W 1924-A

THE INTRODUCTION, SPREAD, AND CONTROL OF NON-NATIVE, INVASIVE SPECIES IN TENNESSEE FORESTS

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An abandoned woods trail containing several invasive species: autumn olive, kudzu, and Japanese stiltgrass (Credit: Wayne Clatterbuck, University of Tennessee).

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The introduction to the following peer-reviewed article originally was written by a natural resource college student to express her concern to the University of Tennessee community about the excessive presence and expansion of non-native species on campus, greenways, parks, neighborhoods, and forested areas in the Knoxville vicinity, often supplanting or displacing the native vegetation. We have expanded the article to include descriptions and control measures of common non-native species, about which UT Extension receives many inquiries. The fact sheets in this publication provide background information about troublesome invasive plants that occur in Tennessee forests: kudzu, tree-of-heaven, callery pear, Japanese stiltgrass (Microstegium), honeysuckles, princess tree (Paulownia), Chinese privet, Chinese silvergrass (Miscanthus), and autumn olive. Weblinks are provided from various universities and organizations with supplemental information that are peer-reviewed.

Kudzu. Most Americans have heard of it. But what do people really know about it? It is everywhere, and it is dreadful. Some may even recognize it as "the vine that ate the South." Why is that?

Kudzu's story starts with its introduction into the United States from Japan in the late 1800s as an ornamental, but it was not until the 1930s that its presence truly exploded as the U.S. Soil Conservation Service utilized kudzu in an initiative to control soil erosion. Little did they know they were introducing (and spreading) a species that would threaten southern forests for decades as one of the leading risks to the natural environment.

Kudzu is a non-native, invasive species, meaning that it has spread out of control with limited or no predation and competes with or displaces native species. Its rapid growth (sometimes a foot a day) allows kudzu to climb its native neighbors, covering them in a thick layer of foliage to intercept much of the available sunlight. Blocked from their natural source of energy, these native species die as they are unable to photosynthesize. Kudzu will also uproot many plants as well.

The University of Tennessee, Knoxville, campushas recognized the presence of kudzu in its midst. In 2019, an arborist at the University started a program of treating the kudzu on campus. He introduced goats to an acre of kudzu-infested land to eat the kudzu back so the subsequent resprouts could be sprayed with herbicide to kill the roots. The initiative was a success. The goats did their job, and the University is constructing a plan to spray the area. However, kudzu is not the only problem. What about the numerous other non-native invasives that are abundant?

The temperate environment in Tennessee is a haven for not just kudzu but a wide variety of non-native, invasive species such as Bradford/callery pear, Chinese silvergrass, privet, tree-of-heaven, Chinese parasol, Japanese barberry, mimosa, and nandina. Many of these plants were planted on the UT Knoxville campus not knowing their invasive properties, even though many instructors promote use of native species. Of the 5,000 non-native plant species that have been introduced and established in the United States, 10 percent of those have become invasive and cost the nation billions of dollars in annual damages for their detection, management, prevention, restoration, and research (Kerns and Guo 2012).

Chris Graves, a senior lecturer at the UT School of Natural Resources and a certified wildlife biologist was recently asked to give a presentation on non-native species present on the Knoxville campus to the University Undergraduate Student Senate. Graves did not take this task lightly as an advocate for native plant communities. Into a room full of formal business-wear, Graves carried a garbage bag of more than 20 different non-native and invasive plant species that he collected from around campus, which he then identified. “Santa Claus is outraged,” he said as he identified and emptied his not-so-jolly sack of leaves and branches. “As a faculty member, I’m embarrassed,” Graves said. There are plenty of native species available for planting in nurseries and greenhouses around Knoxville. Graves tells a story about little bluestem grass being sold at a Walmart and how he was so excited to see a native prairie grass being sold in a popular superstore. He proceeded to purchase their entire bluestem supply. The availability of non-native plants for purchase results in their continued use. The logic is that if a plant is available for purchase, it must be OK to plant. Unfortunately, that is not true with many non-native plants.

Graves urges that the non-native plant issues should be addressed collectively by students, faculty, staff, and everyone in-between on the Knoxville campus. A plan of action should be formulated and a cumulative “naughty list” of non-native plants composed. Then a control and/or eradication program of non-native, invasive vegetation can be implemented and replaced with native alternatives. The kudzu-goat initiative is a step in the right direction for kudzu control. While kudzu is the poster plant of invasive, non-native species, there are many more begging for attention.

CONTROL A LITTLE NOW OR CONTROL A BUNCH LATER

Most invasives that have become issues in Tennessee and elsewhere are “generalist” plants that are able to adapt to a variety of environments and habitats. They can reproduce prolifically, whether by seed or vegetatively (roots) or both, advancing their spread to nearby areas. One example is tree-of-heaven that begins to produce seed within three years after seed germination, but it also root sprouts profusely. Invasive plants should be controlled as soon as they appear or become colonies that are detected. Otherwise, their populations will continue to increase and escalate as suggested in Figure 1. Early detection and rapid response allow greater efficiency in controlling the plant. A low infestation level, invasives covering less than 30 percent of the area, has a high probability of success for invasive control with less costs and shorter periods for suppression.

Once invasives reproduce, multiply, and spread, their abundance accelerates. A medium level of infestation, 30 to 60 percent of the area occupied by the undesirable invasives is achieved. The invasives are not yet inundating the area, but control measures are much more difficult, costly, and time consuming. This medium stage is where invasive control has become a management priority (Figure 1).

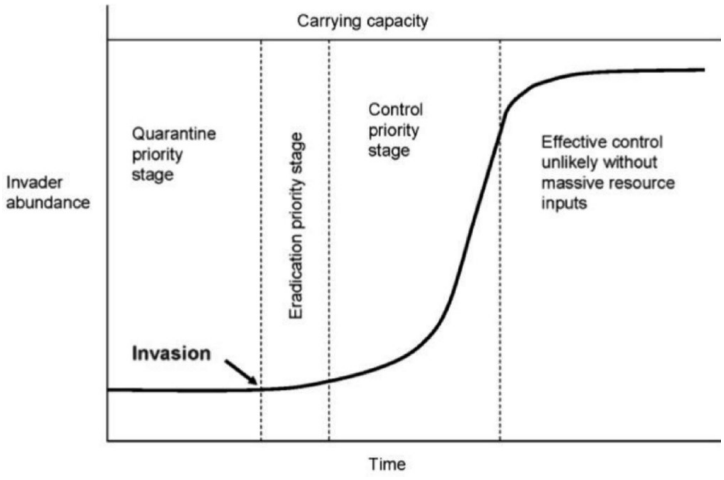

Figure 1. *Control costs versus time since exotic invasion. (Redrawn from Hobbs and Humphries 1995 by Moser et al. 2009)*

Root sprouts extend the spread of the plant and should be controlled (Credit: Wayne Clatterbuck, University of Tennessee).

A high infestation level is when the invasives occupy greater than 60 percent of the area andare dominating and out of control. Effective invasive control is unlikely without massive resources. Several treatments over consecutive years will be necessary to reduce the invasive impact. These areas will require the longest control time and greatest costs and labor.

Controlling invasives and their spread is a process usually involving repeated treatments over time. Most perennial invasive control requires that the roots be killed so the plant does not resprout. Herbicides must be translocated to the roots to suspend metabolic processes resulting in killing the roots. However, many roots are rhizomes or starchy tubers with abundant energy reserves that necessitate repeated applications to deplete those energy reserves and kill the root. Usually, control of invasive plants is a process of several years and not an event where one application is completely effective.

USE OF HERBICIDES

Glyphosate and triclopyr are herbicides that are frequently recommended in this publication for invasive control because they have little soil activity. Other herbicides may be equally effective and should be considered as options for use. Below are a few of the salient features that suggest the safe use of glyphosate and triclopyr by landowners and managers. The herbicides are readily available at supply stores under various tradenames.

Glyphosate

- No soil activity and will not injure desirable plants via root uptake; glyphosate is rapidly deactivated and biodegradable in the soil by micro-organisms.
- Broad spectrum, non-selective herbicide that is absorbed by plant leaves and is systemic (translocated) within the plant.
- Low health and environmental risks. For safety reasons, applicators should wear personal protection equipment (PPE). For more information about possible threats associated with glyphosate, see UT Extension Publication W827 Frequently Asked Questions: Glyphosate.
- The most significant environmental impact from use of glyphosate is the exposure of ground surfaces that are susceptible to soil erosion from killing the invasive plants.

Triclopyr

- Systemic herbicide in two formulations, water-based amine (foliage, hack and squirt) and oil-based ester (basal spray).
- Does not kill grasses or sedges, thus unlikely to result in surface soil exposure.
- Interferes with normal expansion and division of plant cells, resulting in distorted growth such as cupped leaves, twisted stems, and plugged vascular tissues.
- Does not move in the soil.
- More effective than glyphosate on some plants such as black locust. Read the herbicide label for susceptible plants. Applicators should wear PPE.

REFERENCES

Kerns, B., Guo, Q. (September 2012). Climate Change and Invasive Plants in Forests and Rangelands. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. www.fs.usda.gov/ccrc/topics/invasive-plants.

Hobbs, R.J. and S.E. Humphries. 1995. An integrated approach to the ecology and management of plant invasions. Conservation Biology 9:761-770.

Moser, W.K., Barnard, E.L., Billings, R.F., Crocker, S.J., Dix, M.E., Gray, A.N., Ice, G.G., Kim, M., Reid, R., Rodman, S.U., McWilliams, W.H. 2009. Impacts on nonnative invasive species on US forests and recommendations for policy and management. Journal of Forestry 107(6): 320-327.

For a comprehensive guide on non-native and invasive species in southeastern United States forests, consult the reference and weblink below.

Miller, J.H., Manning, S.T., and Enloe, S.F. 2010. A management guide for invasive plants in southern forests. General Technical Report SRS-131. Asheville, NC: U.S, Department of Agriculture, Forest Service, Southern Research Station. 120 p. https://www.srs.fs.usda.gov/pubs/gtr/gtr_srs131.pdf.

DISCLAIMER STATEMENT

This publication contains herbicide recommendations that are subject to change at any time. The recommendations in the publication are provided only as a guide. It is always the herbicide applicator's responsibility, by law, to read and follow all current label directions for the specific herbicide being used. The label always takes precedence over the recommendations in this publication.

The use of trade or brand names in this publication is for clarity and information, it does not imply approval of the product to the exclusion of others that may be of similar, suitable composition, nor does it guarantee or warrant the standard of the product. The authors, the University of Tennessee Institute of Agriculture and University of Tennessee Extension assume no liability resulting from the use of these recommendations.

Margin of a forest and field on University of Tennessee property near the Knoxville campus that contains at least seven invasive, non-native species: tree of heaven, multi-flora rose, Chinese privet, Japanese stiltgrass, Beale's barberry, honeysuckles, and autumn olive. These invasive plants compose more than 60 percent of the vegetation. Control of these non-natives will take considerable time and effort with repeated herbicide applications for several years (Credit: Wayne Clatterbuck, University of Tennessee).

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W 1924-B

The Introduction, Spread, and Control of Non-Native, Invasive Species in Tennessee Forests: Kudzu

Wayne Clatterbuck, Forestry Professor, School of Natural Resources

KUDZU *(PUERARIA MONTANA)*

Kudzu is a perennial, leguminous vine that was introduced to the United States from eastern Asia for use as an ornamental, forage for livestock and for erosion control. The vine is invasive, grows rapidly, and is frequently found on trees, shrubs, utility poles, fences, and buildings. Kudzu can damage or kill most of the vegetation where it resides. The plant is difficult to control, spreading from seed, vines, and root sprouts. The large tuberous root system, which is much like a potato with large starch reserves, fuels the growth of the vines.

Vines grow from buds on a root crown at the soil surface. As the vines spread, rooting occurs from buds at each node on the vine. With vine growth of up to 50 feet per growing season, a single plant can spread to cover large areas each year. Roots developing from the vine nodes usually enlarge into root crowns from which additional vines will arise. Mature stands of kudzu may have root crowns every 1 to 2 square feet.

Although some literature refers to kudzu as a climbing vine, the vine is not actually able to climb on its own accord. Kudzu is a semi-woody vine that cannot support its own weight and it does not have tendrils for climbing such as English ivy or grape vine. Kudzu vines grow into tree crowns by wrapping around successively growing small limbs or on smaller vegetation underneath tree crowns and then reaching 3 to 5 feet above for another source of support. Without tendrils and woody support, kudzu is not able to wrap itself around large diameter stems. Thus, the vine grows into tree crowns by wrapping around small, successive limbs or wrapping around smaller adjacent vegetation and reaching into tree crowns.

Kudzu climbing on a road sign.
Photo Credit: Wayne Clatterbuck

Most of the kudzu present in Tennessee is spread from runner vines of established plants. Although the seed is a hard-coated legume that remains viable for several years and can colonize uninhabited areas, most of the kudzu spread is by vines and the resulting root crowns. Many kudzu infestations originate from old, well-established rootstocks at field edges. Annual cultivation once kept vines from spreading into adjacent areas.

Kudzu was originally planted for erosion control, but it was not particularly effective. The tuberous root system is not exceptionally fibrous. Soil will continue to erode by overland flow underneath the mat of vines during summer and winter. The mat of vines and deciduous leaves will hinder raindrop erosion during the summer.

Roots (tubers) of established crowns can reach several inches in diameter and may grow to depths of three feet. The tubers do not sprout, but the high starch content of the roots supports early spring growth and vigorous regrowth if vines are damaged by mowing or grazing.

Kudzu displacing resident vegetation.
Photo Credit: Wayne Clatterbuck

The starch-rich roots make control difficult because this stored root reserve supports regrowth. Considering the new root growth from expanding nodes and the fleshy tubers, several years of repeated treatments are necessary to deplete the root reserves and to completely control kudzu. The above-ground vines are usually top-killed the first year. Resprouting vines and root crowns should be treated in successive years for eventual control.

With a large tuberous root system and aggressive growth habit, control of kudzu requires persistent treatment. Several strategies can be employed to control kudzu: herbicides, prescribed burning, mowing and livestock grazing. When selecting a control strategy, consider constraints that may prevent broadcast or cut vine treatments of herbicides, use of tractors to spray or mow, proper burning procedures and times, and presence of desirable vegetation. Thick mats of kudzu can hide ditches, gullies, logs, wells, and other hazards. Be careful and plan accordingly!

Mowing --- Repeated mowing can weaken and ultimately control kudzu. Mowing is a good first step toward control, provided it can be done without risk to the operator and equipment. Close mowing reduces the above-ground biomass and makes treatment of regrowth much easier. Without adequate photosynthetic area to support the root system, the roots begin to decline with time. Thick mats of vines are often difficult to mow with light, rotary mowers. Flail mowers with horizontal blades cutting in a chopping motion sever vines close to the ground more effectively.

Burning --- Prescribed fire does not control kudzu, but it can be used to consume vines and leaves to permit inspection of the site and to determine the size and density of the kudzu root crowns. Burning should be done in late winter and early spring to limit the exposure of bare soil to winter rains, thus minimizing soil erosion on steeper areas. Prescribed burning promotes kudzu seed germination. Burning is usually conducted in conjunction with other control treatments. Repeated or annual burns are difficult to sustain because of the lack of fuel to carry the fire.

Grazing --- Kudzu can be used as a forage for cattle, goats, and other livestock. Other sufficient grazing areas are needed to rotate livestock as the kudzu is grazed down. Only by repeated grazing of the regrowth over successive growing seasons will the root reserves of starch be depleted.

Herbicides --- Several herbicides are labeled for kudzu control. Their use requires careful site evaluation and prescription according to the information contained on the herbicide label. Herbicides can be used in combination with other treatments, such as prescribed fire, mowing, or grazing which reduce the amount of vegetation and allow easier application of the herbicide to the weakened plants. A few herbicides for kudzu control are glyphosate, trichlopyr, clopyralid, aminopyralid, and metsulfuron. Follow label instructions. These herbicides are foliar sprayed with a nonionic surfactant to encourage wetting and penetration.

Kudzu control programs require commitment to annual follow-up treatments for at least three growing seasons. The older the kudzu, the more difficult the control and the more follow-up treatments required to deplete the starch reserves of the root system.

FURTHER REFERENCE WEB-LINKS

For Residential Areas from Alabama Cooperative Extension System
https://www.aces.edu/blog/topics/forestry-wildlife/kudzu-control-in-residential-areas/

For Forests from Alabama Cooperative Extension System
https://www.aces.edu/blog/topics/forestry-wildlife/kudzu-control-in-forests-rights-of-way-natural-areas/

From Mississippi State Extension
http://extension.msstate.edu/sites/default/files/publications/publications/p3187.pdf

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W 1924-C

The Introduction, Spread, and Control of Non-Native, Invasive Species in Tennessee Forests: Princess Tree

Wayne Clatterbuck, Forestry Professor, School of Natural Resources

PRINCESS TREE *(PAULOWNIA* SPP*)*

Paulownia, composed of several different species, was introduced to the United States from eastern Asia in the early 1800s. The tree was planted as an ornamental because of its large, showy, pale violet flowers and more recently in plantations for its wood properties primarily for export to Asian markets. The wood is highly desired for its strength and workability with its low density and weight. Paulownia has become naturalized on the landscape and is distinctive with its large, heart-shaped leaves, upright panicles of conspicuous flowers, and numerous seed capsules that persist on the tree throughout the winter. Each capsule contains a thousand or more small, wind-blown seeds. One mature tree can produce millions of seeds each year. Paulownia begins to flower and produce seed after five to seven years.

With its excessive seed production, Paulownia is certainly invasive, but its invasiveness is not as extensive as reported. The small, wind-blown seeds do not germinate and survive unless they fall on sterile soil, which is soil without microbes, pathogens, or living organisms. New germinants of Paulownia have a high rate of mortality from damping-off disease caused by a variety of soil fungi. Paulownia with its prolific seed does not colonize open areas unless sterile soil is present as in construction activities, road cuts, or burned areas where excessive temperatures have eliminated the soil fungi.

Paulownia does not compete well with other trees because it does not maintain a terminal leader with apical dominance. The tree crown typically spreads more horizontally rather than maintaining vertical terminal growth.

Leaves and seed capsules of Paulownia. Photo Credit: James R. Allison, Georgia Dept. of Natural Resources, Bugwood.com

Considering the slower terminal growth and requiring full sunlight for continued development, Paulownia is often overtopped by other species and gradually succumbs. Paulownia is usually found on the forest edge where sunlight is more available than in the forest interior.

Paulownia sprouts profusely when the stem is killed. With its large leaves, Paulownia is extremely susceptible to late season frosts after the leaves have emerged, often top killing the tree. The root system will resprout with several stems. If trying to control and kill the tree, herbicides should be applied that are translocated to the roots impacting resprouts and eventually killing the plant. Typically, Paulownia does not form groves of trees.

For control of large trees, stem injections of glyphosate, triclopyr, or imazapyr can be applied via stem injection on cut stem spacings specified on the herbicide label. For felled trees, apply these herbicides via cut stump treatments as soon as possible after the cut.

Pale purple flowers of Paulownia Photo Credit: James R. Allison Georgia Dept. of Natural Resources, Bugwood.com

Sprout clump of Paulownia (Princess Tree) Photo Credit: Pennsylvania Department of Conservation & Natural Resources – Forestry, Bugwood.org

For saplings, apply triclopyr ester as a basal spray encircling the stem. For resprouts and seedlings, use a foliar spray of glyphosate or triclopyr (amine). Follow label instructions for herbicide application.

Although Paulownia can be invasive with its excessive seed production, the degree of invasiveness of Paulownia is open to conjecture. Due to the strict sunlight and soil requirements of the tree, the amount of Paulownia colonization has diminished in recent years.

Unless occurring as an open-grown tree, the longevity of Paulownia is short because other trees outgrow and overtop the tree in forested settings. Even with increased rates of land disturbances, the amount of Paulownia colonization has not been augmented unless the exposed soil is sterile without soil fungi. Paulownia typically does not colonize abandoned fields.

FURTHER REFERENCE WEBLINK

Southeast Exotic Pest Plant Council
https://www.se-eppc.org/manual/princess.html

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The Introduction, Spread, and Control of Non-Native, Invasive Species in Tennessee Forests: Japanese Stiltgrass

Wayne Clatterbuck, Forestry Professor, School of Natural Resources

JAPANESE STILTGRASS
(MICROSTEGIUM VIMINEUM)

Japanese stiltgrass, also known as Nepalese browntop, Mary's grass, basketgrass, and Japanese grass, arrived in the United States from Asia as a dried packing material in the early 1900s. The seeds from the packing material escaped and have spread into most states east of the Mississippi River. Stiltgrass is an annual, shade tolerant grass that inhabits, reproduces, and spreads in moist, disturbed areas. Seed spread is facilitated by water, animals, fill dirt, contaminated hay, and other human influences usually associated with road construction. The grass is adapted to shady, riparian areas and along woodland roads, openings, and the edges. Once established, the grass can spread to adjacent, undisturbed areas. Stiltgrass will respond vigorously to increased sunlight once established. The grass grows up to three feet tall and forms a thick mat that folds over to the ground once it dies in the fall. The dead grass mat suffocates ground vegetation, covering stiltgrass seed for germination the following spring, preventing additional seed colonization of other vegetation, and thus displacing and replacing resident vegetation.

Japanese stiltgrass frequently occurs on roadsides and margins of fields and woodlands in partial light conditions
Photo Credit: Richard Gardner, Bugwood.org

Stiltgrass spreads primarily by seed since it is an annual grass. The grass can produce up to 1,000 seeds per plant annually and the seed remains viable in the soil for five or more years. Controlling flowering and eventually seed production is the best method to prevent the spread of stiltgrass. Hand pulling, mowing, or use of herbicide before flower and seed formation in September and October are recommended. If mowing or hand pulling is conducted too early, the grass will generate new flowers and produce seed.

Even with control of the plant before flowering, the viable seed already present on the ground will continue to germinate for several years and will require annual treatments for control of the grass.

Most selective grass herbicides such as clethodim, sethydoxin, and fluazifop-p will control Japanese stiltgrass if applied before flowering and seeding and will not influence broadleaf ground vegetation. Non-selective grass herbicide such as glyphosate is effective in control but will also impact other vegetation. Glyphosate should only be applied when stiltgrass provides a solid cover over the ground vegetation. Pre-emergent herbicides (oryzalin and dithiopyr) are effective when applied during winter to early spring before seed germination. Successive annual applications of herbicide are necessary to control viable seeds residing in the soil. Refer to the University of Wisconsin Extension weblink below to evaluate herbicide application choices.

The best method of stiltgrass control is to impede seed production to prevent its spread. Germination of viable stiltgrass seed that is already present in the soil should continue annually with herbicides until the seed supply is depleted.

Infestation of Japanese stiltgrass.
Photo Credit: Richard Gardner, Bugwood.org

Folding of Japanese stiltgrass after the growing season in a planted reforestation area. (Inset) Japanese stiltgrass folded over planted seedlings. Photo Credit: Christopher Oswlat

FURTHER REFERENCE WEBLINK

University of Wisconsin Extension
https://cdn.shopify.com/s/files/1/0145/8808/4272/files/A3924-27.pdf

Missouri Dept. of Conservation
https://mdc.mo.gov/sites/default/files/2020-05/JapaneseStiltgrass.pdf

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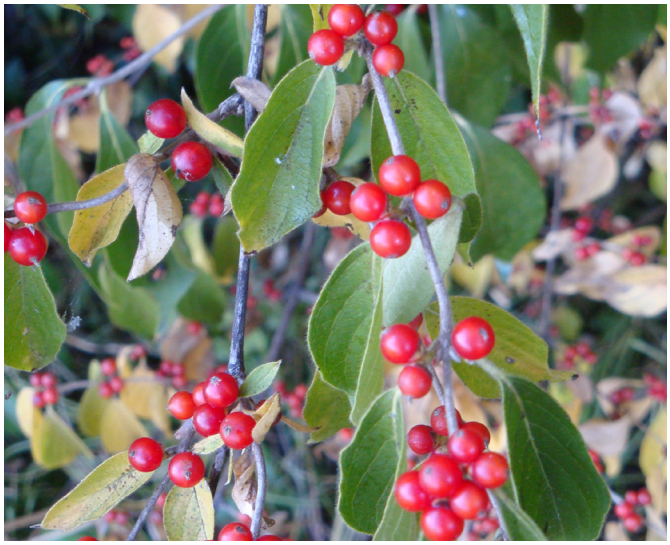
The Introduction, Spread, and Control of Non-Native, Invasive Species in Tennessee Forests: Bush Honeysuckle and Japanese Honeysuckle

Wayne Clatterbuck, Forestry Professor, School of Natural Resources



Fruit of bush honeysuckle. Photo Credit: Wayne Clatterbuck

Flowers of Japanese honeysuckle. Photo Credit: Rich Gardner, Bugwood.org

BUSH HONEYSUCKLE *(LONICERA MAACKII)* **JAPANESE HONEYSUCKLE** *(LONICERA JAPONICA)*

Both species of honeysuckle are highly invasive. Bush honeysuckle is a woody, erect, semi-evergreen shrub that can grow more than 10 feet tall. Japanese honeysuckle is a twining vine that retains its foliage into the winter. The primary source of spread is by birds that consume the fruit (drupe) and distribute the seeds. Bush honeysuckle has red drupes when mature while drupes of Japanese honeysuckle are black. Prescribed burning is often used to suppress the above-ground portion of the plants, but the roots readily resprout as well as runners from Japanese honeysuckle vines that can root at leaf nodes. Follow-up foliar herbicide treatments after burning are necessary to control plant sprouts with herbicide translocation to the roots.

Honeysuckles were imported from Asia in the mid-1800s for erosion control, wildlife food and cover, sweet-smelling flowers, and ornamental plantings. They usually occur in riparian and other moist areas growing in clumps, limiting sunlight penetration. Being allelopathic, honeysuckles inhibit native vegetation. Honeysuckles are mid- to shade-tolerant prospering in transitional areas and communities such as margins of roads, fencerows, rights-of-way, abandoned fields and pastures, woodlands, glades and prairies, and greenways that are not attended.

Controlling honeysuckles requires vigilance because of the vigorous spread of seeds and roots. Plants should be treated when populations are small before they escalate. Simple pulling, cutting, or mowing of plants can be effective if treatments are timed before seed maturity each year and repeated until root reserves are depleted. Non-selective foliar herbicides such as glyphosate and triclopyr (amine formulation) will control honeysuckles, but may also affect non-target, native ground vegetation.

Both honeysuckles retain their leaves remaining green during the fall and winter after most vegetation is dormant. Foliar herbicides should be applied in early spring or late fall before when leaves of other plants are not present and when temperatures are sufficient for honeysuckle to absorb and translocate the herbicide.

For stems of bush honeysuckle too tall for foliar sprays, basal spray of triclopyr (ester/oil) that completely encircles the stem to ensure herbicide penetration is recommended. Stems can also be cut, and stumps treated with glyphosate or triclopyr immediately after severing to control sprouting. Cut stump herbicide treatments can be conducted at most any time except during sap flow in the spring. The same process and herbicides can be applied to vines. For more specific information on control methods for bush and Japanese honeysuckle, refer to both weblinks below.

FURTHER REFERENCE WEBLINKS

University of Wisconsin Extension
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3830307.pdf Bush Honeysuckle

https://cdn.shopify.com/s/files/1/0145/8808/4272/files/A3924-10.pdf Japanese Honeysuckle

Fruit of Japanese honeysuckle. Photo Credit: Chris Evans, Univ. of Illinois, Bugwood.org

Honeysuckle infestation. Photo Credit: Chuck Bargeron, Univ. of Georgia, Bugwood.org

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The Introduction, Spread, and Control of Non-Native, Invasive Species in Tennessee Forests: Chinese Silvergrass

Wayne Clatterbuck, Forestry Professor, School of Natural Resources

CHINESE SILVERGRASS
(MISCANTHUS SINENSIS)

Chinese silvergrass, often referred to as Miscanthus, but also known as zebra grass and maidenhair grass, is a warm season, perennial, non-native bunch grass of several cultivars or varieties that is planted as an ornamental. This grass has escaped from plantings, forming dense infestations on disturbed sites along roadsides and forest margins. Miscanthus is highly flammable and a fire hazard.

The grass grows in dense, upright clumps that are three to six feet tall with blades up to one inch wide. The blades are green to variegated often with green-white horizontal stripes. The leaves have a white midrib, and the leaf tips are curved and sharp. The fan-shaped, terminal panicle seed head is 6 to 24 inches long. Preferred habitats are open areas with full sun and moist, but well-drained soils. Once established, the plant tolerates drought.

Chinese silvergrass in a wildlife opening.
Photo Credit: Lauren Quinn, Bugwood.org

Miscanthus reproduces primarily through rhizomes. Reproduction from seed is not as common as sprouting. Wind and animals disseminate seeds. The abundant sprouts from rhizomes allow the grass to form dense and extensive infestations.

Control of Chinese silvergrass is difficult. Mechanical control through manual removal, burning, or mowing should be conducted before seedheads mature and distribute seeds. Repeated mechanical control is required to deplete rhizome energy reserves. Even then, control is usually ineffective with the ability of the grass to regrow from the ever-present root fragments or rhizomes.

Glyphosate is the recommended chemical control of Chinese silvergrass. The herbicide should be applied when the grass is actively growing so the chemical is transferred to the roots. Unless the entire rhizome system is killed, regrowth will occur the next year. Thus, re-application is necessary several times to control the grass. Glyphosate is a non-selective herbicide and will impact other vegetation if contact with the herbicide occurs. However, the high density of most Miscanthus infestations permits minimal contact with associated vegetation.

FURTHER REFERENCE WEBLINK

Southeast Exotic Pest Plant Council https://www.se-eppc.org/manual/MISI.html

Global Invasive Species Database http://www.iucngisd.org/gisd/species.php?sc=1121

Terminal panicles or seed heads of Chinese silvergrass. Photo Credit: Arthur E. Miller, USDA APHIS PPG, Bugwood.org

Physical feature of stripes on the grass suggests the common of zebra grass. Photo Credit: Chris Evans, University of Illinois, Bugwood.org

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W 1924-G

The Introduction, Spread, and Control of Non-Native, Invasive Species in Tennessee Forests: Callery Pear

Wayne Clatterbuck, Forestry Professor, School of Natural Resources

CALLERY PEAR *(PYRUS CALLERYANA)*

Callery pear was introduced to the United States in the early 1900s for hybridization to develop disease resistance from fire blight that was infecting native pears in the commercial pear industry. Beginning in the 1950s, the "Bradford" cultivar of callery pear was widely planted as an ornamental due to its desirable uniformity and consistency in flowering and form. Individual cultivars are considered self-sterile and do not produce fruit or seed, but different cultivars that are planted near to each other can cross-pollinate and produce fruit. The popularity of planting Bradford pear over-compensated for the possibility of pollination from other pear cultivars. However, Bradford pear is a short-lived tree, prone to breakage. Other cultivars were developed to improve the poor properties of Bradford pear that increased the probability of cross-pollination and the production of fruit. Cultivars are often grafted on rootstocks with varying genetic dispositions.

Callery pear trees in an abandoned field. Some of the trees are flowering while others are green and have complete flowering. Photo Credit: Wayne K. Clatterbuck

Leaves and fruits of callery pear. Photo Credit: David Stephens, Bugwood.org

Rootstocks also sprout generously adding to greater genetic variability and thus fruiting ability. The shoots and the graft can even pollinate each other. The plants that spread are not cultivars, but sexually reproducing populations consisting of multiple genotypes that recombine every generation.

Cross-pollinated trees are loaded with fruit that is consumed by birds and transported great distances. Trees also reproduce vegetatively by sprouts often forming dense thickets within several years. The wide dispersal of callery pear seed is evident in the spring when trees flower in unmanaged areas such as abandoned fields and pastures, disturbed areas, and right of ways.

Callery pears are shade intolerant, grow to 40 feet tall and 25 feet wide, and have a vaselike shape. Wild trees often have sharp spines or thorns that can puncture tires when areas are mowed or bush hogged and injure workers who are applying management practices. Even though prescribed burning may top-kill some trees less than two inches in diameter, the copious sprouting of callery pear encourages vegetative spread. Larger diameter trees usually withstand burning.

Herbicides are required to kill the roots and control the spread of callery pear. Hand-pulling usually does not remove the entire root and remaining roots will sprout. Foliar, systemic herbicides such as glyphosate and triclopyr (amine) can be applied to leaves of actively growing, smaller trees (less than six feet tall) after full leaf out. Both herbicides are non-selective with little soil movement but will impact other vegetation if contact occurs. Reapplication annually may be necessary until the root system is depleted and does not resprout.

Basal spray with triclopyr (ester) is effective on stems less than four inches at ground-line. The application should encircle the entire stem or each individual sprout and be conducted any time of year except April and May when the tree sap is moving upward. Follow-up applications may be necessary if re-sprouting occurs.

For trees greater than four inches in diameter, hack and squirt treatments can be conducted. Downward hacks with a hatchet are made one inch apart on the stem and herbicide is applied with a squirt bottle to each hack. Follow herbicide label instructions. Either glyphosate or triclopyr (amine) is applied to a targeted stem such that there is little to no impact to the environment.

Cut stump treatments with triclopyr (amine) or glyphosate control resprouting from stumps and roots. The application should be conducted as soon as possible after the cut. An alternative, if application to cut stumps is not possible, is foliar herbicide coverage of resprouts at the end of the current growing season or during the next growing season.

Vigilant surveillance of callery pear is required because the seed is constantly being spread from adjacent areas. Control is most effective and less costly when trees are small, roots are diminutive, and sprouting is minimal. Removing isolated individuals or small patches of callery pear should be done before populations continue to multiply and become a nuisance. Since callery pear is very persistent with the ability to invade freely, a regular maintenance and control program of callery pear is recommended.

Thorns on branches of callery pear.
Photo Credit: Nancy Loewenstein, Auburn University, Bugwood.org

Flowers of callery pear.
Photo Credit: Nancy Lowenstein, Auburn University, Bugwood.org

FURTHER REFERENCE WEBLINK

Missouri Dept. of Conservation
https://mdc.mo.gov/trees-plants/invasive-plants/callery-pear-control#:~:text=Medium%20to%20large%20trees%20should,basal%20bark%20treatment%20and%20girdling.

Alabama Cooperative Extension System
https://www.aces.edu/wp-content/uploads/2020/08/FOR-2078_Callery-Pear081120L-A.pdf

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W 1924-H

The Introduction, Spread, and Control of Non-Native, Invasive Species in Tennessee Forests: Chinese Privet

Wayne Clatterbuck, Forestry Professor, School of Natural Resources

CHINESE PRIVET *(LIGUSTRUM SINENSE)*

Chinese Privet is one of several non-native and invasive privets that has spread proficiently in the United States south of a line from Kansas to New York. The species include border, California, European/common, Chinese, Japanese, and glossy privets. Although the habitat of each privet species varies slightly, the control procedures are the same. Privets are shade tolerant, deciduous or semi-evergreen, perennial shrubs that retain their foliage during the winter. They create dense thickets which reduce sunlight and moisture availability for native shrubs and ground vegetation, decreasing plant and animal diversity.

Privets spread primarily through seed distributed by birds that have consumed the fruit. Once established in an area, privet can regenerate from root and stump sprouts. Controlling privet involves killing the root system or by mowing or removing young plants before they become fruit/seed producers. Control methods for privet are similar to those for honeysuckles. Privet produces small, white flowers on terminal clusters in May and June with the fruit maturing in September and October. The fruit is a black drupe containing one to four seeds that remains on the plant during the winter.

Leaves and fruit of privet. Photo Credit: Wayne K. Clatterbuck.

Privet shrub with fruit. Photo Credit: Wayne K. Clatterbuck

Privet prospers in disturbed areas such as fence rows, fields, roadsides, rights-of-way, and other habitat edges that birds frequently visit. Without management, these edge habitats frequently form dense hedges from five to 12 feet tall, displacing resident vegetation. Privet is somewhat drought tolerant with the ability to withstand weather extremes.

Privet retains its leaves during the winter. The timing of foliar herbicide application is critical in controlling privet. A non-selective foliar herbicide such as glyphosate can be broadcast during the late winter or early spring to treat the privet without damage to other dormant vegetation. Otherwise, application of foliar herbicide at other times could impact non-target species, especially after initiation of new leaves.

Privet hedge on field edge and woodland.
Photo Credit: David J. Moorhead, Univ. of Georgia, Bugwood. org

Flowers of privet. Photo Credit:
Karan A. Rawlins, Univ. of Gerogia, Bugwood.org

For larger privet where foliar application is not possible, a basal bark spray with triclopyr (oil/ester) encircling the smaller diameter stems can be applied anytime except during the spring when the sap is rising in the plant. Cut stump treatments can be applied with either glyphosate or triclopyr directly after cutting. The goal is to translocate the herbicide to the roots to kill them. However, with the vigorous root sprouting associated with privet, additional herbicide treatments may be necessary until the roots succumb.

FURTHER REFERENCE WEBLINK

University of Tennessee Extension
https://extension.tennessee.edu/publications/Documents/W324.pdf

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W 1924-I

The Introduction, Spread, and Control of Non-Native, Invasive Species in Tennessee Forests: Autumn Olive

Wayne Clatterbuck, Forestry Professor, School of Natural Resources

AUTUMN OLIVE *(ELAEAGNUS UMBELLATA)*

This highly invasive shrub was introduced to form ornamental hedges, shelterbelts/windbreaks, and a source of food in wildlife openings. Unfortunately, autumn olive produces an abundance of fruit and seed (refer to photograph) that are consumed and transported by birds. The plant is a habitat generalist, occurring on open and transitional (edge) areas. It proliferates in most habitats, except wet areas and dense woods. Landscapes colonized or planted with autumn olive include old fields, pastures, grasslands, savannas, woodlands, roadsides, wildlife openings, and reclaimed strip mines. With its nitrogen-fixing root nodules, the species can adapt to poor soils and droughts once established. Autumn olive should not be planted because of its invasive and seeding abilities. An associated species, Russian olive (Elaeagnus augustifolia) is also invasive, commonly has thorns, occurs mostly in the central and western U.S. where it was planted, and has many of the same biological properties.

Autumn olive furits.
Photo Credit: Leslie J. Mehrhoff, Univ. of Connecticut, Bugwood.org

Autumn olive shrub.
Photo Credit: Chris Evans, Univ. of Illinois, Bugwood.org

Autumn olive begins to produce seeds at 3 years of age. It sprouts vigorously after burning or cutting and grows rapidly. Shrubs can grow to 18 feet tall, and the shade cast supplants ground vegetation. The foliage of autumn olive is distinctive with its silvery lower surface and green upper surface. The elliptical leaves are one to three inches long arranged alternately on the stem.

Control of autumn olive follows that of privet and bush honeysuckle. Hand-pulling, cutting or girdling stems before seed dispersal is effective, but the plant will resprout vigorously unless conducted in conjunction with herbicide application. Foliar application on stems < 6 feet tall with glyphosate or triclopyr (amine), both non-selective herbicides with little soil activity, are best on autumn olive thickets where risk is minimal to non-target plants.

For taller shrubs, basal sprays of triclopyr (ester) that completely encircle the stem should be applied anytime except during the spring when stems are beginning to bud. The dormant season is preferred for basal spray when foliage is absent. The cut stump method can also be used anytime except during sap flow in the spring with glyphosate or triclopyr (amine or ester). The goal with any of these methods is for the herbicide to be translocated to the roots, killing the roots, and thus, affecting re-sprouts. Foliar re-application may be necessary on resprouts to ensure that the energy reserves in the roots are depleted.

FURTHER REFERENCE WEBLINK

Pennsylvania State University Extension
https://extension.psu.edu/autumn-olive

Autumn olive on margin of a woodland.
Photo Credit: Chris Evans. Univ. of Illinois, Bugwood.org

Flowers of autumn olive.
Photo Credit: Nancy Loewenstein, Auburn University, Bugwood.org

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W 1924-J

The Introduction, Spread, and Control of Non-Native, Invasive Species in Tennessee Forests: Tree-of-Heaven

Wayne Clatterbuck, Forestry Professor, School of Natural Resources

TREE-OF-HEAVEN *(AILANTHUS ALTISSIMA)*

Tree-of-heaven is one of the more invasive, non-native tree species in Tennessee. The species is native to China and was introduced first to Europe and later to the eastern United States in the late 1700s. The Chinese also brought the species directly to the west coast of the United States during the mid-1800s.

The tree reproduces and spreads profusely from both seed and root sprouts. Most any disturbances that expose the soil invite the establishment of tree-of-heaven. Viable seeds are produced by 2- to 3-year plants and can be spread 300 feet from the parent tree by wind. Mature trees produce more than 300,000 seeds per year. The double whammy with tree-of-heaven reproduction is that the roots sprout profusely. Cut stump and root segments can sprout and grow more than 10 feet per year during the first year and continue this rate of growth for several years. The sprout growth then amplifies seed production within a few years. Tree-of-heaven is also allelopathic, producing chemicals that affect the establishment of other plants. The fast growth, prolific seeding and sprouting capability, and allelopathy of tree-of-heaven create dense, shade thickets at the expense of other vegetation.

Thicket of tree-of-heaven on a disturbed road bank spreading by seed and root sprouts. Photo Credit: Wayne K. Clatterbuck

Tree-of-heaven is a deciduous tree that can exceed 80 feet tall. The leaves are pinnately compound with 10 to 40 leaflets. The leaves are often mistaken for walnut, hickory, sumac, and ash, but can easily be distinguished by the two circular glands that occur on each lobe on the underside of each leaflet base which smells like rancid peanut butter. The leaflets of the other species are serrated (toothed), while tree-of-heaven leaflets are smooth except for the lobes where the glands are located on the lower margin. The species is dioecious with separate male and female trees. The seed clusters (samaras) occur on the female tree.

Root sprouts can emerge 30 to 50 feet from the nearest existing stem. Tree-of-heaven sprouts can grow 8 to 10 feet in height during the first year, often outgrowing and displacing native species. Seedlings can grow 3 to 6 feet per year. The species should be controlled as soon as it is found.

Mowing, burning, cutting trees, or pulling seedlings are ineffective control measures because of the profuse stump and root sprouting capacity of tree-of-heaven. The root system must be killed before the plant is controlled. The most effective control measure is to use herbicides applied to foliage, stems, or cut surfaces that translocate to the roots and eventually kill the root and the plant. The procedure and chemical used depends on the size of the plant. The good news is that most herbicides will control tree-of-heaven if the chemical is translocated to the roots.

For **large trees**, make stem injections (hack and squirt) and apply glyphosate, triclopyr or imazapyr to cut spacings as specified on the herbicide label (midsummer to midwinter is best). For felled trees, apply these herbicides to the stump surface immediately after cutting taking care not to drip herbicide on the ground. Avoid cut surface applications when the sap is rising prior to leaf emergence.

Tree-of-heaven seed cluster samaras that are wind disseminated. Photo Credit: Wayne Clatterbuck.

A spreading island of tree-of-heaven. Photo Credit: Wayne Clatterbuck.

For **saplings** (less than 4 inches in diameter), apply treatments of triclopyr in a commercially available basal oil with a penetrant to young bark near base of stem as a basal spray. The entire stem should be completely encircled with the application because the portion of the stem not in direct contact with the herbicide may continue to live. Application should be in late summer to early spring before leaves appear.

For **seedlings** and easy to reach saplings, thoroughly wet all leaves with one of the following herbicides in water with a surfactant (July to late September): glyphosate, triclopyr, or imazapyr. Follow herbicide label for foliage applications.

Remember to follow the label-specified herbicide amounts that are permissible to control the target species, i.e., tree-of-heaven. The herbicides mentioned in this article are those that have widespread and traditional use. Other herbicides can be used for tree-of-heaven control.

Well-established tree-of-heaven usually requires follow-up surveillance and further treatment of root sprouts and plant germinants that originate from the soil seed bank. Herbicide application at an early age before seed production or roots become more widespread is necessary. Treatments often only reduce the root system making follow-up applications necessary. Small portions of the original root system that survive after treatment can regrow quickly. Total control of tree-of-heaven requires repeated applications to deplete root reserves, patience, and diligence.

FURTHER REFERENCE WEBLINK

Plant Conservation Alliance (PCA) https://www.invasive.org/alien/fact/pdf/aial1.pdf

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