State of Michigan's Species Profile for Kudzu (*Pueraria montana var. lobata*) Management

Created December, 2023

Introduction and Scope

Kudzu (*Pueraria montana var. lobata*) is a long-lived invasive perennial vine native to eastern Asia and with invasive ranges in all continents besides Antarctica (Global Invasive Species Database, 2023). Kudzu was first introduced into the United States during the Centennial Exposition in Philadelphia, Pennsylvania in 1876. The plant was originally marketed as an ornamental plant but gained popularity as fodder for livestock and soil conservation tool (Bentley & Mauricio, 2016; Coiner et al., 2018; Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). Kudzu was planted extensively throughout the southeastern United States (Simberloff & Rejmanek, 2011). Rapid growth rates, high rates of photosynthesis, the ability to reproduce via rooted stem nodes, and the ability to fix atmospheric nitrogen allow kudzu to quickly outcompete even the most rapidly growing and competitive native species (Forseth & Innis, 2004). As a result of this rapid expansion, this invasive vine can reduce ecosystem biodiversity, alter disturbance cycles and succession regimens, and even change nutrient cycling in local terrestrial and aquatic systems. Kudzu is currently a Watch List species and is present in Michigan (Michigan Department of Natural Resources, 2023).

Synonyms

Scientific Name: *Pueraria edulis and Pueraria phaseoloides*
Common Name: tropical kuzdu, kuzdu, and giant fir

This document is a product of an Environmental Protection Agency Great Lakes Restoration Initiative subgrant between the Michigan Department of Natural Resources and Lake Superior State University. It was made for the purposes of:

- Consolidating current science-based knowledge relative to the biology and ecology of kudzu;
- Summarizing scientific literature and research efforts that inform management options for kudzu in Michigan;
- Identifying future directions for research relative to successful kudzu management in Michigan.

This document was written by Stephen Brillinger under the direction of Dr. Megan Butler and was reviewed by the Michigan Departments of Natural Resources and Agriculture and Rural Development. This document references peer-reviewed journals and publications. Any chemical, company, or organization that is mentioned was included for its involvement in peer-

reviewed, published, publicly shared information, not to imply endorsement of the chemical, company, or organization.

Biology and Ecology

I. Identification

Kudzu is a climbing, herbaceous to semi-woody, deciduous, perennial vine. It can be 35 to 100 ft (10 to 30 m) in length. Kudzu is known for its rapid growth. Under optimal conditions in the Southeastern United States, kudzu can grow 1 ft (30 cm) per day and up to 60 ft (18 m) in a growing season (Forseth & Innis, 2004). As shown in Figure 1, kudzu vines can form heavily overlapping mats that create monocultures (Miller et al., 2010). Leaves and small vines will die with the first frost, and matted dead leaves will remain persistent during winter (Miller et al., 2010).

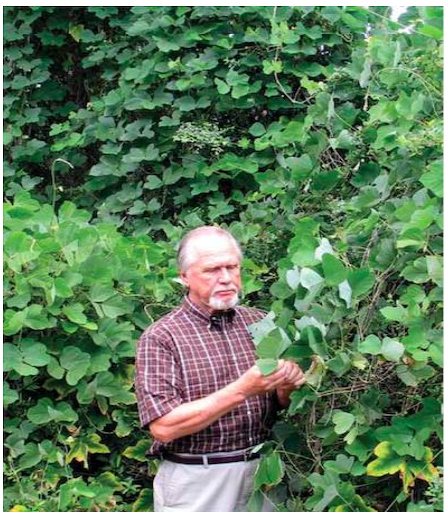

Figure 1: Large monoculture of kudzu (Peuraria montana) present on edge habitat. The kudzu appears so tall as it is covering surrounding vegetation such as trees and shrubs (Miller et al., 2010)

The stems of the vine can reach 10 in (25 cm) in diameter but are commonly 0.6 to 2.5 cm (Lindgren et al., 2013) and round in cross-section (Miller et al., 2010). Stems are succulent and yellow-green and have erect fine tan to gold-colored hairs (Lindgren et al., 2013; Miller et al., 2010). Moderately aged stems and vines become significantly more ropelike and develop light gray bark. Once vines are significantly mature, rough, rigid bark that is dark brown in color will develop (Miller et al., 2010).

Figure 2: Fine golden or tan-colored hairs are found on the stems and undersides of leaves of kudzu (Pueraria montana) (Miller et al., 2010).

Nodes are present along the stem and can develop into new root crowns when in contact with soil. Knot-like root crowns range from 1 to 10 in (2.5 to 25 cm) wide (Miller et al., 2010). Kudzu's lack of required woody support structures allows for the significant allocation of its carbon resources to root growth (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). The plant can have large primary roots, some of which can reach 180 kg and 0.18 m in diameter, where significant storage of starch, water, and nitrogen occurs (Everest et al., 1999; Miller et al., 2010). Extensive, large semi-woody tuberous roots can grow 0.03 m per day and reach depths of 3 to 16 ft (1 to 5 m) with a root crown on top of the soil surface from which vines originate.

Kudzu has alternate, pinnately compound leaves that are trifoliate (Lindgren et al., 2013). Each leaf is 3-7 in (8-18 cm) long and 2.5-8 in (6-20 cm) wide. Leaflets are typically ovate with a tri-lobed, symmetrical middle leaflet and two asymmetric bilobed side leaflets that are often smaller than the center leaflet (Lindgren et al., 2013; Miller et al., 2010). The tips of the leaflets are pointed, with the margins and back side of the leaflets as well as petioles covered with fine golden hairs (Figure 2). The petioles of leaves are 6-12 in (15-30 cm) in length with a thickened pulvinus and two stipules near the base (Lindgren et al., 2013). The stipules are 8-20 mm in length and 2.5-6 mm wide and are lanceolate to hastate in shape (Lindgren et al., 2013; Miller et al., 2010). The leaves of the plant are able to reorient rapidly in relation to the sun. This is possible via the pulvinus motor organ at the base of the leaves and leaflets. This facilitates extremely prolific growth in high light environments (Forseth & Innis, 2004).

Figure 3: Flower of kudzu (Pueraria montana) in bloom. The small pea-like flowers that are burgundy to lavender to white in color are the base of the panicle. Often they will additionally have a yellow center (Miller et al., 2010).

The plant flowers from June to September, with a spike-like panicle 2-12 in (5-30 cm) in length (Miller et al., 2010). The flowers are small and pea-like with burgundy to lavender to white petals that have yellow centers (Figure 3). The flowers appear in groups of two to three and originate from raised pedicels that are 6-10 mm long (Lindgren et al., 2013). The flowers are fragrant with anecdotal reports saying the smell is similar to concord grapes (Miller et al., 2010; Mitich, 2000). These flowers will not commonly appear on vines draped on the ground or within open patches, mainly vertically growing vines (Everest et al., 1999; Forseth & Innis, 2004; Mitich, 2000). Additionally, density of flowers along vines is non-uniform as a population in Maryland was found to range 0.02 to 15.2 racemes per meter, depending on several variables including light exposure (Forseth & Innis, 2004).

Figure 4: Ripe pods of kudzu (Pueraria montana) still containing seeds. Golden hairs are visible as well as the outline of individual seeds (Miller et al. 2010).

Present from September to January, fruits are clusters of dry, legume pods each 1.2-3 in (3-8 cm) in length and 0.3-0.5 in (8-12 mm) in width. They are relatively flat (Figure 4) and allow for the outline of individual seeds to be visible through the exterior of the pod (Miller et al., 2010; Mitich, 2000). Pods present in September are green in color and covered in stiff fine gold hairs. By January, pods will become dry and tan in color. The pods will either fall whole or it will split on one or two sides to release kidney-shaped seeds (Miller et al., 2010) that are 3-4 mm in length (Mitich, 2000).

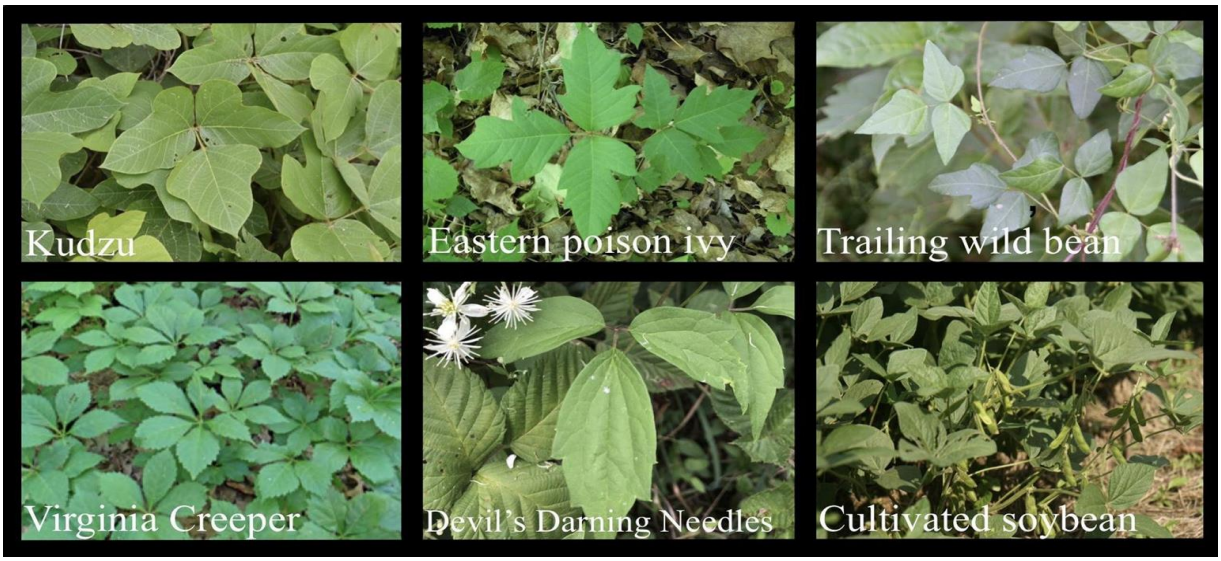

Figure 5: Image comparing the general identification of five plants that would commonly be confused with kudzu, as well as kudzu, including eastern poison ivy (Toxicodendron radicans), trailing wild bean (Strophostyles helvula), Virginia creeper (Parthenocissus quinquefolia), devil's darning needles (Clematis virginiana), and soybean (Glycine max). Image sources: kudzu: u.osu.edu; eastern poison ivy and cultivated soybean: www.michiganflora.net ; trailing wild bean and devil's darning needles: www.marylandbiodiversity.com ; Virginia creeper: www.hort.extension.wisc.edu

Species that could be commonly confused with kudzu include American hog-peanut (*Amphicarpaea bracteata*) (Lindgren et al., 2013), Virginia creeper (*Parthenocissus quinquefolia*), eastern poison ivy (*Toxicodendron radicans*), devil's darning needles (*Clematis virginiana),* and trailing wild bean (*Strophostyles helvola*) (Figure 5). In contrast to kudzu, these plants are native to North America and share a similar native distribution when compared to kudzu's invasive distribution (USDA, 2023). In addition to the similar semi-woody vines, these vines also share multifoliate morphology. In a vegetative state, American hog-peanut may be confused for kudzu as it also has trifoliate leaves, however the vines are much smaller and can either be smooth or have fine white hairs (University of Wisconsin-Madison, 2023). Both American hog-peanut and kudzu have three leaflets that are commonly asymmetric; American hog-peanut has ovate leaves whereas kudzu has lobed leaflets (University of Wisconsin-Madison, 2023). Virginia creeper possesses five symmetrical leaflets that have toothed margins rather than smooth like kudzu (The Ann Arbor News, 2012). Eastern poison-ivy has trifoliate leaves which will often resemble kudzu, however, poison-ivy leaves lack stipules and tend to be glossy (Lindgren et al., 2013). Trailing wild bean is a non-woody species that has runner-like vines similar to kudzu as well as lobed leaflets. Conversely, trailing wild bean is significantly smaller than kudzu with vines only reaching about one meter in length, with smaller leaflets and smaller flowers that are only 0.3-0.6 in (8-14 mm) in size (Lindgren et al., 2013). Additionally, trailing wild bean is listed within Michigan as being of special concern as it is uncommon (Michigan Natural Features Inventory, 2023). Special care should be taken to properly identify a species that is thought to be kudzu, as trailing wild bean is found within counties where kudzu is commonly found, including Allegan, Van Buren, and Berrien.

In addition to these wild plants, many cultivated plants can be confused for kudzu. Soybean (*Glycine max*) is the most common cultivated species that can be confused with kudzu (See figure 5), as it is an important food crop in the Midwest and Canada (Lindgren et al., 2013). However, soybean typically forms more erect stems when compared to kudzu's lax runners and twining stems (Lindgren et al., 2013). Other common cultivars that can be confused with kudzu include garden (common) bean (*Phaseolus vulgaris*), lima bean (*Phaseolus lunatus*), scarlet runner bean (*Phaseolus coccineus*), hyacinth bean (*Lablab purpureus*), and cowpea (*Vigna unguiculata*) (Lindgren et al., 2013). Figure 6 features the leaves of selected cultivated species and varieties. These species are not often found in the wild but occasionally can escape cultivation (Lindgren et al., 2013). Though these cultivated species are similar to kudzu while in their vegetative state, they lack kudzu's characteristic densely haired petioles, young stems, and pods (Lindgren et al., 2013).

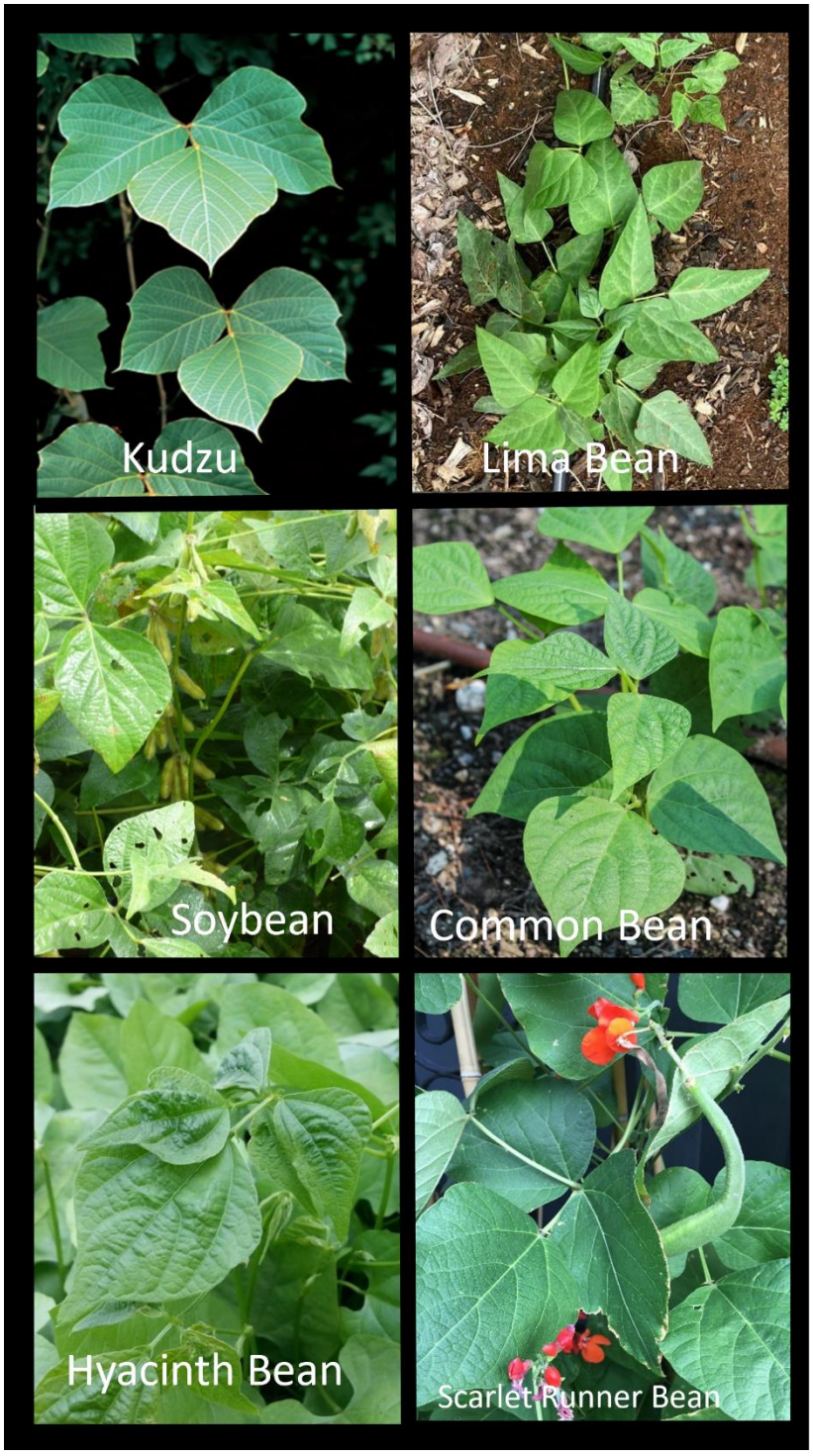

Figure 6: Image depicting kudzu alongside several cultivated species of legumes that may be confused as kudzu, including lima bean (Phaseolus lunatus), soybean (Glycine Max), common bean (Phaseolus vulgaris), hyacinth bean (Lablab purpureus), and scarlet runner bean (Phaseolus coccineus). Image sources: Kudzu (Bodner, 2003), Lima bean (Megan Good, 2023), Soybean (Overduebook, 2015), Common Bean (Jessica Kuovo, 2023), hyacinth bean (Franklin, 2023), and Scarlet runner rean (Swayframe, 2015)

II. History of Kudzu in the United States

Kudzu is commonly thought to have been first introduced into the United States during the Centennial Exposition in Philadelphia, Pennsylvania in 1876 (Forseth & Innis, 2004), though there are reports stating kudzu was present in a nursery prior to this (Waldron & Larson, 2012). Between its introduction in 1876 and 1910 kudzu was marketed as an ornamental shade plant that would provide dense decorative foliage and shade for landowners during the intense heat of the southeastern United States' summers (Shurtleff & Aoyagi, 1985). This, accompanied with the plant's ability to take root in most soils rather easily, allowed kudzu to begin its journey to infamy. Between 1910 and 1935 kudzu was marketed as livestock fodder by the U.S. Department of Agriculture. By 1934 an estimated 10,000 acres of kudzu had been planted in the southeastern United States (Shurtleff & Aoyagi, 1985). Kudzu grew in popularity to the point where landowners could obtain seeds and propagations from mail-order catalogs (Simberloff & Rejmanek, 2011; Shurtleff & Aoyagi, 1985).

By the mid-1930s the United States was promoting soil conservation efforts in response to the Dust Bowl. Experiments found that kudzu's rapid growth, extensive root systems, and ability to form heavy mats of leaf material made it an ideal soil conservation tool (Daly, 2011; Forseth & Innis, 2004; Shurtleff & Aoyagi, 1985). In addition to promoting soil stability, kudzu also fixed atmospheric nitrogen, which helped to re-fertilize soils that had been depleted from decades of poor farming practices on tobacco and cotton fields (Mitich, 2000). During this time, the Federal Soil Erosion Service (now the Natural Resource Conservation Service) provided over 85 million seedlings to be planted across the southeastern United States and paid citizens to plant kudzu through programs like the Civilian Conservation Corps (Simberloff & Rejmanek, 2011). At the same time Channing Cope, a Georgia man who would eventually be known as the "kudzu king", founded the Kudzu Club of America and promoted the plant's soil restoration and erosion control properties on his radio show (Everest et al., 1999; Simberloff & Rejmanek, 2011). The Kudzu Club of America also marketed it as being edible and able to produce starch, paper and cloth products (Bentley & Mauricio, 2016; Coiner et al., 2018; Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). In total, these efforts cumulatively resulted in over 1.2 million hectares of kudzu being planted by 1946 (Simberloff & Rejmanek, 2011).

By 1955 many landowners began seeing the negative impacts of kudzu; it was increasingly recognized as a nuisance plant (Shurtleff & Aoyagi, 1985). Within the span of a few decades Kudzu went from being promoted as a problem-solving crop, to being viewed as a noxious weed. In 1953, the U.S. Department of Agriculture removed kudzu from the approved list of plants that were suitable for soil erosion control and by the 1960's research on the plant shifted from cultivation to eradication. In 1970, Kudzu was officially labeled a weed and in 1997 it was added to the Federal Noxious Weed list (Forseth & Innis, 2004). The end-of-the-millennium issue of *Time* magazine reported the introduction of kudzu into North America as one of the 100 worst ideas of the century (Simberloff & Rejmanek, 2011).

III. Detection

Kudzu is most commonly found in high traffic areas near edge habitat where sunlight is abundant. Additionally, due to the limited ability of kudzu to sexually reproduce in North America, most populations are established from intentional planting or hitchhiking from anthropogenic sources. This results in kudzu commonly being found in close proximity to anthropogenic activity. As a result of one of the primary uses of kudzu being soil and bank stabilization, it is common to find stands along steep embankments and ditches. Due to its ability to create extensive, dense monocultures that are not typical of native plants, kudzu is rather noticeable from the ground. Ariel detection of the plant can be difficult as larger vegetation such as trees shroud the plant.

In addition to manual detection, remote sensing is becoming a popular method of identifying previously undetected invasive species populations. Remote sensing uses a species' unique physiology (such as the color of the flowers or period that leaves are present) for identification. Kudzu, in its invasive range, leaves out later and retains its green summer foliage later than the native plants it competes with (Simberloff & Rejmanek, 2011). Thus, performing time series analysis with high-resolution imagery from the late fall and early winter may allow for detection of kudzu (Jensen et al., 2020). AVIRIS (airborne visible/infrared imaging spectrometer) and HyMap data can be utilized in the prediction of potentially problematic areas that could contain kudzu. However, there are several barriers that make remote sensing less viable for invasive species monitoring. These barriers include cost and the workload necessary to process large amounts of data (Jensen et al., 2020).

IV. Life History and Dispersal

Kudzu can reproduce both asexually and sexually. Asexual generation or vegetative spread occurs via the plant sending down roots from nearly every node that is in contact with the soil along the stem. These nodes then develop into roots that occur every few feet along horizontal stems. These new root crowns and stems will detach from the parent plant and form ramets that are independent from the parent plant within three years (Simberloff & Rejmanek, 2011). The rapid disconnection of stems means ramets form physiological independence quickly. This also creates overlapping of branches and high densities of independent ramets which results in multiple canopy layers (Forseth & Innis, 2004). Plants will continue to spread in every direction via this mechanism. The ability of kudzu to spread via clonal colonization increases as the plants age as a result of their larger more developed root systems (Miller, 1996).

Kudzu is a structural parasite, meaning the support needed to reach the top of the forest canopy comes from other plants (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). This is what makes kudzu especially well-suited for rapid expansion as there is high allocation of nutrients to stem elongation and root growth as well as branch and leaf growth rather than supporting structures (Simberloff & Rejmanek, 2011). The plant's stem can elongate at rates of

1 to 7.5 in (3 to 19 cm) a day (Forseth & Innis, 2004). As there is little allocated to woody material, this allows for high allocation of leaf material that is actively providing nutrients via photosynthesis. These rapid growth rates allow kudzu to reach high-light areas at the top of forest canopies (Simberloff & Rejmanek, 2011) and form dense patches by twining on objects with a diameter less than 4 in (Everest et al., 1999; Miller et al., 2010). Kudzu also has high photosynthesis rates. Under high-light conditions the plant can be equivalent in production to entire forest canopies (Forseth & Innis, 2004). Rapid growth rates, high rates of photosynthesis, the ability to reproduce via rooted stem nodes, and the ability to fix atmospheric nitrogen allow kudzu to quickly outcompete even the most rapidly growing and competitive native tree species in eastern deciduous and southeastern mixed pine ecosystems (Forseth & Innis, 2004).

Sexual reproduction occurs most commonly after the plant's third year. When plants mature, most hanging stems will develop flowers while stems lying on the ground will not (Forseth & Innis, 2004). During sexual reproduction kudzu is primarily cross-pollinated. However, self-pollination can occur (Simberloff & Rejmanek, 2011). Once seeds are developed and dispersed, scarification is required for seed germination to occur (Forseth & Innis, 2004; Munger, 2002). This allows for the seed coat to be more permeable to nutrients and water. Prolonged exposure to warm summer temperatures, fire, exposure to acid, and mechanical scarification all increase seed permeability (Forseth & Innis, 2004; Munger, 2002). Germination can occur without scarification, though to a limited degree. Without scarification, seeds remain dormant in the seed bank (Forseth & Innis, 2004; Munger, 2002).

Native Range

Kudzu is significantly more likely to successfully reproduce sexually in its native range compared to invasive populations. Cross pollination is a key factor in maintaining genetic diversity in kudzu's native range (GISD, 2023). Within its native range, it is common for kudzu to be dispersed by animals, wind, and water (GISD, 2023).

Invasive Range

In Kudzu's invasive range, asexual reproduction is responsible for much of the annual spread and can be quite rapid. For example, kudzu in Oklahoma was projected to be able to spread 104,464 acres in the first year of establishment and up to 297,464 acres total after five years (Harron et al., 2020). Asexual reproduction also allows for unintentional human-assisted migration as above-ground tissue can easily establish in the soil (Bentley & Mauricio, 2016; Coiner et al., 2018). Kudzu dispersal occurs most rapidly in high-traffic areas like roadsides or near strip mines and other sites of human disturbance. Current rates of intentional anthropogenic spread are limited due to the federal restrictions on kudzu cultivation established during the 1970's (Coiner et al., 2018).

Almost a third of kudzu's invasive range is made up of only three clonal lineages. This is most likely due to one large or several introductions from the same region of eastern Asia (Bentley & Mauricio, 2016). Gene flow across populations is rare, with 50% of populations containing only one or two clonal lineages (Forseth & Innis, 2004). This also implies migration of individuals into

existing populations does not occur commonly (Bentley & Mauricio, 2016). Species that favor clonal reproduction have a reduced likelihood of any evolutionary mechanism that results in increased invasiveness (Bentley & Mauricio, 2016). This means that invasive populations of kudzu may adapt less rapidly to new environmental conditions when compared to sexually reproducing populations (Bentley & Mauricio, 2016).

Invasive populations of kudzu have only marginal success with sexual reproduction (Forseth & Innis, 2004). In North America, sexual reproduction is rare and considered to be infrequent when compared to most other herbaceous perennial plants (Bentley & Mauricio, 2016; Forseth & Innis, 2004). Seed production still occurs throughout the entire invasive range, however, seedling survival is reportedly very limited in North America as a whole. (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011).

Research indicates that seed set is low and seed viability is limited outside the southeastern United States due to poorer growing conditions and lack of pollinators (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). However, a population of kudzu in Leamington ON was observed to have *Megachile sculpturalis* (the giant resin bee) visiting flowers (Waldron & Larson, 2012), and native *Hymenoptera* as well as other native and naturalized pollinators have been documented as frequent visitors of racemes (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). In the southeast United States seed pods become visible as early as September. However, they will not mature until October and November. In addition, it has been reported that kudzu populations in Canada are capable of producing viable seeds due to longer growing seasons (Lindgren et al., 2013). Only 1-2 viable seeds will come from a cluster of pods on climbing vines in the southeast (Everest et al., 1999). The agents of seed dispersal in kudzu's invasive range are unknown (Bentley & Mauricio, 2016). Even when invasive kudzu is able to sexually reproduce, seedlings are not nearly as competitive as asexually produced ramets and thus are potentially not cause for great concern to invasiveness as establishment is rare (Coiner et al., 2018; Munger, 2002).

In North America, kudzu is winter-deciduous with stems dying back after the first hard frost and then regrowing each spring (Lindgren et al., 2013; Mitich, 2000). However, while cold may kill back the plant above ground, cold temperatures will not kill kudzu roots and the plant will be able to grow back (MDC, 2023). Coiner et al. (2018) also found that the cold tolerance for kudzu is relative to a population's geographic location i.e., tissues exposed to colder temperatures have higher cold tolerances. This indicates that kudzu is capable of adapting to its environment and winter cold specifically (Coiner et al., 2018). In the northern portion of its invasive range, kudzu actively grows from May until September (Lindgren et al., 2013) and thrives in regions with mild winters.

V. Habitat

Native Range

Kudzu (*Pueraria montana*) is native to eastern Asia, predominantly within eastern China and Japan as well as descending into the Pacific islands (Discover Life, 2023; Invasive Species Alert: Kudzu, 2023). In its native range it is a hardy opportunist and can grow in a wide range of habitats and conditions including wooded areas, rights-of-way, along rivers, roadsides, embankments, borders of fields, abandoned fields, fencerows, non-crop areas and other edge habitats and where it can obtain significant amounts of sunlight (Mitich, 2000). Kudzu can do well in many soil types including nutrient poor, sandy, clayey, or loamy soils (Mitich, 2000), but it does best in deep, well-drained and loamy soils (Everest et al., 1999; Mitich, 2000; Munger, 2002). In contrast, kudzu does not do well on poorly drained, basic soils.

In its native range, kudzu grows from latitudes 44°N to 30°N. In this range it grows in regions where it commonly experiences temperatures that drop to -30° Celsius (Mitich, 2000). As the plant is relatively hardy and a generalist, it can be found growing in lowland regions and on small islands as well as mountainous areas up to elevations of 1,000 m (Mitich, 2000). Figure 7 shows the global distribution of Kudzu including both its native range and the areas where it has become established as an invasive species.

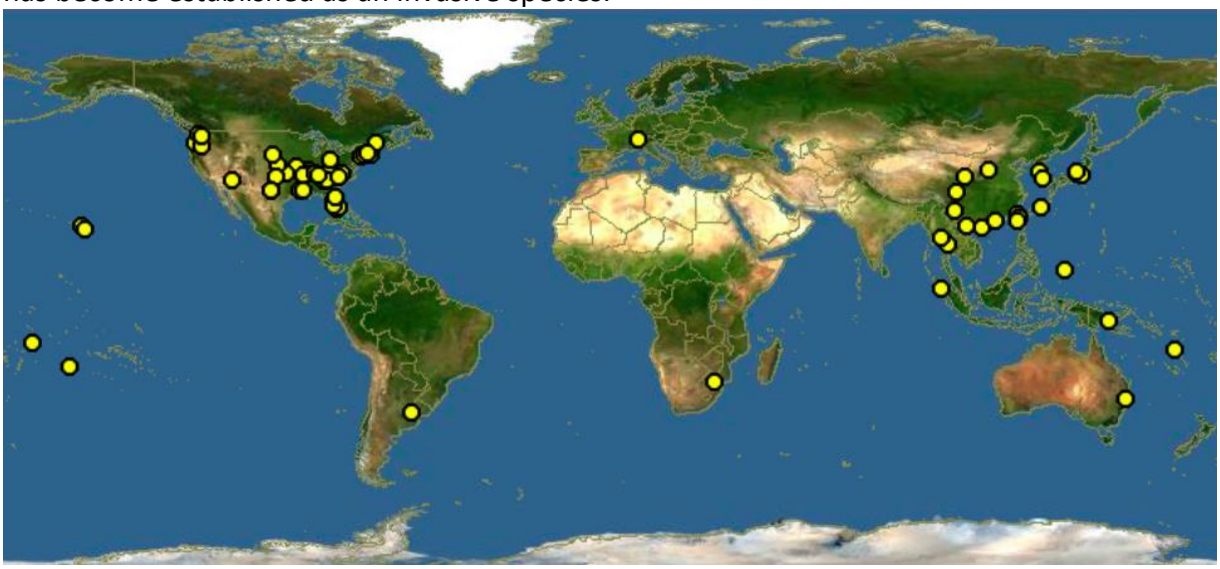

Figure 7: Global distribution of kudzu (Pueraria montana). Source: http://www.discoverlife.org

Invasive Range

Currently, kudzu can be found in 31 U.S. states and one Canadian province (EDDMaps, 2023). Heavy concentrations of kudzu are present in Alabama, Georgia, Mississippi and South Carolina (Miller et al., 2010) with well-established populations ranging latitudinally from southern Florida up the Atlantic coast into the northeastern states of New York and Maine (Discover Life, 2023) and as far west as Oregon and Washington. However, it has confirmed reports further north into Ontario and even has been reported anecdotally as far north as Nova Scotia (Mitich, 2000). Kudzu is very capable of establishing itself in the various climates that span across North America (Figure 8).

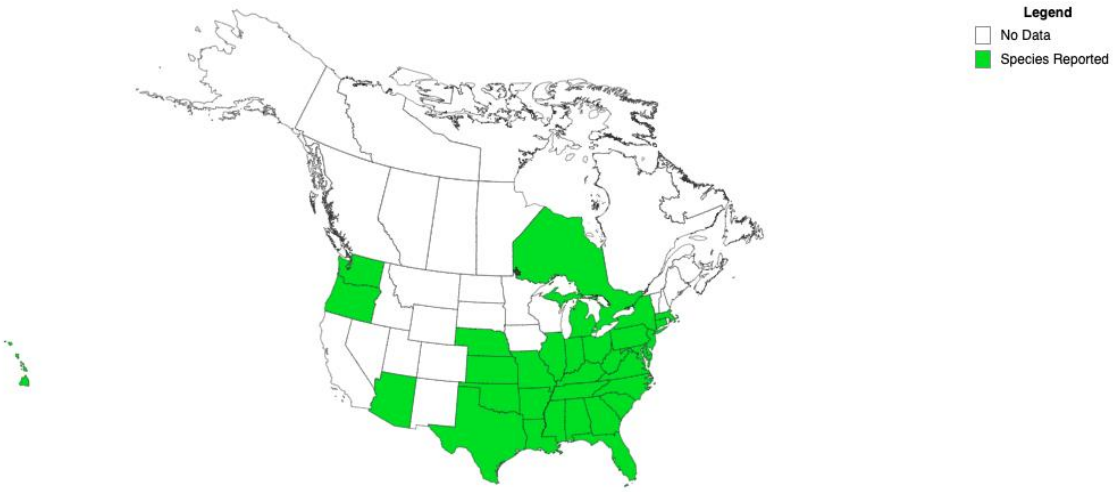

Figure 8: Image depicting the states and provinces in which kudzu (Pueraria lobata) has been documented. Source: EDDMaps.org

In its invasive range, kudzu is more geographically diverse than within its native range. Kudzu can establish in both healthy and disturbed habitats with the ability to invade forest margins and create dense canopy mats on top of trees (Harron et al., 2020; Miller et al., 2010). Kudzu is typically found in open, disturbed areas where the sunlight is abundant. Areas such as roadside ditches, abandoned or open fields, forest edges, and stream banks (Forseth & Innis, 2004; Miller et al., 2010) allow for rapid growth of the vines. The rate of growth is inversely related to the frequency of shaded areas (Forseth & Innis, 2004). As kudzu is able to fix atmospheric nitrogen, it is able to proliferate on poor soil sites that may not be able to support other vegetation (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). Because of this, kudzu has been speculated to be the most competitive in nitrogen-poor environments (Munger, 2002). The plant grows well in areas with mild winters of 40 to 60 degrees Fahrenheit (5 to 15 degrees Celsius) and summer temperatures rising above 80 degrees Fahrenheit (27 degrees Celsius). Additionally, long growing seasons with a minimum of 100 cm of rainfall are ideal for kudzu growth (Mitich, 2000). The plant thrives in regions with abundant sunlight during the growing season (Munger, 2002). This being considered, kudzu grows particularly well in the southeastern United States, especially when compared to midwestern and northeastern states (Mitich, 2000). Kudzu's large roots, which act as water reservoirs, allow kudzu to withstand considerably dry environments (Mitich, 2000).

In the past, winter survival was a factor that was assumed to limit kudzu's northern expansion. Leaves and above-ground stems are killed with the first hard frost of the year (Simberloff & Rejmanek, 2011). However, it is likely that kudzu can survive further north than its current distribution and that winter cold may not be as large of a mechanism in the northern expansion (Coiner et al., 2018; Mitich, 2000). Additionally, with climate change kudzu will likely spread north of its current invasive range. Managers may consider implementing early detection and management strategies near kudzu's northern ranges (Coiner et al., 2018).

Environmental challenges such as climate change, habitat fragmentation, and nutrient deposition all favor kudzu's continued spread. (Foseth & Innis, 2004). Observations related to climate change over the last few decades in the United States, including a decrease in the number of frost days, an earlier date for the last freeze in spring, and a later date for the first freeze in fall favor the spread of kudzu. Currently, leaves are killed by the first hard frost of the season, and leaf expansion in the spring lags that of most forest trees. The projected climate changes will favor kudzu and allow for its total biomass, stem length, number of branches, leaf expansion rate, completion of leaf expansion, leaf size, and leaf production to increase. Growing season at the northward limit should increase several days (Forseth & Innis, 2004).

VI. Effects of Kudzu

Today kudzu currently covers over 3 million hectares of land in the Eastern United States and expands at a rate of 50,000 ha per year (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). While at one point in its history kudzu was planted as a soil conservation solution and fodder for livestock, it is now seen as a very detrimental weed that threatened local ecosystem and causes millions of dollars' worth of damage every year.

Negative Ecological Impacts

Kudzu's rapid growth rate, high leaf area indices, high photosynthetic rates, and frequent ramet growth allow the vine to rapidly spread. As kudzu advances it overtops, smothers and shades out mature trees and understory species while girdling saplings (Forseth & Innis, 2004; Lindgren et al., 2013; Simberloff & Rejmanek, 2011). This results in kudzu monocultures where previously-existing vegetation is completely replaced (Forseth & Innis, 2004; Lindgren et al., 2013). Kudzu also alters long-term successional processes and disturbance regimens. The expansive vines link tree canopies together and can cause several linked trees to fall during storms (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). Additionally, kudzu increases the risk of severe fire as climbing vines form a natural ladder allowing fires to reach forest canopies. Post-disturbance, kudzu may outcompete pioneer species and dominate biomass recovery (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011; Munger, 2002). With all of this considered, the rapid expansion of kudzu in the United States poses a significant threat to native biodiversity (Forseth & Innis, 2004).

In addition, kudzu may have significant impacts on nitrogen cycles, watershed nitrogen saturation, freshwater eutrophication, and air quality (Forseth & Innis, 2004; Lindgren et al., 2013). With climate change of considerable concern, kudzu illustrates the potential to gain from as well as quicken the rate of climate change. Commercial cultivation of legumes is one of the factors that has rapidly increased the amount of nitrogen that is released into the biosphere, which can result in decreased soil fertility and be detrimental to species that are adapted to low levels of nitrogen within the soil (Simberloff & Rejmanek, 2011). Kudzu can fix large amounts of atmospheric nitrogen, and large stands of kudzu show the potential for altering the nitrogen cycles of small streams and watersheds (Forseth & Innis, 2004). The concern of nitrates being leached into nearby watersheds is also increased due to the fact that kudzu was historically planted on hillsides to control erosion (Forseth & Innis, 2004). Additionally, kudzu has been ranked as an intermediate to high emitter of isoprene, a chemical that aids in the formation of smog and ozone (Coiner et al., 2018; Forseth & Innis, 2004), and is responsible for nearly half of the hydrocarbons released into the atmosphere (Forseth & Innis, 2004). Isoprene production is thought to be a response to high temperatures or water stress to avoid short-term thermal damage to photosynthesis (Forseth & Innis, 2004). This concern is lessened with more diverse communities rather than monocultures. However, kudzu establishment frequently results in monocultures (Forseth & Innis, 2004).

Negative Economic Impacts

Kudzu causes significant economic damage in its invasive range. In the U.S. alone, kudzu causes $100 to $500 million (USD) in damage annually when considering annual damages and costs of removal by the forestry industry, power and railroad companies, national and state parks, and agricultural producers (Forseth & Innis, 2004; Simberloff & Rejmanek, 2011). On average it costs forestry companies $500 (US) per hectare over a five-year period to manage kudzu. This exceeds the profits of a 25-year-old pine plantation. It is sometimes cheaper for forestry companies to take property infested by kudzu out of production rather than treat it (Lindgren et al., 2013). Additionally, kudzu commonly interrupts power to residential areas due to the toppling of power lines (Forseth & Innis, 2004). Power companies pay $1.5 million on average each year to manage kudzu and repair power interruptions caused by the vine (Forseth & Innis, 2004; Harron et al., 2020). Railroad companies devote considerable time to prevent vines from covering tracks which can cause wheel slippage and possible derailment. In state and national parks, the largest concern is that kudzu will decrease the aesthetic and historical value of these places (Forseth & Innis, 2004).

Kudzu growing near agricultural fields and orchards has the potential to encroach into crops damaging yields, impacting harvesting timelines, and even damaging farm equipment (Lindgren et al., 2013). In addition, kudzu is a potential wild reservoir of soybean rust (*Phakopsora pachyrhizi*) (Coiner et al., 2018; Harron et al., 2020; Waldron & Larson, 2012). This fungus was introduced into the United States in 2004 and results in lesions, early defoliation, and reduced pod production in legumes. Soybean rust overwinters in kudzu leaves which allows it to survive the winter and infect soybean crops in the spring (Harron et al., 2020). Soybean rust causes crop loss and increases the cost of legume production as it necessitates fungicide application on soybean plantings (Simberloff & Rejmanek, 2011).

Positive Impacts

Kudzu hay produces high quality forage that is quite palatable and is considered to have similar nutrient quality to alfalfa (*Medicago staiva*), with high crude protein and total digestible nutrient value depending on the management and season (Everest et al., 1999). Forage quality is highest in young vines and leaves and is maintained until at least the first frost (Everest et al., 1999). It also has been anecdotally noted as a preferred fodder for livestock when compared to other feeds, especially when the animal is sick (Mitich, 2000; Shurtleff & Aoyagi, 1985). However, the work required to cut and bale the plant is not outweighed by its quality, as the vines are not easily harvested with common equipment. Kudzu has a low forage yield of two to four tons of dry matter per acre per year. In addition, frequent defoliation for three to four years can negatively impact stands of kudzu (Everest et al., 1999).

Because of kudzu's large and frequent roots, it can be cultivated in steep, rocking hillsides that would not typically be able to grow any form of agriculture (Mitich, 2000). This feature is what makes the plant a great soil stabilizer (Everest et al., 1999). Even today Kudzu is often present on steep hillsides, embankments, and bluffs (Everest et al., 1999). However, other non-invasive plants have been found to be just as good at soil stabilization (Everest et al., 1999).

Kudzu has been utilized by the Japanese as a food crop for centuries. The leaves were historically used as a vegetable, but today it is more commonplace for the powdered root to be used as a starch (Mitich, 2000). Additionally, when consumed as a medicinal tea, the powdered root has properties that can aid in the treatment of alcoholism, heart disease, menopausal symptoms, diabetes, fever, the common cold, neck and eye pain, asthma, diarrhea, and more serious ailments such as anemia and apoplexy (Mitich, 2000). Along with the powder, the roots, leaves, and shoots of the plant can be eaten in soups, salads, sauteed dishes, and casseroles (Mitich, 2000; Shurtleff & Aoyagi, 1985). In fact, many cookbooks have been produced that focus specifically on dishes that use kudzu (Shurtleff & Aoyagi, 1985). Within the invasive range, kudzu is commonly used as a food crop in Java, Sumatra, Malay, and Puerto Rico (Mitich, 2000). Kudzu flowers are also known for producing an unusually fragrant, flavorful honey. Some countries import thousands of saplings for the sole purpose of honey production (Mitich, 2000; Shurtleff & Aoyagi, 1985).

Kudzu's fibers are capable of being woven into cloth as well as other garments that share a similar texture to burlap or canvas (Mitich, 2000). Young kudzu vines can be harvested to produce waterproof fibers that can be used for weaving wicker baskets and trunks (Mitich, 2000). The cellulose fiber from the root can be used to make fine traditional paper. It is also used to stuff cushions, beds, and chairs (Mitich, 2000). When burned it is capable of repelling mosquitos in small areas (Mitich, 2000). The plant has also been used to produce biofuel (Mitich, 2000).

Current Status and Distribution in Michigan

Kudzu was first reported in Michigan in 1994 in Allegan County, on a bluff that overlooks Lake Michigan (University of Michigan Herbarium, 2023). As of January 2023, there have been 24 reported observations across eight Michigan counties, though kudzu may be present in additional areas within the state. The most complete report of kudzu locations in Michigan is through Midwest Invasive Species Information Network (MISIN), which reports kudzu in Allegan, Barry, Benzie, Berrien, Clare, Manistee, Ontonagon, and Van Buren counties (MISIN, 2022). An additional report from the Northern Research Station of the U.S. Forest Service reported a population of kudzu within Hillsdale County, documented as positive and verified; however the last visit to this site was in 2007 (EDDMaps, 2023). Currently, areas of kudzu range from being patchy to dense with only one population reaching a complete monoculture. Table 1 provides further information regarding precise locations as well as estimated area and estimated density.

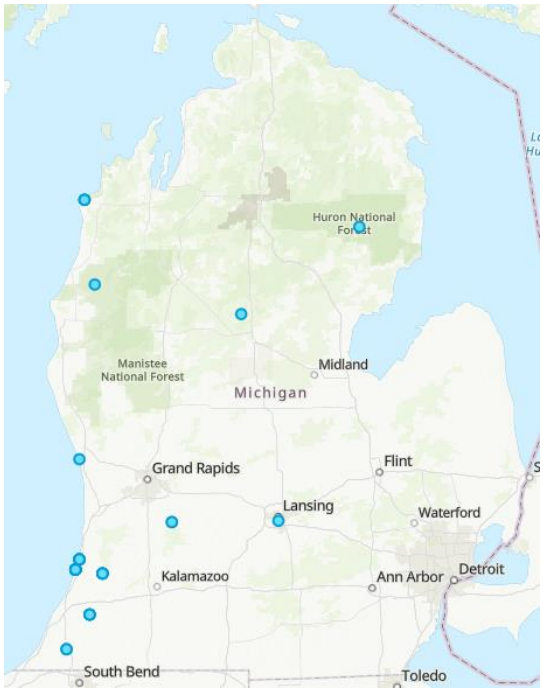

Figure 9: Map of the MISIN observations of Kuzdu as of December 2023

Management

I. Prevention

Best management practices that prevent introduction and promote early detection of kudzu are the most cost-effective and sustainable management options (Harron et al., 2020). When it comes to prevention, decontamination of people and equipment, consistent management of current populations, and monitoring to detect spread early are key. Policies that prohibit the intentional spread and sale of kudzu can also play an important role in preventing the plant's further establishment in Michigan. Finally, it is important to educate the public about how to identify kudzu, the danger it poses to local ecosystems, and how to report it. Indirect management, including limiting the effects of climate change may influence kudzu's ability to establish in regions with more severe winters.

II. Management and Control

Key Considerations

Once kudzu is established, it is increasingly difficult to remove because of the physiological characteristics that allow it to be a strong competitor (Forseth & Innis, 2004; Lindgren et al., 2013), including the ability to rapidly grow via surface vines and underground rhizomes (Miller, 1996). The eradication of kudzu at large scales has proven difficult as there is often a mosaic of property ownerships (Forseth & Innis, 2004; Miller, 1996). Kudzu that is eradicated on one property can be reintroduced from an adjacent property (Forseth & Innis, 2004). Collaboration in treatment must occur, or eradication will be impossible (Miller, 1996, Everest et al., 1999). Control of kudzu on small scales has been documented using many methods, including herbicides, prescribed burning, continual defoliation via mowing and grazing, and harrowing (Miller, 1996; Simberloff & Rejmanek, 2011), but the age, size and location of a population must be considered prior to treatment (Lindgren et al., 2013). Persistence over multiple years is key to successful treatment (Everest et al., 1999; Miller, 1996). Kudzu management is also complicated in areas where the plant was historically planted, as they often contain steep embankments and high amounts of debris and abandoned structures (Miller, 1996).

Previous research suggests that the most effective methods of removal are chemical and mechanical removal (Harron et al., 2020). All root nodes must be either treated with herbicide or physically removed in order to eradicate established populations (Forseth & Innis, 2004). For all methods of treatment to be fully successful, re-establishment of desirable vegetation such as native trees or grasses is necessary to help in long term suppression and reoccurrence of kudzu (Miller, 1996). Grasses help to suppress kudzu regrowth and protect the soil from further disturbance after kudzu removal (Everest et al., 1999). The best treatment is dependent on the size of infested area, proximity to desirable trees, shrubs, or crops; accessibility for grazing, cultivation, or harvesting; and future plans for the infested area (Everest et al., 1999).

Cultural Control

Grazing is a well-documented method for management of kudzu. Many ruminants find kudzu palatable, though cattle have been noted as the most successful for eradication (Miller, 1996). Goats can also control kudzu in a very short period (Mitich, 2000). Close grazing for three to four years can eliminate kudzu when 80 percent or more of the vegetative growth is continuously consumed (Cage, 2023). Grazing is particularly effective between August and September as translocation of carbon to the root structures occurs during this time (Forseth & Innis, 2004; Miller, 1996). Grazing during this period will effectively weaken the following year's new growth (Forseth & Innis, 2004). This form of control is labor-intensive as livestock must be provided with water sources as well as supplementary feed (Miller, 1996). Furthermore, livestock must be fenced leaving potential for vines to become inaccessible (Forseth & Innis, 2004). Additionally, hanging vines must be cut and pulled down so that they are accessible to livestock. Grazing is often accompanied by spot application of herbicides as there is high probability for plants to persist after grazing (Miller, 1996).

Prescribed burning has multiple uses in kudzu management including killing the youngest of kudzu plants, severing hanging vines, removing debris to prepare a site for further treatments, and scarifying potential dormant seeds to eliminate a seed bank (Miller, 1996). Burning is best

performed in the late winter/early spring when dead, dry foliage is compacted to form adequate fuel (Miller, 1996). Prescribed burns also help expose hazards such as wells, gullies, and downed trees that were covered by kudzu's extremely dense foliage and overlapping vines (Miller, 1996). In areas where forest fires are common, prescribed burns can prevent ground fires from spreading into the canopy via draped vines (Forseth & Innis, 2004; Munger, 2002).

Physical Control

Several forms of mechanical control for kudzu include harrow disking, mowing, hand pulling and physical removal of roots. Frequent defoliation using a mower or harrow disk (Everest et al., 1999) produce results similar to grazing. Close mowing or cultivation every 1-2 months during August and September are known to be effective (Everest et al., 1999). However, these forms of control may be best utilized on stands less than 25 years old (Everest et al., 1999). Cutting vines close to the ground with pruning shears or bypass loppers during hot, dry periods of the summer may exhaust nutrition reserves within the roots (Cage, 2023). For small populations, it is also possible to use a shovel to dig out the root crown by hand. However, this method is very labor intensive and causes significant soil disturbance (Trees Atlanta, 2023). The effectiveness of mechanical control is decreased on well-established infestations (Cage, 2023). In addition, mowing may only prevent further spread rather than eradicating kudzu stands (Mitich, 2000). Often physical and cultural control methods are most effective when they are combined with other control methods. For example, grazing can be used to clear vines from a area before digging up root crowns. Hand-cutting can be combined with chemical control to prevent regrowth (Trees Atlanta, 2023).

Chemical Control

Herbicides are effective for controlling kudzu, but they are expensive and require repeated, thorough application. The rooting stem nodes in contact with the ground, combined with the rapid breaking of connections between rooted nodes require repeated applications of herbicide over the course of up to 10 years to eradicate an established population of kudzu completely (Forseth & Innis, 2004). Chemical control also requires proper identification, inspection, and preparation of the site from which kudzu is planned to be eradicated, as well as following label specifications (Miller, 1996). When considering what pesticides would be most effective in the treatment of a patch of kudzu, proximity to highly desired vegetation (sensitive crops, gardens, and ornamental plants), soil type, and proximity to slopes and water sources must be considered. The age of a kudzu stand is important to consider prior to management as older stands of kudzu will have large roots and root crowns and will require greater herbicide rates and more retreatments (Miller, 1996).

Most herbicides can kill the leaves of kudzu. However, only a limited number of herbicides can kill the roots (Miller, 1996). Tordon 101 and Tordon K (active ingredient picloram) have been effective and cost-effective options for kudzu control (Miller, 1996; Everest et al., 1999). The herbicides are applied as sprays to the foliage and must not be washed from the leaves (i.e. by rainfall) before 2days have passed after application to allow the roots to uptake the chemical (Miller, 1996). These herbicides are highly water soluble and should only be used in areas not at

risk of leaching and runoff into local water bodies (Miller, 1996). These herbicides can kill or injure nearby trees with diameters less than 10 in as well as other vegetation (Miller, 1996). Additionally, these pesticides are relatively persistent in the environment after application and if other vegetation is reintroduced too early after treatment it may not survive (Everest et al., 1999; Miller, 1996). It is important to wait about six months following treatment to plant pines or grasses in the area (Everest et al., 1999). It is important to consider the age of the kudzu stand when beginning treatments as varying rates of herbicide application may be most effective (Table 2; Miller, 1996). Timing of the application is important for the uptake of herbicide by kudzu. Application should occur during the months when the plant is actively growing (Everest et al., 1999; Miller, 1996). August and September are considered a good period to apply herbicides, as this is when the plant is beginning to flower (Cage, 2023). However, reading and understanding the label of the herbicide and how the herbicide should be utilized is of greatest importance.

Other herbicides are less effective than Tordon but can be used for containment and management of forested sites, as well as multi-year treatments for possible eradication (Table 2; Miller, 1996). Herbicides that utilize tebuthiuron (e.g. Spike 80W or 20P) as an active ingredient are very persistent and may remain in soils for years after initial treatment. Desirable trees and shrubs that have roots extending into or near areas where tebuthiuron was applied may be killed or injured (Miller, 1996). Spike herbicides are also water soluble and may be transported with runoff, thus must not be applied to areas with slopes. This persistence also may allow for a single initial treatment to control kudzu for over a three-year period (Miller, 1996). Transline (clopyralid) by DowElanco is selective for legumes and is safe for many tree species except black locust, redbud and mimosa (Miller, 1996). Veteran 720 (dicamba and 2,4-D) can be applied near streams and drainage ditches and can provide high percentages of control, within two years of broadcast treatments (Miller, 1996). Glyphosate treatments such as Roundup and Accord are a good option for residential areas but will require many subsequent treatments as they are unable to treat more mature stands of kudzu (Everest et al., 1999; Miller, 1996).

Table 1: Herbicides Used in Kudzu Management
** approved by the EPA for treatment of kudzu*

Herbicide(s)	Manufacturer	Active Ingredient(s)	Rate of Treatment	Most effective Treatment
Tordon 101*	DowElanco	Picloram and 2,4-Dichlorophenoxyacetic acid	1 gallon per acre or 2 gallons per acre	stands <10 years old or stands >10 years on level ground not near water
Tordon K*	DowElanco	Picloram	0.5 galllons per acre	all stands on level ground not near water
Veteran 720*	Riverdale	Dicamba and 2,4-Dichlorophenoxyacetic acid	2 gallons per acre	sites near streams, ponds, and ditches
Transline*	DowElanco	Clopyralid	1 ounce per acre	forest openings and kudzu in desirable trees
Krenite*	Dupont	Ammonium salt of	3 gallons per acre	

		fosamine		
Garlon 3A&4*	DowElanco	Triclopyr	1-2 gallons per acre	older pine plantations
Accord*	Monsato	Glyphosate	1 gallon per acre	
Arsenal AC*	American Cyanamid	Imazapyr	2 quarts per acre	
Oust & Accord*	Dupont, Monsato	Sulfometum and Glyphosate	3 ounces & 2 quarts per acre	
Escort*	Dupont	Metsulfuron	4 ounces per acre	young pine plantations
Roundup*	Monsato	Glyphosate	1-2 gallons per acre	residential sites
Spike 80W	Corteva	Tebuthiuron	6-8 pounds per acre	non-croplands
Spike 20P (pellets)	Corteva	Tebuthiuron 20%	20-30 pounds per acre	non-croplands

Biological Control

The difficulty with finding an appropriate biological control from kudzu's native range is that many species are not host specific and may impact desirable species as well as kudzu (Simberloff & Rejmanek, 2011). Kudzu is also attacked by many native and nonnative insects in the United States and is prone to bacterial blights (Simberloff & Rejmanek, 2011).

Insect predation of seeds has been reported in North Carolina and is thought that on average 80% of the seedbank is lost to insect predation. As a result, successful seedling establishment from seed is rare (Forseth & Innis, 2004). Hemipterans and bruchid beetles are both common species found predating kudzu. One survey found 25 species of insect feeding on kudzu, including two species of weevil and eight beetles which complete larval development in the primary stem roots (Forseth & Innis, 2004)

Fungal pathogens have also shown potential as biological control agents for kudzu. *Myrothecium verrucaria*, a fungal pathogen that heavily decomposes cellulose, is shown to have increased disease development at 30 - 40 °C, indicating a good match between field conditions and fungal pathogenicity. Additionally, a field population was controlled within 14 days by inoculation using conidia, an asexually produced spore. The downside to this treatment is that the fungus produces mycotoxins that are highly toxic to mammals (Forseth & Innis, 2004). The bacteria *Psuedomonas syringae ev. phaseolicola* can be used as a surfactant to facilitate inoculation of these treatments (Forseth & Innis, 2004).

Indirect Management

It is currently thought that kudzu is limited by low winter temperatures; winter warming and the extension of the growing season increases the potential for kudzu to continue its northern spread. By limiting the effects of climate change, this rapid expansion and the resulting effects of that would be diminished (Coiner et al., 2018). Plant species that can out-compete kudzu when it is young have not been identified.

Research Needs

I. Biology and Ecology

Despite substantial amounts of anecdotal evidence of the effects of kudzu on native populations, there is little quantitative research focused on ecological interactions between kudzu and native species or the impacts invasive kudzu has on native successional processes, biodiversity, and nutrient cycles (Forseth & Innis, 2004). Gaining a better understanding of these interactions and impacts is extremely important as many areas where kudzu has become established in the southeastern United States are extremely biodiverse (Forseth & Innis, 2004). Research on kudzu's ecological interactions with native plants, invertebrates, and vertebrates can help inform conservation efforts for these species. It is especially important to understand the impact kudzu has on species with narrow ecological niches, species that demonstrate mutualistic relationships, or species with a monotropic diet as these species may be most vulnerable to kudzu invasion (Forseth & Innis, 2004). Continued research on the ecological impacts of kudzu as well as native species that might out-compete young kudzu will also help researchers understand and project the species' future impacts on native ecosystems (Forseth & Innis, 2004).

Kudzu sexual reproduction in North America is also not well understood and more research is needed, particularly comparing its northern and southern extents (Forseth & Innis, 2004). For example, little is known about light requirements for seed germination, seed coat scarification requirements, or seed bank longevity in soil (Forseth & Innis, 2004). It is also unclear whether seeds can survive temperature extremes. The agents of seed dispersal in kudzu's invasive range are also currently unknown (Bentley & Mauricio, 2016). In addition, the introduction of non-native pollinators may allow for more viable sexual reproduction in kudzu's invasive range. Understanding non-native pollinator interactions with kudzu may be essential for controlling the spread of kudzu in the future.

More research is also needed to understand kudzu's ability to adapt to changing climactic conditions. For example, limited quantitative measurement has been performed to determine the drought tolerance of kudzu, though it is suspected that the roots' water storage capabilities would create an effective buffer to avoid leaf water deficits during periods of high evaporative demands. This is suspected to have negative impacts on native vegetation during intermittent droughts (Forseth & Innis, 2004). Researchers have also hypothesized that warming temperatures will allow kudzu to expand its invasive range into more northern habitats (Coiner et al., 2018). Research that models potential northern expansion routes can help natural resource managers prepare and improve efforts to prevent and manage the species.

II. Detection

Future research should be conducted on the effectiveness, both in terms of cost and accuracy, on determining kudzu's location with hyperspectral data. This could include helping to

determine kudzu's specific spectral signature (allowing for easier future detections) and looking for more cost-effective and accessible methods of detection.

III. Management

More research is needed regarding best management strategies for kudzu in Michigan. The development of best management practices for kudzu prevention and management will help natural resource managers control current kudzu populations and prevent the spread of the species. More research on the combination of management practices that are most effective in northern climates would also be helpful. In addition, future research based on the willingness of stakeholders to pay for best management practices as well as their perceptions of kudzu would be needed. This research would be accompanied by providing said stakeholders with information on the negative impacts and costs that result from lack of management. Estimating future costs could act as an incentive to bring awareness to kudzu and limit its expansion (Harron et al., 2020).

Future Directions for Michigan and Management

Various climate change models have predicted kudzu will move further northward into regions where it was not previously capable of inhabiting (Lindgren et al., 2013). As kudzu's range expands northward, it poses increasing risks to Michigan's native ecosystems. Kudzu has been documented in Indiana, Illinois, Ohio, and Ontario (EDDmaps, 2023). The close proximity poses a significant threat of accidental introductions of kudzu into Michigan. With the most influential factor in transplantation being anthropogenic intentional planting of either adult plants or propagation of portions of the stem can result in the establishment of new populations (Lindgren et al., 2013). The greatest concern is that new propagations of the plant will spread from neighboring populations into the state. It is therefore imperative to prevent the movement and sale of kudzu in Michigan, particularly as sexual reproduction is currently found to be extremely limited. Establishing a coalition among Michigan, surrounding states and Canada to enforce strict regulations on the sale and movement of kudzu would also help limit spread. Cooperative Invasive Species Management Areas (CISMAS) can play an important role in promoting collaborative management within Michigan as well as between states and other nations including tribal nations. Additionally, early detection, rapid response, monitoring, and education efforts would increase management successes by catching new invasions early. It is important to note that the cost-effectiveness of kudzu management is restricted to small populations, as large monocultures become increasingly more costly and more labor-intensive to manage. Thus, it is vital that the status of kudzu remains limited, or ideally is eradicated completely, in Michigan.

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