United States Department of Agriculture

United States
Department of
Agriculture

Animal and
Plant Health
Inspection
Service

December 21,
2018

Version 1

Weed Risk Assessment for *Imperata cylindrica* (L.) P. Beauv. (Poaceae) – Cogongrass

Top left: Cogongrass infestation (source: John D. Byrd, Mississippi State University, Bugwood.org). Top right: Mature panicle (source: Chris Evans, University of Illinois, Bugwood.org). Bottom left: Root ball showing dozens of rhizomes (source: Craig Ramsey, USDA APHIS PPQ, Bugwood.org). Bottom right: Cultivar 'Red Baron' (Charles T. Bryson, USDA Agricultural Research Service, Bugwood.org).

AGENCY CONTACT

Plant Epidemiology and Risk Analysis Laboratory
Center for Plant Health Science and Technology
Plant Protection and Quarantine
Animal and Plant Health Inspection Service
United States Department of Agriculture
1730 Varsity Drive, Suite 300
Raleigh, NC 27606

1. 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 the PPQ weed risk assessment (WRA) process (PPQ, 2015) 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.

The PPQ WRA process includes three analytical components that together describe the risk profile of a plant species: risk potential, uncertainty, and geographic potential (PPQ, 2015). At the core of the process is the predictive risk model that evaluates the baseline invasive or weed potential of a plant species using information related to its ability to establish, spread, and cause harm in natural, anthropogenic, and production systems (Koop et al., 2012). Because the predictive model is geographically and climatically neutral, it can be used to evaluate the risk of a plant species for the entire United States or for any area within it. After generating a risk prediction with the model, we use a stochastic simulation to evaluate how much the uncertainty associated with the risk analysis affects the outcome from the predictive model. The simulation essentially evaluates what other risk scores might result if any answers in the predictive model were to change. Finally, we use Geographic Information System (GIS) overlays to identify those areas of the United States that may be suitable for the establishment of the species. For a detailed description of the PPQ WRA process, please refer to *PPQ Weed Risk Assessment Guidelines* (PPQ, 2015), which is available upon request.

We emphasize that our WRA process is designed to estimate the baseline or unmitigated risk associated with a plant species. We use evidence from anywhere in the world and any type of system (production, anthropogenic, or natural) for the assessment, which results in a very broad evaluation. This is appropriate for the types of actions considered by our agency, such as Federal regulation. Risk assessment and risk management are distinctly different phases of pest risk analysis (IPPC, 2016). Although we may use evidence about existing or proposed control programs in the assessment, the ease or difficulty of control has no bearing on the risk potential for a species. That information could be considered during the risk management (decision-making) process, which is not addressed in this document.

2. Plant Information and Background

SPECIES: *Imperata cylindrica* (L.) P. Beauv. (NGRP, 2018).

FAMILY: Poaceae

SYNONYMS: *Imperata arundinacea* Cirillo, *I. koenigii* P. Beauv, *Lagurus cylindricus* L., *Saccharum koenigii* Retz. (NGRP, 2018).

A few online databases use (L.) Raeusch. as the authority for this species (ITIS, 2017; MBG, 2017; The Plant List, 2017); however, this combination is invalid because the protologue of the 1797 publication by Raeuschel lacks a reference to the basionym (*Lagurus cylindricus* L.) or to any synonym of the species (IPNI, 2017). In the current literature, both authorities are used interchangeably (MacDonald, 2004).

Imperata brasiliensis, which occurs in the southeastern United States, is similar to cogongrass. Some sources consider *I. brasiliensis* to be native to Florida (Hall, 1998; Wunderlin and Hansen, 2018), whereas others list it as an exotic (NGRP, 2018; NRCS, 2018). *Imperata brasiliensis* and I. *cylindrica* can be distinguished because *I. brasiliensis* has one stamen per flower, and *I. cylindrica* has two (Patterson et al., 1980). Hall (1998), however, reports seeing specimens of *I. cylindrica* with one stamen and *I. brasiliensis* with two stamens. As the taxa can hybridize to produce fertile seed, Hall (1998) believes that they should be combined into one species. Molecular work indicates that Florida populations of these two species are not genetically distinct (Lucardi et al., 2014). Until additional work from across the global range of these species is conducted, we follow NGRP (2018), maintaining these taxa as separate species.

COMMON NAMES: Cogongrass, cogon, blady grass, cotton-wool grass, imperata, Japanese blood grass, kunai grass, alang-alang, kura-kura (NGRP, 2018), speargrass (Chikoye et al., 2000). In this assessment, we will refer to this species as cogongrass since that common name is most frequently used in the United States.

BOTANICAL DESCRIPTION: Cogongrass is a perennial, rhizomatous grass (Rusdy, 2017). Leaves are 1 to 4 ft long, and grow in bunches that originate directly from the ground level (Rusdy, 2017). They have a high silica content and are finely serrated, which generally makes the plants undesirable for feed (MacDonald, 2004; Rusdy, 2017). Plant stems are typically 0.15 to 1.2 m tall but can reach heights of 3 m (Bryson and Carter, 1993). Inflorescences are 3 to 20 cm long, consisting of terminal panicles (Holm et al., 1977). Grains (i.e., the seed) are 0.9 to 1.3 mm long, oblong, and brown (Bryson and Carter, 1993; Holm et al., 1977), and attached to long, silky hairs that facilitate wind dispersal (Reed, 1977; Shilling et al., 1997). Cogongrass is the most variable and widespread species in the genus *Imperata* (Bryson and Carter, 1993). For a complete description of the species see Holm et al. (1977) or Bryson and Carter (1993).

Cogongrass is highly variable (MacDonald, 2004) and includes five varieties, with three different ploidy levels (i.e., 2n=20, 40, and 60; cited in MacDonald, 2004). Variety *major* (2n=20) is the most widely distributed and ranges from Japan south through China to Australia, and east to eastern India (Holm et al., 1977). The next most widely distributed variety, *africana* (2n=60), occurs from Senegal and Sudan south through southern Africa. Variety *europa* (2n=40) ranges from Portugal through Central Asia, variety *latifolia* is found only in northern India, and variety *condensata* is found in Chile (Holm et al., 1977). Chromosome numbers for the last two varieties are unknown (MacDonald, 2004).

INITIATION: Cogongrass is regulated as a Federal Noxious Weed (7 CFR § 360, 2018) and as such is restricted from entry into the United States. As APHIS did not have a Weed Risk Assessment for this species at the time of listing (1983), we decided to evaluate the risk of this species using our new weed risk assessment process. Due to emerging concern over the invasive potential of the cogongrass cultivar known as 'Red Baron', we summarized the available information on it in the WRA.

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

FOREIGN DISTRIBUTION: *Imperata cylindrica* has a very broad native distribution that includes Africa, southern Europe (e.g., Portugal, Italy, Greece, and Bulgaria), temperate Asia (e.g., the Arabian peninsula, western Asia, the Caucasus, middle Asia, China, Japan, and Korea), tropical Asia (e.g., the Indian subcontinent, Indo-China, Malesia, Nepal, and Papua New Guinea), and Australia (MacDonald, 2004; NGRP, 2018). It has been introduced and become naturalized in a variety of locations including New Zealand, Cape Verde, Madagascar, Seychelles, Vanuatu, Australia (Lord Howe Island), various countries in the Caribbean and Central America, Chile, and Colombia (NGRP, 2018). Although normally present in warm climates, its range extends to about 45° latitude in both the northern and southern hemispheres (Holm et al., 1977). Cogongrass is considered a weed in over 73 countries (MacDonald, 2004) and is one of the world's most invasive plants (GISD, 2015; Weber, 2003).

U.S. DISTRIBUTION AND STATUS: *Imperata cylindrica* is naturalized and very invasive in the United States. It has been reported in 12 states (Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, North Carolina, Oregon, South Carolina, Tennessee, Texas, and Virginia) but is primarily distributed from Mississippi east to Florida and Georgia (Kartesz, 2017; NRCS, 2018). In 1912, cogongrass was accidentally introduced to the United States in Mobile County, AL as packing material for oranges from Japan (Dickens, 1974). Starting in 1921, and continuing through the 1940s, it was intentionally introduced for forage at multiple sites (Dickens, 1974; MacDonald, 2004), resulting in many large naturalized populations (Bryson and Carter, 1993). Since its introduction, it has spread throughout the southeastern United States (Brewer, 2008; Bryson and Carter, 1993; Dickens, 1974; Patterson et al., 1980), most recently including North Carolina (NCDACS, 2017). Cogongrass is regulated as a U.S. Federal Noxious Weed (7 CFR § 360, 2018) and as a state noxious weed in ten states (NRCS, 2018). Considerable resources have been spent controlling this species in the United States (Divate et al., 2017; Eickwort, 2011; McClure, 2011). Repeated applications of herbicides, discing, mowing, and burn treatments are often needed for effective control (Thomas et al., 1996) and complete eradication may take several years due to regeneration from underground rhizomes (Bryson and Carter, 1993;

[1] "WRA area" is the area in relation to which the weed risk assessment is conducted (definition modified from that for "PRA area") (IPPC, 2017).

Patterson et al., 2004; Sellers et al., No Date). It is unlikely that cogongrass can be eliminated from southern regions where plant populations are large and common; however, in other regions near the edge of its naturalized distribution, such as in North and South Carolina, state officials have active eradication programs (Clemson Regulatory Services, 2018; NCDACS, 2017). With the exception of the red ornamental cultivar, 'Red Baron', we did not find any evidence that cogongrass is sold online in the United States (Univ. of Minn., 2018).

3. Analysis

ESTABLISHMENT/SPREAD POTENTIAL

Cogongrass is a highly invasive plant that readily establishes and spreads. It invades and persists using several survival strategies, including an extensive rhizome system, adaptation to poor soils, drought tolerance, fire adaptability, and high genetic plasticity (reviewed in MacDonald, 2004). When plants cross-pollinate, plant populations can produce thousands of viable wind-dispersed seeds per square meter (Loewenstein et al., 2011). Cogongrass has a very aggressive rhizome system that not only contributes to population expansion, but also helps plants respond to fire and other disturbance events that result in a loss of aboveground parts (MacDonald, 2004; Tominaga, 1993). Within a period of 14 months, a single plant shoot can produce 200 daughter shoots (Tominaga, 1993). Cogongrass forms dense populations (Trautwig et al., 2017) and can grow under relatively shady conditions (Gaffney, 1996). Seeds and rhizome fragments are easily dispersed by people through trade, road construction, and soil movement (AQAS, 2018; Bryson and Carter, 1993; CBP, 2016; Faircloth, 2007; Shilling et al., 1997). Due to the large amount of published information, we had low uncertainty for this risk element. Additional information about seed dormancy and natural dispersal vectors would help to further lower the uncertainty.

Risk score = 19 Uncertainty index = 0.12

IMPACT POTENTIAL

Cogongrass is a weed in over 73 countries (MacDonald, 2004) and causes harm in natural, anthropogenic, and agricultural systems. In natural systems, it reduces biodiversity (Brewer, 2008; Trautwig et al., 2017), changes habitat structure (Brewer, 2008; Hagan et al., 2013), and alters ecosystem properties such as fire regimes (Lippincott, 2000; MacDonald, 2004). It also has an allelopathic effect on surrounding plants (Estrada and Flory, 2015; Hagan et al., 2013). In regions with a high intermixing of wildlands and urban areas, cogongrass-initiated fires may present a potential safety hazard (Faircloth, 2007). Tall grasses growing along roadways and highways may also impact public safety (Willard et al., 1990). In some agricultural areas where tilling is not possible, cogongrass is very competitive, reducing the growth of some crop plants by 85 to 96 percent (MacDonald, 2004). In root and tuber crops, such as cassava and yam, cogongrass not only reduces crop yield through direct competition, but its sharp rhizomes also facilitate fungal infections by wounding crop roots and tubers (Terry et al., 1996). Relative to other grasses, cogongrass has a low digestibility rating, resulting in lower animal productivity in pastures dominated by this species (Rusdy, 2017). In some regions, growers have abandoned their farmland because of infestations (Tominaga, 1993). In the United States, cogongrass also invades pine plantations (Estrada and Flory, 2015). Cogongrass is controlled in all natural, anthropogenic, and agricultural systems (Bryson and Carter, 1993; Dozier et al., 1998; Faircloth, 2007; Jose et al., 2002). Because these impacts are very well documented, we had very low uncertainty for this risk element.

Risk score = 4.7 Uncertainty index = 0.02

GEOGRAPHIC POTENTIAL

Based on three climatic variables, we estimate that about 82 percent of the United States and 12 percent of Canada are suitable for the establishment of cogongrass (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world, using evidence from both point-referenced localities and general areas of occurrence. The map for cogongrass represents the joint distribution of Plant Hardiness Zones 4-13, areas with zero to over 100 inches of annual precipitation, and the following Köppen-Geiger climate classes: tropical rainforest, tropical savanna, steppe, desert, Mediterranean, humid subtropical, marine west coast, and humid continental warm and cool summers.

The area of the United States shown to be climatically suitable (Fig. 1) for species establishment considered only three climatic variables. Other variables, such as soil and habitat type, novel climatic conditions, or plant genotypes, may alter the areas in which this species is likely to establish. Cogongrass grows in a wide range of habitats, including swamps, floodplains, river margins, grasslands, cultivated crop fields, plantations, transportation corridors and other disturbed sites, orchards, levees, and dunes (Holm et al., 1977; Miyoshi and Tominaga, 2017). In the United States, it invades sandhills, pine flatwoods, hardwood hammocks, grasslands, wet pine savanna communities, and other southeastern coastal plain habitats (GISD, 2015). According to MacDonald (2004), "Cogongrass tolerates a wide range of soil conditions but appears to grow best in soils with acidic pH, low fertility and low organic matter." It can grow at elevations ranging from sea level to 2700 m in Indonesia (Bryson and Carter, 1993).

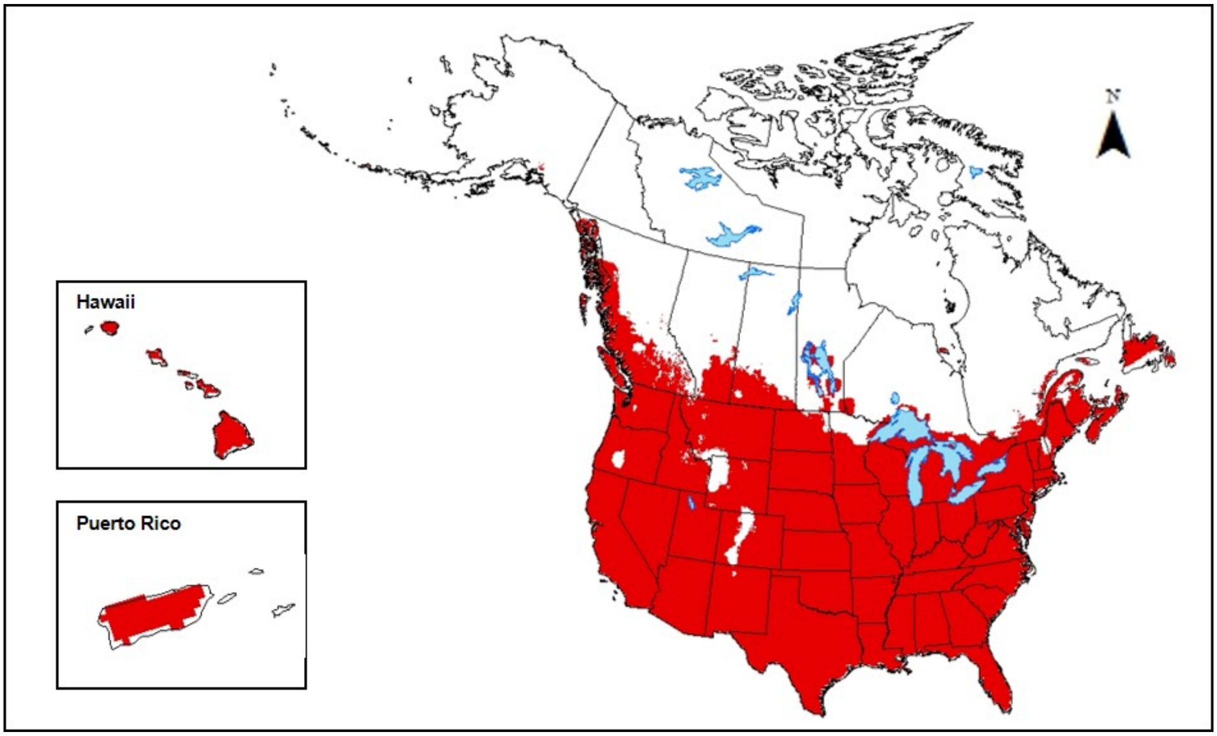

Figure 1. Potential geographic distribution of cogongrass in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

ENTRY POTENTIAL

Although cogongrass is well-established in the southeastern United States (Brewer, 2008; Bryson and Carter, 1993; Dickens, 1974; Patterson et al., 1980), we evaluated this risk element to determine the potential for additional material to enter the United States. On a scale of 0 to 1, where 1 represents the maximum likelihood of entry, cogongrass obtained a risk score of 0.68 on our assessment scale. The most likely pathway for entry is through intentional introduction, as plants are cultivated in Europe as ornamentals (Cullen et al., 2011; RHS, 2018). Cogongrass is also likely to enter as a contaminant of shipping containers, military equipment, and pallets or other products (AQAS, 2018; CBP, 2016). Cogongrass can also contaminate hay (Loewenstein, No Date) and straw (Duever, 2007).

Risk score = 0.68 Uncertainty index = 0.03

4. Predictive Risk Model Results

Model Probabilities: P(Major Invader) = 96.0%
P(Minor Invader) = 3.9%
P(Non-Invader) = 0.1%
Risk Result = High Risk
Secondary Screening = Not Applicable

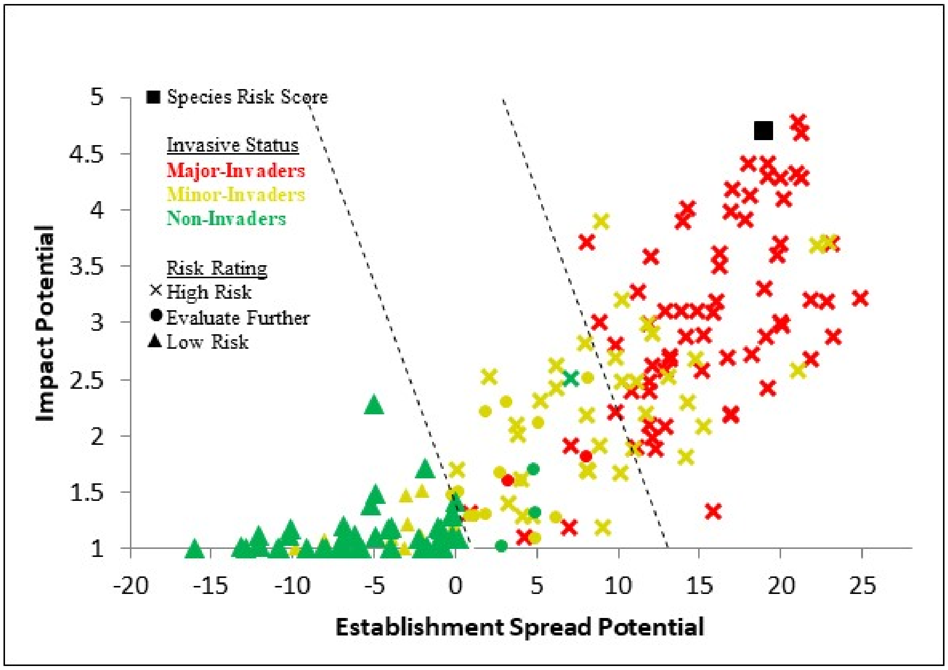

Figure 2. Cogongrass risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

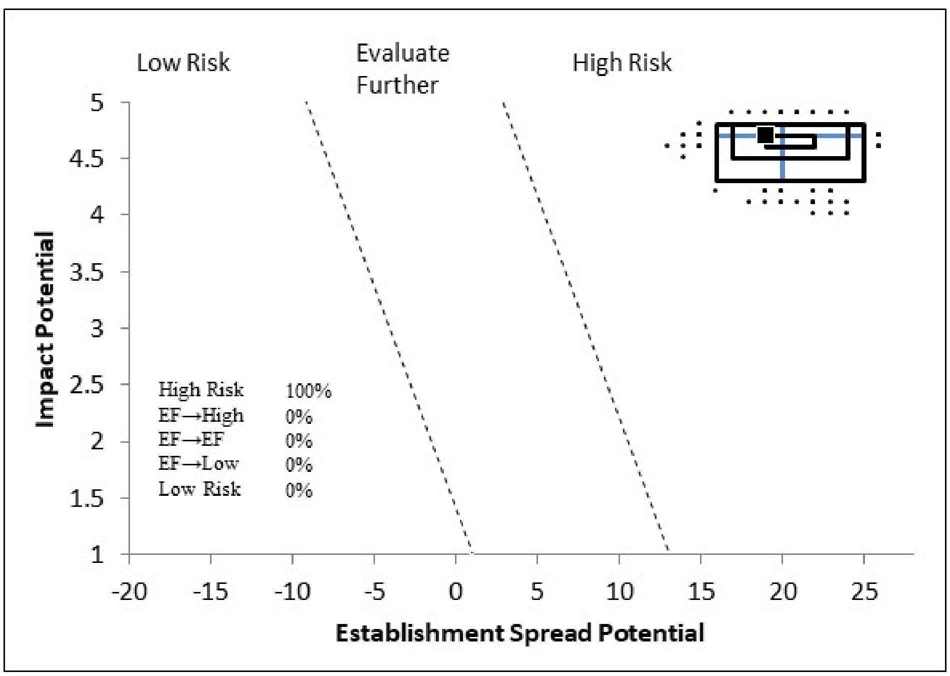

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for cogongrass. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

5. Discussion

The result of the weed risk assessment for cogongrass (*Imperata cylindrica*) is High Risk (Fig. 2, Fig. 3). Cogongrass is a highly invasive perennial grass that has been identified as one of the world's worst weeds (reviewed in MacDonald, 2004). This species is particularly aggressive because it forms an extensive rhizome system that contributes to population expansion and helps it respond quickly to fire and other disturbance events (MacDonald, 2004; Tominaga, 1993). In its native range, it forms large expanses of grasslands that are maintained by frequent fires (Rusdy, 2017). Cogongrass received a very high impact score because it invades natural, anthropogenic, and agricultural systems, causing a variety of significant impacts, including biodiversity loss, changes to fire regimes, crop yield reduction, and increased control costs (Brewer, 2008; Chikoye et al., 2007; Lippincott, 2000; Terry et al., 1996). Cogongrass seeds are small, 0.9 to 1.3 mm long, and attached to long, silky hairs that facilitate wind dispersal (Bryson and Carter, 1993; Holm et al., 1977; Reed, 1977; Shilling et al., 1997). Rhizomes are readily dispersed through road construction and maintenance activities (Faircloth, 2007; Shilling et al., 1997; Willard et al., 1990), and seeds are frequently intercepted in cargo and passenger baggage, and on wood pallets (AQAS, 2018; CBP, 2016).

The Animal and Plant Health Inspection Services (APHIS) regulates cogongrass as a Federal Noxious Weed, restricting its entry into the United States and its movement in interstate commerce (7 CFR § 360, 2018). In concordance with the policies of certain states, however, APHIS allows the movement of an ornamental selection of cogongrass into those states (PPQ, 2014). The selection is often marketed as the cultivars Rubra or Red Baron and is commonly known as Japanese blood grass (Cseke and Talley, 2012). It is sometimes described as var. rubra (MBG, 2018), though we found no evidence that this is a valid botanical name. Japanese botanists recognize the red-leaved forms as *I. cylindrica* var. *koenigii* (Retz.) Durand & Schinz, which are typically shorter than other forms, grow in northern Japan, are more cold-tolerant, and have smaller rhizomes (Mahr, 2011; Ohwi, 1984; Tominaga, 1988). All red-leaved cultivars are probably derived from this Japanese variety (Morton Arboretum, 2018); however, this needs to be confirmed. Some ornamental selections have foliage tinged with a burgundy color, while others have brighter, cranberry-red coloration (Mahr, 2011), suggesting there may be different genotypes of 'Red Baron' in the United States. 'Red Baron' is commonly grown in the United States (Dave's Garden, 2018; Univ. of Minn., 2018) and is promoted as an ornamental grass because of its coloration (River Street Flowerland, 2018). Unlike the wild type of cogongrass, which appears to be restricted to warmer climates, 'Red Baron' will grow in the northern United States (Hall, 1998).

Some sources report that 'Red Baron' rarely flowers and is not invasive (Mahr, 2011; MBG, 2018; San Marcus Growers, 2018); however, after 3 to 10 years (Lassiter, 2017; Snitzer, 2018), plants can revert back to green-leaved forms, which are more robust and spread aggressively (Dozier et al., 1998; Hall, 1998; NCSU, 2018; Shilling et al., 1997; Snitzer, 2018). Also a landscape contractor in Maryland found some 'Red Baron' plants setting seed in a garden two to three years after he planted them, but he destroyed those seed heads before determining if they were viable and never saw any seedlings in his plantings (Snitzer, 2018). One source reports that ‘Red Baron’ plants can produce fertile seed (Cseke and Talley, 2012), but we were unable to confirm this.

Plant reversion appears to occur more frequently when plants are grown in hot locations (Mahr, 2011). One group of researchers that grew different biotypes of cogongrass under different temperature regimes found that hot temperatures may cause red cultivars to revert to green, while cold temperatures may promote some red coloration (Bryson et al., 2004). ‘Red Baron’ plants that revert lose their reddish coloration, grow taller, develop larger rhizomes, and become difficult to distinguish from the typical invasive biotype (Cseke and Talley, 2012; Mahr, 2011). It is not clear whether reverted plants can become as invasive or harmful as other biotypes that are spreading through the southeastern United States. Reverted plants have, however, become naturalized in the United States (Lassiter, 2017). Furthermore, some U.S. gardeners note that plants can become aggressive in their yards, requiring them to establish barriers to keep the plants from spreading (Dave's Garden, 2018). The Morton Arboretum (2018) recommends that reverted plants be removed and destroyed. Additional research comparing the invasive potential of reverted ‘Red Baron’ to wild biotypes is needed.

Imperata cylindrica is a diverse species displaying a wide range of morphological variation and adaptive traits across its range (Holm et al., 1977; MacDonald, 2004; Tominaga, 1988). For example, in Japan, some biotypes are better adapted to wet conditions (Miyoshi and Tominaga, 2017), and others are better adapted to cold conditions (Tominaga, 1988). Regardless of the invasive potential of ‘Red Baron’, we found evidence supporting a concern that these ornamental cultivars could hybridize with invasive biotypes and pass on adaptive genes, such as those for cold tolerance, that could facilitate the expansion of U.S. populations of cogongrass (Bryson and Carter, 1993; Firley, 2016; MacDonald, 2009; Patterson et al., 1980; Shilling et al., 1997). In Japan, hybrids between the wet biotype and the common biotype of cogongrass show broad environmental tolerances for ground water levels and outperform parents under dry and wet environmental conditions (Miyoshi and Tominaga, 2017). If locally-adapted biotypes develop, they could easily persist through vegetative reproduction. Because cogongrass is self-incompatible, introduction and spread of additional biotypes may also result in greater levels of seed production by naturalized populations. It is for these reasons that many southern states ban the sale of ‘Red Baron’ cultivars (Firley, 2016).

6. Acknowledgements

AUTHOR

Anthony L. Koop, Risk Analyst[a]

REVIEWERS

David Bednar, Risk Analyst[a]
Karen Castro, Risk Analyst[b]
Craig Ramsey, Risk Analyst[a]

Claire Wilson, Risk Analyst[b]

[a] USDA APHIS PPQ CPHST Plant Epidemiology and Risk Analysis Laboratory, Raleigh, NC
[b] Canadian Food Inspection Agency, Plant Health Risk Assessment Unit, Ottawa, Ontario

SUGGESTED CITATION

PPQ. 2018. Weed risk assessment for *Imperata cylindrica* (L.) P. Beauv. (Poaceae) – Cogongrass. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ), Raleigh, NC. 31 pp.

DOCUMENT HISTORY

December 21, 2019: Version 1.

7. Literature Cited

7 CFR § 360. 2018. U.S. Code of Federal Regulations, Title 7, Part 360, (7 CFR §360 - Noxious Weed Regulations). U.S. Government Publishing Office.

7 U.S.C. § 1581-1610. 1939. The Federal Seed Act, Title 7 United States Code § 1581-1610.

7 U.S.C. § 7701-7786. 2000. Plant Protection Act, Title 7 United States Code § 7701-7786.

Acevedo-Rodríguez, P., and M. T. Strong. 2012. Catalogue of Seed Plants of the West Indies. Smithsonian Institution, Washington D.C. 1192 pp.

Alba, C., J. E. NeSmith, C. Fahey, C. Angelini, and S. L. Flory. 2017. Methods to test the interactive effects of drought and plant invasion on ecosystem structure and function using complementary common garden and field experiments. Ecology and Evolution 7(5):1442-1452.

APHIS. 2018. Phytosanitary Certificate Issuance & Tracking System (PCIT). United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). https://pcit.aphis.usda.gov/pcit/. (Archived at PERAL).

AQAS. 2018. Agriculture Quarantine Activity Systems (AQAS) Database. United States Department of Agriculture, Plant Protection and Quarantine. https://aqas.aphis.usda.gov/aqas/. (Archived at PERAL).

Aulakh, J. S., S. F. Enloe, N. J. Loewenstein, A. J. Price, G. Wehtje, and J. H. Miller. 2014. Pushing toward cogongrass (*Imperata cylindrica*) patch eradication: The influence of herbicide treatment and application timing on cogongrass rhizome elimination. Invasive Plant Science and Management 7(3):398-407.

BambooPlants. 2018. Imperata cylindrica 'Red Baron': Japanese Blood Grass. BambooPlants.ca. Last accessed December 11, 2018, https://www.bambooplants.ca/.

Basiotis, K. A. 2007. The effects of invasive cogongrass (*Imperata cylindrica*) on the threatened gopher tortoise (*Gopherus polyphemus*). Master of Science, University of South Florida, Tampa, Florida.

Brewer, S. 2008. Declines in plant species richness and endemic plant species in longleaf pine savannas invaded by *Imperata cylindrica*. Biological Invasions 10(8):1257-1264.

Bruneton, J. 1999. Toxic Plants Dangerous to Humans and Animals. Lavoisier Publishing, Paris, France. 545 pp.

Bryson, C. T., and R. Carter. 1993. Cogongrass, *Imperata cylindrica*, in the United States. Weed Technology 7(4):1005-1009.

Bryson, C. T., C. H. Koger, and J. D. Byrd, Jr. 2004. Cogongrass: Green is green and red is red, or are they? United States Department of Agriculture, Agricultural Research Service. 1 pp.

Burrows, G. E., and R. J. Tyrl. 2013. Toxic Plants of North America, 2nd ed. Wiley-Blackwell, Ames, IA. 1383 pp.

CBP. 2016. Carrier conveyance contamination trade outreach. United States Customs and Border Protection (CBP). 43 pp.

Chikoye, D., J. Ellis-Jones, T. R. Avav, P. M. Kormawa, U. E. Udensi, G. Tarawali, and O. K. Nielsen. 2007. Promoting integrated management practices for speargrass (*Imperata cylindrica* (L.) Raeusch.) in soybean, cassava and yam in Nigeria. Journal of Food, Agriculture and Environment 5(3-4):202-210.

Chikoye, D., V. M. Manyong, and F. Ekeleme. 2000. Characteristics of speargrass (*Imperata cylindrica*) dominated fields in West Africa: crops, soil properties, farmer perceptions and management strategies. Crop Protection 19(7):481-487.

Cleary, D. F. R. 2016. Diversity and composition of plants, butterflies and odonates in an *Imperata cylindrica* grassland landscape in East Kalimantan, Indonesia. Journal of Tropical Ecology 32(6):555-560.

Clemson Regulatory Services. 2018. Cogongrass. Clemson University, Regulatory Services. Last accessed April 12, 2018, https://www.clemson.edu/public/regulatory/plant-protection/plant-pest-regulations/state-plant-pest-information/pest-alerts/cogongrass.html.

Cseke, L. J., and S. M. Talley. 2012. A PCR-based genotyping method to distinguish between wild-type and ornamental varieties of *Imperata cylindrica*. Journal of Visualized Experiments 60:1-8. DOI:10.3791/3265.

Cullen, J., S. G. Knees, and H. S. Cubey (eds.). 2011. The European Garden Flora, Flowering Plants: A Manual for the Identification of Plants Cultivated in Europe, Both Out-of-Doors and Under Glass, Volumes I-V. Cambridge University Press, Cambridge. 3185 pp.

Dave's Garden. 2018. Plant files database. Dave's Garden. http://davesgarden.com/guides/pf/go/1764/. (Archived at PERAL).

Dickens, R. 1974. Cogongrass in Alabama after sixty years. Weed Science 22(2):177-179.

Divate, N., D. Solís, M. H. Thomas, S. Alvarez, and D. Harding. 2017. An economic analysis of the impact of cogongrass among nonindustrial private forest landowners in Florida. Forest Science 63(2):201-208.

Dozier, H., J. F. Gaffney, S. K. McDonald, E. R. R. L. Johnson, and D. G. Shilling. 1998. Cogongrass in the United States: History, ecology, impacts, and management. Weed Technology 12(4):737-743.

Duever, L. C. 2007. How can we organize ourselves at the county level to be effective at combating cogongrass?, Pages 58-62 *in* N. J. Loewenstein and J. H. Miller (eds.). Proceedings of the Regional Cogongrass Conference: A Cogongrass Management Guide: Confronting the Cogongrass Crisis Across the South. Auburn School of Forestry and Wildlife Sciences, Alabama Cooperative Extension System, and United States Department of Agriculture, Forest Service, Mobile, AL.

Dutta, S., and M. K. Hossain. 2016. Infestation of *Imperata cylindrica* L. and its impacts on local communities in secondary forests of Sitakunda Botanical Garden and Eco-Park, Chittagong, Bangladesh. International Journal of Conservation Science 7(1):167-180.

Eickwort, J. 2011. Florida Forest Service cogongrass program status. Oral presentation given at the Regional Cogongrass Conference: Cogongrass Workshop (November 3, 2011, Tallahassee, FL). Center for Invasive Species and Ecosystem Health, Tallahassee, FL. Last accessed November 30, 2018, https://bugwoodcloud.org/mura/cogongrass/assets/File/JEickwort.pdf.

Estrada, J. A., and S. L. Flory. 2015. Cogongrass (*Imperata cylindrica*) invasions in the US: Mechanisms, impacts, and threats to biodiversity. Global Ecology and Conservation 3(Supplement C):1-10.

Estrada, J. A., C. H. Wilson, D. Hiatt, and S. L. Flory. 2017. Different factors drive emergence and persistence in an invasive grass. International Journal of Plant Sciences 178(5):406-410.

Estrada, J. A., C. H. Wilson, J. E. NeSmith, and S. L. Flory. 2016. Propagule quality mediates invasive plant establishment. Biological Invasions 18(8):2325-2332.

Eussen, J. H. H., and M. Soerjani. 1975. Problems and control of ‘alang-alang’ [*Imperata cylindrica* (L.) Beauv.] in Indonesia. Pages 58-64 *in* T. Kataoka, S. Furuya, H. Hyakutake, K. Ishizuka, S. Matsunaka, and M. Takabayashi (eds.). Proceedings of the Fifth Asian-Pacific Weed Science Society Conference. Asian Pacific Weed Science Society.

Faircloth, W. 2007. Managing cogongrass on rights-of-way: A challenge to prevent further spread. Pages 34-37 *in* N. J. Loewenstein and J. H. Miller (eds.). Proceedings of the Regional Cogongrass Conference: A Cogongrass Management Guide: Confronting the Cogongrass Crisis Across the South. Auburn School of Forestry and Wildlife Sciences, Alabama Cooperative Extension System, and United States Department of Agriculture, Forest Service, Mobile, AL.

FDACS. 2018. Cogon grass. Florida Department of Agrigculture and Consumer Services (FDACS). Last accessed August 23, 2018, https://www.freshfromflorida.com/Divisions-Offices/Florida-Forest-Service/Our-Forests/Forest-Health/Invasive-Non-Native-Plants/Cogon-Grass.

Firley, S. W. 2016. Cogongrass continues to invade the South. United Stated Department of Agriculture, Forest Service, Southern Research Station. Last accessed August 23, 2018, https://www.srs.fs.usda.gov/compass/2016/08/09/cogongrass-continues-to-invade-the-south/.

Gaffney, J. F. 1996. Ecophysiological and technological factors influencing the management of cogongrass (*Imperata cylindrica*). Ph.D. Dissertation, University of Florida, Gainesville, Florida.

GBIF. 2017. GBIF, Online Database. Global Biodiversity Information Facility (GBIF). http://www.gbif.org/. (Archived at PERAL).

GISD. 2015. Species profile: *Imperata cylindrica*. Global Invasive Species Database (GISD). Last accessed April 12, 2018, http://www.iucngisd.org/gisd/species.php?sc=16.

Hagan, D. L., S. Jose, and C. H. Lin. 2013. Allelopathic exudates of cogongrass (*Imperata cylindrica*): Implications for the performance of native pine savanna plant species in the Southeastern US. Journal of Chemical Ecology 39(2):312-322.

Hall, D. W. 1998. Is cogongrass really an exotic? Wildland Weeds 1(3):14-15.

Haque, M. A., D. N. Barman, M. K. Kim, H. D. Yun, and K. M. Cho. 2016. Cogon grass (*Imperata cylindrica*), a potential biomass candidate for bioethanol: Cell wall structural changes enhancing hydrolysis in a mild alkali pretreatment regime. Journal of the Science of Food and Agriculture 96(5):1790-1797.

Heap, I. 2018. The international survey of herbicide resistant weeds. Weed Science Society of America. http://weedscience.org/. (Archived at PERAL).

Heide-Jorgensen, H. S. 2008. Parasitic Flowering Plants. Brill, Leiden, The Netherlands. 438 pp.

Holm, L. G., J. V. Pancho, J. P. Herberger, and D. L. Plucknett. 1991. A Geographical Atlas of World Weeds. Krieger Publishing Company, Malabar, Florida, U.S.A. 391 pp.

Holm, L. G., D. L. Plucknett, J. V. Pancho, and J. P. Herberger. 1977. The World's Worst Weeds: Distribution and Biology. Krieger Publishing Company, Malabar, Florida, U.S.A. 609 pp.

Hubbard, C. E., R. O. Whyte, D. Brown, and A. P. Gray. 1944. *Imperata cylindrica*: Taxonomy, Distribution, Economic Significance, and Control. Imperial Agricultural Bureaux Joint Publication No. 7. Imperial Bureau Pastures and Forage Crops, Aberystwyth, Wales. Great Britton. 1-63 pp.

IPNI. 2017. The International Plant Names Index, Online Database. The International Plant Names Index (IPNI). http://www.ipni.org/index.html. (Archived at PERAL).

IPPC. 2016. International Standards for Phytosanitary Measures No. 2: Framework for Pest Risk Analysis. Food and Agriculture Organization of the United Nations, Secretariat of the International Plant Protection Convention (IPPC), Rome, Italy. 16 pp.

IPPC. 2017. International Standards for Phytosanitary Measures No. 5: Glossary of Phytosanitary Terms. Food and Agriculture Organization of the United Nations, Secretariat of the International Plant Protection Convention (IPPC), Rome, Italy. 34 pp.

ITIS. 2017. Integrated Taxonomic Information System (ITIS), Online Database. United States Government. http://www.itis.gov/. (Archived at PERAL).

Jose, S., J. Cox, D. L. Miller, D. G. Shilling, and S. Merritt. 2002. Alien plant invasions: The story of cogongrass in southeastern forests. Journal of Forestry 100(1):41-44.

Kartesz, J. 2017. The Biota of North America Program (BONAP). Taxonomic Data Center. http://bonap.net/tdc. (Archived at PERAL).

Koop, A., L. Fowler, L. Newton, and B. Caton. 2012. Development and validation of a weed screening tool for the United States. Biological Invasions 14(2):273-294.

Lassiter, B. 2017. Looking for info on red baron. Personal communication to A. L. Koop on December 1, 2017, from Bridget Lassiter, Weed Specialist, Plant Industry Division, North Carolina Department of Agriculture and Consumer Services.

Lippincott, C. L. 2000. Effects of *Imperata cylindrica* (L.) Beauv. (Cogongrass) invasion on fire regime in Florida sandhill (USA). Natural Areas Journal 20(2):140-149.

Loewenstein, N. J. No Date. Stop cogongrass hitchhikers. Alabama Cooperative Extension System and United States Department of Agriculture. 2 pp.

Loewenstein, N. J., and J. H. Miller. 2007. Proceedings of the Regional Cogongrass Conference: A Cogongrass Management Guide: Confronting the Cogongrass Crisis Across the South. Auburn School of Forestry and Wildlife Sciences, Alabama Cooperative Extension System, and United States Department of Agriculture, Forest Service, Mobile, AL.

Loewenstein, N. J., J. H. Miller, and S. F. Enloe. 2009. Cogongrass seed production across Alabama and Georgia. 11th Annual Southeast EPPC Conference, Georgetown, South Carolina. May 13-15, 2009.

Loewenstein, N. J., J. H. Miller, and S. F. Enloe. 2011. Cogongrass seed production across Alabama and Georgia. Wildland Weeds. 14(1/2):7-9.

Lucardi, R. D., L. E. Wallace, and G. N. Ervin. 2014. Evaluating hybridization as a potential facilitator of successful cogongrass (*Imperata cylindrica*) invasion in Florida, USA. Biological Invasions 16(10):2147-2161.

MacDonald, G. E. 2004. Cogongrass (*Imperata cylindrica*)—Biology, ecology, and management. Critical Reviews in Plant Sciences 23:367-380.

MacDonald, G. E. 2009. Cogongrass (*Imperata cylindrica*) - A comprehensive review of an invasive grass. Pages 267-295 *in* R. K. Kohli, S. Jose, H. P. Singh, and D. R. Batish (eds.). Invasive Plants and Forest Ecosystems. CRC Press, Boca Raton, FL.

MAF Biosecurity Authority. 2001. Import health standard commodity sub-class: Fresh fruit/vegetables pineapple, *Ananas comosus* from Thailand. Ministry for Primary Industries, New Zealand. 17 pp.

Mahr, S. 2011. Japanese Bloodgrass, *Imperata cylindrica* var. *rubra*. University of Wisconsin - Extension, Master Gardener Program. Last accessed September 24, 2018, https://wimastergardener.org/article/japanese-bloodgrass-imperata-cylindrica-var-rubra/.

Martin, P. G., and J. M. Dowd. 1990. A protein sequence study of the dicotyledons and its relevance to the evolution of the legumes and nitrogen fixation. Australian Systematic Botany 3:91-100.

MBG. 2017. Tropicos Database. Missouri Botanical Garden (MBG). http://www.tropicos.org/Home.aspx. (Archived at PERAL).

MBG. 2018. Plant Finder Database. Missouri Botanical Garden (MBG). http://www.missouribotanicalgarden.org/plantfinder/plantfindersearch.aspx. (Archived at PERAL).

McClure, M. 2011. Cogongrass in Georgia: 2011 update. Oral presentation given at the Regional Cogongrass Conference: Cogongrass Workshop (November 3, 2011, Tallahassee, FL). Center for Invasive Species and Ecosystem Health, Tallahassee, FL. Last accessed November 30, 2018, https://bugwoodcloud.org/mura/cogongrass/assets/File/MMcClure.pdf.

McDonald, S. K., D. G. Shilling, T. A. Bewick, C. A. N. Okoli, and R. Smith. 1995. Sexual reproduction by cogongrass, *Imperata cylindrica*. Proceedings of the Southern Weed Science Society 48:188-188.

MFC. 2018. Cogongrass. Mississippi Forestry Commission (MFC). Last accessed August 23, 2018, https://www.mfc.ms.gov/Cogongrass.

Miller, J. H. 2003. Nonnative invasive plants of southern forests (General Technical Report SRS-62). United States Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC. 93 pp.

Miyoshi, I., and T. Tominaga. 2017. Growth of hybrids between the common and early ecotypes of *Imperata cylindrica*. Grassland Science 63(2):128-131.

Morton Arboretum. 2018. Red Baron Japanese blood grass. The Morton Arboretum. Last accessed November 30, 2018, http://www.mortonarb.org/trees-plants/tree-plant-descriptions/red-baron-japanese-blood-grass.

NCDACS. 2017. Cogongrass – Identifying and eradicating a grassy weed. North Carolina Department of Agriculture and Consumer Services (NCDACS). Last accessed August 23, 2018, http://www.ncagr.gov/PLANTINDUSTRY/Plant/weed/Cogongrass.htm.

NCSU. 2018. *Imperata cylindrica* var. *koenigii*. North Carolina State University (NCSU), Extension. Last accessed September 24, 2018, https://plants.ces.ncsu.edu/plants/all/imperata-cylindrica-var-koenigii/.

NGRP. 2018. Germplasm Resources Information Network (GRIN). United States Department of Agriculture, Agricultural Research Service, National Genetic Resources Program (NGRP). https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx?language=en. (Archived at PERAL).

Nickrent, D. 2009. Parasitic plant classification. Southern Illinois University Carbondale, Carbondale, IL. Last accessed June 12, 2009, http://www.parasiticplants.siu.edu/ListParasites.html.

NRCS. 2018. The PLANTS Database. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), The National Plant Data Center. https://plants.usda.gov/java/nameSearch. (Archived at PERAL).

O'Brien, J. J., K. A. Mordecai, L. Wolcott, J. Snyder, and K. Outcalt. 2007. Fire managers field guide: Hazardous fuels management in subtropical pine flatwoods and tropical pine rocklands (U.S. Joint Fire Science Program, Report No. 05-S-02). United States Department of Agriculture, Forest Service, Asheville, NC. 76 pp.

Ohwi, J. 1984. Flora of Japan (edited English version, reprint. Original 1954). National Science Museum, Tokyo, Japan. 1067 pp.

Oladokun, O., A. Ahmad, T. A. T. Abdullah, B. B. Nyakuma, M. F. A. Kamaroddin, and S. H. M. Nor. 2017. Biohydrogen production from *Imperata cylindrica* bio-oil using non-stoichiometric and thermodynamic model [Abstract]. International Journal of Hydrogen Energy 42(14):9011-9023.

Page, S., and M. Olds (eds.). 2001. The Plant Book: The World of Plants in a Single Volume. Mynah, Hong Kong. 1020 pp.

Patterson, D. T. 1980. Shading effects on growth and partitioning of plant biomass in cogongrass (*Imperata cylindrica*) from shaded and exposed habitats. Weed Science 28(6):735-740.

Patterson, D. T., E. P. Flint, and R. Dickens. 1980. Effects of temperature, photoperiod, and population source on the growth of cogongrass (*Imperata cylindrica*). Weed Science 28(5):505-509.

Patterson, M., D. Teem, and W. Faircloth. 2004. Mapping, control, and revegetation of cogongrass infestations on alabama right-of-way. Auburn University, Auburn, Alabama. 60 pp.

PPQ. 2014. Federal noxious weeds decision matrix. Plant Protection and Quarnatine (PPQ), Pest Permit Branch, United States. 2 pp.

PPQ. 2015. Guidelines for the USDA-APHIS-PPQ Weed Risk Assessment Process. United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ). 125 pp.

Randall, R. P. 2017. A Global Compendium of Weeds, 3rd edition. Department of Agriculture and Food, Western Australia, Perth, Australia. 3654 pp.

Reed, C. F. 1977. Economically Important Foreign Weeds. Agricultural Research Service, United States Department of Agriculture, Washington, D.C. 746 pp.

RHS. 2018. Plant Finder Database. Royal Horticultural Society (RHS). http://apps.rhs.org.uk/rhsplantfinder/. (Archived at PERAL).

Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Elchbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters. 1999. Terrestrial Ecoregions of North America: A Conservation Assessment. Island Press, Washington D.C. 485 pp.

River Street Flowerland. 2018. Red baron Japanese blood grass: *Imperata cylindrica* 'Red Baron'. River Street Flowerland, Michigan. Last accessed October 2, 2018, http://plants.riverstreetflowerland.com/12120018/Plant/2598/Red_Baron_Japanese_Blood_Grass/.

Rusdy, M. 2017. A review of the potential of *Imperata cylindrica* (L.) Raeusch as feed for ruminant animals. Tropical Agriculture 94(1):99-106.

San Marcus Growers. 2018. *Imperata cylindrica* var. *koenigii* 'Red Baron' - Blood Grass. San Marcus Growers. Last accessed September 24, 2018, https://www.smgrowers.com/products/plants/plantdisplay.asp?cat_id=5&plant_id=712&page=2.

Santi, C., D. Bogusz, and C. Franche. 2013. Biological nitrogen fixation in non-legume plants. Annals of Botany 111(5):743-767.

Sellers, B. A., J. A. Ferrell, G. E. MacDonald, S. F. Enloe, and S. L. Flory. No Date. Cogongrass (*Imperata cylindrica*) biology, ecology, and management in Florida grazing lands. University of Florida, Institute of Food and Agricultural Sciences Gainesville, Florida. 5 pp.

Shilling, D. G., T. A. Bewick, J. F. Gaffney, S. K. McDonald, C. A. Chase, and E. R. R. L. Johnson. 1997. Ecology, physiology, and management of cogongrass (*Imperata cylindrica*). Final report. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida. 128 pp.

Snitzer, J. 2018. Does reverted red baron produce fertile seed? Personal communication to A. L. Koop on December 3, 2018, from John Snitzer, Landscape Contractor.

Terry, P. J., G. Adjers, I. O. Akobundu, A. U. Anoka, M. E. Drilling, S. Tjitrosemito, and M. Utomo. 1996. Herbicides and mechanical control of *Imperata cylindrica* as a first step in grassland rehabilitation. Agroforestry Systems 36(1):151-179.

The Plant List. 2017. The Plant List, Version 1. Kew Botanic Gardens and the Missouri Botanical Garden. http://www.theplantlist.org/. (Archived at PERAL).

Thomas, R. W., G. S. Donn, F. G. James, and L. C. Wayne. 1996. Mechanical and chemical control of cogongrass (*Imperata cylindrica*). Weed Technology 10(4):722-726.

Tominaga, T. 1988. Genecological studies on the variation of *Imperata cylindrica*, a perennial weed. Dissertation, Kyoto University, Kyoto, Japan.

Tominaga, T. 1993. Rhizome systems and sprouting pattern of shoots in *Imperata cylindrica*. Japanese Journal of Tropical Agriculture 37:120-123.

Tominaga, T. 2003. Growth of seedlings and plants from rhizome pieces of cogongrass (*Imperata cylindrica* (L.) Beauv.). Weed Biology and Management 3(3):193-195.

Trautwig, A. N., L. G. Eckhardt, N. J. Loewenstein, J. D. Hoeksema, E. A. Carter, and R. L. Nadel. 2017. Cogongrass (*Imperata cylindrica*) affects above and belowground processes in commercial loblolly pine (*Pinus taeda*) stands. Forest Science 63(1):10-16.

Univ. of Minn. 2018. Plant Information Online Database. University of Minnesota. http://plantinfo.umn.edu/search/plants. (Archived at PERAL).

Vo, T. D. H., X. T. Bui, D. D. Nguyen, V. T. Nguyen, H. H. Ngo, W. Guo, P. D. Nguyen, C. N. Nguyen, and C. Lin. 2018. Wastewater treatment and biomass growth of eight plants for shallow bed wetland roofs [Abstract]. Bioresource Technology 247:992-998.

Weber, E. 2003. Invasive Plant Species of the World: A Reference Guide to Environmental Weeds. CABI Publishing, Wallingford, UK. 548 pp.

Willard, T. R., D. W. Hall, G. S. Donn, J. A. Lewis, and L. C. Wayne. 1990. Cogongrass (*Imperata cylindrica*) distribution on Florida highway rights-of-way. Weed Technology 4(3):658-660.

Wunderlin, R. P., and P. F. Hansen. 2018. Atlas of Florida Vascular Plants. University of South Florida, Department of Biology, Institute for Systematic Botany. http://florida.plantatlas.usf.edu/Default.aspx. (Archived at PERAL).

Appendix A. Weed risk assessment for *Imperata cylindrica* (L.) P. Beauv. (Poaceae)

The following table includes the evidence and associated references used to evaluate the risk potential of this taxon. We also include the answer, uncertainty rating, and score for each question. The Excel file in which this assessment was conducted is available upon request.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 [What is the taxon's establishment and spread status outside its native range? (a) Introduced elsewhere =>75 years ago but not escaped; (b) Introduced <75 years ago but not escaped; (c) Never moved beyond its native range; (d) Escaped/Casual; (e) Naturalized; (f) Invasive; (?) Unknown]	f - negl	5	Cogongrass has a very broad native distribution that includes Africa, southern Europe (e.g., Portugal, Italy, Greece, Bulgaria), temperate Asia (e.g., the Arabian peninsula, western Asia, the Caucasus, middle Asia, China, Japan, and Korea), tropical Asia (e.g., Indian subcontinent, Indo-China, Malesia, Nepal, and Papua New Guinea), and Australia (MacDonald, 2004; NGRP, 2018). It has been introduced and become naturalized in a variety of locations including New Zealand, Cape Verde, Madagascar, Seychelles, Vanuatu, Australia (Lord Howe Island), several countries in the Caribbean and Central America, Chile, Colombia, and the United States (NGRP, 2018; Rusdy, 2017). It is considered a highly invasive species (GISD, 2015; Weber, 2003). In 1912, cogongrass was accidentally introduced to the United States in Mobile County, AL as packing material for oranges from Japan (Dickens, 1974). Starting in 1921 and continuing through the 1940s, it was intentionally introduced for forage at multiple sites (Dickens, 1974; MacDonald, 2004). Since its introduction, it has spread throughout the southeastern United States (Brewer, 2008; Bryson and Carter, 1993; Dickens, 1974; Patterson et al., 1980) and continues to appear in new places and expand its range (NCDACS, 2017). Cogongrass spreads rapidly by rhizomes and seeds (Hall, 1998). From individual plantlets, rhizomes can spread to a 1-m radius within a few months of planting (Tominaga, 1993). Alternate answers for the uncertainty simulation were both "e."
ES-2 (Is the species highly domesticated)	n - negl	0	We found no evidence that this species is highly domesticated or has been bred for reduced weed potential, although some cultivars, such as 'Red Baron,' are available. The species is highly variable and comprises numerous varieties and cultivars (MacDonald, 2004; Tominaga, 1988), many of which occur naturally throughout the world (NGRP, 2018).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-3 (Significant weedy congeners)	y - mod	1	The genus *Imperata* includes about nine species (MacDonald, 2004). *Imperata brasiliensis* is weedy (Holm et al., 1991; Randall, 2017), spreading in the United States (Bryson and Carter, 1993; Dozier et al., 1998) and regulated as a U.S. Federal Noxious Weed (7 CFR § 360, 2018). *Imperata brasiliensis* is considered native to southern Florida by some sources (Hall, 1998; Wunderlin and Hansen, 2018) but not others (NGRP, 2018; NRCS, 2018) and has become naturalized in Alabama and Louisiana (Hall, 1998). One researcher synonymizes this species with *I. cylindrica* (Bryson and Carter, 1993); however, because several major botanical databases treat *I. brasiliensis* as a separate species (NGRP, 2018; NRCS, 2018), we answered yes to this question.
ES-4 (Shade tolerant at some stage of its life cycle)	y - high	1	Cogongrass is adapted to full sun but can establish and thrive under moderate levels of shade (Bryson and Carter, 1993; Estrada et al., 2016). In a greenhouse experiment, Patterson (1980) grew rhizome and stem propagules of cogongrass under three light levels and found that plants grown in full light produced 3 times more biomass than plants grown in 56 percent of full light, and 20 times more biomass than plants grown under 11 percent light. The plants compensated somewhat to shading by increasing resource allocation to leaves. Plant "performance under low light shows that it could grow under the canopy of common row crops", which typically filter out about 80 to 90 percent of full sunlight. Patterson (1980) concluded that cogongrass could persist for a few months under the canopy of a crop and then respond quickly to increased light levels. One researcher determined experimentally and through greenhouse studies that cogongrass can just survive at about two percent of full sunlight. In a field study in which researchers planted rhizome fragments under open field conditions and in a shady understory receiving only three percent light, Estrada et al. (2017) found that while cogongrass plants could establish in the shade, they were unable to persist a full year. Variation in the outcomes and conclusions of these studies is probably due to the precise amount of light associated with the shade treatments relative to the light compensation point of plants, the size of plants used in the studies, and the length of the study periods. While it is clear that cogongrass prefers high-light environments, the weight of the evidence suggests that adult plants with well-developed rhizomatous mats could persist, if not grow, under some shady conditions and that plants may be able to persist and grow around light levels of about 10 percent. Consequently, we answered yes, but with high uncertainty.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	Cogongrass is an erect, perennial grass that grows in a wide range of terrestrial habitats (Bryson and Carter, 1993; MacDonald, 2004); it is neither a vine nor an herbaceous plant with a basal rosette of leaves.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-6 (Forms dense thickets, patches, or populations)	y - negl	2	Cogongrass forms dense stands in southern Japan (Tominaga, 1993). In some forest stands of *Pinus taeda* in Mississippi, it has a mean coverage of 84 percent (Trautwig et al., 2017). Dense monotypic stands are widely reported in tropical and subtropical forests, savannas, grasslands, pastures, and agricultural fields (GISD, 2015; MacDonald, 2004; Weber, 2003).
ES-7 (Aquatic)	n - negl	0	This species is a terrestrial, upland plant (Bryson and Carter, 1993; Eussen and Soerjani, 1975; MacDonald, 2004).
ES-8 (Grass)	y - negl	1	This species is a perennial, C_4 rhizomatous grass (Brewer, 2008; NGRP, 2018; Rusdy, 2017).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that this species fixes nitrogen. It is not a member of a plant family that is typically associated with nitrogen fixation (e.g., Martin and Dowd, 1990; Santi et al., 2013) and is not woody.
ES-10 (Does it produce viable seeds or spores)	y - negl	1	This species reproduces sexually by seed and asexually via rhizomes (Bryson and Carter, 1993; Eussen and Soerjani, 1975; Rusdy, 2017). Germination rates in cogongrass appear to be quite variable with reported rates as low as 0 and 20 percent and as high as 95 and 98 percent (reviewed in MacDonald, 2004; Shilling et al., 1997).
ES-11 (Self-compatible or apomictic)	n - negl	-1	This species is self-incompatible and requires cross-fertilization to set seed (Miyoshi and Tominaga, 2017; Shilling et al., 1997; McDonald et al., 1995 cited in MacDonald, 2004).
ES-12 (Requires specialist pollinators)	n - negl	0	Cogongrass is wind-pollinated (Miyoshi and Tominaga, 2017; Tominaga, 2003).
ES-13 [What is the taxon's minimum generation time? (a) less than a year with multiple generations per year; (b) 1 year, usually annuals; (c) 2 or 3 years; (d) more than 3 years; or (?) unknown]	a - negl	2	Cogongrass reproduces by seed and rhizome production (Tominaga, 2003). In one experiment, a researcher planted individual 10 cm-length shoots in the middle of 2 x 2 m square plots in early June (Tominaga, 1993). Within three weeks, these plants had produced their first daughter shoot. By the end of October, one parent had produced 49 daughter shoots, up to 1 m away from the parent. Fourteen months after the initial planting, a total of 207 daughter shoots had been produced (Tominaga, 1993). Although some of these daughter shoots were categorized as tillers from the base of other shoots, others represented "individual" shoots produced further away. This study demonstrates the ability of this species to produce multiple vegetative generations per year. Plants begin producing rhizomes within 4 to 12 weeks of germination (MacDonald, 2004). Because we did not find enough information on generation time with respect to sexual reproduction, we based this answer on vegetative reproduction. Alternate answers for the uncertainty simulation were both "b."

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-14 (Prolific seed producer)	y - low	1	Cogongrass seed production is variable (Eussen and Soerjani, 1975; Loewenstein et al., 2011), presumably because plants require pollen from genetically different plants. Several researchers have reported seed production as high as 3000 seeds per plant (Holm et al., 1977; Rusdy, 2017) and 500 seeds per panicle (Tominaga, 1993), but the basis of these seed production rates is not clear from the references. Seed germination rates are variable with reported rates as low as 0 and 20 percent and as high as 95 and 98 percent (reviewed in MacDonald, 2004; Shilling et al., 1997). In their own studies, Shilling et al. (1997) found that spikelets were filled about 30 percent of the time and had germination rates of about 23 to 30 percent; however, when filled caryopses were separated from empty spikelets, germination increased to about 95 percent. They estimated about 400 to 500 spikelets per panicle (Shilling et al., 1997), suggesting that panicles should have between 120 and 150 viable seeds. In a different study, Loewenstein et al. (2011) obtained 56 panicles from a quarter-meter square plot and obtained a mean of 82.3 viable seeds per panicle (± 55.4), which scales up to 18,435 viable seeds per square meter. These results are consistent with anecdotal comments that cogongrass is, or can be, a prolific seed producer (Bryson and Carter, 1993; Dickens, 1974).
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	Cogongrass readily spreads via road construction and maintenance activities due to contamination of soil and road fill with rhizome fragments and seeds (Bryson and Carter, 1993; Faircloth, 2007; Shilling et al., 1997). Evidence from a survey of 8200 km of roadways and highways in Florida suggests that cogongrass has probably spread through fill-soil contaminated with rhizomes (Willard et al., 1990). Cogongrass is sometimes baled as straw and sold as horse bedding, resulting in the establishment of new plants when seed-infested straw is discarded (Duever, 2007).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - negl	2	Cogongrass was accidently introduced into the United States in 1912 as packing material for oranges from Japan (MacDonald, 2004). From 1984 to 2017, it was intercepted 4868 times in permit and general cargo and in passenger baggage (AQAS, 2018, queried on April 12, 2018). It has also been intercepted adhering to wood pallets moving in international trade (CBP, 2016) and can also contaminate hay (Loewenstein, No Date).
ES-17 (Number of natural dispersal vectors)	1	-2	Seed traits for questions ES-17a through ES-17e: Seeds are small, 1.1 mm long, and attached to a long plume of silky hairs (Reed, 1977; Shilling et al., 1997).
ES-17a (Wind dispersal)	y - negl		Plumed cogongrass seeds are carried by wind (Tominaga, 1993). They may disperse very long distances, but most seeds fall within 15 m of the parent plant (Bryson and Carter, 1993). One researcher reported that seeds may travel up to 24 km over open landscapes (Hubbard et al., 1944 cited in MacDonald, 2004).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17b (Water dispersal)	? - max		Cogongrass grows in a wide range of habitats, including in swamps and along rivers (Bryson and Carter, 1993). Because of the long silky plumes, the seeds can probably float; however, we found no direct evidence of dispersal by water.
ES-17c (Bird dispersal)	n - low		We found no evidence. As this is a well-studied species, we used low uncertainty.
ES-17d (Animal external dispersal)	? - max		We found no direct evidence that seeds are dispersed by animals externally. Cogongrass is sometimes baled as straw and sold as horse bedding (Duever, 2007). Because it is possible that these seeds would catch on animal fur, we answered this question as unknown.
ES-17e (Animal internal dispersal)	n - low		We found no evidence. As this is a relatively well-studied species, we used low uncertainty.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	It is not clear to what extent cogongrass seeds can remain viable in the soil. Holm et al. (1977) report that seeds can remain viable for at least a year; however, more recent evidence indicates that "seed viability is extremely short-lived" (Bryson and Carter, 1993). Shilling et al (1997) obtained caryopses from several populations, dried them, and stored them in a cool, dry place. They sampled caryopses, which each contain a seed, every month for 12 months to estimate seed longevity through both germination and tetrazolium[2] tests. Initially, seed germination was about 100 percent, but it steadily declined to 0 percent by the end of the year (Shilling et al., 1997). In another lab-based study, 12-month-old seed had a mean germination rate of 13.1 percent, compared to 37.6 percent for fresh seed (Loewenstein et al., 2009). Cogongrass rhizomes have been reported to remain dormant for a long time (Rusdy, 2017). Because the evidence is conflicting and is primarily based on laboratory studies, we answered unknown.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - negl	1	Cogongrass produces three types of rhizomes, and more than half of its biomass is invested in the rhizomes (MacDonald, 2004; Tominaga, 1993). "Fires stimulate flowering and regrowth of *Imperata*'s rhizomes. The underground rhizomes are fire resistant and if fires are frequent, this plant will gradually become more dominant" (Rusdy, 2017). "Roots and rhizomes are also remarkably resistant to fire and are able to survive in plantations where other weeds are destroyed by controlled burning....1- to 5-cm-long and 2- to 5-cm diam pieces of rhizomes were viable and sprouted from depths of 15 cm or less" (Bryson and Carter, 1993). Rhizome fragments with just one node have a 50 percent chance of establishment (Estrada et al., 2016). The rhizomes of cogongrass possess bands of fibrous tissue (sclerenchyma), which helps conserve water and resist mechanical injury (MacDonald, 2004). Cogongrass dominance tends to decrease if fire is excluded (Eussen and Soerjani, 1975).

[2] A chemical used to indicate cellular respiration.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence that this species has developed resistance to herbicides (e.g., Heap, 2018). Cogongrass is susceptible to herbicides, including glyphosate and imazapyr, but repeated application is required due to inefficient translocation of herbicides to rhizomes (Aulakh et al., 2014; Rusdy, 2017).
ES-21 (Number of cold hardiness zones suitable for its survival)	9	0	
ES-22 (Number of climate types suitable for its survival)	9	2	
ES-23 (Number of precipitation bands suitable for its survival)	11	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	y - low	0.1	Cogongrass is commonly reported to be allelopathic (Bryson and Carter, 1993). Many lab-based, experimental studies using pulverized plant tissues or leachates have found that cogongrass negatively impacts the germination or growth rate of test species (reviewed in Estrada and Flory, 2015). One greenhouse study used leachates from root exudates of cogongrass and native plant mixtures from southern U.S. pine forests (Hagan et al., 2013) and provided evidence that allelochemicals may be contributing to the invasive success of this species in southern forests. Two of the four native plant species (*Aristida stricta* and *Pinus elliottii*) watered with leachates from cogongrass were negatively impacted (Hagan et al., 2013). We answered yes with low uncertainty based on the number of studies finding evidence of allelopathy and the evidence provided by Hagan et al. (2013), who tested natural concentrations of leachates on native plant species.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that this species is parasitic. Furthermore, it is not a member of a plant family known to contain parasitic plants (e.g., Heide-Jorgensen, 2008; Nickrent, 2009).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	y - negl	0.4	Cogongrass has ecosystem-level impacts on nutrient cycling, disturbance regimes, and decomposition (reviewed in Estrada and Flory, 2015). It tends to form fire-climax communities because it promotes very hot, frequent, and continuous fires that change the structure and function of ecosystems (Lippincott, 2000; MacDonald, 2004). In U.S. pine flatwoods and pine rocklands, cogongrass "can introduce fire into sensitive areas that are not usually burned and it can change the fire regime of fire dependent ecosystems by altering the structure of the invaded areas" (O'Brien et al., 2007). In some forests in Indonesia, fire exclusion promotes forest regeneration if drought-tolerant, shade-forming species are able to establish (Eussen and Soerjani, 1975). Areas dominated by cogongrass appear to have reduced soil fertility compared to other vegetation types, and soil erosion may be higher in those areas (Eussen and Soerjani, 1975). Loblolly pines growing in forests heavily invaded by cogongrass had decreased ectomycorrhizal colonization, which will likely limit the ability of trees to access soil nutrients (Trautwig et al., 2017). These authors speculate that cogongrass may be affecting nutrient cycling through effects on vegetation diversity and associated soil micro-organisms but note that another study found no evidence of impacts on nutrient cycling (Trautwig et al., 2017). In one common garden study, light levels at ground level and at 0.5 m height were lower in plots planted with cogongrass (Alba et al., 2017). In that same study, cogongrass mitigated the potential impact of drought (artificially imposed by rainout shelters) by maintaining higher humidity and soil moisture levels and lower ambient temperature relative to controls that were not planted with cogongrass (Alba et al., 2017). Although the impacts of cogongrass on nutrient cycling are less certain, we answered yes with negligible uncertainty due to its impacts on fire regime.
Imp-N2 (Changes habitat structure)	y - negl	0.2	In a longleaf pine community, invasion by cogongrass increased shade at the ground level up to 99 percent and reduced the species diversity of that layer (Brewer, 2008). "In the southeastern US, cogongrass dramatically alters the species and functional composition of native pine (*Pinus* spp.) ecosystems by displacing native groundcover species ... and by inhibiting the performance of sapling trees" (reviewed in Hagan et al., 2013). In Indonesia, change in fire regime associated with the invasion of cogongrass "destroys rain-forest trees and promotes grassland invasion" (Cleary, 2016).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N3 (Changes species diversity)	y - negl	0.2	In De Soto National Forest in the United States, one researcher found that over a five-year period, invasion by cogongrass reduced the diversity of native plants in a longleaf pine community (Brewer, 2008). In some Mississippi forest stands of loblolly pine, cogongrass coverage was negatively associated with vegetation diversity (Trautwig et al., 2017). In its native range in Indonesia and western Africa, it forms massive, monospecific stands called Imperata grasslands that can reach areas of 10,000 contiguous hectares and are climax communities (MacDonald, 2004). In Bangladesh, "[t]he sun grass is growing aggressively and thus occupying the spaces of native plant species in both natural and planted forest patches" (Dutta and Hossain, 2016).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y - negl	0.1	Cogongrass is a threat to many of the rare and threatened understory herbs that are indicative of longleaf pine communities in the southeastern coastal plain (Cleary, 2016). In Florida, one study showed that it effectively eliminates the food sources and habitat of gopher tortoises and disrupts their ability to orient (Basiotis, 2007). It is also threatening the habitat of other endangered plant and animal species in that state (Lippincott, 2000).
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	y - negl	0.1	The southeastern United States contains several globally outstanding ecoregions (Ricketts et al., 1999). Because cogongrass changes ecosystems processes and habitat structure and reduces native species diversity (see evidence above), it threatens these ecoregions (MacDonald, 2004). In the United States, longleaf pine communities are somewhat rare plant communities and are directly threatened by cogongrass invasion (Cleary, 2016).
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	c - negl	0.6	Cogongrass is considered one of the worst weeds in the world (GISD, 2015) and in the southeastern United States, where it is widely controlled (Firley, 2016; Jose et al., 2002; Loewenstein and Miller, 2007; Miller, 2003). In most U.S. regions, managers are merely trying to suppress and contain cogongrass. In some regions at the edge of its U.S. distribution, such as North and South Carolina, however, land managers are trying to eradicate populations as they are discovered (Clemson Regulatory Services, 2018; NCDACS, 2017). Based on a survey of private forest landowners in Florida, Divate et al. (2017) estimated direct regional costs of control to be between \$10 million and \$33 million annually. Cogongrass is best managed using an integrated approach that incorporates burning or mowing, herbicide applications, and discing or revegetation (Dozier et al., 1998; Jose et al., 2002). Cogongrass populations need to be managed over an extended period to weaken and deplete plant rhizomes (Dozier et al., 1998). Alternate answers for the uncertainty simulation were both "b."

Question ID	Answer - Uncertainty	Score	Notes (and references)
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	y - negl	0.1	Because of its tall, dense growth habit, cogongrass is considered a safety concern along roadways and intersections (Dickens, 1974). Like other types of plants, tall grasses growing along roadways and highways may impact public safety (Willard et al., 1990). "Cogongrass creates hot, flashy fires due to greater fine fuel loads and high biomass density. Temperatures can reach up to 842 ºF (450 ºC) and can reach heights of 5 ft (1.5 m)" (O'Brien et al., 2007). In regions with a high intermixing of wildlands and urban areas, cogongrass-initiated fires may present a potential safety hazard (Faircloth, 2007).
Imp-A2 (Changes or limits recreational use of an area)	y - high	0.1	Cogongrass is reported to affect recreation (FDACS, 2018; MFC, 2018), but we found no specific information describing the impact. Cogongrass has finely serrated leaves that deter herbivory (MacDonald, 2004; Rusdy, 2017) and forms dense monospecific stands that exclude native species (Trautwig et al., 2017). As such, it seems likely that it would affect the recreational value of wildlands. In a recent study of nonindustrial, private forests in Florida, the majority of landowners managed their woodlands for wildlife viewing, hunting, and other recreational activities. Twenty-five percent of the surveyed landowners had cogongrass infestations, and most of those were trying to control it on their properties (Divate et al., 2017). Without more specific information, we used high uncertainty.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - mod	0	We found no evidence of this impact.
Imp-A4 [What is the taxon's weed status in anthropogenic systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	c - negl	0.4	This species invades deforested land (Rusdy, 2017), railways, highways, utility lines, pipelines (Bryson and Carter, 1993), and lawns (Dickens, 1974; Patterson et al., 1980). "In 1981, the FDOT Bureau of Maintenance cited cogongrass among nine grassy weed species requiring additional efforts beyond those needed to maintain desired turf species" along roadways and highways (Willard et al., 1990). On right-of-ways, cogongrass has only been effectively controlled with an integrated weed management approach that combines mowing, herbicide application, and revegetation (Faircloth, 2007). Alternate answers for the uncertainty simulation were both "b."

Question ID	Answer - Uncertainty	Score	Notes (and references)
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - negl	0.4	Cogongrass is a weed in annual crops and is also particularly problematic in perennial crops. It is very competitive and reduces soil fertility (Eussen and Soerjani, 1975). We found ample evidence demonstrating that it reduces yield and crop growth in infested regions (reviewed in Holm et al., 1977). For example, in some plantation crops it reduces the growth of plants by as much as 85 to 96 percent (MacDonald, 2004). "In addition to competing for light, water and nutrients, cogongrass interference is caused by allelopathy and physical injury when rhizome apices penetrate crop roots, bulbs, and tubers" (Bryson and Carter, 1993). When cogongrass rhizomes pierce root and tuber crops such as cassava and yams, secondary fungal infections may occur and further decrease yield (Terry et al., 1996). Cogongrass is reported to grow up to 60 cm in the roots of other plants (Holm et al., 1977). Relative to other grasses, it has a low digestibility rating, and as plants mature, their nutritive value decreases. Consequently, animal productivity is lower in pastures dominated by this species (Rusdy, 2017).
Imp-P2 (Lowers commodity value)	y - negl	0.2	Some growers have abandoned farmland infested with cogongrass (Tominaga, 1993). In Africa, millions of hectares of farmland are abandoned each year (Terry et al., 1996). "In 1970 it was estimated that in Indonesia 16 million ha were covered with this grass, while the annual increase was thought to be 150,000 ha" (Eussen and Soerjani, 1975). These areas are potentially valuable as agricultural land, and control methods are needed to convert them into production (Eussen and Soerjani, 1975). Cogongrass-dominated areas can be rehabilitated by planting trees and jump-starting forest regeneration, but it is costly. Once the cogongrass has been replaced by other types of vegetation, the value of these areas increases (Eussen and Soerjani, 1975). Because cogongrass reduces the value of land, we answered yes for this question.
Imp-P3 (Is it likely to impact trade?)	y - low	0.2	Cogongrass is classified as a noxious weed in more than 70 countries (cited in Trautwig et al., 2017). It is regulated by Brazil, Niue, Mexico, Paraguay, Guatemala, Nicaragua, Honduras, New Zealand (APHIS, 2018; MAF Biosecurity Authority, 2001), and likely other countries. Because seeds may contaminate certain agricultural products or conveyances (AQAS, 2018; CBP, 2016; MacDonald, 2004), it may impact trade. For example, New Zealand specifically regulates the introduction of all *Imperata* spp. on pineapples from Thailand (MAF Biosecurity Authority, 2001).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - low	0	We found no evidence of this impact. Given that this species is relatively well-studied, we used low uncertainty.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	We found no specific evidence that cogongrass is toxic to animals (e.g., Bruneton, 1999; Burrows and Tyrl, 2013). If infested pastures are properly managed by burning on an

Question ID	Answer - Uncertainty	Score	Notes (and references)
			annual basis, and grazing or cutting sufficiently close to the ground, the leaves are suitable for forage (Holm et al., 1977) but not necessarily nutritive (Rusdy, 2017). When animals consume older and tougher leaves, they may develop mouth sores (Holm et al., 1977).
Imp-P6 [What is the taxon's weed status in production systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	c - negl	0.6	Cogongrass invades cultivated and grazing land, as well as plantations (Rusdy, 2017; Tominaga, 1993). It is considered a primary weed of tea, rubber, pineapple, coconut, oil palm, and other plantation crops in Asia (MacDonald, 2004). In the United States, cogongrass invades pine plantations (Estrada and Flory, 2015). It is generally considered a major agronomic weed throughout the world. Eussen and Soerjani (1975) and Holm et al. (1977) classify it as one of the ten worst weeds. Frequent deep tillage inhibits or prevents its establishment in row crops (Bryson and Carter, 1993). The goal of mechanical control is to exhaust the regenerative capacity of underground rhizomes (Eussen and Soerjani, 1975). In some regions of Africa, half of the crop production budget is spent on cogongrass control (MacDonald, 2004). In Indonesia, it is recommended that fast-growing crops be used that would overgrow and suppress cogongrass (Eussen and Soerjani, 1975), at least temporarily. In agricultural areas, it is best to use a combination of cultural, chemical, and mechanical techniques to control cogongrass (MacDonald, 2004). Alternate answers for the uncertainty simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2017).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence this species occurs in this Zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence this species occurs in this Zone.
Geo-Z3 (Zone 3)	n - high	N/A	One point in Afghanistan near the edge of Zone 4.
Geo-Z4 (Zone 4)	y - high	N/A	The red cultivars of the species are more cold tolerant and to survive in Zone 4b (Mahr, 2011). This species is reported to grow to the 45th parallel in Japan (Bryson and Carter, 1993), which includes this zone; however, a species distribution map for Japan does not indicate that it grows in this Zone (Tominaga, 1988).
Geo-Z5 (Zone 5)	y - low	N/A	Five points in Japan and two points in Turkey well within this Zone, and one point each in China and Turkey that are near the edge of Zone 6. A gardener in Zone 5 (New Hampshire) reports that the cultivar 'Red Baron' has survived for several years in their yard (Dave's Garden, 2018).
Geo-Z6 (Zone 6)	y - negl	N/A	Some points in Japan, four in China, one in Pakistan, and one in Tajikistan.
Geo-Z7 (Zone 7)	y - negl	N/A	Some points in Japan and a few in China. Two points in France, three in Russia, and one in Turkey. Rhizomes may survive at temperatures as low as -14 °C (Dozier et al., 1998).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z8 (Zone 8)	y - negl	N/A	Australia, China, and the United States. A few points in South Africa. Zones 8-12 are suitable for the species (Page and Olds, 2001).
Geo-Z9 (Zone 9)	y - negl	N/A	Australia, China, South Africa, and the United States. Zones 8-12 are suitable for the species (Page and Olds, 2001).
Geo-Z10 (Zone 10)	y - negl	N/A	Australia, Spain, and the United States. Some points in China, Botswana, and Zimbabwe. Zones 8-12 are suitable for the species (Page and Olds, 2001).
Geo-Z11 (Zone 11)	y - negl	N/A	Australia, Benin, Israel, Spain, and Taiwan. Zones 8-12 are suitable for the species (Page and Olds, 2001).
Geo-Z12 (Zone 12)	y - negl	N/A	Australia, Benin, Israel, Spain, and Taiwan. Zones 8-12 are suitable for the species (Page and Olds, 2001).
Geo-Z13 (Zone 13)	y - negl	N/A	Australia, Benin, and Papua New Guinea. Some points in Taiwan.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	y - negl	N/A	Benin and Papua New Guinea.
Geo-C2 (Tropical savanna)	y - negl	N/A	Australia. Some points in Gabon and Tanzania and some throughout Southeast Asia.
Geo-C3 (Steppe)	y - negl	N/A	Australia, Israel, and Spain.
Geo-C4 (Desert)	y - low	N/A	A few points throughout Saharan Africa and some in Afghanistan and Israel. Cogongrass grows in the coarse sands of desert dunes (Bryson and Carter, 1993).
Geo-C5 (Mediterranean)	y - negl	N/A	Australia, France, Israel, Italy, and South Africa.
Geo-C6 (Humid subtropical)	y - negl	N/A	Australia, China, Taiwan, and the United States.
Geo-C7 (Marine west coast)	y - negl	N/A	Australia, South Africa, and Spain. A few points in New Zealand.
Geo-C8 (Humid cont. warm sum.)	y - low	N/A	Many points in Japan and one in Turkey.
Geo-C9 (Humid cont. cool sum.)	y - high	N/A	Four points in Japan, one point in Turkey, and one in China. In Japan, cogongrass is distributed from Hokkaido to Okinawa prefecture (Miyoshi and Tominaga, 2017), which include this climate class. This species is reported to grow to the 45th parallel in Japan (Bryson and Carter, 1993), which includes this climate class.
Geo-C10 (Subarctic)	n - high	N/A	One point in China, near the edge of areas with humid continental cool summers.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - low	N/A	Some points in Australia, Israel, South Africa, and Spain.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Some points in Australia, Israel, South Africa, and Spain.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Australia, Israel, South Africa, and Spain.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Australia. Weedy in areas receiving 75 to 500 cm annual precipitation (Bryson and Carter, 1993).
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Australia. Weedy in areas receiving 75 to 500 cm annual precipitation (Bryson and Carter, 1993). This species is present in a region of central Africa that includes this precipitation band.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	United States. Occurs in a region of Japan that includes this precipitation band. Weedy in areas receiving 75 to 500 cm annual precipitation (Bryson and Carter, 1993).
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	United States. Growing in an area of Mississippi receiving an average of 1,677 mm of precipitation annually (Trautwig et al., 2017). Occurs in a region of Japan that includes this precipitation band. Weedy in areas receiving 75 to 500 cm annual precipitation (Bryson and Carter, 1993).
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	United States. Weedy in areas receiving 75 to 500 cm annual precipitation (Bryson and Carter, 1993). Occurs in a region of Japan that includes this precipitation band.
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Weedy in areas receiving 75 to 500 cm annual precipitation (Bryson and Carter, 1993). Occurs in a region of Japan that includes this precipitation band.
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Weedy in areas receiving 75 to 500 cm annual precipitation (Bryson and Carter, 1993). Occurs in a region of Japan that includes this precipitation band.
Geo-R11 (100+ inches; 254+ cm)	y - negl	N/A	Papua New Guinea. Weedy in areas receiving 75 to 500 cm annual precipitation (Bryson and Carter, 1993). Occurs in a region of Japan that includes this precipitation band.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - negl	0	Cogongrass is already well-established in the southeastern United States (Brewer, 2008; Bryson and Carter, 1993; Dickens, 1974; Patterson et al., 1980) and is regulated as a federal noxious weed (7 CFR § 360, 2018). To evaluate the likelihood of additional introductions, however, we set this answer to no.
Ent-2 (Plant proposed for entry, or entry is imminent)	n - mod	0	We found no evidence.
Ent-3 [Human value & cultivation/trade status: (a) Neither cultivated or positively valued; (b) Not cultivated, but positively valued or potentially beneficial; (c) Cultivated, but no evidence of trade or resale; (d) Commercially cultivated or other evidence of trade or resale]	d - negl	0.5	The red-leaved forms of cogongrass are cultivated in Europe (RHS, 2018). Cogongrass is widely used as thatch, mulch, and ground-cover material in Southeast Asia, where it is native (Eussen and Soerjani, 1975; Tominaga, 2003). It has been evaluated for potential use in wastewater treatment (Vo et al., 2018) and as a source of biohydrogen (Oladokun et al., 2017) and biomass (Haque et al., 2016). It is also used as a forage grass in some regions (Holm et al., 1977) and is grown in South Korea (Haque et al., 2016).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	y - negl		Cogongrass is native to China (GBIF, 2017). 'Red Baron' is cultivated in Canada (BambooPlants, 2018).
Ent-4b (Contaminant of plant propagative material (except seeds))	n - mod	0	We found no evidence.
Ent-4c (Contaminant of seeds for planting)	n - mod	0	We found no evidence.
Ent-4d (Contaminant of ballast water)	y - low	0.06	Cogongrass was collected from ballast in Portland, OR prior to 1935 (Hall, 1998).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - mod	0	We found no evidence.
Ent-4f (Contaminant of landscape products)	y - negl	0.04	We found ample evidence that this species readily spreads via road construction and maintenance activities due to contamination of soil and road fill with rhizome fragments and seeds (Bryson and Carter, 1993; Faircloth, 2007; Shilling et al., 1997). Evidence from a survey of 8200 km of roadways and highways in Florida suggests that cogongrass has probably spread through fill soil contaminated with rhizomes (Willard et al., 1990). Cogongrass is sometimes baled as straw and sold as horse bedding, resulting in the establishment of new plants when seed-infested manure or straw is discarded (Duever, 2007).
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	y - negl	0.04	Cogongrass was accidently introduced into the United States in 1912 as a packing material for oranges from Japan (MacDonald, 2004). It has also been intercepted adhering to wood pallets moving in international trade (CBP, 2016).
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	y - mod	0.02	New Zealand specifically regulates the introduction of all *Imperata* spp. on pineapples from Thailand (MAF Biosecurity Authority, 2001). U.S. inspectors have intercepted cogongrass on durian fruit (AQAS, 2018 queried on April 12, 2018). Because it is not clear how frequently it contaminates these types of commodities, we used moderate uncertainty.
Ent-4i (Contaminant of some other pathway)	b - mod	0.02	Cogongrass can contaminate hay (Loewenstein, No Date). We chose "b," as it is not clear how important this pathway is.
Ent-5 (Likely to enter through natural dispersal)	n - low	0	We found no evidence that this species is naturalized in a region adjacent to the United States (e.g., Acevedo-Rodríguez and Strong, 2012). Thus, this pathway is unlikely.

Appendix B. A planting of 'Red Baron' in Maryland that may be reverting (source: Al Tasker, USDA-APHIS-PPQ, June 9, 2009).