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Weed Risk Assessment for *Nassella neesiana* (Trin. & Rupr.) Barkworth (Poaceae) – Chilean needlegrass

Left: Infestation of *N. neesiana* in Australia (source: Southern Tablelands and South Coast Noxious Plants Committee; Anonymous, 2013). Right: Seeds of *N. neesiana* with awn still attached (source: Tracey Slotta, USDA-ARS; NRCS, 2013).

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Introduction Plant Protection and Quarantine (PPQ) regulates noxious weeds under the authority of the Plant Protection Act (7 U.S.C. § 7701-7786, 2000) and the Federal Seed Act (7 U.S.C. § 1581-1610, 1939). A noxious weed is defined as "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment" (7 U.S.C. § 7701-7786, 2000). We use weed risk assessment (WRA)—specifically, the PPQ WRA model (Koop et al., 2012)—to evaluate the risk potential of plants, including those newly detected in the United States, those proposed for import, and those emerging as weeds elsewhere in the world.

Because the PPQ WRA model is geographically and climatically neutral, it can be used to evaluate the baseline invasive/weed potential of any plant species for the entire United States or for any area within it. As part of this analysis, we use a stochastic simulation to evaluate how much the uncertainty associated with the analysis affects the model outcomes. We also use GIS overlays to evaluate those areas of the United States that may be suitable for the establishment of the plant. For more information on the PPQ WRA process, please refer to the document, *Background information on the PPQ Weed Risk Assessment*, which is available upon request.

Nassella neesiana **(Trin. & Rupr.) Barkworth. – Chilean needlegrass**

Species Information

Family: Poaceae

Synonyms: *Stipa neesiana* Trin. & Rupr. (Barkworth, 1990; NGRP, 2013). Although the latest treatment of this group of grasses places this species in *Nassella* (Barkworth, 1990), some workers continue to call it *Stipa neesiana* (e.g., EPPO, 2013; Vidal et al., 2011).

Initiation: *Nassella neesiana* was added to the EPPO Alert List in 2009 (EPPO, 2013). This species causes numerous impacts in Australia and is widely regulated there (Bourdôt et al., 2012). PPQ initiated this WRA because we are concerned it may have similar impacts here. APHIS currently regulates a congener, *Nassella trichotoma*, as a Federal Noxious Weed.

Foreign distribution: This species is native to the South American countries of Argentina, Brazil, Bolivia, Chile, Ecuador, Paraguay, Peru, and Uruguay (NGRP, 2013). It has been introduced to and naturalized in Australia, New Zealand, the United Kingdom, and France (NGRP, 2013).

U.S. distribution and status: This species was detected on ballast in Mobile, Alabama on or prior to 1953 (USDA-FS, 1953). It is currently listed as established by USDA PLANTS and the BONAP databases in that county (Kartesz, 2013; NRCS, 2013), but a taxonomic evaluation of the Stipeae (Poaceae) in the United States notes that it has not been collected for some time (Barkworth, 1993). This suggests that it has not established in the United States. An online post from a master gardener program in California notes that *N. neesiana* is invasive and is being phased out of cultivation by the nursery industry, suggesting that this species has been cultivated in the United States, at least on a very minor scale (Geisel, 2011). However, we did not find any other information to support cultivation in the United States.

WRA area[1]: Entire United States, including territories.

1. *Nassella neesiana* analysis

Establishment/Spread Potential *Nassella neesiana* is widely recognized as an invasive species (AWC, 2013) and possesses numerous traits that contribute to its ability to establish and spread. This species produces large numbers of seeds in the grass canopy, in the axils of its inflorescences, and at the base of stems (Gardener et al., 2003a; Grech et al., 2006; Storrie and Lowien, 2003). These later seed locations help ensure some reproduction even if the plant loses most of its aboveground biomass (Gardener et al., 2003a). Seeds readily attach to animal fur (Gardener et al., 2003a); disperse on field equipment (Grech et al., 2010); contaminate hay, wool, hides, and seeds for planting (Haywood and Druce, 1919; Slay et al., 1999; Weller et al., 2012); and disperse in floodwaters (Bourdôt et al., 2012). Seeds can form a persistent seed bank in the soil that requires years of management to deplete (Faithfull et al., 2012; Gardener et al., 2003b). In addition, plants are self-compatible and form dense populations (Faithfull, 2012; Vidal et al., 2011). Some populations in New Zealand have become resistant to one type of herbicide (Heap, 2013). Our uncertainty was very low due to the amount of research done on this species in Australia and New Zealand.

Risk score = 23 Uncertainty index = 0.04

Impact Potential *Nassella neesiana* invades open woodlands, grasslands, and pastures. In natural systems, it reduces native species diversity indirectly by colonizing disturbed areas and preventing natives from reestablishing (Faithfull et al., 2010). It also reduces soil moisture in invaded sites, leading to one hypothesis that it impacts hydrology beyond invaded patches (Faithfull, 2012). This species is “perhaps the most serious environmental weed in remnant native grasslands in southern Victoria ... and poses a major threat to the conservation of this endangered ecosystem" (Morgan and Lunt, 1999). In agricultural systems, *N. neesiana* greatly reduces the carrying capacity of pastures when it is blooming because the inflorescences are not palatable to livestock (Gardener et al., 2003a; Snell and Grech, 2008). Furthermore, the sharp seeds wound animals and leads to the downgrading of wool, skins

[1] “WRA area” is the area in relation to which the weed risk assessment is conducted [definition modified from that for “PRA area” (IPPC, 2012).

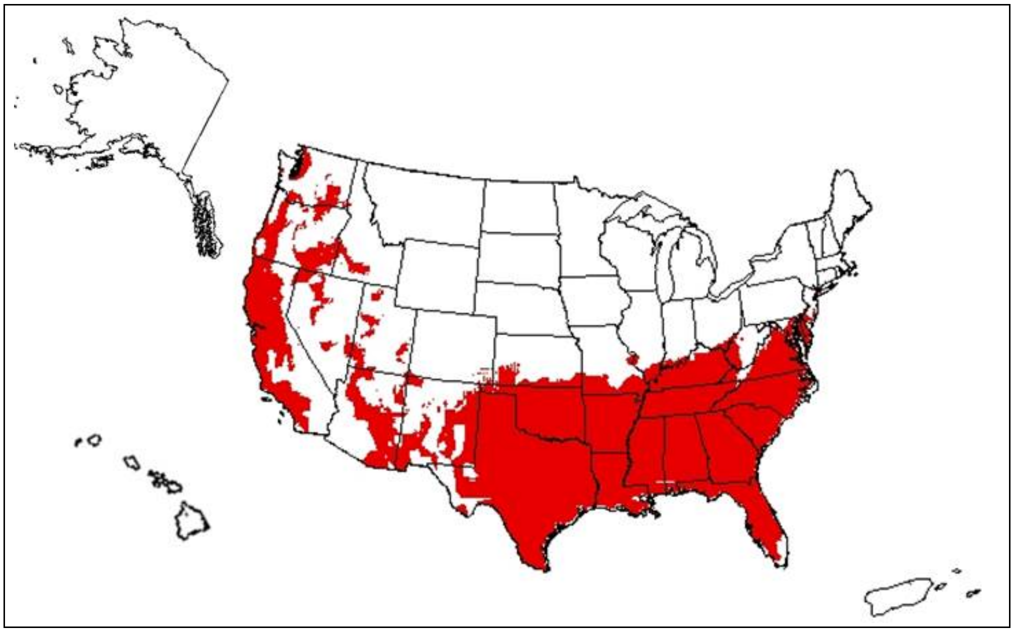
(hides), and carcasses (Bourdôt, 2010; Bourdôt et al., 2012; Gardener et al., 2003a; Storrie and Lowien, 2003). Because of these impacts and others, *N. neesiana* is widely recognized as a major weed and is managed in production, natural, and anthropogenic systems. It is regulated in Australia and listed as a Weed of National Significance (The University of Queensland, 2013). We had slightly less than average uncertainty.
Risk score = 4.3 Uncertainty index = 0.13

Geographic Potential Based on three climatic variables, we estimate that about 32 percent of the United States is suitable for the establishment of *N. neesiana* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *N. neesiana* represents the joint distribution of Plant Hardiness Zones 7-11, areas with 10-70 inches of annual precipitation, and the following Köppen-Geiger climate classes: steppe, Mediterranean, marine west coast, and humid subtropical. *Nassella neesiana* inhabits grasslands, grassy woodlands, rocky outcrops, and pastures (McLaren et al., 2004). In Europe, this species is usually found on well-drained soils (Verloove, 2005), but it tolerates sites subject to seasonal waterlogging (McLaren et al., 2004). This species may also survive in drier regions such as deserts in protected microhabitats. However, we did not consider deserts in our evaluation, as there were only a few points for this region (GBIF, 2013) and they could have been misidentifications. Furthermore, this species does not appear to possess any major adaptations for living in extremely dry environments. A separate climate matching analysis using CLIMEX identified the southeastern United States and the western U.S. coast to be climatically suitable for establishment (not shown). Under global warming scenarios, the percent of suitable U.S. area is expected to decrease, but shift northwards (Bourdôt et al., 2012).

The area estimated likely represents a conservative estimate as it only uses three climatic variables. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish.

Entry Potential Because we did not find strong evidence that *N. neesiana* is currently naturalized or cultivated in the United States (see above), we evaluated its entry potential. We found some evidence this species is cultivated elsewhere (Bourdôt et al., 2012) and is positively valued (Vidal et al., 2011), so it may be intentionally introduced as a plant for planting. *Nassella neesiana* may also enter as a contaminant through several other pathways, including hay, seeds for planting, machinery, clothing, wool, hides, and ship ballast (Gardener et al., 2003a; Haywood and Druce, 1919; Slay et al., 1999; Verloove, 2005; Weller et al., 2012).
Risk score = 0.36 Uncertainty index = 0.37

Figure 1. Predicted distribution of *Nassella neesiana* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.



2. Results and Conclusion

Model Probabilities: P(Major Invader) = 98.0%
P(Minor Invader) = 2.0%
P(Non-Invader) = 0.1%

Risk Result = High Risk

Secondary Screening = Not Applicable

Figure 2. *Nassella neesiana* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

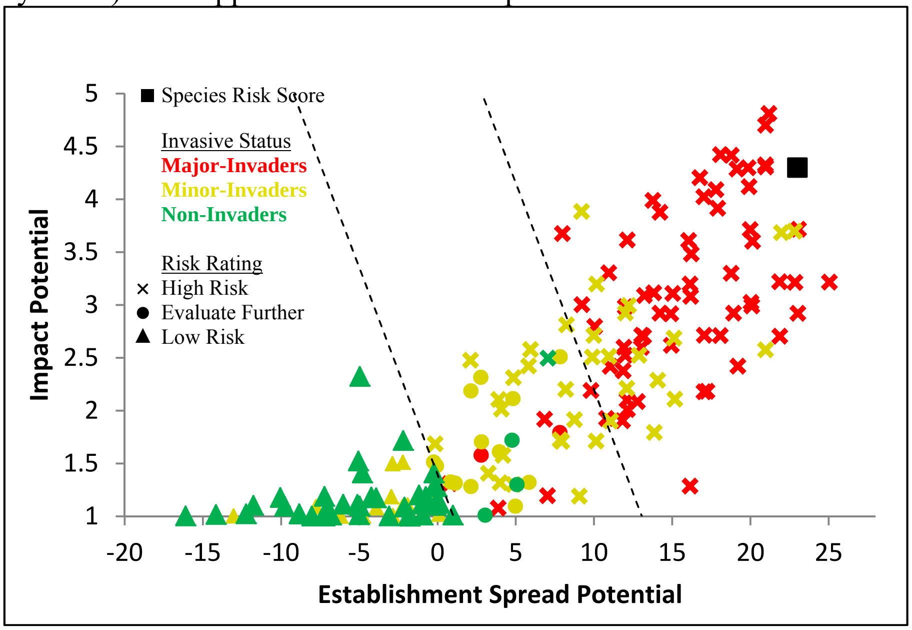
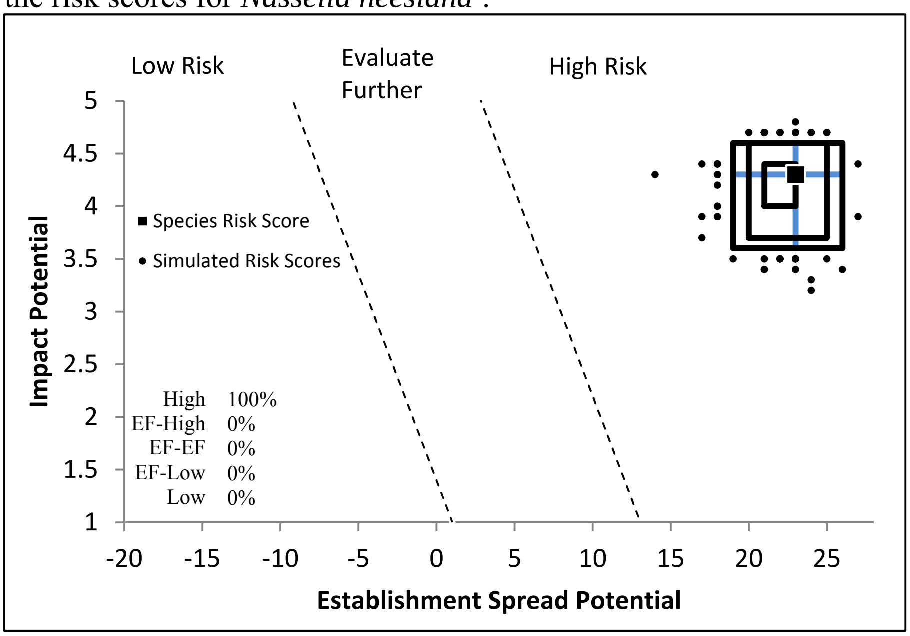


Figure 3. Monte Carlo simulation results (N=5,000) for uncertainty around the risk scores for *Nassella neesiana*[a].



[a] The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *N. neesiana* is High Risk (Fig. 2). Given the overall low level of uncertainty associated with this assessment, and the extreme level of risk presented by the species (Fig. 3), we are very confident in this result. Evaluation with the Australian weed risk assessment system also led to a similar conclusion (Champion, 2005).

In Australia and New Zealand, *Nassella neesiana* is widely recognized as a significant weed because it harms agricultural and natural resources (AWC, 2013; Bell, 2006; McLaren et al., 2002; Weller et al., 2012), and injures livestock (Bourdôt, 2010; Bourdôt et al., 2012; Gardener et al., 2003a; Storrie and Lowien, 2003). A recent review suggests that it does not readily invade healthy grasslands; rather, it depends on disturbance events for establishment (Faithfull et al., 2012). *Nassella neesiana* is difficult to eradicate once established due to the long-lived seed bank and the seeds that develop in the flowering stems and at the base of the plant (Gardener et al., 1999). Management is challenging because this species is only readily detectable when it is in flower (Fox et al., 2009). New infestations can be managed with some persistence (Storrie and Lowien, 2003). For established populations, control can be achieved if using an integrated system of cropping, herbicide application, and grazing strategies (Gardener et al., 1999; Storrie and Lowien, 2003). Researchers developing a surveillance protocol for *N. neesiana* showed that current surveillance and management efforts in Australia are insufficient to eradicate the plant (Fox et al., 2009).

We recommend that risk managers consider the risk posed not only by this species, but by other *Nassella* species. Several other species are considered weedy and problematic (Champion, 2005; EPPO, 2013; Mabberley, 2008; McLaren et al., 1998; McLaren et al., 2004; Randall, 2007). *Nassella neesiana*, *N. mucronata*, and *N. poeppigiana* are often confused and misidentified in Europe (Verloove, 2005).

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Appendix A. Weed risk assessment for *Nassella neesiana* (Trin. & Rupr.) (Poaceae). The following information came from the original risk assessment, which is available upon request (full responses and all guidance). We modified the information to fit on the page.

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 (Status/invasiveness outside its native range)	f - negl	5	This species is native to South America in the countries of Argentina, Brazil, Bolivia, Chile, Ecuador, Paraguay, Peru, and Uruguay (NGRP, 2013). Introduced to Belgium and casual in the early part of the 20th century, but last known record is from 1915 (Verloove, 2006). Casual or naturalized in England (Stace, 2010). Present in France, Italy, Portugal, and Spain (Brunel et al., 2010). Naturalized and spreading in France (Brunel et al., 2010) and present since 1847 (Haywood and Druce, 1919). Naturalized and spreading in Australia (Fox et al., 2009; McLaren et al., 2002; Randall, 2007; Ross and Walsh, 2003), where in some area infestations populations expanded at 5 to 7.5 meters per year (Faithfull et al., 2012). Widespread in southeastern Australia (Richardson et al., 2006). Fully naturalized in New Zealand (Champion, 2005) and spreading into new areas, while prior infestations are becoming denser (Bell, 2006). Alternate answers for the Monte Carlo simulation were both "e."
ES-2 (Is the species highly domesticated)	n - negl	0	Cultivated (Geisel, 2011; Randall, 2012). Cultivated in Europe as an ornamental grass (Bourdôt et al., 2012), but we found no evidence that this species has been bred to reduce weed potential. Because this species is very well studied, we used negligible uncertainty.
ES-3 (Weedy congeners)	y - negl	1	*Nassella* is a genus with about 116 warm and tropical American species; many are distributed in the Andes (Mabberley, 2008). *Nassella tennussima* and *N. trichotoma* are naturalized, invasive, and considered noxious weeds in Australia, New Zealand, and South Africa (Mabberley, 2008; Randall, 2007). *Nassella charruana* and *N. hyalina* are also regulated in Australia (Randall, 2007). "*Nassella* spp. produce distinctive sharp seeds that causes injury to stock and downgrades wool, skins and hides. These seeds can damage pelts, ruin sheep fleeces, blind livestock, and can penetrate the skin and hives and move through to the underlying muscle and cause abscesses. The same threat is posed to humans, which could suffer mechanical injury and subsequent secondary infection" (Champion, 2005). *Nassella trichotoma* has serious impacts in agriculture and the environment (McLaren et al., 1998), along with several other species which are regulated in Australia (McLaren et al., 2004).
ES-4 (Shade tolerant at some stage of its life cycle)	n - low	0	Over-shading from other grass species that have a higher growth rate is a recommended management strategy (Faithfull et al., 2012; Slay et al., 1999). Evidence indicates competition from other grasses slows the invasion of *N. neesiana* (Lunt and Morgan, 2000).
ES-5 (Climbing or smothering growth form)	n - negl	0	A perennial, tussock-forming grass to one meter tall (Brunel et al., 2010).
ES-6 (Forms dense thickets)	y - negl	2	Forms dense infestations with a cover of about 60 percent (Faithfull, 2012). Dense infestations may completely dominate pastures (Brunel et al., 2010). Can form dense, continuous clumps (cited in Fox et al., 2009). A dense infestation was reported by

Question ID	Answer - Uncertainty	Score	Notes (and references)
			Gardener et al. (1999). Although sometimes it is found in restricted numbers, it is able to build up into dense stands and spread (Verloove, 2005). In a large survey of land managers in southeastern Australia, many reported dense infestations (McLaren et al., 2002).
ES-7 (Aquatic)	n - negl	0	Species is a terrestrial, clumping grass (Vidal et al., 2011).
ES-8 (Grass)	y - negl	1	Species is a grass (NGRP, 2013).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	The Poaceae family is not known to contain any nitrogen-fixing species (Martin and Dowd, 1990), and this perennial clumping grass is not woody (Vidal et al., 2011).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	Spreads by seeds (Grech et al., 2010). Reproduces and spreads via seeds (Fox et al., 2009; Snell and Grech, 2008).
ES-11 (Self-compatible or apomictic)	y - negl	1	Species is autogamous and exhibits a selfing rate of close to 100 percent (Vidal et al., 2011). Produces cleistogenes (seeds produced through cleistogamy, see definition in ES-12) in flowering stem joints where they are often concealed by leaf sheaths (Richardson et al., 2006).
ES-12 (Requires special pollinators)	n - negl	0	Because it produces cleistogenes through cleistogamy (production of self-pollinated flowers that do not open) (Gardener et al., 1999; Richardson et al., 2006), this species does not require specialist pollinators.
ES-13 (Minimum generation time)	b - low	1	Juvenile plants can produce 250 seeds in their first year (Fox et al., 2009). Plants can flower in their first season (Storrie and Lowien, 2003). A perennial clumping grass (Barkworth, 1990). Alternate answers for the Monte Carlo simulation were both "c."
ES-14 (Prolific reproduction)	y - negl	1	Seed production is variable with some estimates as low as 1,600 seeds per square meter, but can be as high as 20,000 to 30,000 in a good season (Gardener et al., 2003a; Grech et al., 2006; Storrie and Lowien, 2003). In an experiment, ungrazed plots produced 960 cleistogenes per square meter (Grech et al., 2006). 75-90 percent of panicle seeds are viable (Gardener et al., 2003a; Grech et al., 2006). Cleistogenes mature about four weeks after panicle flowers and account for up to 25 percent of total seed production. This species is well adapted to variable rainfall and seems capable of producing some seeds even during drought years (Gardener et al., 2003a). In one year in Australia, it had two flowering episodes (Gardener et al., 2003a).
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	Commonly spreads through mowing and slashing operations (Grech et al., 2010). Spreads along roads by vehicles (Fox et al., 2009; Snell and Grech, 2008). Dispersal and establishment is promoted by ongoing land management practices (references in Faithfull et al., 2012). Seeds readily adhere to clothing and can be dispersed on farm machinery (Brunel et al., 2010). Spreads on vehicles (Storrie and Lowien, 2003).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - negl	2	Introduced to the Waipawa area of New Zealand in contaminated pasture seed (Slay et al., 1999). Moves in hay bales (Weller et al., 2012). Because it is similar in appearance to desirable hay species in the vegetative state, it may be overlooked by managers (Weller et al., 2012). Present in Genoa, Italy, near leather tanning facilities that processed hides from Argentina (Haywood and Druce, 1919). First found in France at Port Juvenal (Haywood and Druce, 1919). Several taxa of *Nassella* are wool adventives in Europe (Verloove, 2005).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17 (Number of natural dispersal vectors)	3	2	Fruit and seed description for ES17a - ES17e: Fruit is a caryopsis (i.e., a grain), 4-5 mm long (Verloove, 2005). Caryopsis with a long twisted awn attached (Barkworth, 1990). The sharp and pointed callus, which is attached to the caryopsis, has backward pointing hairs which aid in dispersal (Gardener et al., 2003a).
ES-17a (Wind dispersal)	n - mod		Seeds are not readily dispersed by wind (Bourdôt et al., 2012). In one experiment, the maximum dispersal distance due to wind was 2.8 meters (Gardener et al., 2003a). Most seeds fall to the ground; wind dispersal appears to be almost negligible (Storrie and Lowien, 2003). For those reasons, we answered no with moderate uncertainty.
ES-17b (Water dispersal)	y - low		Seeds may be dispersed by floodwater (Bourdôt et al., 2012). Species invades stream banks and has been observed to spread along water courses in Australia (Fox et al., 2009). A dispersal kernel for water dispersal was estimated with a distance parameter of 750 meters (Fox et al., 2009). Although this species does not possess obvious adaptations for water dispersal and is not restricted to riparian habitats, given the evidence discussed here we answered yes with low uncertainty.
ES-17c (Bird dispersal)	n - low		We found no evidence, and the species is well studied.
ES-17d (Animal external dispersal)	y - negl		The seeds readily bore into the skins of animals (Haywood and Druce, 1919), and seeds often disperse on wool, hides and animal carcasses (Bourdôt et al., 2012). The backward pointing hairs on the apex of the seed help anchor seeds on animal fur (Storrie and Lowien, 2003). Seeds can fall from fleece several months later; after five months, unshorn sheep still had 10 percent of seeds remaining (Gardener et al., 2003a).
ES-17e (Animal internal dispersal)	y - high		In an experiment, 1.7 percent of panicle seeds and 5.3 percent of cleistogenes ingested were passed through the digestive system undamaged (Gardener et al., 2003a). 30.3 percent of the recovered panicle seeds were viable, of which 2.5 percent germinated. Fifty percent of the cleistogenes were viable, of which 26.7 percent germinated (Gardener et al., 2003a). Thus, seven cleistogenes in a 1000 are expected to germinate, but more may germinate later because seeds have an after-ripening period that may extend for up to a year (Gardener et al., 2003b). The authors concluded that seeds do not spread to any great extent through ingestion (Gardener et al., 2003a). Although these rates are low, we answered yes with high uncertainty because some dispersal may occur among an entire herd of cattle, particularly when seeds may be excreted within four days of ingestion (Gardener et al., 2003a).
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - negl	1	A seed burial experiment confirmed long-term persistence in the soil (Gardener et al., 2003b). Modeling suggests seeds may survive for 12 years buried in the soil (Gardener et al., 2003b). Biannual herbicidal treatments are needed for at least four years in native grasslands to reduce the soil seed bank (Faithfull et al., 2012).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - low	1	Adult plants are very hardy, surviving heavy grazing and drought (McLaren et al., 2002; Storrie and Lowien, 2003). Under three levels of flower tiller clipping, cleistogenes were still produced (Gardener et al., 2003a). Cleistogenes may mature up to four weeks after panicle seeds (Gardener et al., 2003a). The authors concluded that reducing cleistogene production through

Question ID	Answer - Uncertainty	Score	Notes (and references)
			defoliation is difficult and that management techniques designed to control other grasses won't work on this species; only when plants are killed prior to panicle production can cleistogene production be halted (Gardener et al., 2003a). Basal cleistogenes, those that are often below the soil surface, are still produced even if the tiller was cut just above the soil surface (Gardener et al., 1999). Based on this species' ability to reproduce despite clipping and management, we answered yes.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	y - negl	1	"In 1990, resistance to 2,2-DPA was identified at Waipawa ... necessitating the development of alternative control strategies" (Slay et al., 1999). Species has developed resistance to Group N/26 herbicides in New Zealand (Heap, 2013). Mature cleistogenes are not easily killed by herbicides (Pritchard, 2004).
ES-21 (Number of cold hardiness zones suitable for its survival)	5	0	
ES-22 (Number of climate types suitable for its survival)	4	2	
ES-23 (Number of precipitation bands suitable for its survival)	6	0	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	We found no evidence, and the species is well studied.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence. Species is a grass (NGRP, 2013) in the family Poaceae, which is not known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	y - high	0.4	Soil surface moisture was typically near zero under *N. neesiana* (a C_3 grass) relative to 10 percent under a native C_4 grass in Australian grasslands (Faithfull et al., 2010). Based on work done by others on the reduction of runoff and stream flow by invasive C_3 grasses (see summary in Faithfull et al., 2010), the authors speculate that large patches of *N. neesiana* may affect biodiversity well beyond the areas where it has invaded. "*Nassella neesiana* alters ecohydrological features of grasslands with probable positive feedbacks on its own success, and these changes also probably have off-site biodiversity impact" (Faithfull, 2012).
Imp-N2 (Change community structure)	n - mod	0	We found no evidence. "It dominates the canopy in many invaded native grasslands, although its morphology, biomass and phenology is similar to some of the major native grasses that it replaces. The invaded systems remain as grasslands, and other effects it may cause are poorly known" (Faithfull, 2012).
Imp-N3 (Change community composition)	y - negl	0.2	Reduces native plant species richness in Australian grasslands with greater impacts on forbs than grasses (Faithfull et al., 2010), and reductions are correlated with patch size (Faithfull, 2012). *Nassella neesiana* patches are associated with significantly less insect species richness in the fall than in native grasslands outside the patches (Faithfull et al., 2010). "Investigations of the mechanisms of invasion indicate that much of the diversity impact is attributable to prior disturbances that result in death of the native vegetation and enables *N. neesiana* to invade, including senescence dieback of *T. triandra* – critical invasion drivers most

Question ID	Answer - Uncertainty	Score	Notes (and references)
			probably include major soil disturbance, overgrazing by livestock and short mowing of the vegetation" (Faithfull et al., 2010). Although this last finding suggests that *N. neesiana* does not reduce native species diversity directly, large and presumably older patches of this species continue to have a negative impact on plant biodiversity (Faithfull et al., 2010).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	y - mod	0.1	It invades natural and protected areas in the Canary Islands and rocky slopes in river valleys in France and Italy (Verloove, 2005). Because of that and the potential effects on species richness discussed above, we think it can affect threatened and endangered species.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	y - high	0.1	"*Nassella neesiana* is perhaps the most serious environmental weed in remnant native grasslands in southern Victoria ... and poses a major threat to the conservation of this endangered ecosystem" (Morgan and Lunt, 1999). Globally outstanding ecoregions occur in the regions where this species may establish in the United States (Ricketts et al., 1999).
Imp-N6 (Weed status in natural systems)	c - negl	0.6	Occurs along creeks (Richardson et al., 2006). Riparian weed (Snell and Grech, 2008). Weed of the natural environment in Australia (Faithfull et al., 2012; Randall, 2007). Controlled in native grasslands in Australia; in fact, specific control methodologies have been developed that consider its biology and ability to invade during disturbance events (Faithfull et al., 2012). Researchers have applied for a permit to release a biological control agent for *N. neesiana* in Australia (Anderson et al., 2012). 576 hectares are being controlled in national parks in the Australian Capital Territory (Taylor, 2012). Estimates of control costs in natural areas are reported in McLaren et al. (2002). Alternate answers for the Monte Carlo simulation were both "b."
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human property, processes, civilization, or safety)	n - mod	0	We found no evidence.
Imp-A2 (Changes or limits recreational use of an area)	y - high	0.1	Because the seeds cause discomfort in pets and humans and may lead to other complications (see review in Faithfull, 2012), we answered yes but with high uncertainty because we found no direct evidence.
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	n - mod	0	We found no evidence.
Imp-A4 (Weed status in anthropogenic systems)	c - low	0.4	Widespread weed occurring in roadsides, wasteland, and disturbed sites (Richardson et al., 2006). Present in urban parks in Montpellier and Rome (Verloove, 2005). Invades urban parks and gardens (Snell and Grech, 2008). Managed along Australian roadsides using wick wiping technology (Faithfull et al., 2012). Estimates of control costs along roadsides are reported in McLaren et al. (2002). For example, in Australia it costs on average Aus $17,000 to treat infestations occurring on roadsides. Alternate answers for the Monte Carlo simulation were both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - negl	0.4	*Nassella neesiana* can account for up to 60 percent of canopy cover in infested pastures (Gardener et al., 2003a). Because

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			flowering stems are not palatable (Bourdôt et al., 2012), plant populations greatly reduce stock-carrying capacity during the summer (Gardener et al., 2003a; Snell and Grech, 2008), but is a good forage species during the winter. Flowering stalks are actively avoided by stock (Grech et al., 2006).
Imp-P2 (Lowers commodity value)	y - negl	0.2	Seeds have a very sharp point (Richardson et al., 2006). "Its invasion of these grasslands also leads to the downgrading of wool, skins (hides) and carcasses as a result of the sharp callus and hygroscopic geniculate awn that together facilitate penetration of the mature fruit into the wool, skin and underlying muscle of grazing animals" (Bourdôt, 2010; Bourdôt et al., 2012). The sharp seeds bore into animal skins, causing painful wounds (Haywood and Druce, 1919). Sometimes seed will pierce the skin of sheep, damaging the hide and reducing its value, and irritating the animal (Gardener et al., 2003a; Storrie and Lowien, 2003). Causes vegetable contamination of wool (Gardener et al., 2003a). Yet *N. neesiana* is considered a valuable forage species in Uruguay (Noëll Estapé et al., 2013; Vidal et al., 2011), particularly during the winter months. Plants can exclude more desirable pasture species (Bell, 2006).
Imp-P3 (Is it likely to impact trade)	y - low	0.2	Sale and distribution of this species is prohibited in Australia under the Quarantine Act of 1908 (Bourdôt et al., 2012). In New Zealand and Australia, local legislation also requires homeowners to control and eradicate plants (Bourdôt et al., 2012). Because this species can contaminate wool/hides, hay, and seeds (see evidence under ES-16), it is possible for it to follow a trade pathway. This species was first found in France at Port Juvenal (Haywood and Druce, 1919) and in the United States in Mobile, Alabama (NRCS, 2013), the location of a major port, which further supports an answer of yes.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	? - max		We found no direct evidence of impacts to irrigation in production systems. Snell (2008) reports it is considered a riparian weed. The evidence cited under Imp-N1 is relevant to this question as natural grasslands are often used as rangelands for production. However, because that evidence was speculative, and because we don't want to over-emphasize this weak evidence, we are answering this question as unknown until more direct evidence becomes available.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - mod	0	Faithfull (2012) thoroughly reviewed the direct impacts *N. neesiana* has on animals. In summary, the sharp seeds irritate animals, wound skin, injure eyes, and penetrate muscles. Cattle may also suffer injuries to the mouth and intestinal tract (but see Gardener et al., 2003a). Because the mode of action is not toxicity, and we found no evidence that this species is toxic, we answered no. Moreover, it is considered a valuable forage species in its native range (Vidal et al., 2011), at least when it is not in bloom.
Imp-P6 (Weed status in production systems)	c - negl	0.6	Widespread weed occurring in open pastures and grasslands (Richardson et al., 2006). Weed of agriculture in Australia (Randall, 2007). Methods for sampling this species in rolled hay bales are being developed (Weller et al., 2012). Control in arable land and pastures can be achieved with an integrated system of cropping, herbicide application, and grazing strategies (Storrie and Lowien, 2003), including use of different grazer types (Grech et al., 2006). A survey of Australian weed managers reported control

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			costs averaging Aus $35-157 per hectare on grazing lands depending on whether infestations were scattered or dense (McLaren et al., 2002). Alternate answers for the Monte Carlo simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced, point references obtained from the Global Biodiversity Information Facility (GBIF, 2013).
Plant cold hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence.
Geo-Z5 (Zone 5)	n - negl	N/A	We found no evidence.
Geo-Z6 (Zone 6)	n - high	N/A	A few points in this zone in a mountainous region of western Argentina. Because determining climate in areas with large elevation changes is difficult, we assumed this species does not survive in this zone.
Geo-Z7 (Zone 7)	y - mod	N/A	About two dozen points in a region of western Argentina and Bolivia with rapid elevation changes that includes this zone.
Geo-Z8 (Zone 8)	y - negl	N/A	About two dozen points in a region of western Argentina and Bolivia with rapid elevation changes that includes this zone. Points in the United Kingdom. Regional occurrence in New Zealand (Bell, 2006).
Geo-Z9 (Zone 9)	y - negl	N/A	Australia, Argentina, New Zealand and Uruguay.
Geo-Z10 (Zone 10)	y - negl	N/A	Argentina, 1 point in Paraguay, and 1 point in Chile.
Geo-Z11 (Zone 11)	y - high	N/A	A few points in South Africa, right along the coast. Note that the CLIMEX analysis of this species (Bourdôt et al., 2012) did not show any geo-referenced occurrences for this species in South Africa, but GBIF does list some (2013). We considered the South African points in this analysis, but used high uncertainty.
Geo-Z12 (Zone 12)	n - negl	N/A	We found no evidence.
Geo-Z13 (Zone 13)	n - negl	N/A	We found no evidence.
Köppen-Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence.
Geo-C3 (Steppe)	y - low	N/A	Argentina and South Africa.
Geo-C4 (Desert)	n - high	N/A	Four points in this climate in Argentina. Based on the overall biology of the species, these records seem dubious, unless plants are growing in protected areas, in which case, deserts in general are not suitable for species establishment. It is also possible these points represent misidentifications.
Geo-C5 (Mediterranean)	y - negl	N/A	A few points in Australia, Chile, Portugal, and Italy. One point in South Africa. Grows in Mediterranean climates in Australia (Gardener et al., 1999). Several points in Chile (Bourdôt et al., 2012).
Geo-C6 (Humid subtropical)	y - negl	N/A	Argentina, Australia and Uruguay.
Geo-C7 (Marine west coast)	y - negl	N/A	Argentina, Australia, Bolivia, New Zealand, and the United Kingdom.
Geo-C8 (Humid cont. warm sum.)	n - mod	N/A	We found no evidence.
Geo-C9 (Humid cont. cool	n - negl	N/A	We found no evidence.

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
sum.)			
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - high	N/A	Four points in or at the edge of this band in Argentina and Chile. Based on the overall biology of the species, these records seem dubious, unless plants are growing in protected areas, in which case, deserts in general are not suitable for species establishment. It is also possible these points represent misidentifications.
Geo-R2 (10-20 inches; 25-51 cm)	y - low	N/A	Argentina and South Africa. Some points in Spain (Bourdôt et al., 2012).
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Argentina and Australia. Grows in temperate areas of Australia receiving more than 500 mm of annual precipitation (Gardener et al., 1999).
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Argentina, Australia, New Zealand, and the United Kingdom.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Argentina, New Zealand, and the United Kingdom.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Argentina. Regional occurrence in New Zealand (Bell, 2006).
Geo-R7 (60-70 inches; 152-178 cm)	y - mod	N/A	Mobile, Alabama (NRCS, 2013).
Geo-R8 (70-80 inches; 178-203 cm)	n - high	N/A	We found no evidence.
Geo-R9 (80-90 inches; 203-229 cm)	n - low	N/A	We found no evidence.
Geo-R10 (90-100 inches; 229-254 cm)	n - negl	N/A	We found no evidence.
Geo-R11 (100+ inches; 254+ cm))	n - negl	N/A	We found no evidence.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - high	0	This species was detected on ballast in Mobile, Alabama in or prior to 1953 (USDA-FS, 1953). It is currently listed as established by USDA PLANTS and the BONAP databases in that county (Kartesz, 2013; NRCS, 2013), but a taxonomic evaluation of the Stipeae (Poaceae) in the United States notes that it has not been collected in many years (Barkworth, 1993). This suggests that it has not established in the United States. An online post from a California master gardener program states that *N. neesiana* is invasive and is being phased out of cultivation by the nursery industry, suggesting that this species has been cultivated in the United States, at least on a very minor scale (Geisel, 2011). We found no other information to support cultivation in the United States. Consequently, we analyzed this species' entry potential.
Ent-2 (Plant proposed for entry, or entry is imminent)	n - mod	0	We found no evidence.
Ent-3 (Human value & cultivation/trade status)	c - high	0.25	Cultivated (Randall, 2012). Cultivated in Europe as an ornamental grass (Bourdôt et al., 2012). Other *Nassella* species are cultivated (Geisel, 2011; Page and Olds, 2001). We found no other evidence that it is currently offered for trade or resale.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	n - mod		We found no evidence.
Ent-4b (Contaminant of plant propagative material (except seeds))	? - max		Unknown.
Ent-4c (Contaminant of seeds for planting)	y - low	0.04	Introduced to the Waipawa area of New Zealand in contaminated pasture seed (Slay et al., 1999).
Ent-4d (Contaminant of ballast water)	n - low	0	We found no evidence and does not seem likely.
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - low	0	We found no evidence and does not seem likely.
Ent-4f (Contaminant of landscape products)	? - max		Unknown.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	y - high	0.02	A large population in southern France may have been introduced through railway traffic (Verloove, 2005).
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	y - negl	0.01	Some French infestations may have been introduced in imported cereals from Argentina (Verloove, 2005); assuming that these were for consumption. Contaminant of wool and leather (Haywood and Druce, 1919; Verloove, 2005). Readily sticks to wool (Gardener et al., 2003a).
Ent-4i (Contaminant of some other pathway)	e - negl	0.04	Contaminant of hay (Weller et al., 2012). We answered "e" for 0.4 points because hay is used in agricultural environments where it could easily establish.
Ent-5 (Likely to enter through natural dispersal)	n - low	0	Does not seem likely as it is not present in a bordering country.