Minnesota Noxious Weed Risk Assessment

Developed by the Minnesota Noxious Weed Advisory Committee

Assessment information

Common name: Kudzu

Scientific name: *Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen & S.M. Almeida ex Sanjappa & Predeep (out of use synonym: *Pueraria lobata* (Willd.) Ohwi)

Family name: Fabaceae

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

Date of current review: July 19, 2021

Species description

Photos

Photo caption: Kudzu has trifoliate leaves and pink/purple flowers. Photo credit: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.

Photo caption: Kudzu can cover large areas. Photo credit: Chris Evans, University of Illinois, Bugwood.org.

Why the plant is being assessed

- Kudzu is a widely known invasive plant in the southern and eastern United States. The plant is being assessed for its potential impact to Minnesota.
- Forseth and Innes (2004) note a number of impacts:
    - In 1953, kudzu was removed from the list of approved plants for erosion control, in 1970 it was officially labeled a weed, and in 1997 it was referenced as Federal Noxious Weed.
    - Its rapid elongation rates, high leaf area indices, high photosynthetic rates, and frequent rooting at stem nodes make kudzu an aggressive competitor with native shrubs and trees.
    - The ability of kudzu to overtop and shade forest trees, fix atmospheric nitrogen, and emit isoprene suggest that it may have substantial effects on native forest biodiversity, forest nitrogen cycles, watershed nitrogen saturation, freshwater eutrophication, and regional air quality.
    - Kudzu's growth rate increases strongly in response to increased CO_2, and without the constraint of allocation to woody tissue this response may increase the competitive dominance of kudzu as atmospheric levels of CO_2 increase. This fact, combined with its sensitivity to cold temperatures, implies that kudzu may increase its range in future warmer, high-CO_2 environments.
- Kudzu has been found to have economic impacts through increased costs of management for utilities, railroads and for tree production and habitat management.
- Kudzu is a host of two soybean (*Glycine max*) crop pests, Asian soybean rust (*Phakopsora pachyrhizi*) and kudzu bug (*Megacopta cribraria*), which have negative economic impacts on soybean crops.

Identification, biology, and life cycle

- Kudzu is a perennial, semi-woody vine. Stems regrow from the root system each spring.
- Identifying characteristics from the Wisconsin Department of Natural Resources kudzu webpage (2020):
    - Leaves: Alternate leaves are compound and are comprised of three broad, pointed, slightly lobed leaflets with golden hairs.
    - Flowers: Fragrant purple flowers with a yellow middle occur in leaf axils in long upright panicles from June-September.
    - Fruits and seeds: Flat, brown, golden-haired pods form in clusters and hold 3-10 seeds.

  - Roots: An edible, tuberous root that can be as big as 12’ deep and 400 pounds. Reproduces from runners, rhizomes and vines that root at the node and seeds.
  - Similar species: Large poison ivy (*Toxicodendron radicans*; native) leaves and vining stems look similar to grown kudzu but are hairless on the upper leaf surface. The lower leaf surface is slightly hairy and pale green. Native grapes (*Vitis* spp.) have similar growing habits, but leaves of grapes have long petioles and are hairless on the upper leaf surface. Grapes also have tendrils that aid in climbing.
- Habitats include forests, rights-of-way, roadsides, along rivers and flood plains, embankments, fields, tree plantations, non-crop areas, and open habitats with fertile, well-drained soils (Mitich 2000, Lindgren et al. 2013).

Current distribution

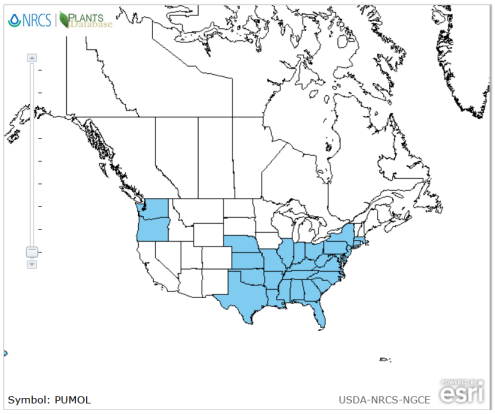

Figure caption: National level map of kudzu by state from U.S. Department of Agriculture (USDA) Plants accessed December 15, 2020. Kudzu is present in a large swath of the southern and eastern United States from Nebraska to Texas to Florida to New York. Kudzu is also present in Washington and Oregon. Kudzu is not known to be present in Minnesota.

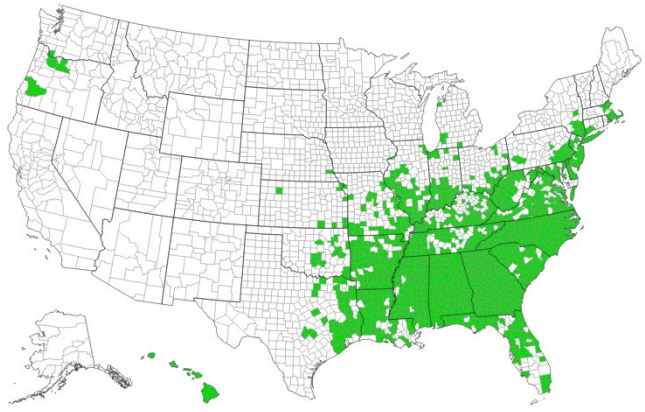

Figure caption: National level map of kudzu by county by EDDMapS accessed December 15, 2020 (EDDMapS 2020). Kudzu is most concentrated in the southeastern United States with scattered counties along the edges of its range. The closest locations to Minnesota are Otoe county in Nebraska and Rock Island county in Illinois.

Current regulation

There are resources that state that kudzu was listed as federal noxious weed in 1997 (Blaustein 2001, Forseth and Innes 2004). The current federal noxious weed list on the U.S. Department of Agriculture website is dated 2010 and does not list kudzu. In a March 2, 2021 personal communication from Dr. Anthony Koop (plant ecologist, USDA Animal Plant and Health Inspection Service, Plant Protection and Quarantine) to Laura Van Riper, he explained that in 1997 Congress amended the definition of a noxious weed in Public Law 105-86 by adding a statement saying that the definition includes kudzu. Then in 2000, when Congress passed the Plant Protection Act, which consolidated several older Acts including the Federal Noxious Weed Act, it redefined noxious weed and excluded the part about kudzu. Kudzu was never included in the actual list of regulated noxious weeds in the Code of Federal Regulations (7 CFR 360).

The USDA Plants list of states that regulate kudzu has: Connecticut, Florida, Illinois, Kansas, Kentucky, Massachusetts, Mississippi, Missouri, Oregon, Pennsylvania, Texas, Washington, and West Virginia.

The National Plant Board list of states that regulate kudzu is: Connecticut Prohibited Plant, Florida Noxious Weed, Idaho - invasive plants energy crop, Illinois noxious weed, Indiana regulated plant, Kansas noxious weed, Massachusetts prohibited plant, Mississippi noxious weed, New Hampshire noxious weed, Ohio prohibited invasive plant, Oregon prohibited "A" weed, Pennsylvania class A noxious weed, Texas noxious and invasive plant (on both lists), Washington class A noxious weed, Wisconsin restricted (*note: this conflicts with the Wisconsin DNR website*), West Virginia noxious weed.

Kudzu is not currently regulated in Minnesota. Wisconsin regulates kudzu as a Prohibited Invasive Species under their NR-40 Rule. Kudzu is not known to be present in Wisconsin at this time.

Risk assessment

Box 1:

Is the plant species or genotype non-native?

Answer: Yes
Outcome: Go to Box 3.
Kudzu is native to east Asia including China, Japan, and Taiwan (Callen and Miller 2015). It was introduced to the U.S. at the 1876 Centennial Expedition in Philadelphia and the 1883 New Orleans Expedition (Miller and Edwards 1983). It was then sold as an ornamental plant, promoted in the early 1900s as food for cattle, and heavily promoted during the 1930s and 40s for erosion control (Forseth and Innes 2004).

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 USDA Plants list of states that regulate kudzu include: Connecticut, Florida, Illinois, Kansas, Kentucky, Massachusetts, Mississippi, Missouri, Oregon, Pennsylvania, Texas, Washington, and West Virginia. Wisconsin regulates kudzu as a Prohibited Invasive Species under their NR-40 Rule. Kudzu is not known to be present in Wisconsin at this time.

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 Question 6B.
Kudzu is not known to be established in Minnesota. The closest locations to Minnesota are Otoe county in Nebraska and Rock Island county in Illinois.

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

Answer: No.
Outcome: Go Question 6C.
Did not find evidence of kudzu becoming established in areas with similar climate to Minnesota. Kudzu hardiness is considered USDA Plant Hardiness zones 5-10 (Missouri Botanical Gardens 2020). In the 2012 hardiness map, the majority of Minnesota is in USDA Plant Hardiness zones 3 and 4 with a very small spot of zone 5 along the Minnesota/Iowa border.

One of the northernmost kudzu populations is near Leamington, Ontario, Canada, on the north shore of Lake Erie near Detroit, Michigan (Conier et al. 2018) which is in plant hardiness zone 6b/7a.

Callen and Miller (2015) compared the climatic niche of kudzu in its native range to the U.S. They found that suitable climatic requirements extended beyond kudzu's current range into the west. Their maps did not show suitable climate in Minnesota.

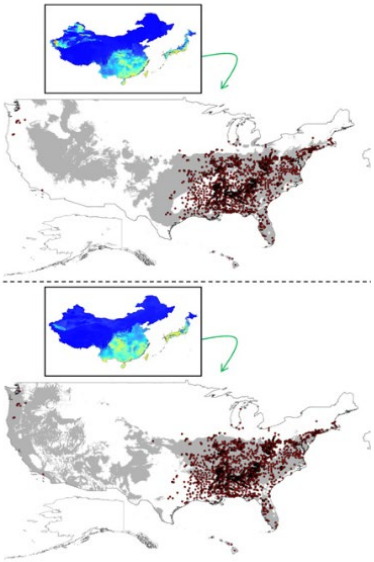

Figure caption: Two Maxent models from Callen and Miller (2015). The gray shading shows areas with suitable climatic requirements for kudzu populations.

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: No.

Outcome: The species is not believed to be a risk.

EDDMapS 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." When only one model is chosen (showing the widest predicted range), kudzu extends into about half of Iowa and the southernmost counties in Wisconsin, but does not extend into Minnesota.

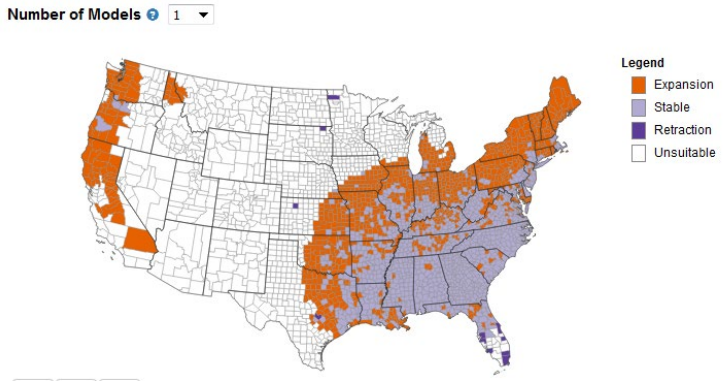

Figure caption: Future climate range of kudzu as predicted by at least one climate model (EDDMapS 2020).

When the maximum number of models are chosen (13 model), kudzu does not extend into Iowa, Wisconsin, and Minnesota.

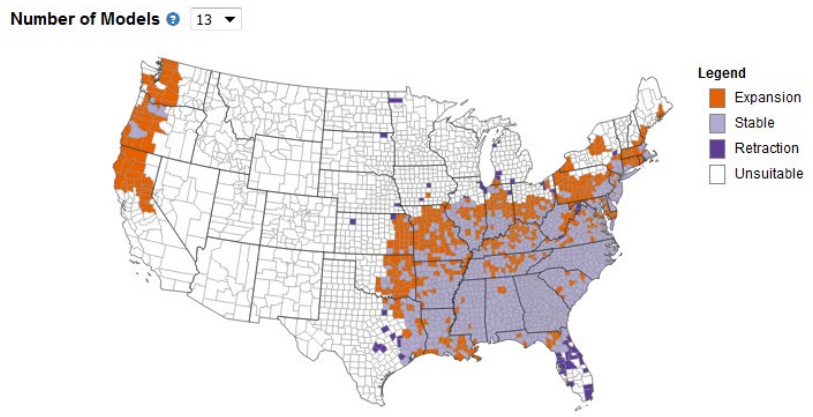

Figure caption: Future climate range of kudzu as predicted by agreement of 13 climate models (EDDMapS 2020).

Coiner et al. (2018) examined kudzu cold tolerance. They found that kudzu seeds exposed to − 36°C *[-32.8°F]* germinated just as well as seeds exposed to − 10°C *[14°F]*. They "used biogeographic and historical evidence to evaluate the hypothesis that kudzu is killed by a 1–2 day exposure to −20°C *[-4°F]* or below." They found that "no above- or belowground stems from seven northern and seven southern populations survived below − 20°C, and only aboveground stems from northern populations survived at −16°C *[3.2°F]*." Additionally, "Belowground stems and roots survived down to −17 and −7 °C [*1.4-19.4°F]*, respectively, which should be sufficient for persistence because soil temperatures in the cool temperate and sub-boreal zones seldom get that cold due to thermal insulation by snow, soil, and litter." They note "consistent with acclimation, the cold tolerance threshold of aboveground stems at the coldest time of year was − 26°C *[-14.8°F]*, while stems insulated from cold extremes survived to − 17°C *[1.4°F]*—colder than the survival limits indicated by kudzu's biogeographic distribution. While these results do not rule out alternative cold limitations, they indicate kudzu can survive winters north of its current distribution." They conclude '"by empirically determining one physiological tolerance threshold—winter survival—we demonstrate that the apparent biogeographic correlation between − 20°C and kudzu's northern range limit does not have the previously presumed mechanism of freezing mortality." In their map of isoclines, the -22°C isocline is just south of Iowa, so it is still quite a distance from Minnesota.

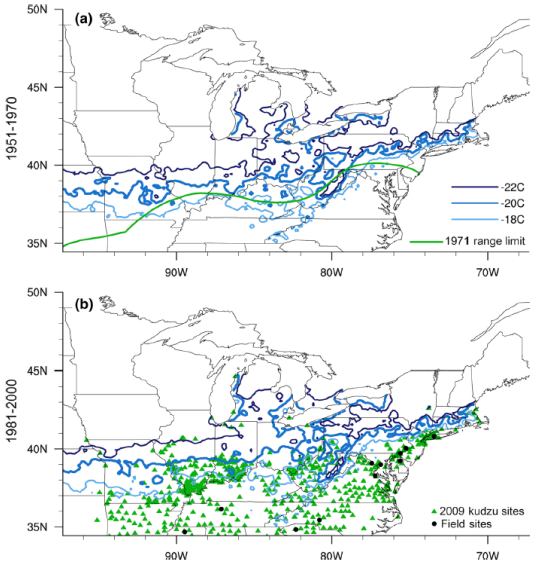

Figure caption: Figure 1 from Coiner et al. (2018) showing the changes in isoclines over time and the location of the -22°C isolcline in relation to Minnesota.

Jarnevich and Stohlgren (2009) modeled potential distribution of kudzu in the United States by 2035 and theiri models did not indicate suitability in Minnesota or neighboring states.

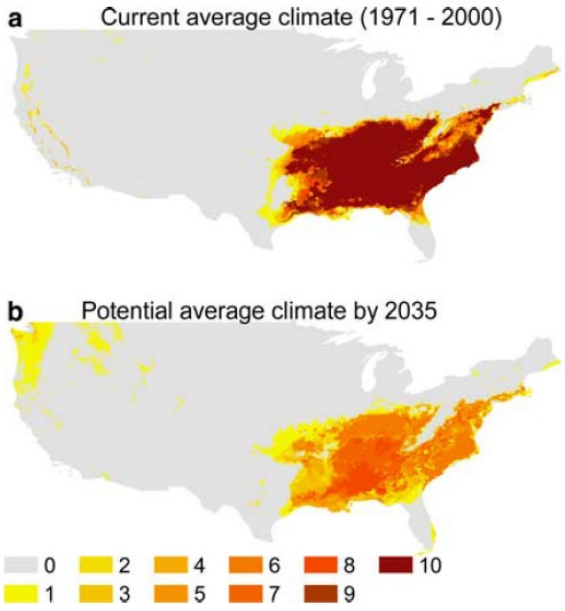

Fig. 3 Potential distribution of *P. montana* in the United States with (**a**) current climatic conditions (average climate from 1971–2000) and (**b**) potential 2035 climate based on the 112 year trend (Fig. 1)

Figure caption: Figure 3 from Jarnevich and Stohlgren (2009) showing potential distribution of kudzu in the United States under 1971-2000 climatic conditions (a) and potential distribution in 2035 based on the 112 year climate trend (b).

Bradley et al. (2010) modeled projected suitable kudzu range in 2100 and their models do not show kudzu range in Minnesota or Wisconsin.

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

No documentation found on cultivars that differ in reproductive properties. Online searches found references to two variegated cultivars: 'Variegata' (North Carolina State University Extension 2021) and ‘Sherman’s Ghost’ (J.C. Raulston Arboretum 2021).

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

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

Vegetative spread occurs when stems contact the ground and root and form independent nodes (root crowns) (Forseth and Innes 2004). Stems can grow 20-30 meters a year and primary, secondary, and tertiary branches

can root (Forseth and Innes 2004). Vegetative spread is thought to be the main way kudzu populations increase (Forseth and Innes 2004).

Lindgren et al. (2013) note:

- "Kudzu is a perennial climbing vine with stems re-growing from the root system each spring. It produces an extensive root system with massive tuber-like swellings (usually described as tuberous roots) up to 2 m long and 18-45 cm wide. Stems are up to 30 m long and approximately 0.6-2.5(-10) cm in diameter. Young twining stems are covered with tan to bronze hairs and often purplish dots or striations; older stems become woody."
- "Kudzu is a semi-woody leguminous vine that can produce 25 or more stems from enlarged rooted stem nodes called crowns. Crowns, which can be at or near the surface (under leaf litter), or a few centimetres underground, are the most important perennating organs, but above-ground stems also overwinter if not killed by extreme conditions (Tsugawa et al. 1988; Coiner 2012)."
- "Rooted nodes enlarge to become independent crowns, and the connecting internodes can, with time, become buried in soil and litter, giving the appearance of underground rhizomes."

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

Answer: No. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***

Outcome: Go to Question 7I (yes) or Question 7D (no)

If a root crown/node is moved to a new place the plant could establish. Lindgrenn et al. (2013) note that "the unintentional transport of shallowly rooted stem nodes on the periphery of a patch by mowers, tractors, or other vehicles may contribute to kudzu dispersal". Longer distance dispersal would require the movement of the root crowns/nodes and/or the soil containing them. It is not clear that this occurs often. In an online presentation about kudzu research in the northeastern United States, M. Frye (2019) comments, "Anecdotally, most kudzu patches observed today were planted at one time, and, kudzu has not spread beyond those existing patches except by climbing vines. Therefore, we consider kudzu to be primarily human dispersed." Callen and Miller (2015) say that "kudzu appears to be dispersal limited and suffers high seedling mortality (Abramovitz, 1983; Coiner, 2012), thereby relying on humans as its primary dispersal agent."

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

Outcome: Go to Question 7G (yes) or Question 7E (no)

Coiner et al. (2018) found that kudzu seeds exposed to − 36°C *[-32.8°F]* germinated just as well as seeds exposed to − 10°C *[14°F]*.

Duell and Hickman (2019) studied kudzu seed viability from three collection sites in Oklahoma. They found that 86 of 900 seeds they collected germinated. One site had 0% germination, one had 10% germination, and the third had 19% germination.

Lindgren et al. (2013) note, "Kudzu is generally considered to produce low numbers of viable seeds relative to the number of flowers, and not every population produces viable seed." and "In Illinois in summer 1997, only six of the 78 populations that flowered produced mature fruits."

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)?

Answer: ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Outcome: Go to Question 7G (yes) or Question 7F (no)
Lindgren et al. (2013) state, "No studies to date have described the longevity of kudzu seeds in the soil; however, because the seeds possess physical dormancy there is the potential to establish a seed bank."

Question 7F: Is the plant self-fertile?

Answer: Somewhat. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Outcome: Go to Question 7G (yes) or Question 7H (no)
Answer text here
There may be some of self-fertility, but cross-pollination increases seed set.

In South Africa, Geerts et al. (2016) found that kudzu could produce seeds when pollinators were excluded from the flowers. They found that 4.6% of the pollinator-excluded flowers produced seed pods while 72% of the flowers open to pollinators produced seed pods.

Lindgren et al. (2013) state, "The maximum seed set for naturally pollinated kudzu flowers in Maryland was only 3.3% (Abramovitz 1983). This increased to 14% with hand-pollination and pod set increased to 20-40%, suggesting pollinator limitation plays a significant role (Abramovitz 1983). However, the increases were modest and not due to infertile pollen, which was estimated to be >95% viable. Seed set may instead depend on a high rate of floral abscission, or on the potential for outcrossing that comes with high genetic diversity."

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

Answer: No. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Outcome: Go to Question 7I (yes) or Question 7H (no)
Lindgren et al. (2013) note that while kudzu seeds are viable, the seedlings are rare in North America and Japan. They note there are cases where seedlings are found, but don't survive until the following year. They suggest that "the absence of seedlings implies that seeds are not dispersed effectively, or that there is some other barrier to seedling establishment. Pods can disperse up to 25 m, but most (92%) stay within 6 m of their origin, and there is no obvious animal vector, although mammals browse kudzu and could ingest seeds. Low overall investment combined with low seed set and low recruitment suggests that sexual reproduction and subsequent seedling recruitment are not currently major factors in dispersal and establishment." In an online presentation about kudzu research in the northeastern United States, M. Frye (2019) comments, "Anecdotally, most kudzu patches observed today were planted at one time, and, kudzu has not spread beyond those existing patches except by climbing vines. Therefore, we consider kudzu to be primarily human dispersed." Callen and Miller (2015) say that "kudzu appears to be dispersal limited and suffers high seedling mortality (Abramovitz, 1983; Coiner, 2012), thereby relying on humans as its primary dispersal agent."

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: No. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***

Outcome: Go to Question 7I (yes or no)
No information was found to indicate that kudzu is hybridizing with other species.

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. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Outcome: This species is not currently believed to be a risk (yes) or Go to Box 8 (no)
No information was found on natural controls native to Minnesota. There have been efforts to find classical biological control insects for kudzu but this is challenging as kudzu is closely related to soybean (*Glycine max*) and so tests of some potential biocontrol insects have found that they impact soybean (Forseth and Innes 2004, Frye et al. 2007). For example, Frye et al. (2007) studied the potential of two insect species from China, *Gonioctena tredecimmaculata* and *Ornatalcides trifidus*. In their conclusion, they note, "the high economic importance of soybean will make it difficult to justify importing these insects for biological control of kudzu unless unequivocal evidence is produced that shows the risk of an expanded host range to be extremely low or nonexistent."

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. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
No information was found to indicate that kudzu causes significant health risks to humans, livestock, or wildlife.

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

Answer: Yes. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Forseth and Innes (2004) note that kudzu reduces forest/tree productivity. They cite estimates of lost forestry productivity from $100-500 million a year and control costs of $500 per ha per year to control kudzu in forests for tree production which is greater than the profits from harvesting trees on those lands.

The weight of kudzu on power lines can damage power lines. Forseth and Innes (2004) cite an estimate of $1.5 million a year for power companies to control kudzu. Railroad companies also have to manage kudzu to prevent kudzu from covering rail lines and causing slippage (Forseth and Innes 2004).

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.***
Forseth and Innes (2004) note that kudzu's Its rapid elongation rates, high leaf area indices, high photosynthetic rates, and frequent rooting at stem nodes make kudzu an aggressive competitor with native shrubs and trees. They also note that the ability of kudzu to overtop and shade forest trees, fix atmospheric nitrogen, and emit isoprene suggest that it may have substantial effects on native forest biodiversity, forest nitrogen cycles, watershed nitrogen saturation, freshwater eutrophication, and regional air quality.

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 to indicate that kudzu is hybridizing with native species.

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.***
Kudzu is a legume and has symbiotic root bacteria that can fix atmospheric nitrogen (N_2) into ammonium (NH_4^+) which is a form of nitrogen available for uptake by plants. Hickman et al. (2010) note: "When symbiotically fixed nitrogen is released to the soil from decomposing tissues or leaked from roots, it becomes available to other plants and microbes. Because of these additions of fixed nitrogen to soils, invasions by N-fixing plants tend to cause the overall rate of microbially mediated N transformations in the invaded ecosystem to increase, including rates of nitrification [the oxidation of NH_4^+ to nitrate (NO3-)] and denitrification (the reduction of NO_3^- to N_2). When rates of these N transformations increase, gaseous emissions of NO [nitric oxide] and the powerful greenhouse gas nitrous oxide (N_2O), which are by-products of nitrification and denitrification, tend to increase as well."

Hickman et al. (2010) provide more detail on N fixation rates: "Estimations based on kudzu's N fixation rates in its native range suggest that it may fix up to 235 kg N ha−1 yr−1 in the United States. These fixation rates are an order of magnitude greater than both the N fixation rates in the invasive tree *Morella* (formerly *Myrica*) *faya* in Hawaii (20 kg N ha^{-1} yr^{-1}) and the rates of atmospheric deposition of nitrogen species in the eastern United States (7–13 kg N ha^{-1} yr^{-1}). With a current distribution of more than 3 million ha and an expansion rate of 50,000 ha yr^{-1}, kudzu coverage in the southeastern United States exceeds that of cultivated soybean, making it the dominant N-fixing plant in the region."

Hickman et al. (2010) examined the effect of kudzu on soils and nitrogen in Georgia. They found: "that rates of net N mineralization increased by up to 1,000%, and net nitrification increased by up to 500% in invaded soils in Georgia. Nitric oxide emissions from invaded soils were more than 100% higher (2.81 vs. 1.24 ng NO-N cm^{-2} h^{-1}). We used the GEOS-Chem chemical transport model to evaluate the potential impact of kudzu invasion on regional atmospheric chemistry and air quality. In an extreme scenario, extensive kudzu invasion leads directly to an increase in the number of high ozone events (above 70 ppb) of up to 7 days each summer in some areas, up from 10 to 20 days in a control scenario with no kudzu invasion. These results establish a quantitative link between a biological invasion and ozone formation and suggest that in this extreme scenario, kudzu invasion can overcome some of the air quality benefits of legislative control."

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.***

Kudzu bug (*Megacopta cribraria*) is native to Asia and was first discovered in the U.S. in 2009 (Liang et al. 2018). It feeds on kudzu and at least nine other plant species found in the U.S. including soybeans (can reduce yields by 59.6%) (Liang et al. 2018) so it is not likely to be used as a biocontrol insect for kudzu and is likely to be actively managed to prevent soybean impacts. Liang et al. (2018) modeled potential kudzu bug range expansion in the U.S. and Minnesota looks to be too cold for kudzu bug establishment in their models.

Asian soybean rust (*Phakopsora pachy-rhizi*) is native to Asia and was first found in the U.S. in 2004 (Christiano and Scherm 2007). Christiano and Scherm (2007) note that Asian soybean rust "is among the most damaging diseases of soybean (*Glycine max*) worldwide. In the absence of control measures, yield reductions up to 80% have been reported from countries in Asia where the pathogen is endemic." For the United States, they note "model-derived yield loss estimates ranged from 11 to 30% for the main soybean-producing areas in the midwestern United States and up to 50% for the southern states." Asian soybean rust is dependent on a living host, such as kudzu over the winter when there are no live soybean plants (Christiano and Scherm 2007).

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

Kudzu is not native to Minnesota. Kudzu is not known to be sold in Minnesota. James Calkins of the Minnesota Nursery and Landscape Association (personal communication with Laura Van Riper, January 7, 2021) has checked and did not know of any kudzu, kudzu varieties, or hybrids of kudzu being grown or sold (plants or seed) by Minnesota growers or garden centers. He notes that seed and plants (most commonly the variegated cultivar 'Sherman's Ghost'; supposedly less vigorous) are available from online sources but not sources based in 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 kudzu 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). They note that although it is possible kudzu is grown on a limited basis in Minnesota, based on the information available, sales did not appear to be a significant contributor to annual nursery and garden center sales and the Minnesota economy at the time this risk assessment was completed.

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. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Kudzu 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. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Kudzu is unlikely to spread to Minnesota either by seeds or root crown fragments on its own from the locations where it is currently present. If kudzu is to be introduced into Minnesota it will likely be by purposeful planting so prohibiting the purchasing and planting of kudzu in Minnesota would address that pathway of introduction. The counter argument is that even if kudzu was planted in Minnesota it is unlikely to be able to survive due to Minnesota winters.

Question 10C: Does this risk assessment support this species being a top priority for statewide eradication if found in the state?
Answer: Yes. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
If kudzu was found in Minnesota and was surviving Minnesota winters, it would be a priority for eradication due to the many negative economic and ecological impacts associated with kudzu.

Question 10D: Does the plant pose a serious human health threat?
Answer: No. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
No human health threats found.

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 <u>eradicated</u> (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. ***This information is supplemental and is not part of the flow chart pathway for this risk assessment.***
Known management tools:
Weaver et al. (2016) summarize known management tools and publish the results of their experiments with kudzu control. They note: "Given the high visibility of kudzu and the considerable negative effects of kudzu infestation in the southern USA, there is comparatively little documentation of successful management of this weed." They find that the herbicides most commonly studied with relation to kudzu are picloram, metsulfuron methyl, clopyralid, triclopyr, aminopyralid, and aminocyclopryachlor. They note "Kudzu management guides recommend a sustained effort of up to 10 years to achieve eradication (reviewed in Forseth & Innis, 2004)". Weaver et al. (2016) found that "field trials at three sites over two years with aminocyclopyrachlor, aminopyralid, fluroxypyr, metsulfuron methyl and combinations of these herbicides achieved 99–100% reduction in aboveground kudzu biomass." Additionally, they found that using the bioherbicide *Myrothecium verrucaria* integrated with mechanical removal of kudzu biomass and the planting of switchgrass (*Panicum virgatum*) provided good control.

Forseth and Innes (2004) note that grazing before the fall translocation of carbon to kudzu roots weakens the plant so that three to four years of close grazing or harvesting during this time period can reduce a population, although it may spread out of the grazed area the method doesn't work well for hanging vines in forests.

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 (2021)

NWAC Listing Subcommittee

Outcome: Do Not List.
Comments: The listing subcommittee found that the current and future suitable climate maps did not include Minnesota. The subcommittee supports not listing kudzu at this time. If kudzu is found to be present in Minnesota, this assessment should be revisited.

NWAC Full Committee

Outcome: Do not list
Comments: The vote was 16-0 in favor and 1 abstained regarding the recommendation to not list.

MDA Commissioner

Outcome: Do not list
Comments: No comments

Risk Assessment Current Summary (07-19-2021)

- Kudzu is known to have negative ecological and economic impacts.
- Minnesota is not likely to have suitable climate for kudzu currently or in the near future.
- Kudzu is not known to be sold in Minnesota.
- Kudzu is thought to be fairly dispersal limited with most populations spreading vegetatively from where they are planted. If humans do not bring kudzu to Minnesota, it is unlikely to arrive on its own. If it is

brought to Minnesota and planted, the climate is not likely to be conducive to growth. There are management techniques for kudzu.
- The recommendation is to not list kudzu at this time. Kudzu should be reassessed if new information is found, such as evidence of it being sold, planted, or growing and surviving in Minnesota.

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