bamboo	3	3		1				2	
Schizostachyum pergracile (Munro) R.B.Majumdar	Tinwa bamboo	1	1		1					
(= *Cephalostachyum pergracile* Munro)										
Chimonobambusa quadrangularis (Fenzi) Makino	Square bamboo	1	1					1		
Chrysopogon zizanioides (L.) Roberty	Vetiver grass	4	3	2	1		1			
Cortaderia jubata (Lem.) Stapf	Purple pampas grass	7	3				3	3		1
Cortaderia selloana (Schult.) Aschers. & Graebn.	Silver pampas grass	6	4		1		2	2		1
Cymbopogon martini (Roxb.) W.Watson	Ginger grass, Palmarosa	1	1		1					
Dendrocalamus asper (Schult.) Backer ex K.Heyne	Giant bamboo	2	2		1				1	
Dendrocalamus brandisii (Munro) Kurz	Velvetleaf bamboo	1	1						1	
Dendrocalamus sikkimensis Gamble ex Oliver	Philippine sweet shoot bamboo	1	1		1					
Dendrocalamus strictus (Roxb.) Nees	Male bamboo	1	1						1	
Drepanostachyum falcatum (Nees) P.C.Keng	Blue bamboo	1	1	1						
Drepanostachyum khasianum (Munro) P.C.Keng	Khasia bamboo	1	1		1					
Echinochloa pyramidalis (Lam.) Hitchc. & Chase	Antelope grass	2	1				1			1
Fargesia fungosa T.P.Yi	Chocolate bamboo	1	1		1					
Fargesia nitida (Mitford) Keng f. ex T.P.Yi	Blue Fountain bamboo	1	1	1						
Gigantochloa apus (Schult.) Kurz	Gigantochloa	2	2		1				1	
Gigantochloa atroviolacea Widjaja	Sweet bamboo, pring legi	1	1		1					

Table 4 continued

Species	Common name	RAs	Reg	Accept	LR	IR	HR	Reject	EF	Other
Gigantochloa atter (Hassk.) Kurz	Sweet bamboo	1	1		1					
Gigantochloa robusta Kurz	Robust bamboo	1	1		1					
Guadua angustifolia Kunth	Guadua, Columbian thorny bamboo	1	1						1	
Hymenachne amplexicaulis (Spreng.) Zuloaga	Hymenachne	1	1					1		
Miscanthus floridulus (Labill.) Warb. ex K.Schum. & Lauterb.	Giant miscanthus	1	1				1			
Miscanthus sinensis Andersson	Chinese silvergrass	8	7		1	1		3		3
Miscanthus × *giganteus* J.M.Greef & Deuter ex Hodk. & Renvoize	Giant miscanthus	3	1	3						
Nastus elatus Holttum	New Guinea edible bamboo	1	1		1					
Neyraudia reynaudiana (Kunth) Keng ex Hitchcock	Burma reed	3	1				2	1		
Otatea acuminata (Munro) C.E.Calderon & T.R.Soderstrom (= *Otatea aztecorum*)	Mexican weeping bamboo	1	1		1					
Cenchrus americanus (L.) Morrone (= *Pennisetum glaucum* (L.) R.Br.)	Pearl millet	1	1		1					
Cenchrus macrourus (Trin.) Morrone (= *Pennisetum macrourum* Trin.)	African feathergrass	1	1					1		
Cenchrus purpureus (Schumach.) Morrone (= *Pennisetum purpureum* Schumach.)	Elephant grass	5	3					5		
Phragmites australis (Cav.) Trin. ex Steud.	Common reed	4	3					1		3
Phyllostachys aurea Rivière & C.Rivière	Golden bamboo	4	3				2	1	1	
Phyllostachys aureosulcata McClure	Yellow groove bamboo	1	1						1	
Phyllostachys nigra (Lodd.) Munro	Black	2	2				1	1		
Pseudosasa japonica (Steud.) Makino	Arrow bamboo	1	1					1		
Saccharum arundinaceum Retz.	Plume Grass	1	1	1						
Saccharum officinarum L.	Sugarcane	3	2	2				2		
Saccharum ravennae (L.) Murr.	Ravenna Grass	1	1					1		
Saccharum spontaneum L.	Wild sugarcane	1	1				1			
Schizostachyum brachycladum (Kurz) Kurz	Sacred Bali bamboo	1	1		1					
Schizostachyum glaucifolium (Rupr.) Munro	Hawaiian bamboo	1	1		1					
Sorghum bicolor (L.) Moench	Sweet Sorghum	8	4	2	1		2	1		1
Zea mays L.	Corn	3	2	1					2	

Number of risk assessments completed (RAs), number of regions evaluated (Reg), and the outcome of the evaluation are shown for each species; low risk (LR), intermediate risk (IR), high risk (HR), reject, evaluate further (EF) and other classification (e.g. prohibit for importation). See Online Resource 3 for a detailed list of all assessments

including *Arundo donax* and *Phragmites australis* (Lambert et al. 2010). Their presence and growth in ecosystems have important consequences for the structure and composition of their communities (Chambers et al. 1999; Meyerson et al. 2000; Meyerson 2000; Holmes et al. 2005; Richardson et al. 2007a; Packer et al. 2017). In particular, invasive reeds efficiently exploit space and nutrients, allowing them to take advantage of natural and human-induced disturbances (Meyerson et al. 1999; Canavan et al. 2018b).

Tall-statured grass species (e.g. *Cortaderia jubata, Cortaderia selloana*, *Miscanthus sinensis, Panicum virgatum*) are also widely used for ornamental horticulture and bioenergy production. Many species used for this purpose escape from cultivation and spread into natural areas (Lambrinos 2000; Quinn et al. 2010; Schnitzler and Essl 2015). Interestingly, food crop TSGs (e.g. maize, sugarcane, pearl millet, sorghum), tend not to be invaders although they are widely propagated making up a vast component of landscapes altered by humans for agricultural purposes around the world, and they are very commonly planted as hybrids.

Extent and incidence of naturalisation of TSGs

Although we did not find that all models yielded a significant effect of stature, we did show that TSG categorisation is relevant with respect to probability for naturalisation. Specifically, we found that stature is associated with naturalisation success in grasses, but only when woody bamboos are excluded (Table 2). While stature is unlikely the proximate factor driving naturalisation, naturalisation patterns support the notion that being a TSG contributes to invasion potential. In agreement with other studies, we also found that the presence in horticultural trade is an important correlate of both naturalisation incidence and extent (Dehnen-Schmutz et al. 2007; van Kleunen et al. 2007, 2018; Pyšek et al. 2010). We also found that TSGs seem to have naturalised more on islands, probably due to the long history of bamboos being widely introduced and cultivated on islands along early trade routes (Canavan et al. 2017b).

Competitive features of TSGs

The heights obtained by TSGs (including bamboos) result in unique traits that can confer a competitive advantage over other co-occurring vegetation, including lignified stalks, production of large amounts of biomass (often at a rate faster than woody shrubs and trees; Linder et al. (2018)), formation of dense monospecific stands and extensive root and rhizome systems (See Table 1). Although these traits are not unique to TSGs and are present in other plant groups including shorter grasses, the combination of these traits enables some TSGs to have increased impacts.

Tall-statured grasses are also often the dominant components of the vegetation communities in ecosystems where they occur and thus have a strong effect on ecosystem functioning. As such, they have impacts at different trophic levels when they become invasive (Gordon-Gray and Ward 1971; Onimaru and Yabe 1996; Larpkern et al. 2011; Pagad 2016; Maceda-Veiga et al. 2016). For example, the accumulation of dead biomass creates thick litter mats that can suppress the growth of emerging plants over time (Haslam 2010; Amougou et al. 2012; Rohani et al. 2014). The increase of litterfall, and therefore standing biomass, can also lead to changes in fire regimes through increased fuel loads which can inflict ecosystem-level changes, including transformed nutrient cycling and increased susceptibility of the ecosystem to further invasion (Rieger and Kreager 1989; Dwire and Kauffman 2003; Herrera and Dudley 2003; Brooks et al. 2004).

For most TSGs, vegetative growth is both a crucial competitive mechanism and a reproductive strategy for dispersal with tillers, shoots, ramets, rhizomes, stolons or fallen stems forming clonal networks (Wang et al. 2017). The connectivity of biomass between stands has many advantages: greater resource acquisition and sharing (de Kroon and Kalliola 1995; Stueffer et al. 1996; van Kleunen and Stuefer 1999); allowing invasion into closed canopies or low resource-patches (Welker and Briske 1992; Wang et al. 2016); and allowing the storage of resources (Grace 1993). The increased amount of below-ground vegetative biomass of TSGs, compared to shorter grasses and other plants like trees, likely gives populations added resilience to disturbances and provides a greater capacity for energy storage.

Sexual reproduction and seed dispersal is not a prerequisite for the spread of many TSGs (Ahmad et al. 2008; Hardion et al. 2012; Canavan et al. 2017a). Clonal TSGs use stem-derived spacers such as underground rhizomes or above-ground stolons to disperse which can be further aided by anthropogenic activities such as the movement of TSGs for ornamental horticulture and other purposes (SFAPRC 2006; Isagi et al. 2016). The ability of some TSGs to successfully colonise a wide variety of environmental gradients and yet have such low genetic diversity may also indicate that other important mechanisms are implicated, such as increased phenotypic plasticity in response to environmental changes (Canavan et al. 2017a).

Invasive clonal plants like *Arundo donax* may possess a 'general-purpose-genotype', i.e. a genotype that allows for phenotypic plasticity and thus adaptation to a wide range of conditions (Van Doninck et al. 2002). Further, many TSGs have an allopolyploid origin and incorporate high genetic diversity in their genomes (Soltis and Soltis 2000).

Although vegetative growth clearly carries several advantages for the establishment of TSGs, this mode of dispersal alone has limitations. When TSGs can also reproduce sexually they have the added advantage of being able to achieve long-range dispersal independently (e.g. without the need for disturbance or human-facilitation) into adventive ranges. Sexual reproduction also produces genetic diversity and increases the opportunities for naturalisation and eventually adaptation to new habitats and ranges (Colautti and Lau 2015). Increased height can also be a competitive advantage in seed dispersal by wind, as pollen and seeds can travel above the canopy and cover long distances (Thomson et al. 2011). A number of TSGs have been found to disperse widely via seed production (Quinn et al. 2010; Ecker et al. 2015), but can also invade new ranges through the distribution of seeds (Chambers et al. 1999; Belzile et al. 2010; McCormick et al. 2010; Kettenring et al. 2011; Bonnett et al. 2014).

Risks of invasion and impacts

We found that a majority of risk assessments that have evaluated TSGs have been for horticultural introductions and more recently for bioenergy projects (Scurlock et al. 2000; Blanchard et al. 2017; Lieurance et al. 2018). Since TSGs are the grasses most often selected for bioenergy and biofuel production, this usage category will probably continue to drive future introductions from the group (Cousens 2008; Gordon et al. 2011; Hartman et al. 2011; Amougou et al. 2011; Jung et al. 2015; Smith et al. 2015; Corneli et al. 2016). Potential bioenergy TSG crops tend to receive higher risk scores than TSGs selected for other uses (See Online Resource 3). The most commonly mentioned candidates for biofuels include *Arundo donax*, *Cenchrus purpureus* (= *Pennisetum purpureum*), *Miscanthus* × *giganteus* (importantly neither parental species grows to ≥ 2 m, indicating selection for greater height), *Saccharum* spp., as well as *Panicum virgatum*, (although just short of the 2 m threshold). The high risk of biofuel-selected species is in line with previous studies; a comprehensive analysis by Buddenhagen et al. (2009) found that biofuel species are two to four times more likely to establish and become invasive than species introduced to Hawaii for other purposes.

An additional risk associated with biofuel and bioenergy crops is the intention to develop more robust and vigorous cultivars through genetic manipulation to produce crops that yield more biomass (Bouton 2007). Many of the selected traits overlap with known weedy attributes, such as: (1) fast growth rates; (2) high seed production; (3) wide range of climatic tolerance; (4) adaptability to a wide range of environmental conditions; and (5) few herbivores, pests and diseases in receiving ecosystems (IUCN 2009; Richardson and Blanchard 2011; Flory et al. 2012). In general, the high levels of domestication and breeding of TSGs, both historically and currently, have likely increased invasion risks of some species, as more robust cultivars have been and continue to be developed. Concerns have been expressed that, in general, current risk assessment frameworks and policies are limited in their ability to evaluate subspecies or lower taxa (e.g. cultivars, genotypes) and hybrids (Meffin 2013). For example, a cultivar of a species may perform very differently to the wild type of the species as it occurs in nature. Greater intraspecific diversity of a species has been found to be associated with an increased likelihood of naturalisation or establishment [e.g. South African *Iridaceae* species; van Kleunen et al. (2007)] and invasion or spread [e.g. bamboos and lineages of *Phragmites*; further; Meyerson et al. (2010), Kettenring et al. (2011), Meyerson (2013), Canavan et al. (2017a)], highlighting the need for better understanding of intraspecific dynamics. Even natural variations within a species can be problematic in this regard; this has been the case with *P. australis* where a certain haplotype (Saltonstall 2002) and smaller genome sizes (Pyšek et al. 2018) are more invasive than others (e.g. displacement of native haplotypes in North America). Invasive genotypes likely exist within other TSGs and other plant taxa more generally [e.g., *Phalaris arundinacea*; Lavergne and Molofsky (2007)], although they go unrecognised due to the difficulty in identifying intraspecific diversity. Additional criteria are needed to evaluate the invasion risks of subspecific or lower taxa, particularly to keep pace with the increasing selection and breeding of TSGs for biofuel and other uses surrounding high biomass yielding variations.

The TSG concept and future directions

While there is no clear break in the height distribution of grasses, TSGs are an important functional group as they cause distinct impacts and raise particular concerns for management and biosecurity. We suggest a number of directions that can be taken with the TSG group including: (1) studying subgroups of TSGs in particular biogeographical realms (e.g. Afrotropic TSGs), or habitat types in which they primarily occur (e.g. riparian, estuarine, or forest TSGs). Understanding the reasons for the differences between woody bamboos and other TSGs would be an important first step; (2) determining why different pathways and the traits selected in TSGs are associated with varying levels of risks. For example, trying to better understand why TSGs selected for biofuels are associated with high-risks, whereas food crops tend to be low-risk; (3) reviewing the importance of TSGs in their native range for resisting invasions. For example, the composition of dominant native grasses have been found to be mediators of invasions as well as important predictors of the ability of a system to resist invasion (Tilman et al. 1997; Pokorny et al. 2005; Richardson et al. 2007b; Young et al. 2009; Wang et al. 2013); and (4) reviewing whether there is merit in expanding the functional group to encompass tall Poales [order of monocotyledons that include grasses, bromeliads and sedges] more generally, as many sedges and rushes employ similar mechanisms to disrupt and produce ecosystem-level changes through biomass production and accumulation [e.g. the removal of invasive *Typha* × *glauca* biomass increased native plant diversity along Great Lake coastal wetlands; Angeloni et al. (2006), Farrer and Goldberg (2009), Lishawa et al. (2015)].

In summary, we believe that the group of TSGs, including bamboos, are a useful functional group both for invasion science and management and that further research on the group, on both the biological reasons and the socio-economic imperatives that drive invasions, is warranted. Tall-statured grasses also provide an important counter-point to other analyses as to when generalisations can be made in invasion science (Kueffer et al. 2013).

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Online Resource 1

List of tall-statured grasses (TSGs; 929 species). We define tall-statured grass species as those that normally attain self-sustaining heights of 2 m or more. Height data were retrieved from Kew's GrassBase (http://www.kew.org/data/grasses-db.html). Species names were cleaned, updated and corrected to create this species list (synonyms listed in brackets following the updated species name, where applicable); non-bamboo grasses were checked for synonyms using Kew's World Checklist of Selected Plant Families (http://apps.kew.org/wcsp/qsearch.do) and bamboo species were checked using the International Network for Bamboo and Rattan's (INBAR) global 2016 checklist.

Acidosasa breviclavata
Acidosasa chinensis
Acidosasa edulis
Acidosasa glauca (= Acidosasa chinouensis)
Acidosasa guangxiensis
Acidosasa lingchuanensis
Acidosasa nanunica
Acidosasa notata (= Pleioblastus intermedius)
Acidosasa purpurea
Actinocladum verticillatum
Ampelocalamus hirsutissimus
Ampelocalamus melicoideus
Ampelocalamus mianningensis
Ampelocalamus microphyllus
Ampelocalamus naibunensis
Ampelocalamus patellaris
Ampelocalamus saxatilis
Ampelocalamus yongshanensis
Andropogon bicornis
Andropogon chevalieri
Andropogon cordatus
Andropogon gabonensis
Andropogon gayanus
Andropogon incomptus
Andropogon macrophyllus
Andropogon monocladus
Andropogon tectorum
Andropogon vetus (= Andropogon perdignus)
Apoclada simplex
Arundinaria gigantea
Arundinella cochinchinensis
Arundinella decempedalis
Arundinella deppeana
Arundo donax
Arundoclaytonia dissimilis
Aulonemia amplissima
Aulonemia herzogiana
Aulonemia longiaristata
Aulonemia nitida
Aulonemia parviflora
Aulonemia queko
Aulonemia radiata (= Aulonemia fimbriatifolia)
Aulonemia robusta
Aulonemia ulei
Aulonemia viscosa
Austroderia fulvida (= Cortaderia fulvida)
Austrostipa elegantissima (= Stipa elegantissima)
Bambusa affinis
Bambusa albolineata
Bambusa amplexicaulis
Bambusa angustiaurita
Bambusa angustissima
Bambusa arnhemica
Bambusa aurinuda
Bambusa australis
Bambusa balcooa
Bambusa bambos
Bambusa basihirsuta
Bambusa beecheyana
Bambusa bicicatricata
Bambusa boniopsis
Bambusa brunneoaciculia
Bambusa burmanica
Bambusa cacharensis
Bambusa cerosissima
Bambusa chungii
Bambusa chunii
Bambusa clavata
Bambusa comillensis
Bambusa contracta
Bambusa copelandii
Bambusa corniculata
Bambusa cornigera
Bambusa crispiaurita
Bambusa diaoluoshanensis
Bambusa dissimulator
Bambusa distegia
Bambusa dolichoclada
Bambusa duriuscula
Bambusa eutuldoides
Bambusa farinacea
Bambusa fimbriligulata
Bambusa flexuosa
Bambusa funghomii
Bambusa gibba
Bambusa gibboides
Bambusa glabrovagina
Bambusa glaucophylla
Bambusa grandis
Bambusa guangxiensis
Bambusa heterostachya
Bambusa indigena
Bambusa insularis
Bambusa intermedia
Bambusa jacobsii
Bambusa jaintiana (= Bambusa alamii)
Bambusa khasiana
Bambusa kingiana
Bambusa lako
Bambusa lapidea
Bambusa latideltata
Bambusa laxa
Bambusa lenta
Bambusa longipalea
Bambusa longispiculata
Bambusa macrotis
Bambusa maculata
Bambusa malingensis
Bambusa microcephala
Bambusa mollis
Bambusa multiplex
Bambusa mutabilis
Bambusa nepalensis
Bambusa nutans
Bambusa odashimae
Bambusa oldhamii
Bambusa oliveriana
Bambusa pachinensis
Bambusa pallida
Bambusa papillata
Bambusa papillatoides
Bambusa pervariabilis
Bambusa pierreana
Bambusa piscatorum
Bambusa polymorpha
Bambusa procera
Bambusa prominens
Bambusa ramispinosa
Bambusa remotiflora
Bambusa riauensis
Bambusa rigida
Bambusa rongchengensis
Bambusa rugata
Bambusa rutila
Bambusa salarkhanii
Bambusa schizostachyoides
Bambusa semitecta
Bambusa sinospinosa
Bambusa stenoaurita
Bambusa subaequalis
Bambusa subtruncata
Bambusa surrecta
Bambusa teres
Bambusa textilis
Bambusa truncata
Bambusa tsangii
Bambusa tulda
Bambusa tuldoides
Bambusa utilis
Bambusa valida
Bambusa variostriata
Bambusa vinhphuensis
Bambusa viridis
Bambusa vulgaris
Bambusa wenchouensis
Bambusa xiashanensis
Bambusa xueana
Bashania qingchengshanensis (= Arundinaria qingchengshanensis)
Bergbambos tessellata (= Thamnocalamus tessellatus)
Bonia amplexicaulis
Bonia saxatilis
Bonia tonkinensis
Calamagrostis mesathera
Cathariostachys capitata
Cenchrus americanus (= Pennisetum glaucum)
Cenchrus elegans (= Pennisetum macrostachyum)
Cenchrus latifolius (= Pennisetum latifolium)
Cenchrus macrourus (= Pennisetum macrourum)
Cenchrus michoacanus (= Pennisetum crinitum)
Cenchrus nervosus (= Pennisetum nervosum)
Cenchrus peruvianus (= Pennisetum peruvianum)
Cenchrus pirottae (= Pennisetum pirottae)
Cenchrus preslii (= Pennisetum bambusiforme)
Cenchrus prolificus (= Pennisetum prolificum)
Cenchrus sieberianus (= Pennisetum sieberianum)
Cenchrus trisetus (= Pennisetum trisetum)
Cenchrus tristachyus (= Pennisetum tristachyum)
Cenchrus unisetus (= Pennisetum unisetum)
Cephalostachyum burmanicum
Cephalostachyum chinense (= Schizostachyum chinense)
Cephalostachyum flavescens
Cephalostachyum sanguineum (= Schizostachyum sanguineum)
Chasmopodium afzelii
Chasmopodium caudatum
Chimonobambusa angustifolia
Chimonobambusa armata
Chimonobambusa brevinoda
Chimonobambusa callosa
Chimonobambusa communis
Chimonobambusa convoluta
Chimonobambusa fansipanensis
Chimonobambusa grandifolia
Chimonobambusa hejiangensis
Chimonobambusa hirtinoda
Chimonobambusa hsuehiana
Chimonobambusa lactistriata
Chimonobambusa leishanensis
Chimonobambusa luzhiensis
Chimonobambusa macrophylla
Chimonobambusa marmorea
Chimonobambusa metuoensis
Chimonobambusa microfloscula
Chimonobambusa montigena
Chimonobambusa ningnanica
Chimonobambusa opienensis
Chimonobambusa pachystachys
Chimonobambusa paucispinosa
Chimonobambusa puberula
Chimonobambusa pubescens
Chimonobambusa purpurea
Chimonobambusa quadrangularis
Chimonobambusa rigidula
Chimonobambusa szechuanensis
Chimonobambusa tuberculata
Chimonobambusa tumidissinoda
Chimonobambusa utilis
Chimonocalamus baviensis (= Arundinaria baviensis)
Chimonocalamus burmaensis
Chimonocalamus delicatus
Chimonocalamus dumosus
Chimonocalamus fimbriatus
Chimonocalamus gallatlyi
Chimonocalamus griffithianus
Chimonocalamus longiligulatus
Chimonocalamus longiusculus
Chimonocalamus makuanensis
Chimonocalamus montanus
Chimonocalamus nagalandianus
Chimonocalamus pallens
Chionachne cyathopoda
Chionachne macrophylla
Chrysopogon elongatus
Chrysopogon festucoides
Chrysopogon nigritanus
Chrysopogon verticillatus
Chrysopogon zizanioides
Chusquea abietifolia
Chusquea albilanata
Chusquea anelytroides
Chusquea angusta (= Neurolepis angusta)
Chusquea antioquensis
Chusquea aristata (= Neurolepis aristata)
Chusquea asymmetrica (= Neurolepis asymmetrica)
Chusquea bilimekii
Chusquea caparaoensis
Chusquea circinata
Chusquea culeou
Chusquea cumingii
Chusquea erecta
Chusquea fernandeziana
Chusquea fimbriligulata (= Neurolepis fimbriligulata)
Chusquea juergensii
Chusquea lehmannii
Chusquea longiligulata
Chusquea longipendula
Chusquea lorentziana
Chusquea maclurei
Chusquea magnifolia (= Neurolepis pittieri)
Chusquea meyeriana
Chusquea mimosa
Chusquea mollis (= Neurolepis mollis)
Chusquea neurophylla
Chusquea nutans
Chusquea paludicola
Chusquea patens
Chusquea perotensis
Chusquea peruviana
Chusquea petiolata (= Neurolepis petiolata)
Chusquea polyclados
Chusquea spectabilis (= Neurolepis aperta)
Chusquea spencei
Chusquea subtessellata
Chusquea subtilis
Chusquea subulata
Chusquea sulcata
Chusquea talamancensis
Chusquea tarmensis
Chusquea tessellata
Chusquea tonduzii
Chusquea uliginosa
Chusquea vulcanalis
Coelorachis afraurita
Coelorachis balansae
Coelorachis glandulosa
Coelorachis khasiana
Coelorachis rottboellioides
Cortaderia atacamensis
Cortaderia bifida
Cortaderia jubata
Cortaderia richardii
Cortaderia selloana
Cortaderia speciosa
Cortaderia splendens

Cortaderia toetoe
Cymbopogon flexuosus
Cymbopogon giganteus
Cymbopogon martini
Cymbopogon winterianus
Cyrtochloa major
Danthoniopsis simulans
Davidsea attenuata
Dendrocalamus asper
Dendrocalamus bambusoides
Dendrocalamus barbatus
Dendrocalamus brandisii
Dendrocalamus buar
Dendrocalamus calostachyus
Dendrocalamus cinctus
Dendrocalamus elegans
Dendrocalamus exauritus (= Drepanostachyum exauritum)
Dendrocalamus farinosus
Dendrocalamus fugongensis
Dendrocalamus giganteus
Dendrocalamus hait
Dendrocalamus hamiltonii (= Dendrocalamus semiscandens)
Dendrocalamus hirtellus
Dendrocalamus hookeri
Dendrocalamus jianshuiensis
Dendrocalamus liboensis
Dendrocalamus longispathus
Dendrocalamus membranaceus
Dendrocalamus messeri
Dendrocalamus minor
Dendrocalamus nudus
Dendrocalamus pachystachyus
Dendrocalamus peculiaris
Dendrocalamus pendulus
Dendrocalamus poilanei
Dendrocalamus pulverulentus
Dendrocalamus sahnii
Dendrocalamus sericeus
Dendrocalamus sikkimensis
Dendrocalamus sinicus
Dendrocalamus somdevae
Dendrocalamus strictus
Dendrocalamus tibeticus
Dendrocalamus tomentosus
Dendrocalamus tsiangii
Dendrocalamus yunnanicus
Didymogonyx longispiculatum (= Rhipidocladum longispiculatum)
Digitaria pellita
Diplachne gigantea (= Leptochloa gigantea)
Drepanostachyum ampullare
Drepanostachyum annulatum
Drepanostachyum falcatum
Drepanostachyum fractiflexum
Drepanostachyum intermedium
Drepanostachyum khasianum
Drepanostachyum semiorbiculatum
Echinochloa pyramidalis
Elymandra gossweileri
Elymandra subulata
Eremocaulon aureofimbriatum
Eremocaulon capitatum
Fargesia acuticontracta
Fargesia albocerea
Fargesia altior
Fargesia angustissima
Fargesia brevissima
Fargesia caduca
Fargesia canaliculata
Fargesia circinata
Fargesia communis
Fargesia concinna
Fargesia conferta
Fargesia contracta
Fargesia cuspidata
Fargesia declivis
Fargesia decurvata
Fargesia denudata
Fargesia dulcicula
Fargesia dura
Fargesia edulis
Fargesia elegans
Fargesia exposita
Fargesia extensa
Fargesia farcta
Fargesia ferax
Fargesia fungosa
Fargesia glabrifolia
Fargesia gongshanensis
Fargesia grossa
Fargesia hainanensis
Fargesia hsuehiana
Fargesia hygrophila
Fargesia jiulongensis
Fargesia lincangensis
Fargesia longiuscula
Fargesia lushuiensis
Fargesia macclureana
Fargesia mali
Fargesia murielae
Fargesia nitida (= Fargesia emaculata)
Fargesia nujiangensis
Fargesia obliqua
Fargesia orbiculata
Fargesia papyrifera
Fargesia perlonga
Fargesia pleniculmis
Fargesia plurisetosa
Fargesia porphyrea
Fargesia praecipua
Fargesia qinlingensis
Fargesia rufa
Fargesia sagittatinea
Fargesia scabrida
Fargesia semicoriacea
Fargesia similaris
Fargesia solida
Fargesia stenoclada
Fargesia strigosa
Fargesia subflexuosa
Fargesia sylvestris
Fargesia tenuilignea
Fargesia utilis
Fargesia wuliangshanensis
Fargesia yuanjiangensis
Fargesia yulongshanensis
Fargesia yunnanensis
Fargesia zayuensis
Ferrocalamus rimosivaginus
Ferrocalamus strictus
Gaoligongshania megalothyrsa
Gelidocalamus kunishii
Gelidocalamus latifolius
Gelidocalamus longiinternodus
Gelidocalamus solidus (= Gelidocalamus albopubescens)
Gelidocalamus stellatus
Gelidocalamus tessellatus (= Gelidocalamus subsolidus)
Gelidocalamus velutinus
Gigantochloa achmadii
Gigantochloa albociliata
Gigantochloa albopilosa
Gigantochloa albovestita
Gigantochloa apus
Gigantochloa atroviolacea
Gigantochloa atter
Gigantochloa aya
Gigantochloa baliana
Gigantochloa balui
Gigantochloa calcicola
Gigantochloa cochinchinensis
Gigantochloa compressa
Gigantochloa densa
Gigantochloa felix
Gigantochloa hasskarliana
Gigantochloa hirtinoda
Gigantochloa holttumiana
Gigantochloa kuring
Gigantochloa latifolia
Gigantochloa levis
Gigantochloa ligulata
Gigantochloa longiprophylla
Gigantochloa luteostriata
Gigantochloa macrostachya
Gigantochloa magentea
Gigantochloa manggong
Gigantochloa membranoidea
Gigantochloa multiculmis
Gigantochloa nigrociliata
Gigantochloa papyracea
Gigantochloa poilanei
Gigantochloa pruriens
Gigantochloa pubipetiolata
Gigantochloa ridleyi
Gigantochloa robusta
Gigantochloa rostrata
Gigantochloa scortechinii
Gigantochloa serik
Gigantochloa taluh
Gigantochloa thoi
Gigantochloa tomentosa
Gigantochloa velutina
Gigantochloa verticillata
Gigantochloa vietnamica
Gigantochloa vinhphuica
Glaziophyton mirabile
Greslania rivularis
Guadua amplexifolia
Guadua angustifolia
Guadua calderoniana
Guadua chacoensis
Guadua latifolia
Guadua longifolia
Guadua macclurei
Guadua macrostachya
Guadua paniculata
Guadua paraguayana
Guadua refracta
Guadua sarcocarpa
Guadua superba
Guadua tagoara
Guadua trinii
Guadua velutina
Guadua virgata
Guadua weberbaueri
Gynerium sagittatum
Himalayacalamus asper
Himalayacalamus brevinodus
Himalayacalamus collaris
Himalayacalamus cupreus
Himalayacalamus falconeri
Himalayacalamus fimbriatus
Himalayacalamus hookerianus
Himalayacalamus porcatus
Holttumochloa magica
Hymenachne pernambucensis (= Panicum pernambucense)
Hyparrhenia coriacea
Hyparrhenia cyanescens
Hyparrhenia cymbaria
Hyparrhenia dichroa
Hyparrhenia diplandra
Hyparrhenia gossweileri
Hyparrhenia madaropoda
Hyparrhenia rudis
Hyparrhenia schimperi
Hyparrhenia subplumosa
Hyparrhenia variabilis
Hyperthelia colobantha
Hyperthelia cornucopiae
Hyperthelia dissoluta
Hyperthelia edulis
Indocalamus bashanensis
Indocalamus guangdongensis
Indocalamus hirsutissimus
Indocalamus hirtivaginatus
Indocalamus petelotii
Indocalamus pseudosinicus
Indocalamus quadratus
Indocalamus tessellatus
Indosasa angustata
Indosasa bacquangensis
Indosasa crassiflora
Indosasa gigantea
Indosasa glabrata
Indosasa hispida
Indosasa ingens
Indosasa lipoensis
Indosasa longispicata
Indosasa lunata
Indosasa parvifolia
Indosasa patens
Indosasa singulispicula
Indosasa sinica
Indosasa sondongensis
Indosasa spongiosa
Indosasa triangulata
Ischaemum amethystinum
Kinabaluchloa nebulosa
Kinabaluchloa wrayi
Kuruna densifolia (= Arundinaria densifolia)
Kuruna walkeriana (= Arundinaria wightiana)
Leymus condensatus
Loudetia flammida
Loudetia phragmitoides
Loudetiopsis thoroldii
Melocanna arundina
Melocanna baccifera
Merostachys abadiana
Merostachys annulifera
Merostachys argentea
Merostachys brevispica
Merostachys burmanii
Merostachys calderoniana
Merostachys ciliata
Merostachys claussenii
Merostachys filgueirasii
Merostachys kunthii
Merostachys lanata
Merostachys latifolia
Merostachys leptophylla
Merostachys magellanica
Merostachys maguireorum
Merostachys medullosa
Merostachys multiramea
Merostachys neesii
Merostachys petiolata
Merostachys pilifera
Merostachys polyantha
Merostachys retrorsa
Merostachys riedeliana
Merostachys skvortzovii
Merostachys sparsiflora
Merostachys speciosa
Merostachys ternata
Miscanthus ecklonii
Miscanthus floridulus
Miscanthus fuscus
Miscanthus junceus
Miscanthus lutarioriparius
Miscanthus violaceus
Muhlenbergia gigantea
Muhlenbergia mutica
Muhlenbergia robusta
Myriocladus cardonae
Myriocladus churunensis
Myriocladus distantiflorus
Myriocladus exsertus
Myriocladus grandifolius
Myriocladus longiramosus
Myriocladus paludicola
Myriocladus virgatus
Nastus elatoides
Nastus elatus
Neohouzeaua helferi
Neohouzeaua kerriana
Neohouzeaua mekongensis
Neohouzeaua stricta
Neohouzeaua tavoyana
Neololeba amahussana (= Bambusa amahussana)
Neololeba hirsuta
Neyraudia arundinacea
Neyraudia curvipes
Neyraudia reynaudiana
Ochlandra ebracteata
Ochlandra keralensis
Ochlandra scriptoria
Ochlandra setigera
Ochlandra spirostylis
Ochlandra stridula
Ochlandra talbotii
Ochlandra travancorica (= Ochlandra sivagiriana)
Oldeania alpina (= Yushania alpina)
Oligostachyum gracilipes
Oligostachyum hupehense
Oligostachyum lanceolatum
Oligostachyum lubricum
Oligostachyum nuspiculum
Oligostachyum oedogonatum
Oligostachyum paniculatum
Oligostachyum scopulum
Oligostachyum shiuyingianum
Oligostachyum spongiosum
Oligostachyum sulcatum
Oligostachyum wuyishanicum
Olmeca clarkiae (= Aulonemia clarkiae)
Oryza grandiglumis
Oryza latifolia
Otatea acuminata (= Otatea aztecorum)
Otatea fimbriata
Otatea glauca
Oxytenanthera abyssinica

Panicum petersonii
Panicum tamaulipense
Paspalum cinerascens
Paspalum haumanii
Paspalum turriforme
Pentameris thuarii
Perrierbambus madagascariensis
Perrierbambus tsarasaotrensis
Phacelurus gabonensis
Phaenosperma globosum
Phragmites australis
Phragmites karka
Phragmites mauritianus
Phyllosasa tranquillans
Phyllostachys acuta
Phyllostachys angusta
Phyllostachys arcana
Phyllostachys atrovaginata
Phyllostachys aurea
Phyllostachys aureosulcata
Phyllostachys bissetii
Phyllostachys carnea
Phyllostachys circumpilis
Phyllostachys dulcis
Phyllostachys edulis
Phyllostachys elegans
Phyllostachys fimbriligula
Phyllostachys flexuosa
Phyllostachys glabrata
Phyllostachys glauca
Phyllostachys incarnata
Phyllostachys iridescens
Phyllostachys kwangsiensis
Phyllostachys lofushanensis
Phyllostachys makinoi
Phyllostachys mannii
Phyllostachys meyeri
Phyllostachys nidularia
Phyllostachys nigella
Phyllostachys nigra (= Phyllostachys guizhouensis)
Phyllostachys nuda
Phyllostachys parvifolia
Phyllostachys platyglossa
Phyllostachys prominens
Phyllostachys propinqua
Phyllostachys reticulata
Phyllostachys rivalis
Phyllostachys robustiramea
Phyllostachys rubicunda
Phyllostachys rutila
Phyllostachys shuchengensis
Phyllostachys stimulosa
Phyllostachys sulphurea
Phyllostachys tianmuensis
Phyllostachys varioauriculata
Phyllostachys veitchiana
Phyllostachys verrucosa
Phyllostachys violascens
Phyllostachys virella
Phyllostachys viridiglaucescens
Phyllostachys vivax
Phyllostachys yunhoensis
Pleioblastus altiligulatus
Pleioblastus amarus
Pleioblastus argenteostriatus (= Arundinaria chino)
Pleioblastus gramineus (= Arundinaria graminea)
Pleioblastus hsienchuensis
Pleioblastus incarnatus
Pleioblastus kodzumae (= Arundinaria kodzumae)
Pleioblastus linearis (= Arundinaria linearis)
Pleioblastus maculatus
Pleioblastus matsunoi (= Arundinaria matsunoi)
Pleioblastus rugatus
Pleioblastus sanmingensis
Pleioblastus simonii (= Arundinaria simonii)
Pleioblastus solidus
Pleioblastus truncatus
Pleioblastus wuyishanensis
Pleioblastus yixingensis
Pseudosasa aeria
Pseudosasa amabilis
Pseudosasa japonica
Pseudosasa longiligula
Pseudosasa maculifera
Pseudosasa nabeshimana
Pseudosasa orthotropa
Pseudosasa subsolida
Pseudosasa viridula
Pseudosasa wuyiensis
Pseudoxytenanthera ritcheyi
Pseudoxytenanthera stocksii
Racemobambos novohibernica
Rhipidocladum bartlettii
Rhipidocladum clarkiae
Rhipidocladum harmonicum
Rhipidocladum pacuarense
Rhipidocladum panamense
Rhynchoryza subulata
Saccharum × sinense
Saccharum alopecuroides
Saccharum arundinaceum
Saccharum asperum
Saccharum beccarii
Saccharum bengalense
Saccharum giganteum
Saccharum longisetosum
Saccharum maximum
Saccharum narenga
Saccharum officinarum
Saccharum procerum
Saccharum ravennae
Saccharum robustum
Saccharum rufipilum
Saccharum spontaneum
Saccharum stewartii
Saccharum wardii
Sarocalamus spanostachyus (= Arundinaria spanostachya)
Sasa palmata (= Sasa cernua)
Sasa suzukii
Sasa tomentosa
Sasa tsuboiana
Sasaella bitchuensis (= Sasa bitchuensis)
Sasaella masamuneana (= Sasa masamuneana)
Schizostachyum aequiramosum
Schizostachyum andamanicum
Schizostachyum atrocingulare
Schizostachyum auriculatum
Schizostachyum bamban
Schizostachyum beddomei
Schizostachyum blumei
Schizostachyum brachycladum
Schizostachyum castaneum
Schizostachyum caudatum
Schizostachyum copelandii
Schizostachyum coradatum (= Neohouzeaua coradata)
Schizostachyum cuspidatum
Schizostachyum diffusum
Schizostachyum distans
Schizostachyum dumetorum
Schizostachyum flexuosum
Schizostachyum funghomii
Schizostachyum glaucifolium
Schizostachyum glaucocladum
Schizostachyum gracile
Schizostachyum grande
Schizostachyum griffithii
Schizostachyum hainanense
Schizostachyum hantu
Schizostachyum insulare
Schizostachyum iraten
Schizostachyum jaculans
Schizostachyum kalpongianum
Schizostachyum khoonmengii
Schizostachyum latifolium
Schizostachyum lengguanii
Schizostachyum lima
Schizostachyum lumampao
Schizostachyum lutescens
Schizostachyum mampouw
Schizostachyum pergracile (= Cephalostachyum pergracile)
Schizostachyum perrieri
Schizostachyum pilosum
Schizostachyum pseudolima
Schizostachyum rogersii
Schizostachyum silicatum
Schizostachyum tessellatum
Schizostachyum zollingeri
Semiarundinaria fastuosa
Semiarundinaria fortis
Semiarundinaria kagamiana
Semiarundinaria shapoensis
Semiarundinaria sinica
Semiarundinaria yashadake
Setaria grandis
Setaria megaphylla
Sinobambusa baccanensis
Sinobambusa farinosa
Sinobambusa henryi
Sinobambusa incana
Sinobambusa intermedia
Sinobambusa nephroaurita
Sinobambusa solearis
Sinobambusa tootsik
Sinobambusa yixingensis
Sorghum × almum
Sorghum amplum
Sorghum arundinaceum
Sorghum bicolor
Sorghum exstans
Sorghum grande
Sorghum intrans
Sorghum macrospermum
Sorghum plumosum
Sorghum propinquum
Sorghum stipoideum
Spodiopogon lacei
Sporobolus cynosuroides
Sporobolus elatior
Sporobolus maximus
Stipa gigantea
Suddia sagittifolia
Thamnocalamus spathiflorus
Themeda caudata
Themeda cymbaria
Themeda gigantea
Themeda intermedia
Themeda novoguineensis
Themeda villosa
Thyrsostachys oliveri
Thyrsostachys siamensis
Thysanolaena latifolia
Triodia lanosa (= Symplectrodia lanosa)
Triodia longiloba
Triodia pascoeana
Triodia plectrachnoides
Tripsacum australe
Tripsacum cundinamarce
Tripsacum dactyloides
Tripsacum intermedium
Tripsacum jalapense
Tripsacum latifolium
Tripsacum laxum
Tripsacum pilosum
Trisetum virletii
Urelytrum giganteum
Valiha diffusa
Vietnamocalamus catbaensis
Yushania addingtonii
Yushania ailuropodina
Yushania anceps
Yushania bojieiana
Yushania brevipaniculata
Yushania burmanica
Yushania cartilaginea
Yushania cava
Yushania collina
Yushania complanata
Yushania crassicollis
Yushania crispata
Yushania dafengdingensis
Yushania elegans
Yushania elevata
Yushania exilis
Yushania falcatiaurita
Yushania farcticaulis
Yushania farinosa
Yushania flexa
Yushania glandulosa
Yushania glauca
Yushania grammata
Yushania hirsuta
Yushania humbertii
Yushania lacera
Yushania laetevirens
Yushania levigata
Yushania lineolata
Yushania longiuscula
Yushania maculata
Yushania madagascariensis
Yushania maling
Yushania menghaiensis
Yushania mitis
Yushania multiramea
Yushania niitakayamensis
Yushania oblonga
Yushania pauciramificans
Yushania perrieri
Yushania rolloana
Yushania shangrilaensis
Yushania straminea
Yushania tessellata
Yushania velutina
Yushania vigens
Yushania wardii
Yushania wuyishanensis
Yushania xizangensis
Yushania yadongensis
Zea luxurians
Zea mays
Zea mexicana
Zea nicaraguensis
Zeugites hackelii
Zizania palustris
Zizaniopsis bonariensis
Zizaniopsis killipii
Zizaniopsis microstachya
Zizaniopsis miliacea

Online Resource 2

Additional information regarding Risk Assessment schemes (RAs) used to evaluate tall-statured grasses (TSGs)

Risk Assessment schemes (RAs) are often a modified version of the Australian Weed Risk Assessment model (A-WRA) developed by Pheloung et al. (1999). A number of RAs were used by several authors to evaluate the impact potential of TSG on all continents, i.e. AWRAM (Aquatic Weed Risk Assessment Model by Champion et al., 2010); C-WRA (Canada Weed Risk Assessment, modified version of the original A-WRA to evaluate alien plants in Canada by McClay et al. (2010); H-WRA (Hawaiian Weed Risk Assessment, a modified version of the original A-WRA to evaluated the ecosystems of Hawaii and the Pacific Islands by Daehler et al. (2004)); I-WRA (Italian Weed Risk Assessment, modified of the original A-WRA to evaluate alien plants in Tuscany, Italy by Lazzaro et al. (2016)); J-WRA (Japanese Weed Risk Assessment, modified version of the original A-WRA to evaluate alien plants in Japan by Nishida et al. (2009)); US-WRA (U.S Weed Risk Assessment, modified version of the original A-WRA for separate evaluation at the state and national scales in US by Gordon et al. (2011)); USAqWRA (US Aquatic Weed Risk Assessment, modified version of the original A-WRA to evaluate alien aquatic plants in the USA by Gordon et al. (2012), then applied in South America by Lozano et al. (2018)); WRA-ChAr (Weed Risk Assessment-Chile-Argentina, modified version of the original A-WRA to evaluate alien plants in Chile and Argentina by Fuentes et al. (2010); M-WRA (Mediterranean Weed Risk Assessment, modified version of the original A-WRA to evaluate alien plants in Spain by Gassó et al. (2010)); WG-WRA (Risk Assessment for Central Europe developed by Weber et al. (2004)), also we considered the information from EPPO PRA (EPPO Pest Risk Analysis); PRE (Plant Risk Evaluation to evaluated the invasive potential to ornamental plants developed by Conser et al. (2015)); PPQ WRA (Weed Risk Assessment Plant Protection and Quarantine, US Department of Agriculture, to evaluate the risk potential of plants, including those newly detected in the USA) and ODA PRA (Oregon Department of Agriculture Plant Pest Risk Assessment. This Risk Assessment was modified by ODA from the USDA-APHIS Risk Assessment for the introduction of new plant species. The potential risk scores obtained from the RA schemes represent an outcome that classify different categories of invasion in the endangered area, e.g. HR (High Risk), EF (Evaluate Further), or LR (Low Risk). Accept, Reject or Evaluate. Invasive, Minor Concern (MC) or Lower Priority (LP). The higher the value (ranking for each RA), the greater the species invasiveness. In some cases a secondary screening was used i.e. if the species was classified as Evaluate Further by the main model, it undergoes a secondary screening process that focuses on a few factors that will be predictive of risk potential. Following secondary evaluation, species may be classified as HR (High Risk) or LR (Low Risk), Accepted or Reject.

References

Conser C, Seebacher L, Fujino DW, et al. (2015) The development of a plant risk evaluation (PRE) tool for assessing the invasive potential of ornamental plants. PLoS ONE 10:e0121053

Daehler CC, Denslow JS, Ansari S, et al. (2004) A risk-assessment system for screening out invasive pest plants from Hawaii and other Pacific islands. Conservation biology 18:360-368

Fuentes N, Ugarte E, Kühn I, et al. (2010) Alien plants in southern South America. A framework for evaluation and management of mutual risk of invasion between Chile and Argentina. Biological Invasions 12:3227-3236

Gassó N, Basnou C, Vila M (2010) Predicting plant invaders in the Mediterranean through a weed risk assessment system. Biological Invasions 12:463-476

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Gordon DR, Tancig KJ, Onderdonk DA, et al. (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass and Bioenergy 35:74-79

Lazzaro L, Foggi B, Ferretti G, et al. (2016) Priority invasive alien plants in the Tuscan Archipelago (Italy): comparing the EPPO prioritization scheme with the Australian WRA. Biological invasions 18:1317-1333
Lozano V, Brundu G (2018) Prioritisation of aquatic invasive alien plants in South America with the US Aquatic Weed Risk Assessment. Hydrobiologia 812:115-130
McClay A, Sissons A, Wilson C, et al. (2010) Evaluation of the Australian weed risk assessment system for the prediction of plant invasiveness in Canada. Biological Invasions 12:4085-4098
Nishida T, Yamashita N, Asai M, et al. (2009) Developing a pre-entry weed risk assessment system for use in Japan. Biological invasions 11:1319
Pheloung PC, Williams PA, Halloy SR (1999) A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. Journal of Environmental Management 57:239-251
Weber E, Gut D (2004) Assessing the risk of potentially invasive plant species in central Europe. Journal for Nature Conservation 12:171-179

Online Resource 4. The frequency of tall-statured grasses (TSGs) and non-TSGs in terms of their naturalisation success. Data are the number of species within categories that are reported as naturalised in at least one region of the world (n=843) in the GloNAF database (see van Kleunen et al. 2015 for details). Mean number ± S.E. of regions from which the species is recorded as naturalised is shown for species that appear in the GloNAF database. Note that the group of bamboos refers to species within the Bambuseae and Arundinarieae tribes; "other grasses" are species in all other grass tribes.

	Stature	Number of species			Percentage naturalised	Number of regions where naturalised
		Naturalised	Not naturalised	Total		
All grasses	TSG	106	823	929	11.4%	16.0±3.4
	non-TSG	1120	8769	9889	11.3%	20.7±1.2
Woody bamboos	TSG	57	692	749	7.6%	7.2±2.0
	non-TSG	8	394	402	2.0%	2.2±0.6
Other grasses	TSG	49	131	180	27.2%	26.3±6.7
	non-TSG	1112	8375	9487	11.7%	20.8±1.2

Scientific name	Common name	Risk Assessment scheme	Endangered area	Score	Evaluation (RA outcome)	TSG Purposes/Uses in the endangered area	References
Andropogon bicornis L.	West Indian foxtail grass	H-WRA	Hawaii	18	HR		http://www.hear.org/pier/wra/pacific/Andropogon_bicornis_PMC.pdf
Andropogon gayanus Kunth	Gamba grass	A-WRA	Australia	8	Reject		http://www.hear.org/pier/wra/australia/angay-wra.htm
Arundo donax L.	Giant Reed	A-WRA	Australia	4	EF	Biofuel feedstock	Barney JN, DiTomaso JM (2008) Nonnative species and bioenergy: are we cultivating the next invader?
Arundo donax L.	Giant Reed	WRA-ChAr	Argentina and Chile	12	Reject	Bioenergy crops species. Biofuel use: Ethanol	Buddenhagen CE, Chimera C, Clifford P (2009) Assessing biofuel crop invasiveness: a case study. PLoS One 4:e5261.; Fuentes N, Ugarte E, Kühn I, Klotz S (2010) Alien plants in southern South America. A framework for evaluation and management of mutual risk of invasion between Chile and Argentina. Biol Invasions 12:3227–3236. doi: 10.1007/s10530-010-9716-9; Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed
Arundo donax L.	Giant Reed	PRE	U.S	14	Reject	Ornamental	Conser C, Seebacher L, Fujino DW, et al (2015) The Development of a Plant Risk Evaluation (PRE) Tool for Assessing the Invasive Potential of Ornamental Plants. PloS One 10:e0121053.
Arundo donax L.	Giant Reed	M-WRA	Mediterranean region (Spain)	8	—	Cultivated, multi-purposes species	Gassó N, Basnou C, Vila M (2010) Predicting plant invaders in the Mediterranean through a weed risk assessment system. Biol Invasions 12:463–476.
Arundo donax L.	Giant Reed	H-WRA	Bonin Islands (Japan)	19	Reject	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Arundo donax L.	Giant Reed	US-WRA	U.S (Florida)	11	Reject	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Arundo donax L.	Giant Reed	H-WRA	Hawaii	12	Reject	Bioenergy crops species. Biofuel use: Ethanol	https://gd.eppo.int/reporting/article-249; http://www.hear.org/pier/wra/pacific/arundo_donax_htmlwra.htm
Arundo donax L.	Giant Reed	PPQ WRA	U.S and Canada	13; 3.3 *	HR	Biofuel use: Ethanol	https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Arundo_donax_WRA.pdf
Arundo donax L.	Giant Reed	EPPO P	Tuscan (Italy)	—	INV		Lazzaro L, Foggi B, Ferretti G, Brundu G (2016) Priority invasive alien plants in the Tuscan Archipelago (Italy): comparing the EPPO prioritization scheme with the Australian WRA. Biol Invasions 18:1317–1333.
Arundo donax L.	Giant Reed	I-WRA	Tuscan (Italy)	12	Reject		Lazzaro L, Foggi B, Ferretti G, Brundu G (2016) Priority invasive alien plants in the Tuscan Archipelago (Italy): comparing the EPPO prioritization scheme with the Australian WRA. Biol Invasions 18:1317–1333.
Arundo donax L.	Giant Reed	USAqWRA	South America	69	Reject	Cultivated	Lozano V, Brundu G (2016) Prioritisation of aquatic invasive alien plants in South America with the US Aquatic Weed Risk Assessment. Hydrobiologia 1–16.
Arundo donax L.	Giant Reed	WG-WRA	Central Europe	37	HR	Biofuel crops	Weber E, Gut D (2004) Assessing the risk of potentially invasive plant species in central Europe. J Nat Conserv
Bambusa bambos (L.) Voss	Thorny Bamboo	H-WRA	Tanzania	6	EF	Cultivated	Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Bambusa chungii McClure	Emperors blue bamboo	H-WRA	Hawaii	-1	LR	Cultivated/Ornamental	http://www.hear.org/pier/wra/pacific/bambusa_chungii_htmlwra.htm
Bambusa glaucophylla Widjaja	Malay dwarf bamboo	H-WRA	Hawaii	-3	LR	Ornamental	http://www.hear.org/pier/wra/pacific/bambusa_glaucophylla_htmlwra.htm
Bambusa lako Widjaja	Timor black bamboo	H-WRA	Hawaii	-1	LR		http://www.hear.org/pier/wra/pacific/bambusa_lako_htmlwra.htm
Bambusa lako Widjaja	Timor black bamboo	US-WRA	U.S (Florida)	1	EF		http://www.hear.org/wra/tncflwra/pdfs/tncflwra_bambusa_lako_gg.pdf
Bambusa multiplex (Lour.) Raeusch. ex Schult.	Chinese dwarf bamboo	H-WRA	Bonin Islands (Japan)	9	Reject		Clout MN, Kawamichi M, De Poorter M, Iwatsuki K (2006) Assessment and control of biological invasion risks.
Bambusa multiplex (Lour.) Raeusch. ex Schult.	Chinese dwarf bamboo	PRE	U.S	10	Accept	Ornamental	Conser C, Seebacher L, Fujino DW, et al (2015) The Development of a Plant Risk Evaluation (PRE) Tool for Assessing the Invasive Potential of Ornamental Plants. PloS One 10:e0121053.
Bambusa multiplex (Lour.) Raeusch. ex Schult.	Chinese dwarf bamboo	H-WRA	Hawaii	5	EF	Cultivated/Ornamental	http://www.hear.org/pier/wra/pacific/Bambusa_multiplex_CGC.pdf
Bambusa oldhamii Munro	Oldhamii Bamboo	PRE	U.S	7	Accept	Ornamental	Conser C, Seebacher L, Fujino DW, et al (2015) The Development of a Plant Risk Evaluation (PRE) Tool for Assessing the Invasive Potential of Ornamental Plants. PloS One 10:e0121053.
Bambusa oldhamii Munro	Oldhamii Bamboo	H-WRA	Hawaii	1	EF	Ornamental	http://www.hear.org/pier/wra/pacific/bambusa_oldhamii_htmlwra.htm
Bambusa oliveriana Gamble	Bush bamboo	H-WRA	Hawaii	-2	LR	Ornamental	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Bambusa pervariabilis McClure	Puntingpole bamboo	H-WRA	Hawaii	-4	LR	Ornamental	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Bambusa textilis McClure	Weaver's bamboo	H-WRA	Hawaii	-3	LR		http://www.hear.org/pier/wra/pacific/bambusa_textilis_htmlwra.htm
Bambusa tuldoides Munro	Buddha Belly Bamboo	H-WRA	Hawaii	2	EF	Ornamental	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Bambusa vulgaris Schrad.	Common Bamboo	H-WRA	Bonin Islands (Japan)	6	EF		Clout MN, Kawamichi M, De Poorter M, Iwatsuki K (2006) Assessment and control of biological invasion risks.
Bambusa vulgaris Schrad.	Common Bamboo	H-WRA	Tanzania	3	EF		Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Bambusa vulgaris Schrad.	Common Bamboo	WRA-ChAr	Argentina and Chile	18	Reject		Fuentes N, Ugarte E, Kühn I, Klotz S (2010) Alien plants in southern South America. A framework for evaluation and management of mutual risk of invasion between Chile and Argentina. Biol Invasions
Bambusa vulgaris Schrad.	Common Bamboo	H-WRA	Hawaii	5	LR (2°)		http://www.hear.org/pier/wra/pacific/bambusa_vulgaris_htmlwra.htm
Cephalostachyum pergracile Munro	Tinwa bamboo	H-WRA	Hawaii	0	LR	Ornamental	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Chimonobambusa quadrangularis (Fenzl) Makino		H-WRA	Tanzania	9	Reject	Cultivated	Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Chrysopogon zizanioides (fertile) (L.) Roberty	Vetiver grass wild type	H-WRA	Hawaii	9	HR		http://www.hear.org/pier/wra/pacific/chrysopogon_zizanioides_fertile_htmlwra.htm
Chrysopogon zizanioides (L.) Roberty	Vetivergrass	H-WRA	Bonin Islands (Japan)	-6	Accept		Clout MN, Kawamichi M, De Poorter M, Iwatsuki K (2006) Assessment and control of biological invasion risks.
Chrysopogon zizanioides (L.) Roberty	Vetivergrass	H-WRA	Tanzania	-9	Accept		Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Chrysopogon zizanioides 'Sunshine' (L.) Roberty	Vetiver grass 'Sunshine'	H-WRA	Hawaii	-8	LR		http://www.hear.org/pier/wra/pacific/chrysopogon_zizanioides_sunshine_htmlwra.htm
Cortaderia jubata (Lemoine ex Carrière) Stapf	Purple Pampas Grass	PRE	U.S	20	Reject	Ornamental	Conser C, Seebacher L, Fujino DW, et al (2015) The Development of a Plant Risk Evaluation (PRE) Tool for Assessing the Invasive Potential of Ornamental Plants. PloS One 10:e0121053.
Cortaderia jubata (Lemoine ex Carrière) Stapf	Purple Pampas Grass	H-WRA	Hawaii	17	Reject	Ornamental	Daehler, C.C. and D.A. Carino. 2000. Predicting invasive plants: Prospects for a general screening system based on current regional models. Biological Invasions 2: 92-103.
Cortaderia jubata (Lemoine ex Carrière) Stapf	Purple pampas grass	A-WRA	Australia	22	Reject		http://www.hear.org/pier/wra/australia/cojub-wra.htm
Cortaderia jubata (Lemoine ex Carrière) Stapf	Purple pampas grass	H-WRA	Hawaii	26	HR		http://www.hear.org/pier/wra/pacific/cortaderia_jubata_htmlwra.htm
Cortaderia jubata (Lemoine ex Carrière) Stapf	Purple pampas grass	PPQ WRA	U.S	17; 4.1 *	HR		https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Cortaderia_jubata_WRA.pdf
Cortaderia jubata (Lemoine ex Carrière) Stapf	Purple Pampas Grass	WG-WRA	Spain	32	HR	Ornamental	Pheloung P, Williams P, Halloy S (1999) A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. J Environ Manage 57:239–251.; Weber E, Gut D (2004) Assessing the risk of potentially invasive plant species in central Europe. J Nat Conserv 12:171–179.; https://gd.eppo.int/reporting/article-478
Cortaderia jubata (Lemoine ex Carrière) Stapf	Purple Pampas Grass	WRA	Spain	20	Subjected to import prohibition		Pheloung P, Williams P, Halloy S (1999) A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. J Environ Manage 57:239–251.; Weber E, Gut D (2004) Assessing the risk of potentially invasive plant species in central Europe. J Nat Conserv 12:171–179.; https://gd.eppo.int/reporting/article-478
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	Pampas Grass	PRE	U.S	20	Reject	Ornamental	Conser C, Seebacher L, Fujino DW, et al (2015) The Development of a Plant Risk Evaluation (PRE) Tool for Assessing the Invasive Potential of Ornamental Plants. PloS One 10:e0121053.
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	Pampas Grass	M-WRA	Mediterranean region (Spain)	26	—		Gassó N, Basnou C, Vila M (2010) Predicting plant invaders in the Mediterranean through a weed risk assessment system. Biol Invasions 12:463–476.
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	Pampas Grass	RAP	Ireland	15	MD		http://invasivespeciesireland.com/toolkit/risk-assessment/amber-list-recorded-species/
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	Silver pampas grass	A-WRA	Australia	24	Reject		http://www.hear.org/pier/wra/australia/cosel-wra.htm
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	Silver pampas grass	H-WRA	Hawaii	24	HR		http://www.hear.org/pier/wra/pacific/cortaderia_selloana_htmlwra.htm; http://www.hear.org/pier/wra/pacific/cortaderia_selloana_htmlwra.htm
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	Pampas grass	EPPO P	EPPO region	—	LP	Horticulture	https://gd.eppo.int/taxon/CDTSE/categorization; https://gd.eppo.int/reporting/article-1963
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	Pampas grass	PPQ WRA	U.S	15; 4.3 *	HR	Cultivated/Ornamental	https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Cortaderia_selloana_WRA.pdf
Cymbopogon martini (Roxb.) W.Watson	Ginger grass, Palmarosa	H-WRA	Hawaii	5	LR		https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Dendrocalamus asper (Schult.) Backer	Giant bamboo	H-WRA	Hawaii	-3	LR		http://www.hear.org/pier/wra/pacific/Dendrocalamus%20asper.pdf
Dendrocalamus asper (Schult.) Backer (= Gigantochloa aspera)	Giant Bamboo	H-WRA	Tanzania	2	EF		Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Dendrocalamus brandisii (Munro) Kurz	Velvetleaf bamboo	H-WRA	Hawaii	2	EF		https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Dendrocalamus sikkimensis Gamble ex Oliv.	Philippine sweet shoot bamboo	H-WRA	Hawaii	0	LR	Ornamental	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Dendrocalamus strictus (Roxb.) Nees	Male Bamboo	H-WRA	Tanzania	4	EF		Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Drepanostachyum falcatum (Nees) Keng f.	Blue bamboo	US-WRA	U.S (Florida)	-3	Accept	Cultivated	http://www.hear.org/wra/tncflwra/pdfs/tncflwra_drepanostachyum_falcatum_ispm.pdf
Drepanostachyum khasianum (Munro) Keng f.	Khasia bamboo	H-WRA	Hawaii	0	LR	Cultivated/Ornamental	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Echinochloa polystachya (Kunth) Hitchc.	Aleman grass	A-WRA	Australia	13	Reject		http://www.hear.org/pier/wra/australia/ecpol-wra.htm
Echinochloa pyramidalis (Lam.) Hitchc. & Chase	Antelope grass	PPQ WRA	U.S	13; 3.5 *	HR	Cultivated	https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Echinochloa_pyramidalis_WRA.pdf
Echinochloa pyramidalis (Lam.) Hitchc. & Chase	Antelope grass	PPQ WRA	U.S	52.8	—	Cultivated	Labrada R, Officer FW (2002) The need for weed risk assessment. EXPERT Consult WEED RISK Assess 1.
Fargesia fungosa T.P.Yi	Chocolate bamboo	H-WRA	Hawaii	-4	LR		https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Fargesia nitida (Mitford) Keng f. ex T.P.Yi	Blue Fountain Bamboo	PRE	U.S	3	Accept	Ornamental	Conser C, Seebacher L, Fujino DW, et al (2015) The Development of a Plant Risk Evaluation (PRE) Tool for Assessing the Invasive Potential of Ornamental Plants. PloS One 10:e0121053.
Fargesia nitida (Mitford) Keng f. ex T.P.Yi	Blue Fountain Bamboo	US-WRA	U.S (Florida)	-4	Accept	Ornamental	http://www.hear.org/wra/tncflwra/pdfs/tncflwra_fargesia_nitida_ispm.pdf
Gigantochloa apus (Schult.) Kurz	Gigantochloa	H-WRA	Tanzania	4	EF		Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Gigantochloa apus (Schult.) Kurz	Tabashir bamboo	H-WRA	Hawaii	2	LR (2°)	Ornamental	http://www.hear.org/pier/wra/pacific/Gigantochloa%20apus.pdf
Gigantochloa atroviolacea Widjaja	Sweet bamboo, pring legi	H-WRA	Hawaii	-2	LR	Cultivated	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Gigantochloa atter (Hassk.) Kurz	Sweet bamboo	H-WRA	Hawaii	-3	LR		http://www.hear.org/pier/wra/pacific/Gigantochloa%20atter.pdf
Gigantochloa robusta Kurz	Robust bamboo	H-WRA	Hawaii	-4	LR		http://www.hear.org/pier/wra/pacific/Gigantochloa%20robusta.pdf
Guadua angustifolia Kunth	Guadua, Columbian thorny bamboo	H-WRA	Hawaii	5	EF	Multiple uses	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments
Hymenachne amplexicaulis (Rudge) Nees	Hymenachne	A-WRA	Australia	21	Reject		http://www.hear.org/pier/wra/australia/hyamp-wra.htm
Miscanthus floridulus (Labill.) Warb. ex K.Schum. & Lauterb.	Giant miscanthus	H-WRA	Hawaii	18	HR	Cultivated/Ornamental	http://www.hear.org/pier/wra/pacific/Miscanthus_floridulus_revised.pdf
Miscanthus sinensis Andersson	Chinese silvergrass	A-WRA	Spain	15	LR		Andreu J, Vila M, Hulme PE (2009) An assessment of stakeholder perceptions and management of noxious alien plants in Spain. Environ Manage 43:1244–1255.
Miscanthus sinensis Andersson	Chinese silvergrass	M-WRA	Mediterranean region (Central Italy)	11	Reject	Biofuel	Crosti R, Cascone C, Cipollaro S (2010) Use of a weed risk assessment for the Mediterranean region of Central Italy to prevent loss of functionality and biodiversity in agro-ecosystems. Biol Invasions 12:1607–1616.
Miscanthus sinensis Andersson	Chinese silvergrass	WRA-ChAr	Argentina and Chile	11	Reject		Fuentes N, Ugarte E, Kühn I, Klotz S (2010) Alien plants in southern South America. A framework for evaluation and management of mutual risk of invasion between Chile and Argentina. Biol Invasions
Miscanthus sinensis Andersson	Chinese silvergrass	US-WRA	U.S (Florida)	14	Reject	Horticulture	http://www.hear.org/wra/tncflwra/pdfs/tncflwra_miscanthus_sinensis_ispm.pdf
Miscanthus sinensis Andersson	Chinese silvergrass	WG-WRA	Spain	24	IR		https://gd.eppo.int/reporting/article-478. Andreu and Vila 2010
Miscanthus sinensis Andersson	Chinese silvergrass	EPPO P	EPPO region	—	Alert list	Biofuel crops used in Hungary	https://gd.eppo.int/taxon/MISSI/categorization
Miscanthus sinensis Andersson	Chinese silvergrass	C-WRA	Canada	13	—		McClay A, Sissons A, Wilson C, Davis S (2010) Evaluation of the Australian weed risk assessment system for the prediction of plant invasiveness in Canada. Biol Invasions 12:4085–4098. doi: 10.1007/s10530-010-9819-3
Miscanthus sinensis Andersson	Chinese silvergrass	J-WRA	Japan	20	—		Nishida T, Yamashita N, Asai M, et al (2009) Developing a pre-entry weed risk assessment system for use in Japan. Biol Invasions 11:1319–1333. doi: 10.1007/s10530-008-9340-0

Miscanthus x giganteus	Miscanthus	A-WRA	U.S	-2	Accept	Bioenergy crops species	Barney JN, DiTomaso JM (2008) Nonnative species and bioenergy: are we cultivating the next invader?
Miscanthus x giganteus	Miscanthus	US-WRA	U.S	-9	Accept	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Miscanthus x giganteus	Miscanthus	US-WRA	U.S (Florida)	-8	Accept	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Nastus elatus Holttum	New Guinea edible bamboo	H-WRA	Hawaii	2	LR (2°)		http://www.hear.org/pier/wra/pacific/nastus_elatus_htmlwra.htm
Neyraudia reynaudiana (Kunth) Keng ex Hitchc.	Burma reed	US-WRA	U.S (Florida)	11	Reject		http://www.hear.org/wra/tncflwra/pdfs/tncflwra_neyraudia_reynaudiana_ispm.pdf
Neyraudia reynaudiana (Kunth) Keng ex Hitchc.	Burma reed	PPQ WRA	U.S	7; 1.9 *	HR		Koop AL, Fowler L, Newton LP, Caton BP (2012) Development and validation of a weed screening tool for the United States. Biol Invasions 14:273–294.
Neyraudia reynaudiana (Kunth) Keng ex Hitchc.	Burma reed	WRA	U.S	12	Reject		Koop AL, Fowler L, Newton LP, Caton BP (2012) Development and validation of a weed screening tool for the United States. Biol Invasions 14:273–294.
Otatea aztecorum (McClure & E.W.Sm.) C.E.Calderón ex Soderstr.	Mexican weeping bamboo	H-WRA	Hawaii	4	LR (2°)	Cultivated	http://www.hear.org/pier/wra/pacific/otatea_aztecorum_htmlwra.htm
Cenchrus americanus (L.) Morrone (=Pennisetum glaucum)	Pearl millet	H-WRA	Hawaii	3	LR (2°)	Cultivated	http://www.hear.org/pier/wra/pacific/pennisetum_glaucum_htmlwra.htm
Cenchrus macrourum Trin.	African feathergrass	A-WRA	Australia	26	Reject		http://www.hear.org/pier/wra/australia/pemac-wra.htm
Cenchrus purpureus Schumach. (= Pennisetum purpureum)	Elephantgrass	A-WRA	Australia	10	Reject	Bioenergy crops species. Biofuel use: Ethanol	Andreu J, Vila M, Hulme PE (2009) An assessment of stakeholder perceptions and management of noxious alien plants in Spain. Environ Manage 43:1244–1255.
Cenchrus purpureus Schumach. (= Pennisetum purpureum)	Elephantgrass	H-WRA	Hawaii	16	Reject	Bioenergy crops species. Biofuel use: Ethanol	Buddenhagen et al. 2009 ; Gordon et al. 2011
Cenchrus purpureus Schumach. (= Pennisetum purpureum)	Elephantgrass	US-WRA	U.S	18	Reject	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Cenchrus purpureus Schumach. (= Pennisetum purpureum)	Elephantgrass	US-WRA	U.S (Florida)	18	Reject	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Cenchrus purpureus Schumach. (= Pennisetum purpureum)	Elephantgrass	H-WRA	Bonin Islands (Japan)	18	Reject	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.; http://www.hear.org/wra/tncflwra/pdfs/tncuswra_pennisetum_purpureum_2010.pdf
Phragmites australis (Cav.) Trin. ex Steud.	Common Reed	AWRAM	New Zealand	75	Managed for eradication nationally		Champion PD, Clayton JS, Hofstra DE (2010) Nipping aquatic plant invasions in the bud: weed risk assessment and the trade. Hydrobiologia 656:167–172. doi: 10.1007/s10750-010-0446-x
Phragmites australis (Cav.) Trin. ex Steud.	Common Reed	WRA-ChAr	Argentina and Chile	23	Reject		Fuentes N, Ugarte E, Kühn I, Klotz S (2010) Alien plants in southern South America. A framework for evaluation and management of mutual risk of invasion between Chile and Argentina. Biol Invasions
Phragmites australis subsp. australis	Common Reed	ODA PRA I	U.S (Oregon)	49	Noxius weed	Horticulture	https://www.oregon.gov/ODA/shared/Documents/Publications/Weeds/PlantPestRiskAssessmentPhragmities_
Phragmites australis subsp. australis	Common Reed	ODA PRA II	U.S (Oregon)	15	Noxius weed	Horticulture	https://www.oregon.gov/ODA/shared/Documents/Publications/Weeds/PlantPestRiskAssessmentPhragmities_
Phyllostachys aurea Rivière & C.Rivière	Golden bamboo	H-WRA	Bonin Islands (Japan)	12	Reject		Clout MN, Kawamichi M, De Poorter M, Iwatsuki K (2006) Assessment and control of biological invasion risks.
Phyllostachys aurea Rivière & C.Rivière	Golden Bamboo	H-WRA	Tanzania	6	EF		Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Phyllostachys aurea Rivière & C.Rivière	Golden bamboo	H-WRA	Hawaii	9	HR	Ornamental	http://www.hear.org/pier/wra/pacific/Phyllostachys_aurea_PMC.pdf
Phyllostachys aurea Rivière & C.Rivière	Golden bamboo	PPQ WRA	U.S	8; 3.2 *	HR	Cultivated/Ornamental	https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Phyllostachys_aurea_WR
Phyllostachys aureosulcata McClure	Yellow groove bamboo	PPQ WRA	U.S	5; 2.6 *	EF	Cultivated/Ornamental	https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Phyllostachys_aureosulcata_WRA.pdf
Phyllostachys nigra (Lodd. ex Lindl.) Munro	Black Bamboo	H-WRA	Tanzania	8	Reject	Cultivated	Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Phyllostachys nigra (Lodd. ex Lindl.) Munro	Black Bamboo	H-WRA	Hawaii	12	HR	Ornamental	http://www.hear.org/pier/wra/pacific/Phyllostachys_nigra.pdf
Pseudosasa japonica (Steud.) Makino	Arrow bamboo	H-WRA	Bonin Islands (Japan)	12.5	Reject		Clout MN, Kawamichi M, De Poorter M, Iwatsuki K (2006) Assessment and control of biological invasion risks.
Saccharum arundinaceum Retz.	Plume Grass	US-WRA	U.S (Florida)	3	Accept (2°)	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Saccharum officinarum L.	Sugarcane	H-WRA	Hawaii	-2	Accept	Bioenergy crops species. Biofuel use: Ethanol	Buddenhagen CE, Chimera C, Clifford P (2009) Assessing biofuel crop invasiveness: a case study. PLoS One 4:e5261.; Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy
Saccharum officinarum L.	Sugarcane	US-WRA	U.S (Florida)	5	Accept (2°)	Bioenergy crops species. Biofuel use: Ethanol	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Saccharum officinarum L.	Sugarcane	H-WRA	Bonin Islands (Japan)	5	Reject (2°)	Bioenergy crops species. Biofuel use: Ethanol	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.; http://www.hear.org/wra/tncflwra/pdfs/tncuswra_pennisetum_purpureum_2010.pdf
Saccharum ravennae (L.) L.	Ravenna Grass	PRE	U.S	18	Reject	Ornamental	Conser C, Seebacher L, Fujino DW, et al (2015) The Development of a Plant Risk Evaluation (PRE) Tool for Assessing the Invasive Potential of Ornamental Plants. PloS One 10:e0121053.
Saccharum spontaneum L.	Wild sugarcane	H-WRA	Hawaii	17	HR		http://www.hear.org/pier/wra/pacific/saccharum_spontaneum_htmlwra.htm
Schizostachyum brachycladum (Kurz) Kurz	Sacred Bali bamboo	H-WRA	Hawaii	-1	LR		http://www.hear.org/pier/wra/pacific/schizostachyum_brachycladum_htmlwra.htm
Schizostachyum dullooa (Gamble) R.B.Majumdar		H-WRA	Tanzania	-1	Accept	Cultivated	Dawson W, Burslem DF, Hulme PE (2009) The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. Biol Conserv 142:1018–1024.
Schizostachyum glaucifolium (Rupr.) Munro	Hawaiian bamboo	H-WRA	Hawaii	0	LR		http://www.hear.org/pier/wra/pacific/schizostachyum_glaucifolium_htmlwra.htm
Sorghum bicolor (L.) Moench	Sweet Sorghum	M-WRA	Mediterranean region (Italy)	6	Reject (2°)	Bioenergy crops species. Biofuel	Crosti R, Cascone C, Cipollaro S (2010) Use of a weed risk assessment for the Mediterranean region of Central Italy to prevent loss of functionality and biodiversity in agro-ecosystems. Biol Invasions 12:1607–1616.
Sorghum bicolor (L.) Moench	Sweet Sorghum	A-WRA	Australia	3	EF	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Sorghum bicolor (L.) Moench	Sweet Sorghum	US-WRA	U.S	3	Accept	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Sorghum bicolor (L.) Moench	Sweet Sorghum	US-WRA	U.S (Florida)	2	Accept	Bioenergy crops species	Gordon D, Tancig K, Onderdonk D, Gantz C (2011) Assessing the invasive potential of biofuel species proposed for Florida and the United States using the Australian Weed Risk Assessment. Biomass Bioenergy 35:74–79.
Sorghum bicolor (L.) Moench	Sweet Sorghum	H-WRA	Hawaii	6	LR	Cultivated	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments_
Sorghum bicolor (L.) Moench	Sweet Sorghum	PPQ WRA	U.S	21; 2.6 *	HR	Bioenergy crops species	https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/sorghum-bicolor-
Sorghum bicolor (L.) Moench	Sweet Sorghum	EPPO P	Tuscan (Italy)	—	MC		Lazzaro L, Foggi B, Ferretti G, Brundu G (2016) Priority invasive alien plants in the Tuscan Archipelago (Italy): comparing the EPPO prioritization scheme with the Australian WRA. Biol Invasions 18:1317–1333.
Sorghum bicolor (L.) Moench	Sweet Sorghum	A-WRA	Tuscan (Italy)	6	Reject		Lazzaro L, Foggi B, Ferretti G, Brundu G (2016) Priority invasive alien plants in the Tuscan Archipelago (Italy): comparing the EPPO prioritization scheme with the Australian WRA. Biol Invasions 18:1317–1333.
Sorghum bicolor subsp. drummondii (Nees ex Steud.) de Wet ex Davidse	Shattercane	H-WRA	Hawaii	17.5	HR	Cultivated	https://sites.google.com/site/weedriskassessment/assessments/Download-Assessments_
Zea mays L.	Corn	M-WRA	Mediterranean region (Central Italy)	-1	Accept	Biofuel	Crosti R, Cascone C, Cipollaro S (2010) Use of a weed risk assessment for the Mediterranean region of Central Italy to prevent loss of functionality and biodiversity in agro-ecosystems. Biol Invasions 12:1607–1616.
Zea mays L. subsp. mays	Corn	PPQ WRA	U.S	1; 1.2 *	EF	Cultivated	https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Zea-mays-subsp-mays.pdf
Zea mays L. subsp. mays (GM herbicide resistant)	Corn	PPQ WRA	U.S	2; 2.4 *	EF	Cultivated	https://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/downloads/wra/Zea-mays-subsp-mays.pdf

A-WRA	Australian Weed Risk Assessment system Pheloung 1999
AWRAM	Aquatic Weed Risk Assessment Model
C-WRA	Canada Weed Risk Assessment
EPPO P	EPPO Prioritization process
H-WRA	Daehler et al. (2004) further developed the A-WRA specifically for the tropical ecosystems of Hawaii and the Pacific Islands (hereafter H-WRA).
I-WRA	Italy Weed Risk Assesment
J-WRA	Japan Weed Risk Assesment
M-WRA	Mediterranean Weed Risk Assessment
ODA PRA	Oregon Department of Agriculture Plant Pest Risk Assessment. This Risk Assessment was modified by ODA from the USDA-APHIS Risk Assessment for the
ODA PRA I	Oregon Department of Agriculture. Noxious Qualitative Weed Risk Assessment version 3.8
ODA PRA II	Oregon Department of Agriculture. Noxious Weed Rating System version 3.2
PPQ WRA	Plant Protection and Quarantine Weed Risk Assessment
PRE	Plant Risk Evaluation
RAP	Risk analysis and prioritisation for invasive and non-native species in Ireland and Northern Ireland
USAqWRA	US Aquatic Weed Risk Assessment
US-WRA	United States Weed Risk Assesment
WG-WRA	Risk Assessment for Central Europe developed by Weber & Gut (2004)
WRA	Weed Risk Assessment
WRA-ChAr	Modified version of the Australian Weed Risk Assessment method to evaluate alien plants in Chile and Argentina (hereafter WRA-ChAr)

*	first number: **Score for Establishment/Spread**. Second number: **Score for Establishment/Spread Potential**
EF	Evaluate further
HR	High risk
INV	Invasive
IR	Intermediate risk
LP	Lower priority / List of Invasive Alien Plants
LR	Low risk
LR(2°)	LR(second screen): Pacific and Florida (U.S.) risk assessments with scores between 1 and 6 are subject to a second screen to determine a recommendation.The screening system initially recommended further evaluation for 24% of these species, but an additional secondary screening was applied to this group, thereby reducing the rate of indecision to only 8%.
(2°)	(second screen): http://www.hear.org/pier/wra/second_screen.htm
MC	Minor concern