Minnesota Noxious Weed Risk Assessment

Developed by the Minnesota Noxious Weed Advisory Committee

Assessment information

Common name: Johnsongrass, johnsongrass

Scientific name: *Sorghum halepense* (L.) Pers.

Family name: Poaceae

Current reviewer name and organizational affiliation: Laura Van Riper, Minnesota Department of Natural Resources

Date of current review: August 22, 2022

Species description

Photos

Photo caption: Johnsongrass plant. Photo credit: Steve Dewey, Utah State University, Bugwood.org

Photo caption: Johnsongrass growing densely in a forest opening. Photo credit: John M. Randall, The Nature Conservancy, Bugwood.org.

Photo caption: A distinguishing identification feature of Johnsongrass is that it has a membranous ligule that is 1/10 of an inch long with short hairs. Photo credit: James H. Miller & Ted Bodner, Southern Weed Science Society, Bugwood.org.

Why the plant is being assessed

The Noxious Weed Advisory Committee chose Johnsongrass for assessment because it is regulated in a neighboring state (Wisconsin) and because of its toxicity and potential agricultural economic impacts. Johnsongrass is a well-known invasive species with economic and ecological impacts. It is one of the most significant weeds impacting native ecosystems and agricultural production throughout the world (Warwick and Black 1983, Klein and Smith 2021). The Wisconsin Department of Natural Resources (2021) Johnsongrass webpage summarizes these impacts with these statements:

- “This species is considered one of the 10 worst invasive weeds in the world. Fifty-three countries, ranging in latitude from 55°N to 45°S report Johnsongrass as invasive.

- Invades wetlands, floodplains, irrigation ditches, undisturbed grasslands, prairies, savannas and riparian zones.
- A prolific self-seeder, Johnsongrass also spreads via an extensive rhizome system.
- Plant breeders, seed dealers and growers often observe off-type plants or "rogues" of hybrid grain sorghum. Common rogues are the tall outcrosses to sudangrass, Johnsongrass or other sorghum types. Sorghum outcrosses with Johnsongrass as the male parent often has rhizomes resembling those of Johnsongrass. Johnsongrass-grain sorghum hybrids can become a significant weed threat.
- It contains a toxic cyanide-containing substance that can poison cattle and other livestock."

The taxonomy of species in the *Sorghum* genus is complicated and there has been extensive agricultural breeding and hybridization. There are a number of *Sorghum* species including Columbus grass (*S. almum*), annual sorghum (*S. bicolor*), Sudangrass (*S. bicolor* ssp. *drummondi* also sometimes referred to as *S. drummondii*), and commercial hybrids of various *Sorghum* species.

There is ongoing research into the cold hardiness of Johnsongrass, the frequency and potential impacts of herbicide resistance in Johnsongrass, and management techniques to reduce the impacts of Johnsongrass on crops and animals that may use it as forage.

Identification, biology, and life cycle

- The Wisconsin Department of Natural Resources (2021) Johnsongrass webpage summarizes Johnsongrass characteristics:
  - A warm-season perennial grass with dense rhizomes.
  - Leaves and Stems: Leaves and stems (culms) are coarse. Plants can reach up to 12 feet tall when flowering.
  - Flowers, Fruits and Seeds: Open panicle inflorescence ranges from 4-24 inches. Spikelets occur in pairs, with up to 350 per panicle. Lemmas are ciliate usually without awns, but sometimes very short and twisted in some forms.
  - Roots: Rhizomatous, sometimes forming tuber-like organs. Forms dense tangled root systems in the upper soil surface, extending deeper in loose rich soils.
  - Habitat includes wetlands, floodplains, irrigation ditches, undisturbed grasslands, prairies, savannas and riparian zones.
- One of the best ways to distinguish Johnsongrass from other similar looking species is to inspect the ligule where the leaf and leafstalk meet. Ligules are membranous with short hairs along the margin and edge and are about 1/10 of an inch long. Look for the presence of rhizomes as it is also a key distinguishing feature.
- Look alike species:
  - The Ohio State University (2021) lists these look alike species: "Young plants of johnsongrass may resemble a narrow-leafed corn (*Zea mays*) plant. Seedlings of johnsongrass may be distinguished by the remnant seed attached to the root, and shoots may be distinguished by the presence of rhizomes. Johnsongrass and shattercane (*Sorghum bicolor*) are close relatives, but shattercane is an annual and does not produce rhizomes. In addition, the leaf blades of shattercane are much wider, and the seeds are larger and more rounded. Common reed (*Phragmites australis*) may resemble johnsongrass, but grows much taller and has dense, feathery flower heads and thin seeds."

- Reports of Johnsongrass in Minnesota have turned out to be species such as yellow foxtail (*Setaria pumila*), barnyardgrass (*Echinochloa crus-galli*), and proso millet (*Panicum miliaceum*) (Laura Van Riper, personal observation, January 11, 2021).
- There are other *Sorghum* species including Columbus grass (*S. almum*) which is also perennial with rhizomes and annual sorghum (also called shattercane) (*S. bicolor*).

Current distribution

There are no confirmed reports of Johnsongrass in Minnesota. An online search of the University of Minnesota herbariums found no herbarium specimens of Johnsongrass from Minnesota (search date: January 11, 2021.) The state level map from USDA Plants (2021) shows Johnsongrass reported in all states except Minnesota and Maine. The more detailed county level map from EDDMapS (2022) shows that some states have limited reports.

There are multiple Johnsongrass herbarium records from Wisconsin, including Trempealeau County which borders Winona County in Minnesota. In a personal communication with Roger Becker (University of Minnesota), Mark Renz (University of Wisconsin) stated that he and his team had looked into the herbarium records and thought they were likely not Johnsongrass, but were likely shattercane (*Sorghum bicolor*) or cross of species (March 1, 2021). It has been reported in Clay County, South Dakota which borders Nebraska. The report in Williams County, North Dakota is from McGregor et al. (1977) which references a plant that "grew for several years beside a building in an alley in Williston". There are no currently known Johnsongrass plants in North Dakota (personal communication between Roger Becker and Clair Keene (Williston Research Extension Center), March 1, 2021). In Iowa, Iowa State University Extension (Hartzler and Vittetoe 2022) indicates that "Johnsongrass rhizomes are intolerant of Iowa's winters, thus it is not a significant problem in the state."

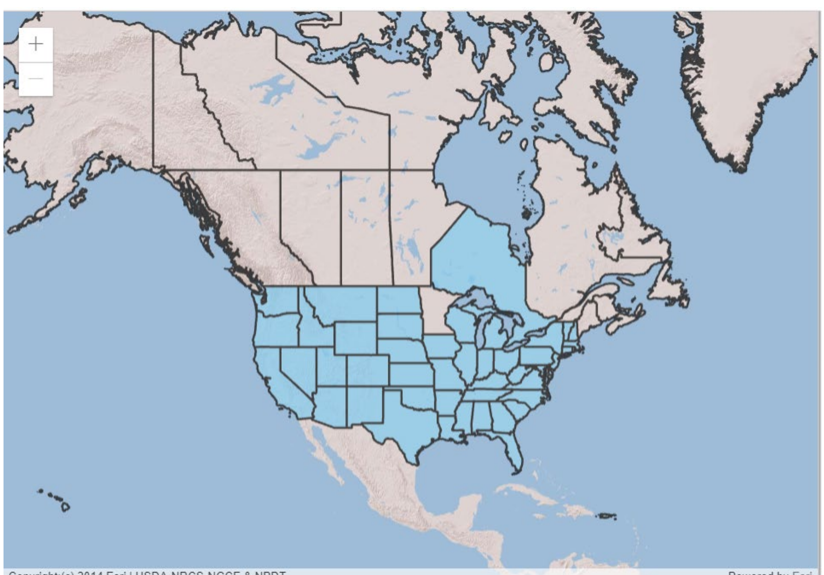

Figure caption: National level map from USDA Plants (2022) showing Johnsongrass as reported in all states in the continental United States except for Minnesota and Maine. Map accessed August 22, 2022.

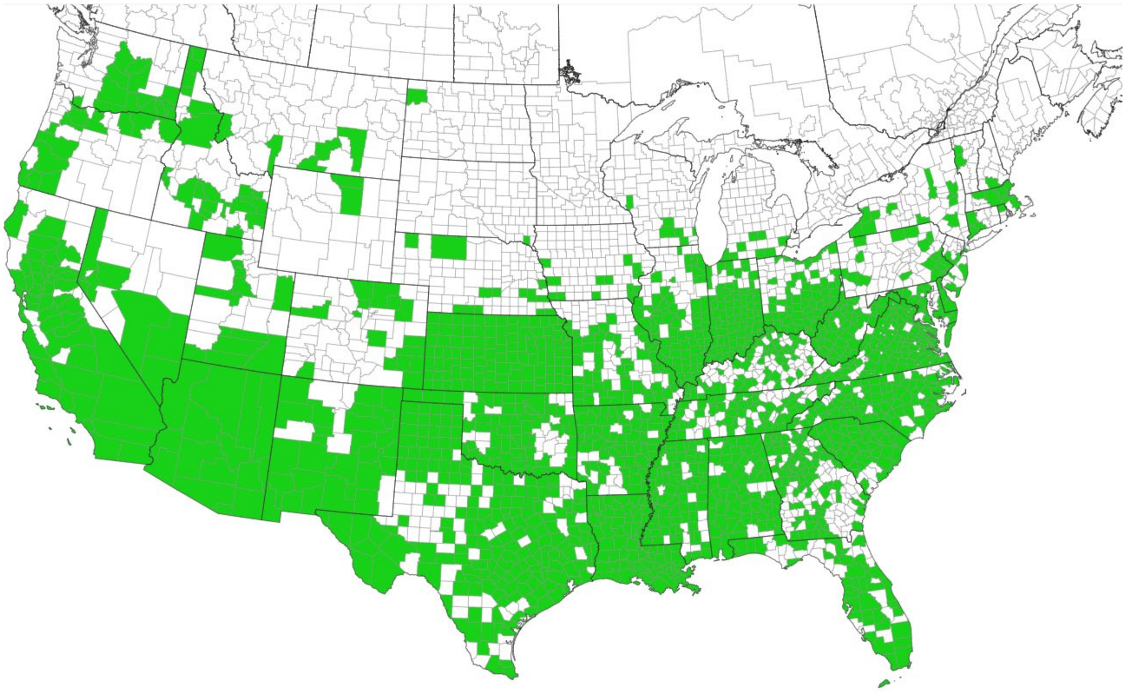

Figure caption: National level map from EDDMapS (2022) showing counties with Johnsongrass noted as present. No presence reported in Minnesota. The nearest location to Minnesota is Trempealeau County in Wisconsin. Map accessed August 22, 2022.

Current regulation

Johnsongrass is listed as a noxious weed seed under the Federal Seed Act (7 U.S.C. 1551-1611). Additionally, the National Plant Board (2022) list of states that regulate Johnsongrass as a noxious weed or regulated plant includes: Arizona Class C noxious weed, Colorado List C, Idaho Control, Illinois noxious weed, Kansas noxious weed, Maryland noxious weed, Michigan noxious weed, Missouri county option noxious weed, Nevada category C weed, Ohio prohibited noxious weed, Oregon B weed, Pennsylvania class B noxious weed, South Dakota regulated plant species, Utah noxious weed, Washington class A noxious weed, Wisconsin prohibited, West Virginia noxious weed.

Johnsongrass is not currently regulated in Minnesota. Two neighboring states regulate Johnsongrass. Wisconsin regulates Johnsongrass as a Prohibited Invasive Species under their NR-40 Rule. South Dakota regulates Johnsongrass as regulated plant species. Brenda Sievers from the South Dakota Department of Agriculture (personal communication to Laura Van Riper, February 26, 2021) explained that regulated plant species are part of their quarantine law (SDCL 38-24A-6). This statute is under South Dakota plant quarantine and treatment laws, giving the state the ability to quarantine items as necessary when the secretary determines that action is necessary to prevent the spread in the state. This is a regulatory tool that is separate from the noxious weed and seed laws, and applies to other products, situations, or even non-seed parts of the plant, if a specific problem arises. The regulated plant species list notifies people that these are particular species to be careful of.

Risk assessment

Box 1:

Is the plant species or genotype non-native?

Answer: Yes.
Outcome: Go to Box 3
Johnsongrass is native to southern Eurasia (Warwick and Black 1983). The ecotype introduced to North America is thought to be from the Mediterranean region (Warwick and Black 1983). Johnsongrass was introduced to the southeastern United States in the early 1800s for forage (Warwick and Black 1983). By 1900, Johnsongrass was considered a weed in the U.S. and was the subject of the first U.S. federal weed control appropriation (Warwick and Black 1983).

Box 2:

Does the species pose significant human or livestock concerns or have the potential to significantly harm agricultural production?

Question 2A: Does the plant have toxic qualities that pose a significant risk to livestock, wildlife, or people?
Outcome: Decision tree does not direct to this question.

Question 2B: Does the plant cause significant financial losses associated with decreased yields, reduced quality, or increased production costs?
Outcome: Decision tree does not direct to this question.

Box 3:

Is the species, or a related species, documented as being a problem elsewhere?

Answer: Yes
Outcome: Go to Box 6
The United States Department of Agriculture completed a risk assessment for Johnsongrass resulting in a score of "high risk" (USDA APHIS 2015, 2022). Wisconsin completed a risk assessment for Johnsongrass (Aubin 2011) and regulates Johnsongrass as a Prohibited Invasive Species under their NR-40 Rule. South Dakota regulates Johnsongrass as regulated plant species. The National Plant Board list of states that regulate Johnsongrass has: Arizona Class C noxious weed, Colorado List C, Idaho Control, Illinois noxious weed, Kansas noxious weed, Maryland noxious weed, Michigan noxious weed, Missouri county option noxious weed, Nevada category C weed, Ohio prohibited noxious weed, Oregon B weed, Pennsylvania class B noxious weed, South Dakota regulated plant species, Utah noxious weed, Washington class A noxious weed, Wisconsin prohibited, West Virginia noxious weed.

Travlos et al. (2019) note: "Johnsongrass (*Sorghum halepense*) is one of the most common and troublesome weeds with a worldwide distribution. It is considered a serious weed in more than 53 countries, causing increases in the costs of production as well as important yield losses in a wide range of field crops including corn, grain sorghum, soybean, sunflower, sugarcane, cotton, pastures and alfalfa but also in several perennial crops. Johnsongrass is also an alternate host of numerous pathogen species and can be toxic to livestock."

Box 4:

Are the species' life history and growth requirements understood?

Outcome: Decision tree does not direct to this question.

Box 5:

Gather and evaluate further information

Outcome: Decision tree does not direct to this question.

Box 6:

Does the species have the capacity to establish and survive in Minnesota?

Question 6A: Is the plant, or a close relative, currently established in Minnesota?

Answer: No.
Outcome: Go to Box 6B
Johnsongrass is not known to be present in Minnesota at this time.

Question 6B: Has the plant become established in areas having a climate and growing conditions similar to those found in Minnesota?

Answer: No, although there is disagreement among habitat suitability maps.
Outcome: Go to Box 6C.
Johnsongrass has been reported in North Dakota, South Dakota, Iowa, and Wisconsin (EDDMapS 2022), although as noted previously, the North Dakota plant is likely no longer there and the Wisconsin herbarium specimens are likely mis-identified. Further, Hartzler and Vittetoe (2022) indicate that Johnsongrass rhizomes are not tolerant of winter in Iowa. Worldwide, Johnsongrass has been found from latitude 55°N to latitude 45°S (Travlos et al. 2019), though it is not clear that it is equally problematic in all areas. The USDA Animal Plant Health Inspection Service (APHIS) prepared a national risk assessment for the species (APHIS 2015) that included a climate suitability map for the species. The map was updated in 2021 after an inquiry by NWAC committee member Robert Venette (Minnesota Invasive Terrestrial Plants and Pests Center and USDA Forest Service) to Anthony Koop (National Lead for Weeds, Plant Epidemiology and Risk Analysis Laboratory, USDA Animal and Plant Health Inspection Service). On December 23, 2021, Dr. Koop gave the following reply and attached the following figure (Koop 2021):

"I looked at the map and our original layer for plant hardiness zones and see what you mean. I suspect that we made a mistake when we extracted the appropriate levels for PHZ [Plant Hardiness Zone]. Attached is a revised copy of the map that correctly shows only the extreme bottom edge of MN as being suitable. Note that we did not re-survey the literature to identify new records of this species' distribution; we only re-did the map to correct the original mistake. This new map is different from the previous one because we are now incorporating uncertainty into our maps to produced more nuanced predictions. Essentially, the darker the color on the map, the more confident we are the climate in that area is suitable for the species. That confidence is based on the number of point records we found in similar climates around world. Please note that the new map is still based on the same climate layers that were used in the original map, and those layers are 10 years old. We are currently working to update those layers to account for climate change in the last decade. It is possible that potential range of johnsongrass has shifted a little bit due to recent climate change."

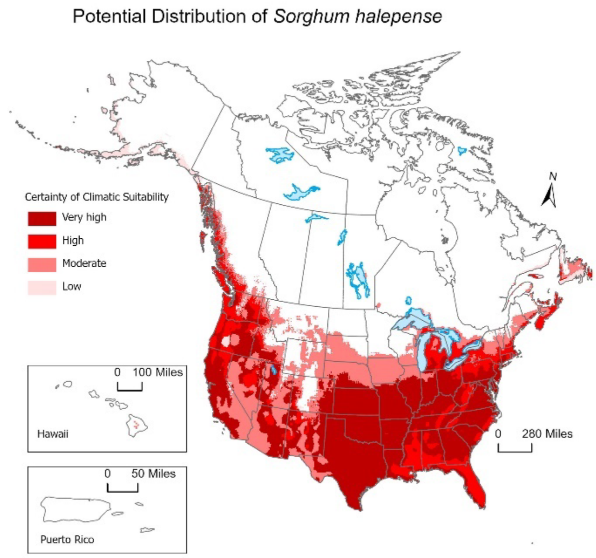

Figure caption: 2021 map from Anthony Koop (USDA APHIS) showing an updated climate suitability map for Johnsongrass. Only a small portion of the southern edge of Minnesota is mapped as suitable, with moderate level of certainty.

USDA APHIS (2022) published an updated risk assessment for Johnsongrass. That risk assessment includes the following map which shows Minnesota as unsuitable habitat for Johnsongrass. The assessment states "We estimate that about 64 percent of the United States is suitable for the establishment of johnsongrass (red and light red areas in Figure 2). The predicted area represents the joint distribution of Plant Hardiness Zones 5b to 14b, areas with 0 to 100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: Tropical areas, deserts, steppe, most temperate climates, and some cold climates with no dry season."

While the USDA 2022 map shows area that have Johnsongrass reports as being not suitable for Johnsongrass, they give this explanation: "Areas shown in gray in Figure 2 are not likely to be suitable for johnsongrass. We found some plant occurrence records for these areas but not enough to consider the climates suitable. The status of those reported plants is typically uncertain, and they probably represent either cultivated or casual[3] plants, which are excluded from our climate-matching process. Furthermore, in our analysis we found that several researchers question the validity of many of the northern U.S. records of this species." They also state "Plant Hardiness Zones 5a and 5b have enough U.S. point and county records (e.g., Iowa, Wisconsin, Nebraska, Wyoming, Montana, Idaho) to suggest that johnsongrass may be established in these zones. It is not clear, however, whether some or most of these records represent johnsongrass or shattercane, a subspecies of *S. bicolor*. Johnsongrass and shattercane are very similar and are primarily distinguished by the presence of rhizomes in johnsongrass (Warwick and Black, 1983). These two taxa are closely related and sometimes hybridize to produce *S.* × *almum* (Paterson et al., 2020). Without more detailed study of the plants that have been collected from Zones 5a and 5b, it is impossible to verify their identity. Several weed scientists and researchers believe that most of the johnsongrass records from the northern United States were either misidentified or were collected from plants that never became established (Barney, 2022; Hartzler, No Date; MNHP, No Date; Renz, 2022)."

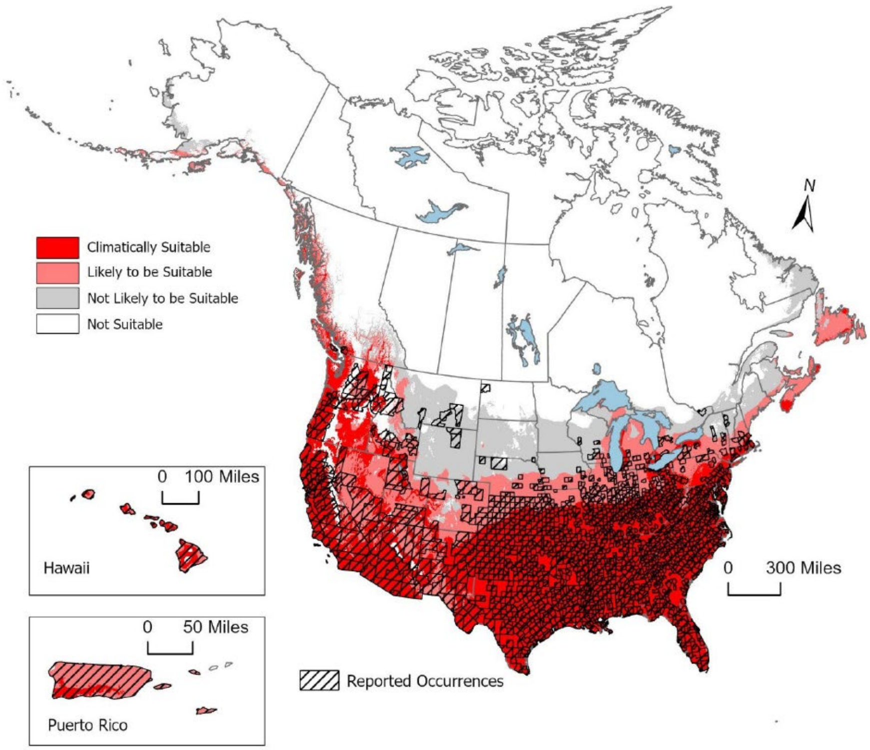

Figure caption: Figure 2 map from USDA APHIS (2022) Johnsongrass risk assessment with Minnesota mapped as not likely to be climatically suitable.

The US Geological Survey has also developed habitat suitability maps for invasive species using the USGS **In**vasive Species **Habi**tat **T**ool (INHABIT) (Jarnevich et al. 2021). The tool is available online and a map of Johnsongrass suitable habitat is available and shown in the figure below (US Geological Survey 2022). According to this tool, the northern half of Minnesota is climatically dissimilar to any areas where Johnsongrass has been reported, so no forecasts could be made. In the southern half of Minnesota, climate might be suitable for Johnsongrass, but this assessment has moderate to low confidence as 5 or fewer models (out of 10 possible) came to this conclusion.

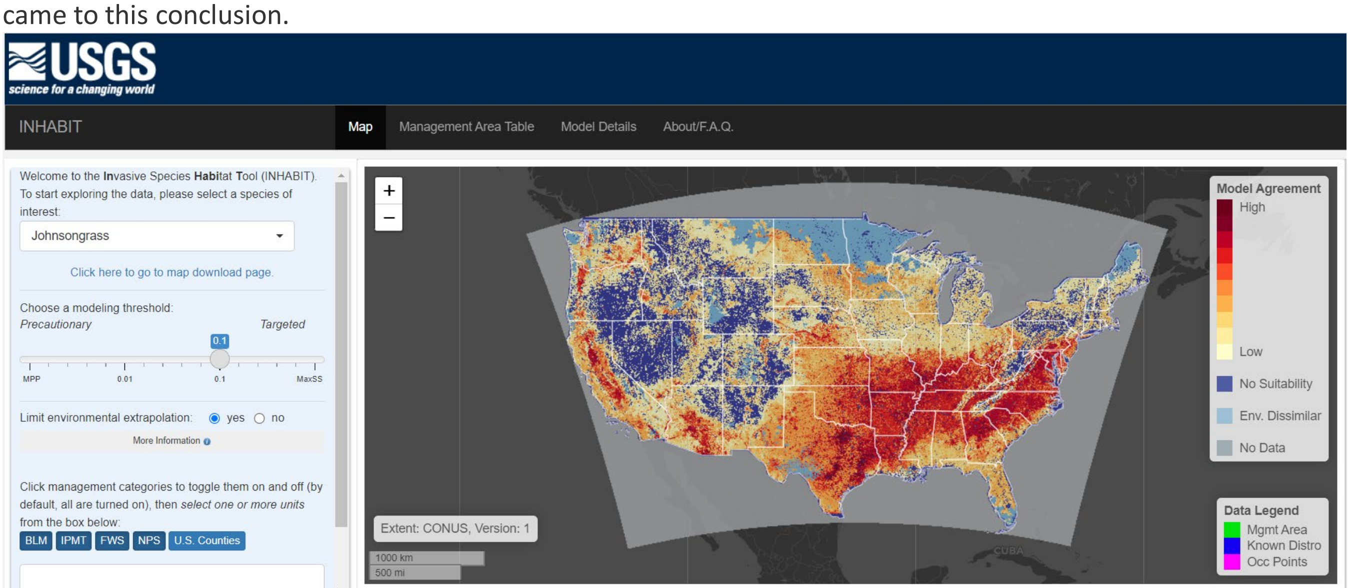

Figure caption: Johnsongrass habitat suitability map from USGS INHABIT tool. Accessed 6 May 2022. In this map the southern half of Minnesota has areas of low to moderate habitat suitability.

NWAC committee member, Robert Venette expressed concern that data used to create the INHABIT suitability maps may include incorrect reports (Venette 2022). As shown below, the analysis includes a report from Wisconsin that might be shattercane, *Sorghum bicolor*, or a cross of species (Renz 2021). Venette is concerned that those reports cause some models to have a more northern distribution than they would otherwise. The INHABIT map is likely pulling from reports that the 2022 APHIS risk assessment removed from consideration in their suitability map.

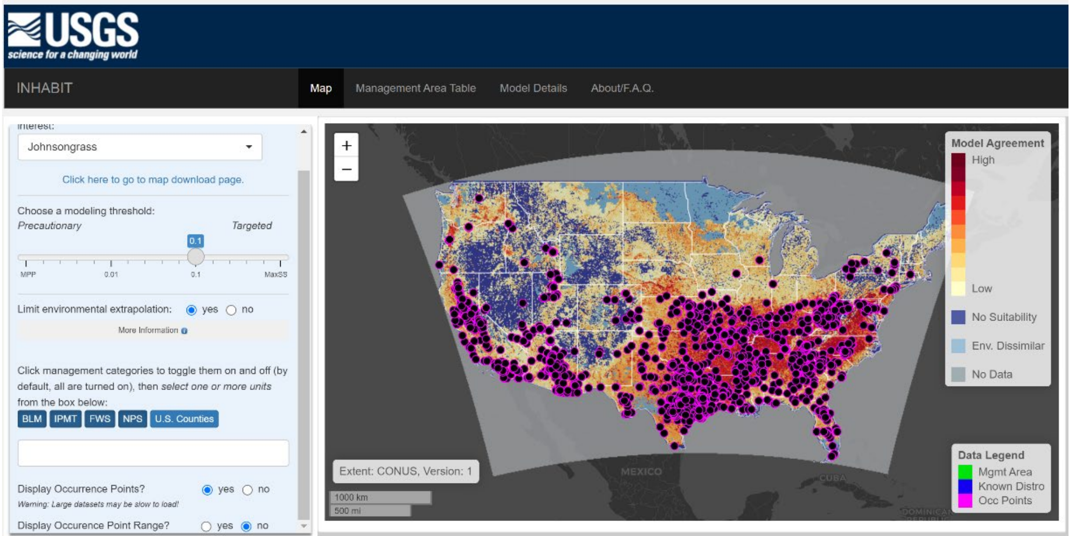

Figure caption: Johnsongrass habitat suitability map from USGS INHABIT tool showing Johnsongrass locations used to develop the model. Accessed 24 June 2022.

The cold tolerance of Johnsongrass remains a significant source of uncertainty. A recent study by Lakoba et al. (2021a) compared the cold tolerance of seeds and rhizomes. In the control of 22°C (71.6°F), 31.2% of the seeds germinated. After 24 hours at -20°C (-4°F), 27.7% of the seeds germinated when returned to suitable conditions. After 24 hours at -85°C (-121°F), 12.3% of the seeds germinated when returned to suitable conditions. They note "extreme cold tolerance across Johnsongrass populations informed us that seed freezing [from acute cold exposures] is likely not range limiting." Additionally, Lakoba et al. (2021a) tested single node rhizome fragment viability under several temperatures and calculated the LT90, the temperature at which 90% of the rhizomes die (i.e., do not have plant growth after being returned to favorable conditions). The single node rhizome fragments had an average LT90 of -5.1°C (22.8°F). Effects of longer cold exposures were not tested. Lakoba et al. (2021a) note "Given the relatively high winter temperatures that rhizomes cannot survive, rhizome segments likely cease to be feasible propagules for range expansion in regions with climates similar to southern Ontario, where populations persist only via seed (Warwick and Black 1983)." They also note that "Given that Johnsongrass persists in places with colder winter temperatures than the rhizome LT90 of -5°C, thermal dynamics of soil are clearly a factor that prevents us from simply predicting cold temperature range limitation." They summarize, "Drastic differences in cold tolerance between seeds and rhizome and evidence for seeds' local adaptation to land use and climate suggest that its spread is likely limited by winter rhizome survival, as well as adaptability of germination behaviors to longer winters."

Lakoba et al. (2021b) note little evidence for an increase in cold tolerance since Johnsongrass was introduced to North America. They state: "Since its introduction into North America from the Middle East in the early 1800s, Johnsongrass has expanded into wetter environments, then into non-agricultural habitats, where its thermal niche narrowed, all the while maintaining a consistent cold temperature niche boundary. Once in North America, Johnsongrass abandoned some of the hottest climates it occupied (available in Africa and South Asia), while expanding into many wetter climates that had already been available to it in Afro-Eurasia, with only localized partial barriers to dispersal. In moving from agricultural to non-agricultural habitats in North America (Sezen et al., 2016), the latter ecotype has since narrowed its climate niche, particularly in terms of temperature. The non-agricultural climate niche has shifted very slightly overall toward colder temperatures but is associated with very little unfilling or expansion and virtually no abandonment or pioneering of climates. Thus, Johnsongrass has not yet exploited the abundance of colder and wetter non-agricultural environments in North America despite their availability. Assuming niche stability of North American populations in the 21st century, both ecotypes and Johnsongrass as a whole will see large increases to suitable climates across the continent, likely leading to northward range expansion, particularly in the upper Midwestern United States." Their analyses make two salient points: 1) the climate in Minnesota is currently not climatically suitable for agricultural or non-agricultural ecotypes of Johnsongrass [green areas in the maps below]; and 2) the southern third of Minnesota might become suitable for agricultural ecotypes over the next 80 years with continued climate change and no change in the climatic niche for the species.

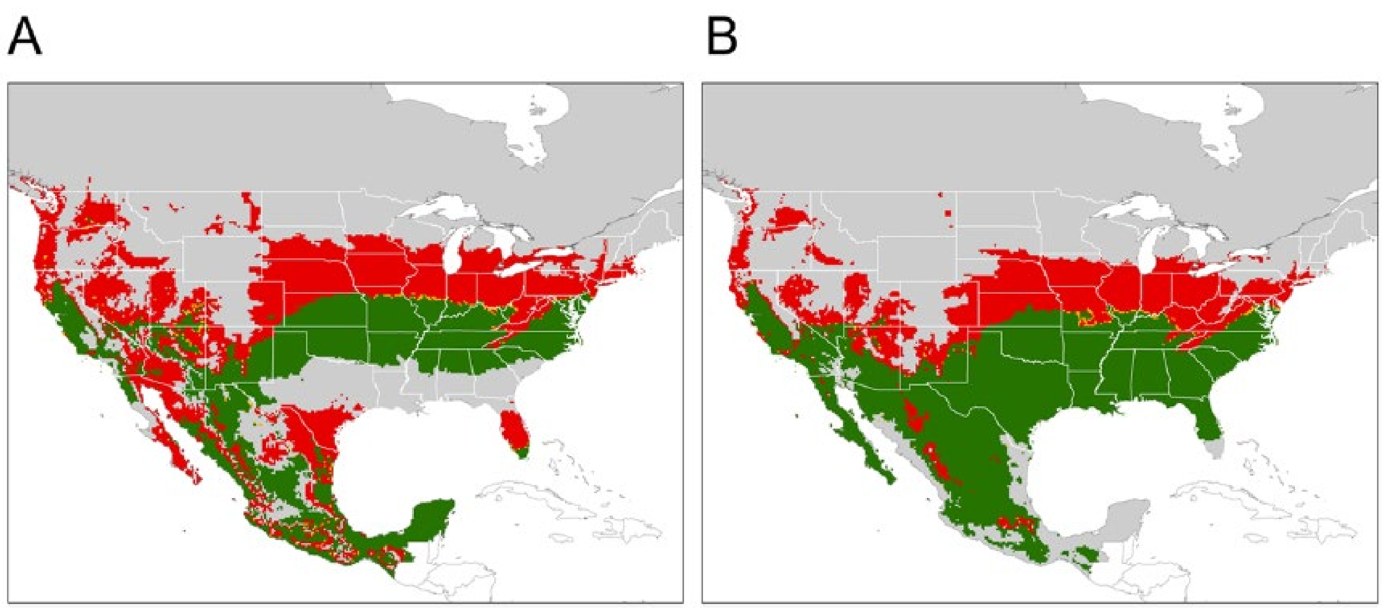

Figure caption: Figure 5 from Lakoba et al. (2021b) shows the "Maxent environmental suitability maps of North American (A) agricultural and (B) non-agricultural ecotypes in 2021 (green) and 2100 based on sustainable development (SSP126; gold) and fossil fuel development (SSP585; red) climate scenarios." Note that the figure does contain gold, but those sections are very small and are generally found at the edges between the red and green areas.

Question 6C: Has the plant become established in areas having a climate and growing conditions similar to those projected to be present in Minnesota under future climate projections?

Answer: Yes, but the data used to develop the map may be inaccurate.

Outcome: Go to Box 7.

EDDMapS (2022) and Lakoba et al. (2021b) published maps of climate suitability under future climate conditions. To our knowledge, neither of them disregarded the more northern reports that were removed from consideration in the APHIS (2022) risk assessment. Therefore, the conclusions based on these maps may be inaccurate. APHIS (2022) did not publish a distribution under future climate map, but included this statement:

"Furthermore, climate change seems likely to result in further expansion (Follak and Essl, 2013). In the United States, johnsongrass has been moving into progressively colder regions over the last few decades (Warwick et al., 1986), suggesting either that these areas are becoming more favorable for this species due to climate change or that johnsongrass populations are adapting to colder temperatures, or both".

EDDMapS (2022) developed maps of future distribution range for various invasive species by 2040-2060. They note: "Invasive species are expected to shift their ranges to track preferred environments as climate changes. This map indicates expected county-level range dynamics for the selected species by 2040 - 2060 based on currently available evidence. Assignment of range expansion, contraction, or no change is determined by the chosen number of models predicting. The higher the number selected, the more future climate models must agree." The figure below shows how future range by the number of models that predict the counties will be acceptable for Johnsongrass. The southern half of Minnesota is widely agreed upon to have acceptable climate conditions.

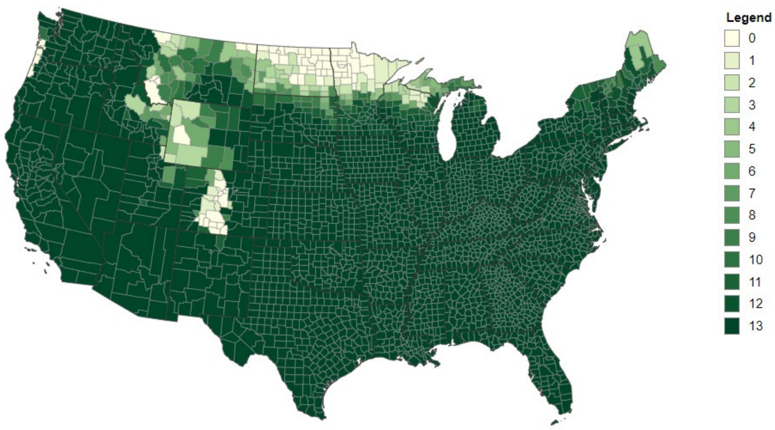

Figure caption: Future climate range of Johnsongrass a predicted by 0-13 climate models (EDDMapS 2022).

Lakoba and Barney (2020) collected Johnsongrass seeds from five non-agricultural and five agricultural populations, placed them in a common garden greenhouse experiment, and tested adaptation to water and nutrient stress. They found that "agricultural and nonagricultural ecotypes did not respond differently to experimentally applied stresses. However, non-agricultural populations from more drought-prone and nutrient-poor locations outperformed their agricultural counterparts in shoot allocation and chlorophyll production, respectively. We also found evidence for root allocation adaptation to hotter climates, in line with other C4 grasses, while greater adaptation to drought treatment was associated with soil organic carbon (SOC)-rich habitats. These findings imply that adaptation to land-use types can interact with other macrohabitat parameters, which will be fluctuating in a changing climate and resource-needy world. We see that invasive plants are poised to take on novel habitats within their introduced ranges, leading to complications in the prevention and management of their spread."

Lakoba et al. (2021b) note: "Johnsongrass's northward range expansion appears imminent given climate change; however, its magnitude could vary widely, depending on the global climate trajectory in this century. Overall, ecotypic differences in projected climate change-driven range potential mirror current suitability differences (i.e., somewhat broader suitability for the agricultural ecotype). This primarily latitudinal change northward is linked with temperature (i.e., temperature minima and variability) being the most explanatory bioclimatic variables of Johnsongrass's niche globally and in North America. We predict that, in North America, the species will track rising temperatures northward, due in part to an apparently stable rhizome cold tolerance limit

(Lakoba unpublished data; manuscript in review).” However, the northward expansion of climatically suitable habitat may not progress into Minnesota.

Lakoba et al. (2021b) also note: “The Midwest is an unsurprising invasion front due to its smooth latitudinal transition in climate, topography, and soils, compared to the coastal regions and Appalachian and Rocky Mountains (Sayre et al., 2009). The crop damage niche in these new areas will likely be in corn (McDonald et al., 2009) and soybean (McWhorter and Anderson, 1981), which are associated with a robust body of knowledge on Johnsongrass management (e.g., Dale, 1981; Winton-Daniels et al., 1990; Ghosheh and Chandler, 1998). However, issues of herbicide resistance and other factors in a changing climate mean that this will not necessarily be a linear process (Johnson et al., 2014; Matzrafi et al., 2016; Vazquez-Garcia et al., 2020).”

Models from Lakoba et al. (2021b) show suitability of Minnesota for the agricultural ecotype in 2100, but not the non-agricultural ecotype. They found the southern third of Minnesota suitable for the agricultural ecotype of Johnsongrass in 2100 while the non-agricultural ecotype edge is south of Minnesota along the northern edge of Iowa. See the Figure at the end of Question 6B for the map: Figure 5 from Lakoba et al. (2021b).

Box 7:

Does the species have the potential to reproduce and spread in Minnesota?

Question 7A: Are there cultivars of the plant that are known to differ in reproductive properties from the species?

Answer: No.

Outcome: Go to Questions 7B

No information was found indicating that there are cultivars that differ in reproductive properties.

Question 7B: Does the plant reproduce by asexual/vegetative means?

Answer: Yes

Outcome: Go to Question 7C

Plants can spread by underground rhizomes growing 60-90m in a season (Warwick and Black 1983). Fragments of rhizomes can grow into new plants with one study working with rhizomes as short as 2.5cm long (Warwick and Black 1983).

Question 7C: Are the asexual propagules - vegetative parts having the capacity to develop into new plants - effectively dispersed to new areas?

Answer: No

Outcome: Go to Question 7D

Seed spread is likely the main way plants are brought to new areas. No references were found stating that rhizome segments were likely major dispersal vectors. Additionally, Lakoba et al. (2021a) tested single node rhizome fragment viability under several temperatures. LT90 means the temperature at which 90% of the rhizomes do not have plant growth emerge from the rhizome. The single node rhizome fragments had an average LT90 of -5.1°C (22.8°F). Lakoba et al. (2021a) note “Given the relatively high winter temperatures that rhizomes cannot survive, rhizome segments likely cease to be feasible propagules for range expansion in regions with climates similar to southern Ontario, where populations persist only via seed (Warwick and Black 1983).” They also note that “Given that Johnsongrass persists in places with colder winter temperatures than the rhizome LT90 of -5°C, thermal dynamics of soil are clearly a factor that prevents us from simply predicting cold temperature range limitation.”

Question 7D: Does the plant produce large amounts of viable, cold hardy seeds? For woody species, document the average age the species produces viable seed.

Answer: Yes.

Outcome: Go to Question 7G

Plants in Mississippi produced an average of 1.1kg of seeds per year (Warwick and Black 1983). Seeds are initially dormant due to a strong seed coat. Studies have shown seed viability of 60-75% after two years of being buried in soil and 50% viability after five years (Warwick and Black 1983). Johnsongrass can produce thousands of seeds within a few months after germination and forms a long-term soil seedbank (USDA APHIS 2015).

Lakoba et al. (2021a) compared germination rates among different cold treatments. In the control of 22°C (71.6°F), 31.2% of the seeds germinated. At -20°C (-4°F), 27.7% of the seeds germinated. At -85°C (-121°F), 12.3% of the seeds germinated. They note "extreme cold tolerance across Johnsongrass populations informed us that [acute] seed freezing is likely not range limiting."

Question 7E: For species that produce low numbers of viable seeds, do they have a high level of seed/seedling vigor or remain viable for an extended period (seed bank)?

Outcome: Decision tree does not direct to this question.

Question 7F: Is the plant self-fertile?

Answer: Yes. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***

Plants in the *Sorghum* genus are generally self-pollinated (Warwick and Black 1983). Kaur and Soudan (2017) found that bagged flowers had 13% seed set while open pollinated flowers had 65% seed set. They note, "heavy pollen loads on stigmas caused by synchronous maturation of anthers and stigmas in bisexual florets and abrupt anther dehiscence created conditions for self pollination" but that outcrossing is "the predominant mode of sexual reproduction".

Question 7G: Are sexual propagules – viable seeds – effectively dispersed to new areas? List and consider all vectors.

Answer: Yes.

Outcome: Go to Question 7I

Seeds spread by shattering of the seed head, water, wind, ingestion by birds and cattle, and through contamination of hay, grain, and equipment (Warwick and Black 1983). Gheersa et al. (1993) found that combines in corn crops increased Johnsongrass seed spread. Kaur and Soudan (2017) note that the tough glumes protect seeds that are eaten by livestock allowing the seeds to pass through the animals undamaged. Rudi et al. (2019) found that seeds could disperse hundreds of meters along irrigation channels and that more than half of Johnsongrass seeds could float.

Question 7H: Can the species hybridize with native species (or other introduced species) and produce viable seed and fertile offspring in the absence of human intervention?

Answer: Yes. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***

Johnsongrass hybridizes and produces fertile offspring with *Sorghum vulgare*, *S. bicolor*, *S. nervosum*, *S. sublabrescens*, and *S. roxburghii* (Warwick and Black 1983, Ohadi et al. 2017). Arriola and Ellstrand (1996) found Johnsongrass and crop sorghum (*S. bicolor*) hybrids at distances of 0.5-100m from the crop of crop sorghum. See

Question 8B for additional information on why hybridization with other *Sorghum* species can have economic implications.

Question 7I: Do natural controls, species native to Minnesota, which have been documented to effectively prevent the spread of the species in question?

Answer: No.

Outcome: Go to Box 8 (no)

No information was found documenting potential natural controls in Minnesota.

Question 7J: Was the answer to Question 7A (Are there cultivars that differ in reproductive properties from the original species) "Yes"?

Outcome: Decision tree does not direct to this question.

Box 8:

Does the species pose significant human or livestock concerns or have the potential to significantly harm agricultural production, native ecosystems, or managed landscapes?

Question 8A: Does the plant have toxic qualities, or other detrimental qualities, that pose a significant risk to livestock, wildlife, or people?

Answer: No.

Outcome: Go to Question 8B

Has toxic qualities, but perhaps not significant. Johnsongrass can produce cyanogenic compounds that cause prussic acid poisoning in grazing animals. Environmental conditions such as frost, heat, or drought can increase the compounds and increase the risk of poisoning (Warwick and Black 1983). An article geared toward hay and forage growers (Friedrichsen 2022) points out that Johnsongrass can be used for grazing or hay and that it is good in terms of nutrients and producing large quantity of grass for livestock. The article does caution that "Risk of prussic acid poisoning and nitrate toxicity are arguably johnsongrass' worst attributes. The former is a concern for grazing livestock, especially in drought conditions and after a frost. The latter can also cause problems in pastures, but nitrate levels remain high when johnsongrass is harvested for hay, too."

Johnsongrass pollen may be a source of allergies in people (Warwick and Black 1983).

Question 8B: Does, or could, the plant cause significant financial losses associated with decreased yields, reduced crop quality, or increased production costs?

Answer: Yes.

Outcome: Go to Box 9

Dilpreet et al. (2011) confirmed the first documented glyphosate resistant biotype in the United States from plants from Arkansas. The management of glyphosate resistant Johnsongrass could result in large economic costs to crop systems. Multiple populations of Johnsongrass have evolved glyphosate resistance (Fernandez et al. 2013). The International Herbicide-Resistant Weed Database lists 31 herbicide resistant biotypes of Johnsongrass (Heap 2022). The biotypes are found in a variety of crop types including soybean, corn (maize), and cotton. Resistance has been developed to a number of herbicides with differing modes of action, including glyphosate, haloxyfop-P-methyl, nicosulfuron, foramsulfuron, imazamox, sethoxydim, and more. Fourteen of the 31 herbicide resistant biotypes are from the United States. The states the biotypes originated in are: Mississippi, Kentucky, Tennessee, Virginia, Louisiana, Texas, West Virginia, Indiana, Arkansas, and Missouri (some states had multiple biotypes originate within them).

The pollen of Johnsongrass can contaminate sorghum grown for seed resulting in reduced yield (Warwick and Black 1983).

Arriola and Ellstrand (1996) found Johnsongrass and crop sorghum (*S. bicolor*) hybrids at distances of 0.5-100m from the crop of crop sorghum. They raised the concern that transgenes introduced into cultivated crop sorghum could spread to wild hybrids. Ohadi et al. (2017) summarize documented hybridization between crop sorghum and other "weedy/wild" *Sorghum* species including Johnsongrass. Anthony Cortilet from the Minnesota Department of Agriculture (personal communication to Laura Van Riper, February 26, 2021) notes that there are sorghum crops being bred for acetolactate synthase (ALS) herbicide tolerance. There is concern that the gene flow that has been documented between sorghum and Johnsongrass could pass herbicide resistant traits from sorghum eventually into Johnsongrass. There is ongoing research on this topic such as that being done by Muthu Bagavathiannan and his team at Texas A&M University.

Question 8C: Can the plant aggressively displace native species through competition (including allelopathic effects)?

Answer: Yes. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Johnsongrass has a rapid growth rate and can deplete the soil of nutrients allowing it to outcompete other species (Warwick and Black 1983). Majumdar et al. (2017) found that soils with Johnsongrass had higher levels of phenolics and lower levels of nitrogen than comparison sites without Johnsongrass. Rout and Chrzanowski (2009) note that the competitive ability of Johnsongrass may be enhanced because of associated endophytic nitrogen-fixing bacteria in the plant.

Allelopathy may play a role in Johnsongrass abundance. The cyanogenic glycoside dhurrin was found in Johnsongrass rhizomes and other studies have found that extracts from Johnsongrass leaves, rhizomes, and soils inhibited barley, clover, crown vetch, soybean, wheat, and Johnsongrass itself (Warwick and Black 1983). Huang et al. (2017) found that Johnsongrass "secretes the phenolic compounds, p-hydroxybenzoic acid (*p*-HBA) and *p*-hydroxybenzaldehyde (*p*-HBAL), as the dominant allelochemicals in the root exudates" and that the allelochemicals may affect the bacterial composition of the soil by inhibiting *Proteobacteria* and increasing *Acidobacteria*, *Chloroflexi*, *Verrucomicrobia* and *Cyanobacteria*.

Question 8D: Can the plant hybridize with native species resulting in a modified gene pool and potentially negative impacts on native populations?

Answer: No. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
No information was found indicating a negative impact on native species due to hybridization.

Question 8E: Does the plant have the potential to change native ecosystems (adds a vegetative layer, affects ground or surface water levels, etc.)?

Answer: Yes. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Rout and Chrzanowski (2009) note that in prairie ecosystems the native plants can be displaced by Johnsongrass. They found that Johnsongrass has endophytic bacteria in its rhizomes and roots that can fix atmospheric nitrogen. They also note that the bacteria isolated can also play a role in mobilizing phosphorus and iron

chelation. They posit that the endophytic bacteria can help Johnsongrass persist by "altering fundamental ecosystem properties via significant changes in soil biogeochemistry".

Question 8F: Does the plant have the potential to introduce or harbor another pest or serve as an alternate host?

Answer: Yes. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***

Johnsongrass is an alternate host to pests of sorghum and corn (maize) including *Contarinia sorghicola* (sorghum midge), *Graminella nigrifrons* (a leaf hopper that vectors corn stunt disease), and *Rhopalosiphum maidis* (corn leaf aphid) (Warwick and Black 1983). Johnsongrass is a host for numerous nematodes, bacteria, and viruses including corn stunt disease, maize chlorotic dwarf virus, maize dwarf mosaic virus (Warwick and Black 1983).

Box 9:

Does the species have clearly defined benefits that outweigh associated negative impacts?

Question 9A: Is the plant currently being used or produced and/or sold in Minnesota or native to Minnesota?

Answer: No.

Outcome: Go to Box 10

Johnsongrass is not native to Minnesota. Johnsongrass is not known to be sold in Minnesota. James Calkins of the Minnesota Nursery and Landscape Association (personal communication with Laura Van Riper, February 2, 2021) has checked and did not know of any Johnsongrass plants or seeds being grown or sold by Minnesota growers or garden centers. He noted that Johnsongrass seeds are available online from sellers outside of Minnesota.

In 2020, the Minnesota Nursery and Landscape Association (MNLA) reached out to wholesale nursery growers in an attempt to get an estimate of the wholesale value, and ultimately the combined monetary value (wholesale plus value-added retail) of species Johnsongrass to the Minnesota economy for inclusion in the risk assessment for this species (James Calkins, Minnesota Nursery and Landscape Association; personal communication, April 12, 2021). No evidence that Johnsongrass is grown commercially in Minnesota has been found leading to the conclusion that sales of Johnsongrass do not contribute to the nursery and landscape economy or the state economy.

Question 9B: Is the plant an introduced species and can its spread be effectively and easily prevented or controlled, or its negative impacts minimized, through carefully designed and executed management practices?

Outcome: Decision tree does not direct to this question.

Question 9C: Is the plant native to Minnesota?

Outcome: Decision tree does not direct to this question.

Question 9D: Is a non-invasive, alternative plant material or cultivar commercially available that could serve the same purpose as the plant of concern?

Outcome: Decision tree does not direct to this question.

Question 9E: Does the plant benefit Minnesota to a greater extent than the negative impacts identified at Box #8?
Outcome: Decision tree does not direct to this question.

Box 10:

Should the species be regulated as Prohibited/Eradicate, Prohibited/Control, or Restricted Noxious Weed?

Question 10A: Is the plant currently established in Minnesota?
Answer: No.
Outcome: Go to Question 10B
Johnsongrass is not known to be present in Minnesota.

Question 10B: Would prohibiting this species in trade prevent the likelihood of introduction and/or establishment?
Answer: Yes.
Outcome: Go to Question 10C
Prohibiting the movement of Johnsongrass into the state both by purposeful and contaminant pathways would reduce the likelihood of introduction and establishment.

Question 10C: Does this risk assessment support this species being a top priority for statewide eradication if found in the state?
Answer: Yes.
Outcome: Go to Question 10D
Johnsongrass could have large negative economic impacts to agriculture.

Question 10D: Does the plant pose a serious human health threat?
Answer: No.
Outcome: Go to Question 10F
Johnsongrass does not pose a serious human health threat.

Question 10E: Is the health threat posed by the plant serious enough, and is the plant distribution sufficiently small enough to be manageable, and are management tools available and effective enough to justify listing as Prohibited / Eradicate species?
Outcome: Decision tree does not direct to this question.

Question 10F: Is the plant known to cause significant ecological or economic harm and can the plant be reliably eradicated (entire plant) on a statewide basis using existing practices and available resources considering the distribution, reproductive biology and potential for spread?

- *For distribution, note if the distribution is well documented, the number and acreage of known infestations and how widespread they are in the state. Note if there are infestations in border areas.*

- *For reproductive biology, note if there are reproductive biology factor that make the plant easier to control and eradication more likely (for example, long pre-reproductive period, self-incompatible pollination, short-lived seed bank).*
- *For potential for spread and re-invasion of controlled areas, note its potential to spread beyond places where it is being controlled such as deliberate planting by people, wildlife vectors, re-infestation from border states, or other factors that facilitate spread.*
- *For known management tools, note what management tools are available, potential non-target impacts, and the reasonableness of state management or mandating that landowners throughout the state use the management tools to eradicate or control existing plants.*
- *For available resources, consider the capacity of state and local personnel and availability of funding to respond to new and existing infestations.*

Answer: Yes.
Outcome: LIST THE PLANT AS A PROHIBITED / ERADICATE NOXIOUS WEED
Distribution:
Johnsongrass is not known to be present in the state.

Reproductive biology:
There are no reproductive biology factors that make the plant easier to control and eradication more likely. Johnsongrass has a short pre-reproductive period, self-compatible pollination, and a long-lived seed bank (Warwick and Black 1983, USDA APHIS 2015).

Potential for re-invasion:
There are limited current vectors or nearby populations, so control at an isolated area is likely to remain controlled and not be quickly re-invaded.

Known management tools:
Travlos et al. (2019) state: "the management of Johnsongrass requires the effective control of both plants emerged from seeds and plants emerged from rhizomes. Since the rhizome system of Johnsongrass is extremely extensive and spreads very quickly in the first year, it is really crucial to take action as early as possible. Thus, killing the below-ground tissues and depleting their carbohydrate stores is usually the primary goal of its chemical control. In a consistent, integrated program preventive, cultural, mechanical, and chemical methods should be used together. It is also crucial to prevent the transport of seeds and rhizomes from infested fields to uninfected fields. However, the adequate control of *S. halepense* is very difficult without the use of herbicides, with repeated treatments being necessary to maintain long term control." Travlos et al. (2019) conclude, "Changes in crop management practices, improved tillage management, and diverse chemical-based techniques are among the best options for the effective control of *S. halepense*. A number of these effective techniques could be used in combination with herbicides."

Travlos et al. (2019) give additional detail on cultural control practices: "Cultural weed control practices were used for the control of johnsongrass before the extended use of herbicides. The growth and reproduction of a troublesome weed species like Johnsongrass may be actively discouraged by introducing several crops and practices into a rotation. The inclusion of cover crops in the rotation also suppresses weed development. An effective crop rotation consists two-to-four years of alfalfa, two years of cotton (or other row crop), and one or two years of small grain. If the infestation of johnsongrass is heavy, either pasture or summer fallow and disking or plowing frequently during the summer can be effective. Alfalfa and other frequently mowed or grazed crops grown for three or more consecutive years deplete johnsongrass seed stocks in the soil. Several Brassicaceae species can be used as part of the rotation or as cover crops against johnsongrass. DeGregorio and Ashley and Else and Ilnicki found that clover mulches can provide weed control comparable to commercial herbicide programs in maize, sweet corn and snap beans. Another cultural method is the application of fertilizers along with or near the crop row in order to increase the uptake of nutrients by the crop and their competitive ability against weeds such as johnsongrass. Crop row spacing can be also modified and used as an additional cultural method against *S. halepense*. For instance, Bendixon (1988) recorded a significantly lower density of johnsongrass in soybean seeded in 25 cm rows compared with those of 76 cm."

Travlos et al. (2019) give additional detail on mechanical practices: "The optimum timing for mechanical weed control is influenced by the competitive ability of the crop and the growth stage of the weeds. Hand hoes, push hoes and hand-weeding are still used in order to prevent the weed from spreading and dominating. Hand-weeding may also be used after mechanical inter-row weeding to control weeds left in the crop rows. In general, multiple tillage operations can deplete johnsongrass stands if seedlings and sprouts are regularly uprooted and rootstocks are desiccated. Sharp tools set at the proper depth and operated to overlap are needed to uproot all the johnsongrass. Repeated and deep summer tillage before *S. halepense* grows to a height of 20 cm reduces stands and sometimes eradicates it, while usual seedbed preparations retard the spread of johnsongrass but do not affect its stands."

Peerzada et al. (2017) state: "Conventional management approaches are limited in their scope to control this weed due to its rapid vegetative growth and increasing herbicidal tolerance. Integration of chemical methods with cultural or mechanical approaches is important for restricting its future spread to non-infested areas."

University of Missouri Extension (2021) states "Preventing johnsongrass from becoming established in new areas is the best available control method, because the weed spreads in so many ways. Because johnsongrass is a perennial weed, single cultural control measures or herbicide applications rarely provide adequate control. Johnsongrass control programs should:

- Prevent spread of rhizomes from infested to uninfested areas.
- Kill or weaken established plants and their underground rhizome system.
- Control seedlings originating from shattered seed.
- Prevent production of seed and its spread to new areas.
- Use fall tillage to bring rhizomes to soil surface, where they may be killed by winter conditions.

These objectives are closely related and are equally important to the success or failure of a control program. In limited infestations, it is possible and desirable to use herbicides to kill the weed and prevent seed production. The critical time to kill johnsongrass is while the weed is becoming established and before it has spread over the entire field. For sites with established infestations, a fall application of Roundup or Touchdown will kill emerged tissue and often developing rhizomes."

For chemical control, University of Missouri Extension (2021) states: "To reduce johnsongrass infestations with herbicides, it will be necessary to use an integrated approach consisting of soil-applied herbicides, postemergence herbicides, crop rotation and tillage. Weedy plants such as johnsongrass adapt quickly to a cultural system that does not change from year to year." They note that "specific postemergence herbicides for Johnsongrass control in corn include Accent, Beacon, Poast HC and Roundup Ultra."

Johnsongrass cultural, mechanical, and chemical treatments can be tailored to the particular crop or non-agronomic settings that the Johnsongrass is found in. Landowners of confirmed Johnsongrass reports would likely be directed to experts to provide advice on treatments for their particular situation.

Available resources:
Johnsongrass is threat to row agriculture. Agriculture has high economic value in Minnesota. It is likely that resources would be acquired to address Johnsongrass infestations.

Uncertainties: Two key uncertainties affect this assessment. First, it is not clear whether the climate of Minnesota is or will be suitable for permanent establishment of Johnsongrass. It seems unlikely that rhizomes of Johnsongrass would survive winters in Minnesota. It may be able to persist as seed., though this possibility is based on scant information. If the assumption is made that Johnsongrass could persist as seed, the next key uncertainty is whether it would be economically damaging. A precautionary approach would be list it a Prohibited-Eradicate noxious weed so that work can be it would be illegal to introduce the species to the state, facilitate education on prevention and identification, and increase the chances of early detection and rapid response. A pitfall of listing Johnsongrass as a Prohibited-Eradicate noxious weed is that it makes the noxious weed list longer. New education and prevention efforts that relate to Johnsongrass could come at the expense of efforts towards species that are already present in Minnesota or are more likely to be able to survive in the state.

Question 10G: Is the plant known to cause significant ecological or economic harm and can the plant be reliably controlled to limit spread on a statewide basis using existing practices and available resources? Would the economic impacts or other hardships incurred in implementing control measures be reasonable considering any ongoing or potential future increase of ecological or economic harm?

- *Also consider all bullet points listed under 10F when evaluating 10G*

Outcome: Decision tree does not direct to this question.

Question 10H: Would prohibiting this species in trade have any significant or measurable impact to limit or reduce the existing populations or future spread of the species in Minnesota?
Outcome: Decision tree does not direct to this question.

Question 10I: Are there any other measures that could be put in place as Special Regulations which could mitigate the impact of the species within Minnesota?
Outcome: Decision tree does not direct to this question.

Box 11:

The species is being proposed to be designated as a Specially Regulated Plant. What are the specific regulations proposed?

Outcome: Decision tree does not direct to this question.

Final recommendations of risk assessment (2022)

NWAC Listing Subcommittee

Outcome: Listed as a Prohibited Eradicate Noxious Weed (06/17/2022)
Comments: The Listing Subcommittee was not unanimous in supporting of the outcome as a Prohibited Eradicate noxious weed.

6-29-2022 Discussion which occurred before the USDA APHIS 2022 risk assessment was published:
One member thought that the current evidence did not support the need for a regulatory change in this species. No new evidence is presented to show that Johnsongrass has become an imminent threat to the state. Johnsongrass is a significant weed in the southern United States, and its damage potential there has been recognized for decades. It is not clear that Johnsongrass is established in Wisconsin or North Dakota. Winters in Iowa are considered too cold for rhizomes. Most analyses of the climate where Johnsongrass has been reported conclude that that the climate in Minnesota cannot reliably be classified as suitable for Johnsongrass. Climate suitability may change over the next 80 years. Seed is likely to be more cold-tolerant than rhizomes. But, even if the possibility of persistence of the weed through seed is assumed, evidence is inconclusive about the extent of damage that Johnsongrass might cause without the opportunity to form rhizomes. The thought is that since habitat suitability in Minnesota is likely low at this time, it is better to keep the noxious weed list shorter and not add Johnsongrass.

Other subcommittee members stressed the interest in being proactive and protecting the agricultural economy and following the results of the risk assessment which show that some models show the potential for Minnesota to be suitable to Johnsongrass in the future. Multiple recent research papers have encouraged states to be forward thinking with a focus on prevention and preparing for climate change and to be more proactive in their regulatory lists (Lakoba et al. 2020, Beaury et al. 2021, Cuthbert et al. 2022). If Johnsongrass is not listed at this time, the Listing Subcommittee recommends that the risk assessment is reviewed regularly as the science around this species seems to be expanding somewhat rapidly as it is a high-interest species. The Minnesota Department of Agriculture should also consider if Johnsongrass should be added to the noxious weed seed list to help prevent its introduction to the state.

NWAC Full Committee

Outcome: List as a Prohibited Eradicate Noxious Weed. (12/13/2022)
Comments: The vote was 15 in favor and 3 against.

MDA Commissioner

Outcome: List as a Prohibited Eradicate Noxious Weed.
Comments: No comments

Risk Assessment Current Summary (08-22-2022)

- Johnsongrass can have negative economic impacts as an agricultural weed of corn and soybeans. There are herbicide resistant strains in the United States which can increase the cost of agricultural production. Johnsongrass is also an alternate host to pests that affect corn.
- Johnsongrass can be toxic to grazing animals.
- Johnsongrass can invade native habitats and outcompete native plants.
- Johnsongrass seeds spread by water, wind, ingestion by birds and cattle, and through contamination of hay, grain, and equipment.
- Johnsongrass is not known to be present in Minnesota, but Minnesota some models show that Minnesota has suitable habitat and climate at this time, while other models show Minnesota as unsuitable. Additional models show that portions of Minnesota may become suitable under future climate conditions.
- If Johnsongrass was found in Minnesota, its removal would be a statewide priority. By adding Johnsongrass as a Prohibited Noxious Weed on the Eradicate List it would aid in prevention efforts to keep Johnsongrass from being brought into the state.

- The Minnesota Department of Agriculture should also consider if Johnsongrass should be added to the noxious weed seed list to help prevent its introduction to the state.
- Since the current and future climate suitability of Johnsongrass in Minnesota is debatable, an argument could be made not to list Johnsongrass at this time. It would continue to be legal to bring in Johnsongrass either purposefully or as a seed contaminant. Then if it was found to be surviving in Minnesota, its listing could be revisited. Not listing Johnsongrass would keep the Minnesota weed list shorter. Listing Johnsongrass would be proactive with an eye toward preventing future introductions and costly management efforts. Multiple recent research papers have encouraged states to be forward thinking with a focus on prevention and preparing for climate change and to be more proactive in their regulatory lists (Lakoba et al. 2020, Beaury et al. 2021, Cuthbert et al. 2022).

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