Invasive Plant Inventory and Management Report for White's Woods Nature Center, Indiana, Pennsylvania

Prepared by

Sara Kuebbing, Ph.D.
Marion Holmes, Ph.D.

FINAL REPORT

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Report Purpose

This report was commissioned by the Friends of White's Woods to understand the extent and potential impact of nonnative, invasive plants within White's Woods Nature Center. While developing this report, we conducted two vegetation surveys in May and August 2021. Our goal in writing this report is to provide the following information:

1) an inventory and map of populations of nonnative, invasive plants;
2) a summary of current scientific knowledge about the ecological, economic, or human health impacts on forested ecosystems for each species found in White's Woods;
3) a summary of best management practices for each species found in White's Woods;
4) a list of resources about detecting and managing nonnative, invasive plants.

This report provides a status assessment that can help inform the development of an invasive plant management plan for White's Woods but should not be considered a management plan on its own. Development of an invasive plant management plan should involve the following additional components: a) input from all relevant constituents and stakeholders for the property; b) identification of conservation, recreation, or other goals for the property; and c) budget of funding and labor available to implement various management options. We do not provide criteria for prioritizing management actions or objectives, but we do outline the benefits and risks of each possible management action.

Definition of Terms

We use define the following terms based on the USDA National Invasive Species Council.[1]

a) Ecosystem means the complex of a community of organisms and its environment.
b) Introduction means the intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity.
c) Invasive species means a nonnative species whose introduction does or is likely to cause economic or environmental harm or harm to human health.
d) Native Species means, with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.
e) Nonnative Species means, with respect to a particular ecosystem, any species including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.
f) Species means a group of organisms all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves, and show persistent differences from members of allied groups of organisms.

We also use the following terms and definitions to describe specific populations of nonnative, invasive plants found at White's Wood.

a) Encroaching means an invasive plant we detected on White's Woods property, but primarily found along the forest exterior around trailheads, roadsides, and margins of the forest.
b) Uncommon means an invasive plant species that was detected in the forest interior, but only scattered individuals or small populations in a single or few locations.

[1] National Invasive Species Council website: https://www.doi.gov/invasivespecies; President William Clinton's Executive Order 13112 on Invasive Species. Issued on February 3, 1999 and available online: https://www.doi.gov/sites/doi.gov/files/uploads/eo_13112.pdf.

c) Well-established means an invasive plant species that was found in the forest interior with multiple non-contiguous populations within the forest.

Site Description

White's Woods Nature Center is a 250-acre park owned and managed by the White Township. The property was purchased in 1968 through Pennsylvania's Project 70 Land Acquisition and Borrowing Act to protect the area for recreation, conservation, and history preservation.

Site history

Most of White's Woods was forested in 1938 (Map 1). The exception, an area that is now some of the youngest forest in the park, is a section of the ridgetop and south-facing slope in the Northern and Western section of the park (a). This area appeared to be old-field vegetation that grew following recent abandonment from agriculture, most likely pasturing. Erosion channels are visible on the soil surface in the westernmost area. The present forest includes a few trees with spreading, open-grown branching that indicates they grew in an open habitat. Several of these isolated trees are visible in the 1938 aerial photo within the old field matrix (b). This area is one of the flattest parts of White's Woods, and flat sites are often maintained in agriculture longer than steeper slopes and rocky areas. It is possible that other parts of White's Woods were used for agriculture in the past, but these sites would have been abandoned no later than the early 1900s.

Map 1: Aerial map of White's Woods from 1938.

The forests in 1938 were not uniform in age or history. Canopy texture in the central upland area indicated that forest here was comparatively young (c) and likely dates to the early 1900s. The Eastern slope (d) appears to have been fairly open, with individual trees visible. This suggests possible selective logging. The northeastern corner (e) appears to have been a shrubland or very young forest recruiting on previously cleared land that may have been used for agriculture. The only old forest in 1939 was the North-facing slope just outside the park (f). We can conclude, based on canopy texture, that all the forest stands in White's Woods have been cleared, at least partially, prior to 1938. Most clearance likely took place in the 1800s, most forest present in 1938 had regrown following prior cutting.

Forest Description

The forest communities at White's Woods are dominated by broadleaf deciduous species. The community is typical of forests in the Unglaciated Allegheny Plateau and contains sections that

resemble the Tuliptree-Beech-Maple, Red oak-Mixed hardwood, and Dry oak-Heath communities[2]. Oaks (*Quercus* spp.), maples (*Acer* spp.), and sweet birch (*Betula lenta*) are common. Other canopy species include hickories (*Carya* spp.), black gum (*Nyssa sylvatica*), and cucumber magnolia (*Magnolia acuminata*). The tree canopy composition varies by slope position: American beech (*Fagus grandifolia*) is most common on steep slopes and valleys while the ridgetop community—the driest, highest-elevation area—is dominated by oaks, especially black oak (*Q. velutina*) and chestnut oak (*Q. montana*).

Photo 1: goldenseal

Native Species of Interest

Native plant communities at White's Woods include a diverse assemblage of species (Appendix 1). A large population of state-threatened goldenseal (*Hydrastis canadensis*) is present (Photo 1). Species typical of older forests such as black cohosh (*Actaea racemosa*), maidenhair fern (*Adiantum pedatum*), and wild leeks (*Allium tricoccum*) are also common in parts of the forest.

Observed ecological threats to native vegetation

The forest floor plant community is the most biologically diverse part of eastern temperate forests with an estimated 80% of forest plant biodiversity occupying this forest layer. Protecting the integrity of the forest floor is critical for maintaining plant biodiversity at White's Woods. Both invasive plant species and overabundant white-tailed deer are present at White's Woods and pose two of the largest ecological threats to native flora in the region. Overabundant deer inhibit regeneration of canopy trees, browse native understory plants, and promote invasion by nonnative plants or clonal native species like hay-scented fern (*Dennstaedtia punctilobula*) and New York fern (*Thelypteris noveboracensis*).
. Evidence of heavy browse pressure can be observed in the sparse herbaceous layer in many parts of the forest (Photo 2), browse line on forest shrubs and small trees (absence of branches and leaves within reach of deer, Photo 3), and presence of large colonies of deer-resistant native plant species like hay-scented fern at White's Woods (Photo 4). We did not detect native plants that are favored by deer, including pink lady's slipper orchid (*Cypripedium acaule*) and trillium (*Trillium* spp.), suggesting that overbrowse by deer may have significantly reduced or extirpated populations of these plants previously found at the site. Removing widespread nonnative, invasive plants that can suppress native plant species or reducing the grazing pressure of overabundant deer can protect or increase native understory plants. However, reducing invasive plants or deer populations may not be sufficient to restore diverse understory flora if native soil seedbanks are depleted or native plant seeds cannot disperse back into the forest.

Photos 2, 3, and 4:

[2] Communities defined in *Terrestrial & Palustrine Plant Communities of Pennsylvania* by Jean Fike. Pennsylvania Natural Diversity Inventory, 1999. Available Online: https://www.naturalheritage.state.pa.us/fikebook.aspx.

Invasive Plant Inventory

We detected a total of 12 nonnative, invasive plants at White's Woods, including herbaceous forbs and grasses found in the forest understory and woody vines and shrubs common to the forest midstory (Table 1). These are all typical nonnative invasive plants within deciduous forests in Pennsylvania. Most of these species were uncommon within the forest interior with only a few scattered individuals present. Many species were congregated around the trailheads (12th Street and along Fulton Run Road near the transformers) and along the forest edge running along the powerlines (see Map 1). The three most common species found within the forest were garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergii*) and Japanese stiltgrass (*Microstegium vimineum*). Barberry was found in a few large patches within the forest while stiltgrass and garlic mustard were widespread (Map 2).

Table 1: Overview of nonnative plants deemed invasive by PA Department of Conservation and Natural Resources (DCNR) found in White's Woods in the spring and summer of 2021.

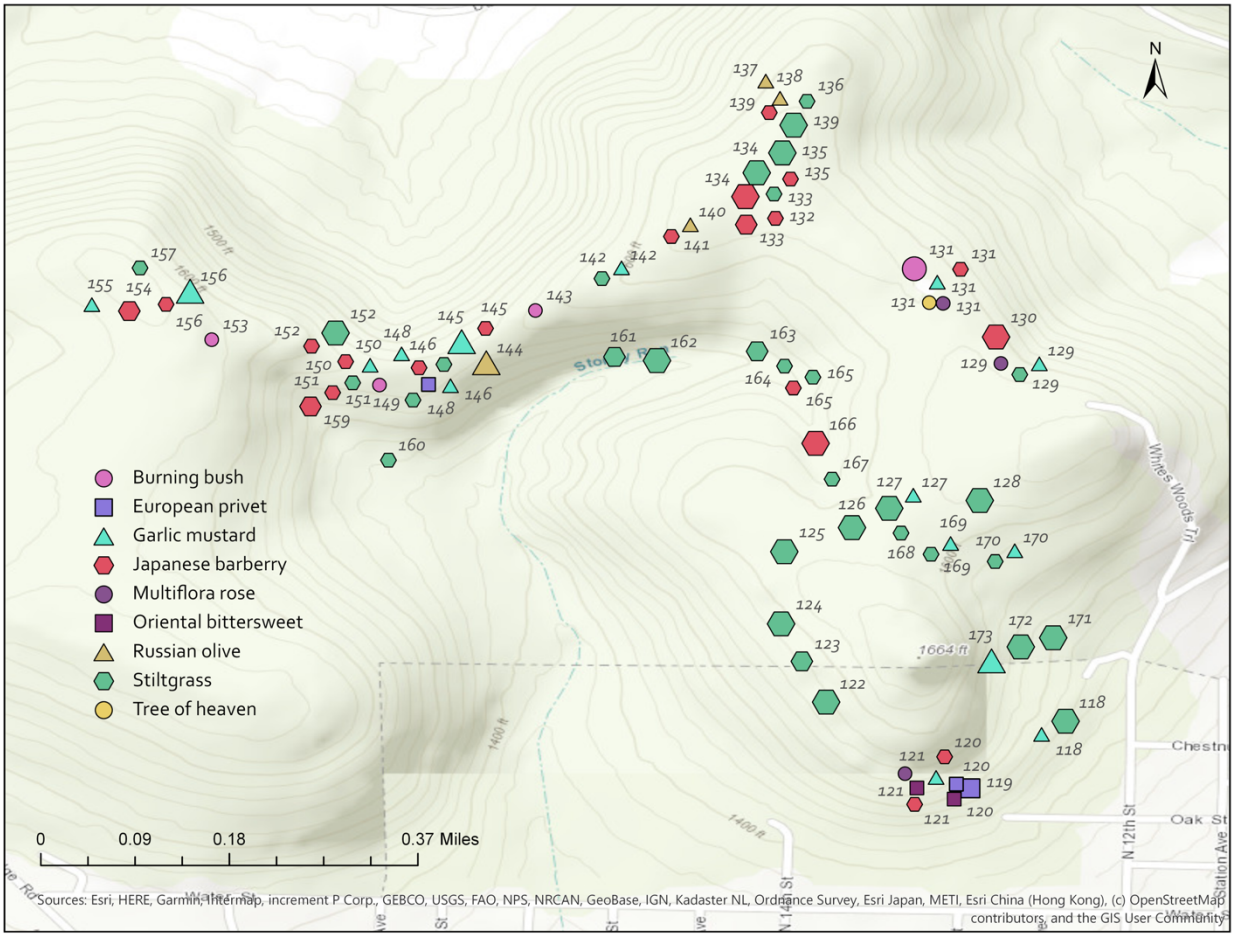
Common Name	Scientific Name	Plant form	DCNR Rank[3]	Site Status	Management options
Tree of heaven	*Ailanthus altissima*	tree	1	uncommon	Chemical
Garlic mustard	*Alliaria petiolata*	biennial forb	1	widespread	Mechanical, chemical
Japanese barberry	*Berberis thunbergii*	shrub	1	widespread	Mechanical, chemical
bittersweet	*Celastrus orbiculatus*	vine	1	uncommon	Mechanical, chemical
Autumn olive	*Elaeagnus umbellata*	shrub	2	uncommon	Mechanical, chemical
Burning bush	*Euonymus alatus*	shrub	2	uncommon	Mechanical, chemical
English privet	*Ligustrum vulgare*	shrub	2	uncommon	Mechanical, chemical
Japanese honeysuckle	*Lonicera japonica*	vine	1	uncommon	Chemical
Japanese stiltgrass	*Microstegium vimineum*	annual grass	1	widespread	*prevention of increasing infestations*
Jetbead	*Rhodotypos scandens*	shrub	1	Uncommon	Mechanical, chemical
Multi-flora rose	*Rosa multiflora*	shrub	1	uncommon	Mechanical, chemical
Common periwinkle	*Vinca minor*	vine	3	Uncommon	Chemical

[3] DCNR Rankings are from the PA DCNR Invasive Plant List that was created to guide management of DCNR lands. Rankings are as follows: Rank 1 – Severe Threat. Exotic [nonnative] plant species that possess characteristics of invasive species and spread easily into native plant communities and displace native vegetation. Includes species that are or could become widespread in Pennsylvania; Rank 2 – Significant Threat. Exotic [nonnative] plant species that possess characteristics of invasive species but are not presently considered to spread as easily and aggressively into native plant communities as those species listed as Rank 1; Rank 3 – Lesser Threat. Exotic [nonnative] plant species that spread in or near disturbed areas, and are not presently considered a major threat to undisturbed native plant communities

Map of Invasive Plants White's Woods Nature Center

We note the location of nine of the twelve invasive plants detected at White's Woods. The size of the point represents the density of the invasive population at that location ranging from a single plant (smallest points), to moderate infestations (medium points), to dense infestations (large points).

Map 2: Map of nonnative invasive plants found during surveys of White's Woods in the spring and summer of 2021.



Overview of Common Invasive Plant Management Practices

We summarize the most common invasive plant management techniques used in temperate forest deciduous ecosystems in the eastern United States. Broadly, these techniques fall into the following three categories: mechanical control, chemical control, and biological control. Most nonnative plants will respond to multiple control options. In the "Invasive Species Descriptions" sections below, we outline the current best management options for each species we detected at White's Woods. While the goal of invasive plant management is to reduce the spread and impact of nonnative invasive plants on natural systems, the tools and techniques for managing invasive plants can have unintended consequences. Unintended consequences can include soil disturbance or compaction that might facilitate the spread of further invaders ("secondary invasions"), negatively impact non-target native plant populations in the vicinity, or human health and safety risks such as the application of herbicides. Therefore, for each species' specific management options, we also provide possible unintended consequences that should also be considered when making decisions about what type (if any) management strategy should be undertaken at the site.

Mechanical Control

One of the most common forms of invasive plant management is the physical removal of invasive plants. This can be completed manually with non-mechanical tools like hands, shovels, saws, axes, or other digging and cutting implements or mechanically using tools such as mowing equipment, brush-cutters, or chainsaws. The method is generally most appropriate when the invasive plant population is small or you are treating scattered individuals throughout a site.

Advantages – Manual control methods require minimal training for safe use of equipment and the costs of equipment are low. Mechanical control methods will require increased training to safely use equipment, and for larger equipment may require certification or insurance. While mechanical control methods tend to have a larger need for more labor, many management programs have successfully overcome this hurdle by organizing volunteer workdays with community members and other users of the natural area. Importantly, volunteer workdays can build volunteers' appreciation for the natural area and sense of place. Mechanical control can be quite successful at reducing the size of existing invasive plant populations or eradicating populations with thorough long-term planning and commitment.

Disadvantages – The most common unintended consequence of most mechanical control methods is soil disturbance and/or compaction at the invaded site. Uprooting invasive plants, especially larger woody vines and shrubs, will lead to localized soil disturbance depending on the size of the root system. Use of any heavy equipment will likewise disturb and compact the soils in larger areas and could kill existing vegetation at the site. Disturbed soils and loss of native vegetation are likely to lead to reinvasion of the site, either by new nonnative plants that disperse into the site or reinfestation of the target invaders. Likewise, volunteer work crews can also trample native vegetation while on site, but typically the disturbance caused by human foot traffic is significantly less that soil and vegetation disturbance caused by heavy machinery. Volunteers can avoid trampling sensitive vegetation with proper training and oversight. Finally, invasive plant seeds can be easily dispersed into and out of a management site on large, heavy mechanical equipment or mowers. Soils stuck in tire treads or vegetation caught in mowers can be transported into and out of a management site quite easily.

Mitigation Measures – Well-trained volunteers and site supervisors can keep volunteers out of high-value areas, which can reduce vegetation trampling or soil compaction. Following species-

specific guidelines for properly disposing of harvested plant material and managing invasive plants when they are not actively setting seed or fruiting can reduce the change of unintentional spread of the plant. There are limited means to reduce the impacts of large mechanical equipment on vegetation and soils; however, requiring all motorized vehicles to clean their tire treads or mowers to remove all soil and vegetation can reduce the spread of seeds into a site (by cleaning before entering) or out of a site to a new location (by cleaning before exiting).

Chemical control

Chemical control methods are also quite common for invasive plant management, especially for larger infestations. This method can take the following forms: foliar application where herbicides is sprayed directly on green leaf tissue, basal bark application where herbicide is sprayed directly onto stem bark 12-18 inches from the ground (only for woody trees, shrubs or vines), cut-stump where herbicide is applied to a cut stem near the ground (typically for small trees and shrubs), or hack-and-squirt where herbicide is applied to large cuts made into the plant trunk (only for larger woody trees and shrubs).

Advantages – Chemical control is very effective at reducing or eradicating invasive plants when applied correctly and can reduce the number of years of follow-up treatment for woody invasive plant control. For example, cutting stumps can remove woody trees or shrubs, but most invasive plants will resprout from cut stumps if not treated after cutting and will require multiple years of treatment for effective control. Chemical control methods are typically used for larger infestations or when there is limited labor to achieve effective control mechanically.

Disadvantages – Adding chemicals to a forest can be unsafe for human applicators and other plants and wildlife if applied incorrectly. Some forms of herbicides can impact water quality or soil quality if incorrect forms are used at sites or mixed at the wrong concentrations. Foliar herbicide applications may have the greatest risk of negatively impacting non-target plant at a site because of herbicide drift. Herbicides can also have human health implications if applicators are not wearing proper safety equipment or improperly trained. The application of certain herbicides or in certain areas may be regulated by municipal or state guidelines. More information on pesticide regulation in Pennsylvania can be found here: https://extension.psu.edu/pesticide-laws-and-regulations.

Mitigation Measures – Many conservation and land management organizations safely use targeted chemical control to effectively manage populations of nonnative, invasive species. Groups like Penn State Extension have species' specific established guidelines for selecting the correct type of herbicide, the correct timing of herbicide application, and the correct application rates. Groups can mitigate environmental and human safety risks by following established guidelines for application, working with or hiring someone who is a registered herbicide applicator, and wearing proper safety equipment. A person with appropriate licensing and training should be involved in determining an herbicide treatment plant and always be present when applying herbicides.

Biological control

Biological control methods involve the introduction of predators, parasites, herbivores, or pathogens to attack an invasive plant species. Today, all biological control agents go through an exhaustive regulatory and research program overseen by the US Department of Agriculture (USDA). There are currently no USDA-approved biological control organisms for any of the invasive plant species found at White's Woods.

Invasive Species Descriptions

We provide brief descriptions of all nonnative, invasive plants detected during our surveys. We describe the species, provide a status overview of populations at the site, outline the known ecological economic, or human health impacts of the species, provide viable management options for the species based on our site surveys, and provide links to additional references on identifying and managing the species.

Ailanthus altissima (Tree-of-heaven)

Species description

Tree-of-heaven is deciduous tree that can grow up to 80 feet tall and 6 feet in diameter. The bark is light gray or brownish-green and smooth when young, turning slightly textured and lighter brown-grey as it ages. The leaves of the tree are pinnately compound, and a single leaf can range in size from 1-4 feet. Leaflets are dark green with smooth margins and have two glands at the base of each leaflet that emit a strong, foul odor when crushed. Mature female trees (the plant is dioecious) can produce thousands of wind-dispersed seeds (samaras) each year. Trees also spread through root suckering that can emerge as far as 50 feet from the parent plant. Typically, a single stand of tree-of-heaven stems are the same individual.

Photo 5: Tree-of-heaven seedling near Fulton Run Road trailhead.

Tree-of-heaven can grow in a wide variety of soils, including polluted mine spoils, compacted urban soils, or forest edges (Photo 5). It most quickly colonizes disturbed, high-light areas but can also be found in semi-shaded light conditions. It does not grow in dense shade, such as an intact forest canopy, but can quickly move into interior forests when canopy trees are removed and more light reaches the forest floor.

This plant is native to northeastern and central China and Taiwan. It was first introduced in the late 1700s to the Philadelphia, Pennsylvania area as an ornamental planting. It was initially an economically valuable plant, especially in urban areas where it was touted as a fast-growing ornamental shade tree that could withstand a wide range of soil conditions and poor air quality. However, its aggressive spread through root sprouting and foul-smelling leaves (described by some as “rotting peanut butter”) eventually decreased the popularity of the species as an ornamental tree. It is not sold ornamentally today. The first collected specimen of tree-of-heaven in Indiana County, PA was in 1901 east of Blairsville intersection (Carnegie Museum of Natural History Herbarium, Catalog # CM060564).

Status at White’s Woods

Tree-of-heaven is localized to a single location at White’s Woods (Map 2, Photo 5) near a trailhead entrance along Fulton Road Run, the power lines and the transformer station.

Impacts

Although tree-of-heaven is widely distributed in the eastern United States, it is less frequently viewed as an ecological threat to in-tact forest ecosystems because of its intolerance to dense shade and prevalence in disturbed soils and urban ecosystems.

Ecological – The most frequently cited ecological impact of tree-of-heaven is its potential to reduce the growth of other tree seedlings and plants through the production of several allelopathic compounds in the soil (Gómez-Aparicio and Canham 2008, Sladonja et al. 2015). Researchers have shown in field studies that red maple (*Acer rubrum*), sugar maple (*A. saccharum*), and red oak (*Quercus rubra*) seedlings were smaller and grew more slowly in tree-of-heaven stands relative to tree-of-heaven stands where soil allelopathic chemicals were neutralized (Gómez-Aparicio and Canham 2008). The dense, clonal growth of tree-of-heaven is also implicated in reduced plant diversity in invaded areas. However, because the plant is predominantly found in highly disturbed environments that also tend to have lower plant diversity the relationship between tree-of-heaven abundance and impacts on native plant diversity and abundance are not clear.

The recent introduction of a new nonnative, invasive insect pest—the spotted lanternfly (*Lycorma delicatula*)—has heighted ecologist and foresters concerns about the prevalence of tree-of-heaven in the landscape. Tree-of-heaven is a preferred host to the spotted lanternfly adults (Murman et al. 2020). Adults lay significantly more egg masses and juvenile spotted lanternfly survival and growth rates were higher on tree-of-heaven relative to other native trees (Uyi et al. 2021). Spotted lanternfly feeds on over 70 species of plants in North America, including economically valuable plants for the forestry (maple, oak, walnut, tulip trees), horticultural (willow, birch), and agricultural (apples, grapes, and stone fruits) industries, and can rapidly kills plants through its feeding behavior and secretion of sweet excrement that leads to damaging sooty mold infections on vegetation.

Economic – There has been no formal assessment of the economic costs or benefits of tree-of-heaven in the US. However, because tree-of-heaven serves as a preferred host of the spotted lanternfly, tree-of-heaven is implicated in the extreme economic losses surrounding spotted lanternfly infestations (Urban 2020). For example, vineyards infested with spotted lanternfly can lose up to 90% of their annual grape yield (Murman et al. 2020) and the economic values of vineyards and orchards is $915 million in US states with known lanternfly infestations. Because of the strong association between these two species, land managers are actively managing and targeting tree-of-heaven infestations to reduce population sizes of spotted lanternfly to protect a wide-range of economically valuable plant species (Urban 2020).

Human Health – Likely because of its prevalence in cities around the globe, tree-of-heaven has a range of potential impacts on human health. The tree's pollen is allergenic and can cause allergic responses and respiratory ailments. Sap from the trees can cause a body rash or dermatitis (Sladonja et al. 2015).

Management Options

Tree-of-heaven can be difficult to control because of its clonal nature, tendency to resprout from cut stems, and ease of developing root suckers. Small individual seedlings can be hand-pulled, but not small root suckers off a main plant. Managers report the most effective means for controlling tree-of-heaven is chemical herbicides. For any chemical applications, please see Penn State Extension resources for further details on the types of herbicides and recommended application rates. Management is most successful when treatments are timed correctly and applied over several years.

Chemical (foliar)– Penn State Extension recommends treating low growing trees with foliar chemical spray in late summer as the plant is shunting resources into its root system. Smaller tree-of-heaven stems at White's Woods could be treated with a foliar herbicide.

Chemical (basal bark or hack-and-squirt) – For larger individuals, direct herbicide application to the bark in the late summer is effective and controlling tree-of-heaven that is too tall to apply foliar herbicides. For individuals generally less than six inches in diameter, application

of herbicide 12-18 inches from the ground around the entire stem can girdle a plant. For individuals larger than six inches, “hack-and-squirt” application provides effective control. Using a hatchet, chemical applicators will cut into the bark tissue in regular intervals around the stem and apply herbicide to the cuts. As with foliar application, bark application is most effective when applied in late summer.

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Alliaria petiolata (garlic mustard)

Species description

Garlic mustard is a biennial, herbaceous forb in the mustard family (Brassicaceae). The plant spends its first year as a rosette of dark green, deeply toothed, kidney-bean shaped round leaves. The rosettes can overwinter, and second year plants begin growing new leaves in the early spring (March-April), bolt and flower in late spring (April-May). Second year plants have mature fruits by mid-summer (June-July). Leaves off the flowering stalk tend to be more triangular and have a strong garlic odor when crushed. Garlic mustard flowers are small, white with four petals and found at the top of the bolting stem. Fruits are produced in long, green, branching stems (called siliques) found along the upper half of the bolting stem and the siliques turn brown as the seeds ripen. Second year plants senesce quickly after flowering, but dead stalks can remain standing in the forest through the summer. Individual plants can produce hundreds of seeds that typically fall to the ground below the plant but can also be dispersed during management if dried stalks with seeds are pulled and shaken. Seeds are likely to remain viable in the soil upwards of five years, suggesting that management of established populations will require multiple years of control to exhaust the existing seed bank.

This plant is native to Europe and was thought to be introduced as a potted herb by early English colonists to North America. Young leaves are edible and are sometimes wild harvested. It was first documented in New York State in 1868 and has spread widely within forests and forest edges in the northeastern United States. The first collected specimen of garlic mustard in Indiana County, PA was in 2002 along Crooked Creek near the Thomas Covered Bridge (Carnegie Museum of Natural History Herbarium, Catalog # CM499875).

Status at White's Woods

Garlic mustard is well-established within the forest interior and exterior at White's Woods. We recorded 15 locations of garlic mustard, ranging from a few individuals to larger patches found along slopes adjacent to North 12th street and IUP property (Map 2).

Impacts

Garlic mustard is a well-studied forest invader with hundreds of scientific articles discussing the ecology of the species in its nonnative range.

Ecological – Garlic mustard is typically found in sites with lower plant species diversity, and there is some evidence that garlic mustard can reduce the growth and fitness of nearby forest herbs and woody seedlings through the excretion of an allelopathic secondary chemical compound (sinigrin, a glucosinolate) thorough its roots and decomposing leaf and stem tissue (Cipollini 2016). High levels of sinigrin in the soil are associated with reductions of beneficial mycorrhizal fungi populations, which in turn can reduce the growth of native tree seedlings and perennial herbaceous forbs that rely heavily on these mycorrhizal fungi (Rodgers 2008, Cipollini 2016). Changes to mycorrhizal fungi populations, as well as other soil microbial fauna, can also alter the decomposition rates of leaf litter in invaded forests (Rodgers 2008). Older garlic mustard populations appear to produce reduced amount of allelochemicals relative to younger garlic mustard populations, and some native herbaceous plants (clearweed, *Pilea pumila* and jewelweed, *Impatiens capensis*) have showed adaptive capacity and evolved resistance to the allelopathic impacts of garlic mustard. It is unknown whether other herbaceous species or woody plants have also evolved resistance (Cipollini 2016).

Garlic mustard can also impact food webs in forests. It has been implicated in the population decline of an insect herbivore (the West Virginia white butterfly, *Pieris virginiensis* and the mustard white butterfly, *Pieris napi oleracea*). Garlic mustard is an alternative host for eggs and caterpillars of these butterflies, which would typically use other native species in the mustard

family, but fewer eggs hatch on garlic mustard relative to the preferred native host species (Rodgers et al. 2008). Garlic mustard can increase the abundance of cobweb-building spiders in a forest, which colonize dead garlic mustard stalks for web building. The increased abundance of spider predators leads to decreased abundance of herbivore and parasitoid arthropod species and can increase soil phosphorus levels within garlic mustard patches, which may benefit some native plant species (Smith-Ramesh 2017).

Economic – There has been no formal assessment of the economic costs or benefits of garlic mustard. However, the reduction in tree seedling growth owing to allelopathic chemical production suggests that the plant could affect forest canopy tree regeneration with economic consequences for forests under commercial management.

Human Health – There are no associated human health impacts with garlic mustard.

Management Options

Because garlic mustard can form long-lasting seed banks (>5 years), management will generally require multiple years of treatments to treat germinating seeds from the seed bank.

Mechanical (hand pulling) – Garlic mustard is typically found in moist soils that allows for easy hand pulling of plants and roots. Stems, especially of second-year larger plants, can snap off at the base, leaving roots in the soil; however, because garlic mustard is not known to resprout from the tap root removing stems is an effective control. This method is most appropriate for small or sparsely scattered populations, like at White's Woods, because it has the lowest probability of impacting non-target plants or creating large soil disturbances. First-year plants (rosettes) can be pulled at any time of the year and are most obvious in the early spring when most native plants are still dormant. Second-year plants are ideally pulled before they produce fruit to reduce unintentional seed spread and are most conspicuous while flowering. Hand pulled plants should be placed in trash bags and removed from the site, which reduces the introduction of allelopathic chemicals into the soil and reduces the chances of spreading early matured seeds of fruiting second-year plants.

Chemical (foliar spraying) – Large, dense infestations of garlic mustard may also be treated with glyphosate- or triclopyr-based herbicides. These herbicides degrade in the soil and do not stop germination of seeds from an existing seed bank. Because first-year garlic mustard plants retain the rosette leaves throughout the winter and new leaves emerge very early in the spring, this plant can be treated from late to early spring when most native vegetation is dormant. This reduces accidental treatment of nontarget species.

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Berberis thunbergii (Japanese barberry)

Species description

Barberry is deciduous shrub that grows 2-8 feet tall and can form dense thickets in the forest understory (Photo 6). The most notable aspect of the plant are the short, abundant spines found in sets of three along the entire stem. Barberry leaves are distinct, small, and spatula-shaped that emerge in the early spring (April-May) before canopy tree leaf out, which may allow for the species persistence in closed-canopy forests (Silander and Klepeis 1999). The plant produces small yellow flowers in the spring (April-May), shortly after leaf-out, which are somewhat inconspicuous and dangle below the branches. The plants don't produce fruit until late summer into the fall (August-September), and fruits can remain on the branches through mid-winter. Most fruit falls below mature barberry canopies, but long-range dispersal of fruits is possible as some forest birds including Ruffed grouse, cedar waxwings, American robins, and other thrushes have been observed consuming fruit, although there is limited evidence that it is a preferred food source (Silander and Klepeis 1999).

Photos 6 &7: Barberry patches (top) and individual plants (bottom) were detected at White's Woods

Barberry invasions tend to be associated with second-growth forests that were previous agricultural fields, pasture, or surface mine sites. Notably, the timing of Japanese barberry's rapid spread within eastern North America aligns nicely with the widespread agricultural land abandonment in the mid-20th century. This suggests that many barberry invasions are relics of past land use patterns. While they are shade-tolerant and persist within closed-canopy forests, this also suggests that barberry is perhaps most likely to spread or increase in population size when forest canopies are disturbed, and more light is allowed to reach the forest floor (Silander and Klepeis 1999).

Barberry is native to China and Japan. It was first introduced as an ornamental shrub in the 1875 to the Arnold Arboretum in Boston and was later promoted as a substitute for another nonnative shrub, English barberry (*Berberis vulgaris*) that was susceptible to black stem rust disease (Silander and Klepeis 1999). Japanese barberry is still an ornamental commodity sold widely at home garden centers and frequently planted in commercial and private landscaping. Although it comes in multiple varieties that vary in size and leaf color (red, golden yellow, variegated), offspring of ornamental plants have been detected in nearby forests and appear to readily revert to green-leafed varieties. The first collected specimen of barberry in Indiana County, PA was in 1942 in a cut-over forest near the north end of 15th Street (Academy of Natural Sciences of Drexel University, Catalog # PH00516670).

Status at White's Woods

Mature patches of Japanese barberry are widespread within White's Woods, with the multiple large patches found within the preserve (Map 2). Scattered individual barberry are also found in other sites in the forest (Photo 7) away from dense patches.

Impacts

There are a wide range of potential impacts of barberry invasions in eastern deciduous forests.

Ecological – There are few studies on the impact of Japanese barberry on forest plant communities. Dense barberry patches with >90% aerial cover are associated with significantly lower tree seedling density than nearby uninvaded forested areas (Link et al. 2018), although survivorship of one-month old black cherry (*Prunus serotina*) seedlings was higher in barberry plots relative to uninvaded forested areas or areas where barberry had been managed (Link et al. 2019). However, in a survey of the impact of more scattered, individual barberry plants, there was no evidence that single barberry shrubs reduced native plant diversity or abundance (Flinn et al. 2014).

Barberry invasions are also associated with changes to soil food webs and soil nutrient cycles. Predatory arthropods are less frequent in barberry stands, suggesting that the species might alter soil food webs by reducing their complexity (Clark and Seewagen 2019). Likewise, the presence of barberry leaf litter can decrease soil fungal abundance, increase soil bacteria abundance, and increased litter decomposition rates, which all can lead to faster nutrient cycling and reduced leaf litter on the forest floor (Elgersma and Ehrenfeld 2011). Increasing nutrient cycling in invaded sites is common and is generally associated with higher abundance and diversity of other invasive plants.

Economic – While there are no comprehensive assessments of the economic costs or benefits of Japanese barberry in the US, barberry is an economically valuable plant to the horticulture industry. In 2019, the USDA Census of Horticultural Specialties assessed barberry crops were valued $21,253,000 within the US (USDA National Agricultural Statistics Service 2019). Natural areas invaded by barberry may impose economic costs to communities. Because barberry invasions in forests may increase risks of contracting Lyme disease or other tick-borne illnesses (see below), communities with recreation areas containing dense barberry stands may also bear the costs of higher human infection rates and associated health care costs. Environmental economists argue “cost of illness” studies can help weigh restoration costs against community health costs of infection to aid in management decision-making (Morlando et al. 2012).

Human Health – Blacklegged ticks (*Ixodes scapularis*), which vector the bacteria (*Borrelia burgdorferi*) that causes Lyme disease in humans, are more abundant and have a higher probability of infection *Borrelia* bacteria in patches of Japanese barberry relative to uninvaded areas of the forest. Management of barberry shrubs reduced number of ticks and prevalence of Lyme disease to levels of uninvaded areas (Williams et al. 2017).

Management Options

Japanese barberry is troublesome to control because of its sharp spines and large taproot. Please see Penn State Extension Fact Sheet for more details on appropriate herbicides, application rates, and safety information.

Mechanical (hand-pulling)– Small seedlings of barberry can be easily hand-pulled (heavy gloves highly recommended!). Larger, more mature plants may require a hoe, mattock, or specialized tool (the UpRooter ®, https://www.theuprooter.com or the Extractigator ®, https://extractigator.com) for uprooting deep shrub tap roots. This form of management is highly labor intensive and is typically recommended for smaller infestations.

Chemical (foliar) – Because of Japanese barberry’s extended leaf phenology relative to most native species (early leaf-out in the spring, delayed leaf senescence in the fall), foliar chemical sprays can be applied while other forest plants are dormant and reduce non-target plant impacts.

Chemical (basal bark) – For larger individuals, direct herbicide application to the bark 12-18 inches above the soil is effective any time throughout the year.

Mechanical+ (cut-stump + stump treatment) – For larger individuals, barberry stems can be cut near the soil surface and the top shoots and stems can be removed. This immediately removes the upper canopy of the shrub and may allow for quicker recovery of native plants. Removed brush can be taken off-site for mulching or composting or can be piled or spread around the forest. If shrubs have mature fruits on them, taking off site is not recommended as it may further the spread of the plant to new locations. Cut stumps will resprout if they are not treated after cutting. Using a small amount of herbicide applied immediately after cutting has the highest mortality rate (~90% of treated stems) but use of a directed propane flame torch (100,000 BTU) caused high mortality as well (~40% of treated stems; Ward et al. 2009). Note that cut stump herbicide application decreases the total amount of herbicide applied in a forest relative to foliar application.

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Celastrus orbiculatus (Asiatic bittersweet)

Species description

Bittersweet is deciduous woody vine that can be found as a dense groundcover or climbing up and over 50-foot trees. The stem diameter of mature vines can reach up to 4 inches and can strangle tree or shrub trunks and smoother tree canopies. Bittersweet leaves are round, glossy, and finely toothed. The plant's flowers are green and inconspicuous and unripe fruits are a dull yellow color. Once the fruit mature, usually in the fall, the yellow fruit casing split open to reveal a bright red, fleshy fruit that remain on the vine through early winter. Wildlife eat and disperse the fruits but humans also collect the fruiting vines for indoor fall decorations (wreaths, flower bouquets, etc.) that spread the plant to new locations.

Photo 8: Asiatic bittersweet vines on forest floor near 12th street entrance of White's Woods. Native vine American hog peanut also present in photo (lighter green leaves with three leaflets).

Dense bittersweet patches are most common in high-light forest edges, open fields, or canopy gaps. However, once established, the vine can penetrate from the forest edge into closed canopy forest and persist as a dense understory vine. In open fields, bittersweet invasions can arrest succession to forested communities and turn open areas into 'vinelands' (Fike and Niering 1999). There is some evidence that bittersweet has a higher chance of establishment in certain habitat types. A field experiment in New Jersey forests found that bittersweet seed germination and survival was higher in post-agricultural forests dominated by tulip poplars (*Liriodendron tulipifera)* relative to non-disturbed forests dominated by oaks (*Quercus* spp.), which may have been driven by higher soil moisture in tulip poplar forests (Kuhman et al. 2013). Conversely, a study in northern Michigan found that bittersweet germination rates were higher in oak-hickory forests relative to oak forests and beech-maple forests (Leicht-Young et al. 2013). Bittersweet vine can be one of the first nonnative plants to establish and spread quickly after timber harvesting because of its quick growth.

Bittersweet is native to eastern China, the Korean peninsula, and Japan. The introduction history of the plant is unclear but the plant was likely first introduced in the latter half of 19th century. However, the plant did not start spreading and invading natural habitats until the 1960s after the National Arboretum in Washington, D.C. widely distributed the plant to nurseries in 30 US states (McKenzi-Gopsill and MacDonald 2021). The first collected specimen of bittersweet in Indiana County, PA was in White's Woods in 2009 in the same location we found plants - along the 12th street trailhead entrance (Carnegie Museum of Natural History, Catalog #CM521409).

Status at White's Woods

Bittersweet is uncommon at White's Woods and was only detected at a single location near the 12th Street trailhead entrance (Map 2).

Impacts

There are a wide range of ecological impacts of bittersweet invasions in eastern deciduous forests.

Ecological –

Bittersweet has been documented as affecting native plant communities, soil characteristics, and ecosystem processes. Riparian forests invaded by bittersweet are associated with

decreased native plant richness, abundance, and diversity (Browder 2011). Bittersweet leaf litter is higher in nitrogen than the leaf litter of many native species and increased bittersweet leaf litter on the forest floor can lead to increased soil nitrogen levels, soil pH, and rates of nitrogen mineralization (Leicht-Young et al. 2015).

Economic – There is no comprehensive assessment of the economic impacts of bittersweet in forested ecosystems. Large invasions could impede canopy tree growth and regeneration, although the evidence for the impact of bittersweet on the growth economically valuable trees is limited and mixed (Horton et al. 2014, Ladwig and Meiners 2009). While the plant was once available for purchase, it is infrequently sold today. However, there is evidence that many garden retailers selling native American bittersweet (*Celastrus americana*) are mislabeling and selling the nonnative, invasive *C. orbiculatus* (Zaya et al. 2017). The two species can be distinguished when flowering and fruiting; the native vine will only have flowers and fruits at the terminal end of each branch while the nonnative invasive can flower and fruit all along the stem.

Human Health – There are no known human health impacts of bittersweet.

Management Options

Bittersweet can be difficult to control when it is wrapped around the stems of other woody plants or the vine's canopy is high in the tree canopy. For these reasons, most management strategies focus on chemical application. Please see Penn State Extension Fact Sheet for more details on appropriate herbicides, application rates, and safety information.

Mechanical (cutting) – A single bittersweet plant can have multiple stems that wind around multiple trees or shrubs. Cutting a "window cut" of each vine stem (one cut near the ground and another cut 2-3 feet up the vine) can effectively kill the vine canopy. After cutting, do not try to pull vines out of the tree canopy, as it may cause more damage to the host tree. Cut stumps of vines will resprout vigorously after cutting if not treated with herbicide.

Chemical (foliar) – Spraying the leaves of bittersweet that is growing as ground cover or new resprouts after cutting the vine's main stem can provide good control of plants. Care should be taken to reduce the chance of applying herbicides to non-target plant species, and it is not recommended to spray foliage of mature vines that are climbing living vegetation.

Chemical (cut-stump) – For larger individuals, bittersweet stems can be cut near the soil surface and immediately treated with a small amount of herbicide to reduce resprouting. Note that cut stump herbicide application will introduce lower total herbicides on the landscape because of its direct application.

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Elaeagnus umbellata (Autumn olive)

Species description

Autumn olive is deciduous shrub or small tree that grows up to 20 feet tall. It can form dense thickets, but typically in open, high-light habitats along forest edges, roadsides, or abandoned fields (Photos 9 &10). The leaves of the plant are narrow lance-shaped, dark green on top, and distinctively silver on the underside with visible scales. Yellow flowers appear shortly after the plant's leaves emerge in the spring (May-June) and mature into red fruits in the late summer that are dispersed by birds and sometimes mammals. The fruits also have silver scales on them once ripe and are sometimes collected by humans for jams and preserves. This too can spread the species if human-collected berries are improperly disposed of or placed in household garbage or compost. The stems of the plant are grey-brown, very flexible, and often have thorns. Autumn olive can form mutualistic affiliations with nitrogen-fixing bacteria in soils (*Frankia* spp.) depending on the site and soil conditions.

Photos 9 & 10: Autumn olive at White's woods. An individual shrub at the forest's edge near the Fulton Street trailhead (top) and a larger patch, likely intentionally planted, near a gas wellhead in the forest interior.

Autumn olive is native to eastern China and Japan. It was first introduced as an ornamental shrub in the 1830s and was extensively promoted by the US Soil Conservation Service (now, US Natural Resources and Conservation Service) as a good plant for wildlife and windbreaks (Allan and Steiner 1972, Dittberner et al. 1992). It began spreading from cultivation in the mid-20th century, and now is considered an extremely problematic invader in riparian woodlands where it forms dense, impenetrable stands. There first recorded specimens of Autumn olive in Indiana County, PA was in 1993 in Conemaugh Township approximately 2 km northeast of Tunnelton (Carnegie Museum of Natural History, Catalog # CM388565).

Status at White's Woods

There are two large patches of mature Autumn olive in open canopy areas near gas wells within White's Woods and a few scattered individuals around the forest edge (Map 2). Based on their arrangement and dense planting, these individual olive trees might have been intentionally planted near the gas wells to provide a windbreak or screen the wells from view.

Impacts

Autumn olive is typically found in open, high light environments in open fields, canopy openings within forests, or along forest edge and rarely deep in the forest interior. Though common, there is limited knowledge on the ecological, economic and human health impacts of this species.

Ecological – Autumn olive is a nitrogen-fixing woody tree with leaf litter that is higher in nitrogen than most native forest species. These traits lead to increased plant-available nitrogen (ammonia and nitrate) in soils near autumn olives, and also are linked with changes in the composition of soil bacterial communities (Malinich et al. 2017).

Autumn olive fruits appear to be a preferred food source for European Starlings and American Robins, over other nonnative fruit and native fruit common in forest ecosystems. This suggests that birds may disproportionately spread autumn olive over other species into new areas in the forest (Lafleur et al.2007). However, migratory songbirds appear to prefer high-fat fruit in the Fall prior to migration, and Autumn olive fruits are high carbohydrate but low fat and may be of lower nutritional value for migratory versus resident bird species (Smith et al. 2007). Autumn olive fruit is also edible to humans, and some people harvest the fruit to make jams and preserves. However, we recommend extreme caution if harvesting autumn olive fruit as humans can also aid in the dispersal of the plant if collected seeds are dropped, lost, or put into home compost bins.

Economic –There are no comprehensive assessments of the economic costs or benefits of Autumn olive in the US, or specifically in the northeastern US.

Human Health – There are no known human health impacts of Autumn olive.

Management Options

Management of autumn olive is similar to management of other woody invasive shrubs. Please see Penn State Extension Fact Sheet for more details on appropriate herbicides, application rates, and safety information.

Mechanical (hand-pulling) - Small seedlings of Autumn olive can be hand-pulled, but this species can resprout from remaining roots. For this reason, larger individuals tend to be too hard to remove because of the large root system.

Chemical (foliar) – Foliar herbicides are effective when applied mid-May through the summer, before Autumn olive leaves begin to change color. While effective, this method has more potential for herbicide drift to non-target plants and a more limited application window than other chemical treatment options.

Chemical (basal bark) – For larger individuals, direct herbicide application to the bark 12-18 inches above the soil is effective for controlling mature Autumn olive. This can be done any time throughout the year.

Chemical (cut-stump) – For larger individuals, Autumn olive stems can be cut near the soil surface and the top shoots and stems can be removed. This immediately removes the upper canopy of the shrub and may allow for quicker recovery of native plants. Removed brush can be taken off-site for mulching or composting or can be piled or spread around the forest. If shrubs have mature fruits on them, taking off site is not recommended as it may further spread of the plant. Cut stumps should be treated with a targeted herbicide application to prevent resprouting, as this provides better long-term control of the plant (Franke et al. 2018).

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Euonymus alatus (Burning bush, winged euonymus)

Species description

Burning bush is deciduous shrub that can grow up to 20 feet tall and can produce dense thickets in some forested settings, primarily southern New England states. The most notable characteristics of the plant is its corky ridged stems and the fuchsia-colored leaves in the fall. The shrub is one of the earlier shrubs to leaf out in the spring and holds its leaves longer than most native shrubs in the fall. The plant produces small, inconspicuous, yellow-green flowers in the in the early spring and bright red fruit in the late Fall.

Burning bush is native to central and northeastern China and Japan. It was first introduced as an ornamental shrub in the 1860 and is still an ornamental commodity sold widely at home garden centers and frequently planted in commercial and private landscaping. Although it comes in multiple varieties and cultivars, nearly all of them produce hundreds to thousands of seeds each year with a ~30% germination rate (Brand et al. 2012). The first collected specimen of burning bush in Indiana County, PA was in 2012 along the Conemaugh River at the foot of High Street in Saltsburg, Conemaugh Township (Carnegie Museum of Natural History, Catalog # CM526598).

Photo 11: Single burning bush shrub in wood interior near Fulton Run Road trailhead. Note deer browse line where deer have over-browsed lower branches.

Status at White's Woods

Burning bush was uncommon at White's Woods with scattered mature individuals detected at four locations around the property (Map 2, Photo 11). Burning bush is a preferred shrub by white-tailed deer, which can prevent the spread and development of dense burning bush patches (Faison 2013) and it is likely that the high deer population is preventing population growth and expansion of burning bush at this site. Should deer population density be reduced at the site, this plant may be expected to spread with reduced browsing pressure unless mature, fruiting individuals are removed to reduce the seed source within the forest interior.

Impacts

There is limited information on the impacts of burning bush.

Ecological – There are very few studies on the ecological impact of burning bush in deciduous forests. Burning bush appears to be a preferred food for white-tail deer (Faison 2013, Photo 11), which may control spread of burning bush in forests with high-density deer populations. Burning bush is also a potential food source for the nonnative, invasive gypsy moth (*Lymantria dispar*) and could sustain high gypsy moth populations during outbreaks (McEwan et al. 2009).

Economic – While there are no comprehensive assessments of the economic costs or benefits of burning bush in the US, it is an economically valuable plant to the horticulture industry. In 2019, the USDA Census of Horticultural Specialties assessed euonymus crops were valued $28,649,000 within the US (USDA National Agricultural Statistics Service 2019). Although this value includes other *Euonymus* species including a closely related nonnative, invasive vine *E. fortunei* (wintercreeper), a nonnative shrub *E. japonicus* (golden euonymus) as well as native *Euonymus* shrubs *E. atropupureus* (eastern wahoo) and *E. americanus* (strawberry bush), burning bush is by far the most commonly sold *Euonymus* species in the horticultural trade.

Human Health – There are no known human health impacts of burning bush.

Management Options

Because burning bush does not typically form dense stands in southwestern Pennsylvania, management of the species can be less work than other nonnative, invasive shrubs. Please see Penn State Extension Fact Sheet for more details on appropriate herbicides, application rates, and safety information.

Mechanical (hand-pulling)– Small burning bush seedlings can be easily hand-pulled. Larger, more mature plants may require a hoe, mattock, or specialized tool (the UpRooter ®, https://www.theuprooter.com or the Extractigator ®, https://extractigator.com) for uprooting shrub tap roots. This form of management is highly labor intensive and is typically recommended for smaller infestations.

Chemical (foliar) – Because of burning bush's extended leaf phenology relative to most native species (early leaf-out in the spring, delayed leaf senescence in the fall), foliar chemical sprays can be applied while other forest plants are dormant and reduce non-target plant impacts.

Chemical (basal bark) – For larger individuals, herbicide application to the bark 12-18 inches above the soil is effective any time throughout the year.

Chemical (cut-stump) – For larger individuals, burning bush stems can be cut near the soil surface and the top shoots and stems can be removed. This immediately removes the upper canopy of the shrub and may allow for quicker recovery of native plants. Removed brush can be taken off-site for mulching or composting, or can be piled or spread around the forest. If shrubs have mature fruits on them, taking off site is not recommended as it may further spread of the plant. Cut-stumps will resprout if they are not treated after cutting.

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Ligustrum vulgare (European privet)

Species description

European privet is semi-evergreen shrub that can grow up to 20 feet tall and prefers moist soils and riparian areas. The plant's leaves are small, dark green, and smooth and can remain on the shrub throughout the winter. The plant produces white flowers in the summer (June and July) and fruit that turn dark blue in the late summer and fall (September-October). Fruits remain on the plant through the winter and into the following spring. The plant is difficult to distinguish from Chinese privet (*Ligustrum sinense)* and can only be distinguished when flowering. Chinese privet is much more common in the southeastern United States while European privet is more common in the northeastern United States.

European privet is native to Europe, Morocco, and western Asia and was originally introduced as an ornamental shrub for hedge rows. There are no recorded herbarium specimens of European privet in Indiana County, PA. The first records of the species in the region were in 1982 at Powdermill Nature Preserve in Westmoreland County (Carnegie Museum of Natural History, Catalog #CM285011) and in 1992 in Crooked Creek Lake State Park in Armstrong County (Carnegie Museum of Natural History, Catalog #CM473430).

Status at White's Woods

Privet was uncommon in White's Woods and only detected in two locations, one along the 12th Street trailhead and another group of individuals on the slopes above Story Run creek (Map 2). White-tailed deer forage on privet year-round and it is a preferred food source over other nonnative, invasive plants including plants found at White's Woods like garlic mustard, Japanese barberry, and Japanese stiltgrass (Averill et al. 2016). Intense deer browse pressure may be preventing the spread of privet at White's Woods.

Impacts

There is limited research on the impacts of European privet in forested ecosystems.

Ecological – There is some evidence that European privet changes the composition and abundance of beneficial soil organisms. In a greenhouse experiment, native plants had lower colonization of roots by beneficial arbuscular mycorrhizal fungi when soils had previously held privet plants relative to soils without privet growing (Shannon et al. 2014).

Economic – There are no comprehensive assessments of the economic costs or benefits of European privet in the US.

Human Health – There are no known human health impacts of European privet.

Management Options

Managers have many options for controlling privet in forests. Please see Penn State Extension Fact Sheet for more details on appropriate herbicides, application rates, and safety information

Mechanical (hand-pulling)– Small privet seedlings can be hand-pulled, but it is sometimes difficult to remove the larger tap root system. Larger, more mature plants may require a hoe, mattock, or specialized tool (the UpRooter ®, https://www.theuprooter.com or the Extractigator ®, https://extractigator.com) for uprooting deep shrub tap roots. This form of management is highly labor intensive and is typically recommended for smaller infestations.

Chemical (foliar) – Because of privet's extended leaf phenology relative to most native species (early leaf-out in the spring, delayed leaf senescence in the fall), foliar chemical sprays can be applied while other forest plants are dormant and reduce non-target plant impacts.

Chemical (basal bark) – For larger individuals, direct herbicide application to the bark 12-18 inches above the soil is effective for controlling mature privet plants. This can be done any time throughout the year.

Chemical (cut-stump) – For larger individuals, privet stems can be cut near the soil surface and the top shoots and stems can be removed. This immediately removes the upper canopy of the shrub and may allow for quicker recovery of native plants. Removed brush can be taken off-site for mulching or composting or can be piled or spread around the forest. If shrubs have mature fruits on them, taking off site is not recommended as it may further spread of the plant. Cut stumps will resprout if they are not treated after cutting, and a small amount of herbicide can be applied directly after cutting to reduce the chance of resprouting. Note that cut-stump herbicide application will introduce lower total herbicides on the landscape because of its direct application.

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Lonicera japonica (Japanese honeysuckle)

Species description

Japanese honeysuckle is a perennial evergreen to semi-evergreen vine that is typically found trailing along the forest floor. In high light areas of the forest like canopy gaps or forest edges, it can twirl and grow up and around other plants creating a dense mat of vines (Schierenbeck 2004). Leaves are light green, slightly pubescent, and oval. Some leaves may be lobed. The vine produces very fragrant yellow and white flowers in summer (April to July) and again in the fall (September to November). Fruit production is typically lower than flower production on the plant, but dark blue to black berries appear in late summer on some plants and are eaten and dispersed by a many forest birds.

Japanese honeysuckle is native to eastern China, Korea, and a Japan and was first introduced to the US in the early 19th century. It was previously planted throughout the eastern US as an ornamental vine and for erosion control and wildlife habitat. The first record of the species in the county was in 1995 along Reynolds Road ~1 mile from PA 259 and Blairsville (Carnegie Museum of Natural History, Catalog #CM399709).

Status at White's Woods

Japanese honeysuckle was uncommon in White's Woods and only detected in scattered places during initial spring surveys.

Impacts

Ecological – There is some evidence that sites with heavy Japanese honeysuckle infestations can have reduced native plant diversity and abundance, and that disturbance to the canopy cover can increase the growth and size of honeysuckle vine populations (Larson et al. 2007, Schierenbeck 2004). Some foresters report that honeysuckle vines can prevent tree seedling regrowth after harvesting (Larson et al. 2007, Schierenbeck 2004). Honeysuckle leaves and vines are a preferred food source for white-tailed deer, while the berries are eaten by a variety of forest birds (Munger 2002).

Economic – There are no comprehensive assessments of the economic costs or benefits of Japanese honeysuckle in the US. Although Japanese honeysuckle is available for sale online and at some nurseries, a 2004 estimate of its economic value in Florida found that its value was less than 1% of the total horticultural industry sales (Wirth et al. 2004).

Human Health – There are no known human health impacts of Japanese honeysuckle.

Management Options

Because of the trailing and climbing nature of this plant, it typically grows interspersed among other vegetation making management of the species more difficult than other invaders than grow in dense monoculture patches.

> *Chemical (foliar)* – Japanese honeysuckle has an extended leaf phenology (early leaf out in the spring, delayed leaf senescence in the fall) relative to other native species and sometimes retains its leaves throughout the winter. Foliar chemical sprays can be applied while other forest plants are dormant and reduce the chances of non-target plant impacts. The Missouri Department of Conservation has a fact sheet with more details on appropriate herbicides, application rates, and safety information (https://mdc.mo.gov/trees-plants/invasive-plants/japanese-honeysuckle-control).

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Microstegium vimineum (Japanese stiltgrass)

Species description

Stiltgrass is a shade-tolerant annual grass species (Poaceae) that can grow up to three feet high by the end of the summer. It can grow in upland forests, but it typically is found in moister microsites and along trails and roads through forests (Photo 12). Seedlings begin germinating in late spring or early summer (May), but plants do not reach full maturity to fruit and flower until late summer or early Fall (August-September). The leaves are usually a pale green, long and lance shaped, with a shiny grey or white line along the midrib. The plant stalks and leaves senesce and turn brown in the Fall and are very slow to decompose leaving a notable layer of hay-like thatch on the landscape through winter and early spring. Individual plants can produce hundreds of seeds that typically fall to the ground below the plant but can also be dispersed during management if grass stalks with seeds are pulled and shaken. Seeds are likely to remain viable in the soil upwards of three years, suggesting that management of established populations will require multiple years of control to exhaust the existing seed bank. The modes of seed dispersal are unknown, but the plant is known to move quickly (1-2 years) into forest interiors along logging trails and establish large populations in logged areas of forests. It is likely that seeds, carried in mud in tire treads of vehicles, is major local source of seed dispersal.

Photos 12 &13: Dense patches of stiltgrass line most of the trails within White's Woods (top) with barely any other vegetation growing within patches (bottom).

This plant is native to eastern Asia and was first identified in Tennessee in 1919. It is thought to have arrived accidentally within packing material. Since its introduction, the species has spread widely within forests and forest edges and is now found from Florida to Vermont and New Hampshire. The first collected specimen of stiltgrass in Indiana County, PA was in 2008 along Black Lick Creek west of Josephine, Center Township (Carnegie Museum of Natural History Herbarium, Catalog # CM469167).

Status at White's Woods

Stiltgrass is widespread throughout much of the forest interior and exterior at White's Woods, including along major trail corridors and near existing infrastructure (wells) at the site. Most of the populations are robust, dense, and contain few other native plants (Photo 13). We recorded 33 locations of stiltgrass patches found along trails especially larger trails and near gas wells (Map 2).

Impacts

Stiltgrass is a well-studied forest invader with hundreds of scientific articles discussing the ecology of the species in its nonnative range.

Ecological – Stiltgrass is common in disturbed locations, including riparian areas with river scour, or areas disturbed by human foot or vehicle traffic, or recently logged forests. Winter leaf litter disturbance is also associated with increased invasion potential of the grass (Oswalt et al. 2007, Oswalt and Oswalt 2010). Heavy stiltgrass infestations are associated with lowered plant diversity and abundance and its annual growth habit allows populations to rapidly expand and create dense monospecific stands that can suppress natural native plant regeneration—including native trees, shrubs, forbs, and grasses—in disturbed forests (Oswalt et al. 2007, Oswalt and Oswalt 2010). One way stiltgrass may suppress native plant germination and growth is through the creation of a thick thatch layer of dead stiltgrass stems that are slow to decompose and can build-up through time. A dense thatch layer can reduce germination or emergence of native forbs, change the soil microclimate to cooler and wetter, and potentially increase levels of certain plant pathogens in the soil (Benitez et al. 2021). There is mixed evidence of the impact of stiltgrass invasions on arthropods, with one study showing increases in diversity and abundance of arthropods in invaded relative to uninvaded forest areas (Landsman et al. 2020) and one study showing decreases in diversity and abundance of arthropods in experimentally invaded areas relative to areas with higher native plant diversity (Simao et al. 2010).

Stiltgrass also is also associated with a range of impacts on forest soil nutrients and carbon. Stiltgrass can increase rates of litter decomposition and carbon cycling, which can lead to lower quantities of total carbon stored in forest soils (Strickland et al. 2010, Craig et al. 2015). Stiltgrass invasions also increases rates of soil nitrification in forests, which can create a positive feedback loop that benefits the growth of *Microstegium vimineum* plants over native forest herbs (Lee et al. 2012). The likelihood of changes to soil nutrients and carbon cycle can depend on multiple features of the invaded forest, including its prior land-use history, the types of tree species at the site, and levels of continued soil disturbance (Craig et al. 2015, Lee et al. 2012).

Economic – There has been no formal assessment of the economic costs or benefits of stiltgrass. The reduction in tree seedling growth and regeneration could impact commercially managed forests (Oswalt et al. 2007), while declines in soil carbon pools in invaded areas may decrease the ecosystem services provided by invaded forests.

Human Health – There are no associated human health impacts with stiltgrass. However, there is evidence that survival of the lone start tick (*Amblyomma americanum*) and American dog tick (*Dermacentor variabilis*)—two species that vector multiple human diseases—is lower in areas invaded by stiltgrass relative to uninvaded areas (Civitello et al. 2008)

Management Options

Stiltgrass is extremely difficult to control because of its annual growth form and ability to establish long-lasting seed banks (>3 years). Management of established populations will generally require multiple years of treatments to continue removal of germinating seeds from the seed bank. No matter the management option, because this plant is an annual, treatment should occur before late August when flowers and fruits begin to develop. Treatment after this period is more likely to spread seeds or have limited effect on population growth. By far the best management option is to reduce or prevent the further spread of the species by establishing early-detection protocols that can remove new plants found in new areas of the forest, where a seed bank has not established. Additionally, the species will respond quickly to increased light availability when canopy trees are disturbed or removed (through natural tree fall or intentional tree harvesting) by increasing the population size and density of individuals within a patch. The references, below, provide more detailed information on the timing and application of each management option.

Mechanical (hand pulling) – Stiltgrass is typically found in moist soils, which allows for easy hand pulling of plants and roots. This method is most appropriate for small patches of stiltgrass, but many of the stiltgrass patches at White's Woods are large enough that this method may not be feasible. Plants will generally not reach a large enough size to hand-pull until mid-summer, and if pulled early a second flush of germinating seeds will likely emerge. Pulled plant material can be left in the forest (it will create a thatch layer), which will reduce the likelihood of spreading stiltgrass seeds to new sites. Hand weeding can reduce stiltgrass abundance at the end of each growing season, which allows for recovery of native plants. However, hand weeding requires multiple years of effort to successfully reduce stiltgrass populations through time (Flory 2010).

Mechanical (mowing or cutting) – Stiltgrass can also be mowed or cut along the stalks, but this treatment must be completed during a small time window that is late enough in the growing season that the plant does not have time to resprout from cut stems but before the plant begins producing flowers and fruit. Penn State Extension reports that hand-held string trimmer is more effective than mowing equipment at reducing regrowth of cut stalks. All mowing equipment should be cleaned well on site to reduce the likelihood that seeds will be transported off site. Note that larger mowing equipment may also move soil with seeds stuck in wheels or tire treads.

Chemical – Penn State Extension has detailed protocols for applying pre-emergent herbicides to the soils to reduce germination in the seed bank and post-emergent foliar sprays for stiltgrass. However, pre-emergent herbicides are likely to affect any plant seeds (native or nonnative) within the soil seed bank and suppress natural regeneration (Flory 2010). Likewise, because stiltgrass actively grows when many native plants are active, foliar spray may have a higher likelihood to also impact non-target plants growing within or near stiltgrass patches.

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Rhodotypos scandens (jetbead)

Species description

Jetbead is a deciduous shrub that can grow up to 6 feet tall and is highly tolerant of deep canopy shade. The plant's leaves are dark green with deep ribbed veins and doubly serrate edges. The plant produces large, four-petaled white flowers in the spring and distinctive, red fruit that turn black and bead-like in the late summer. The fruits tend to grow in sets of four.

Jetbead is native to eastern Asia and was originally introduced as an ornamental shrub. There are no recorded herbarium specimens of jetbead in Indiana County, PA and few records outside of Allegheny County in southwestern PA. The first record of the species in the region was in 2017 in Upper Burrell Township of McIntrye Lane in Westmoreland County (Carnegie Museum of Natural History, Catalog #CM534660).

Photo 14: Jetbead growing in the woods near the Fulton Run Road trailhead.

Status at White's Woods

Jetbead was uncommon in White's Woods and only detected around the transformer station and trailhead near Fulton Run Road.

Impacts

There is no research on the ecological, economic, or human health impacts of jetbead in forested ecosystems. There are many reports of dense stands of jetbead in closed-canopy forests in southeastern Pennsylvania (Albrecht 2001), New York City and southern Hudson Valley, and jetbead is on the "watch list" for the mid-Atlantic states (Swearingen et al. 2010)

Management Options

There is limited specific information on the management of jetbead in forested ecosystems. It is reasonable to assume that it will respond similarly to the following management techniques used for other nonnative, invasive woody shrubs. Please see Penn State Extension Fact Sheet and the Lower Hudson Partnership for Regional Invasive Species Management (PRISM) for more details on appropriate herbicides, application rates, and safety information.

Mechanical (hand-pulling)– Small seedlings or saplings can be hand-pulled, but it is likely difficult to remove the larger tap root system of bigger plants. Larger, more mature plants may require a hoe, mattock, or specialized tool (the UpRooter ®, https://www.theuprooter.com or the Extractigator ®, https://extractigator.com) for uprooting deep shrub tap roots. This form of management is highly labor intensive and is typically recommended for smaller infestations.

Chemical (foliar) – Foliar chemical sprays can be applied to green leaf tissue but may need to be repeated multiple times during the growing season.

Chemical (basal bark) – For larger individuals, direct herbicide application to the bark 12-18 inches above the soil is effective for controlling mature plants. This is recommended to be done between July and September.

Chemical (cut-stump) – For larger individuals, jetbead stems can be cut near the soil surface and the top shoots and stems can be removed. This immediately removes the upper canopy of the shrub and may allow for quicker recovery of native plants. Removed brush can be taken off-site for mulching or composting or can be piled or spread around the forest. If shrubs have mature fruits on them, taking off site is not recommended as it may further spread of the plant. Cut stumps will likely resprout if they are not treated after cutting, and a

small amount of herbicide can be applied directly after cutting to reduce the chance of resprouting. Note that cut-stump herbicide application will introduce lower total herbicides on the landscape because of its direct application.

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Rosa multiflora (Multiflora rose)

Species description

Multiflora rose is deciduous shrub with large, recurved thorns growing along arching, wandering stems. Typically growing as a shrub, the stems can sometimes act like vines and climb over vegetation or up trees. The shrubs can form, dense, impenetrable thickets in fields, forest edges, or sometimes closed canopy forests. The leaves are divided into 5-11 sharply toothed leaflets with distinctive fringed leaf stipules that look like eyelashes. The shrub is one of the earliest to leaf out in the spring. The shrub produces large white flowers prolifically in mid-spring (May) that develop into bright red fruit in the last summer (August) than can persist on the shrub through the fall (October).

Multiflora rose is native to eastern China, the Korean peninsula, and Japan. It was first introduced as rootstock for other ornamental roses in 1866. It was later promoted by the US Soil Conservation Service in the mid-1900s as 'living fences' for fields to confine livestock and for erosion control. It is today common in secondary forests that were formerly agricultural pastureland in the mid-1900s. The first collected specimen of multiflora rose in Indiana County, PA was in 1993 in a disturbed field 2 km west of Tunnelton, Conemaugh Dam (Carnegie Museum of Natura History, Catalog # CM484020).

Status at White's Woods

Mature multiflora roses are found in scattered locations in the eastern side of White's Woods, including near the 12th street trailhead (Map 2).

Impacts

There is limited research on the impact of multiflora rose on forested ecosystems.

Ecological – Dense multiflora rose stands are associated with decreased leaf litter layers on the forest floor (Adalsteinsson et al. 2016), although the reason for this association has not been determined.

Economic – Although originally introduced in the US for ornamental horticultural purposes, multiflora rose is no longer sold today as an ornamental plant. There is no comprehensive economic impact assessment of this species.

Human Health – As with other invasive woody shrubs, dense thickets of multiflora rose can increase the infection rates of ticks carrying the bacterium that causes Lyme disease in humans (*Borrelia burgdorferi*). However, while tick infection rates are higher in forests invaded by multiflora rose, lower amounts of leaf litter covering the forest floor associated with lower number of total ticks in invaded forests (Adalsteinsson et al. 2016, Adalsteinsson et al. 2018).

Management Options

Large infestations of multiflora rose can hard to control because of the longevity of seeds in the seed bank (estimated to up to 20 years) and potential for resprouting root and stem fragments. Please see the Penn State Extension Fact Sheet for more details on appropriate herbicides, application rates, and safety information.

Mechanical (hand-pulling)– Small seedlings of multiflora rose can be hand-pulled (heavy gloves highly recommended to protect hands from thorns). The entire root system of the shrub needs to be removed to prevent resprouting, and this method is only recommended for infestations that are small or young.

Chemical (foliar) – Rose responds to foliar chemical herbicides at any time during the year. Sprawling, mature plants can be cut once before treating, allowed to resprout, and then

treated. Cutting first can stress the plant and make foliar treatment more effective. Applicators should take care to avoid application of herbicide to nearby plants.

Chemical (cut-stump) – For larger individuals, multiflora rose stems can be cut near the soil surface and the top shoots and stems can be removed. This immediately removes the upper canopy of the shrub and may allow for quicker recovery of native plants. Removed brush can be taken off-site for mulching or composting or can be piled or spread around the forest. If shrubs have mature fruits on them, taking off site is not recommended as it may further spread of the plant. Cut stumps will resprout if they are not treated after cutting. Note that cut-stump herbicide application will introduce lower total herbicides on the landscape because of its direct application. Please see Penn State Extension Fact Sheet for more details on appropriate herbicides, application rates, and safety information.

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Vinca minor (common periwinkle)

Species description

Periwinkle is mostly evergreen woody vine that grows as a dense, tailing groundcover on the forest floor. Periwinkle leaves are dark green, oval, glossy, and thick and persist throughout the winter. The plant's flowers are purple and bloom in the spring (March-June) but infrequently produces fruit, which likely limits the spread of this plant. Instead, the plant's predominate mode of dispersal is vegetatively through rhizomes

Periwinkle is native to Europe and was first introduced to the US in the 1700s as an ornamental vine. Because of its low likelihood of producing and spreading by fruit, large patches of periwinkle in forests are typically found near old homesteads where the plant was likely first planted. The first collected specimen of periwinkle in Indiana County, PA was in 1946 at the edge of the woods across from Crete Church 4 miles northwest of Homer City (Academy of Natural Sciences at Drexel University, Catalog #PH00386207).

Status at White's Woods

Periwinkle is uncommon at White's Woods and was only detected at a single location near houses along 12th street at the site. This population likely is an expansion of periwinkle that was once planted nearby as an ornamental plant.

Impacts

There is limited research on the ecological, economic, or human health impacts of periwinkle in forested ecosystems.

Ecological – Dense periwinkle patches are associated with lower tree seedling abundances than nearby forested areas without periwinkle, which is likely owing to shading and competitive effects of the vine mats (Darcy and Burkart 2002). A study of predatory spiders, an important component of the soil food web, found that the spider community changed in invaded forest sites relative to uninvaded sites. In dense periwinkle stands, spider diversity was lower and comprised different feeding guilds of spiders, which likely reflects changes to leaf litter environment in periwinkle stands (Bultman and DeWitt 2008).

Economic – There is no comprehensive assessment of the economic impacts of periwinkle in forested ecosystems.

Human Health – There are no known human health impacts of periwinkle.

Management Options

There are limited recommendations for managing this species relative to other nonnative, invasive species in forested ecosystems.

> *Chemical (foliar)* – A study in Michigan where periwinkle was growing among native forest wildflowers found that cutting periwinkle in the late summer (after wildflowers were dormant) and then treating the resprouting periwinkle with a 2% glyphosate herbicide solution reduced periwinkle abundance 3-fold and did not alter the abundance of native wildflowers in plots (Tatina 2015). Similarly, a study in Kentucky found that two alternative herbicides, pelargonic acid (sold under trade name, Scythe, Mycogen Corporation) and a combination of cinnamon oil and clove oil (sold under trade name Weed Zap, J.H. Biotech), provided similar control of periwinkle vines as glyphosate herbicides (Carreiro et al. 2020). However, these alternative herbicides are most costly than glyphosate and required one additional application to reach the same reduction in periwinkle density.

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Early Detection of New Nonnative-Invasive Plants

We provide brief descriptions of non-native plants that we did not detect at White's Woods but could become invasive on the property. This list was curated from two sources. First, a larger list of potentially invasive plants for Indiana County, PA created by the EDDMapS *Invasive Range Expanders Listing Tool* (https://www.eddmaps.org/rangeshiftlisting/). This listing tool provides a list of invasive plants that are already present within the contiguous United States and that are expected to expand their range into Indiana County by the middle of this century (Allen and Bradley 2016). Second, we selected potentially invasive species from a list of nonnative plants that are currently listed as invasive by the Pennsylvania Department of Natural Resources (https://www.dcnr.pa.gov/Conservation/WildPlants/InvasivePlants/Pages/default.aspx). We only selected species from these lists that are known to invade closed-canopy forests. This list could be used for monitoring for early detection efforts of future invasive plants at the site.

Scientific Name	**Common Name**	**Growth Habit**	**Currently Present in Indiana County?***
Acer platanoides	Norway Maple	Tree	Yes
Akebia quinate	Chocolate vine	Woody vine	No
Aralia elata	Japanese Angelica tree	Tree	No
Cardamine impatiens	Narrowleaf bittercress	Annual herb	Yes
Cardamine flexuosa	Woodland bittercress	Perennial herb	Yes
Catalpa ovata	Chinese catalpa	Tree	No
Eleutherococcus sieboldianus	Five-leaf aralia	Shrub	No
Euonymus fortunei	Wintercreeper	Woody vine	No
Ficaria verna	Lesser celandine	Perennial herb	Yes
Frangula alnus	Glossy buckthorn	Tree	No
Koelreuteria paniculata	Goldenrain tree	Tree	No
Oplismenus hirtellus	Wavyleaf basketgrass	Perennial grass	No
Prunus avium	Sweet cherry	Tree	No
Pyracantha coccinea	Scarlet firethorn	Perennial shrub	No
Pyrus calleryana	Callery pear	Tree	No
Rhamnus cathartica	Common buckthorn	Shrub/Tree	No
Rubus phoenicolasius	Wine raspberry	Shrub	No
Spiraea japonica	Japanese spirea	Shrub	Yes
Ulmus parvifolia	Chinese elm	Tree	No
Ulmus pumila	Siberian elm	Tree	No
Viburnum dilatatum	Linden viburnum	Shrub	No
Viburnum opulus	Guelder rose	Shrub/Tree	No
Viburnum plicatum	Doublefile viburnum,	Shrub	No

* We used the Mid-Atlantic Herbaria database (https://midatlanticherbaria.org) to search for records of each species in Indiana, County.

Author Biographies

Dr. Sara Kuebbing is an ecologist with expertise in forest ecology and invasive species. She has 5 years of professional experience working with local and regional conservation organizations on the management and conservation of protected lands, including invasive plant management. Dr. Kuebbing is currently an Assistant Professor at the University of Pittsburgh, where she runs an invasion ecology research lab.

Dr. Marion Holmes is an ecologist working as a postdoctoral fellow in Dr. Sara Kuebbing's lab. She has over 15 years of experience with wild plant identification and has participated in conservation projects, including mapping and management of non-native species, on both public and private lands. Dr. Holmes specializes in understanding the impacts of past land use on plant populations and communities, including the distributions of non-native species.

References

Writing an Invasive Plant Management Plan

U.S. Fish and Wildlife Service and California Invasive Plant Council. 2018. Land Manager's Guide to Developing an Invasive Plant Management Plan. Cal-IPC Publication 2018-01. National Wildlife Refuge System, Pacific Southwest Region, Inventory and Monitoring Initiative, Sacramento, CA. California Invasive Plant Council, Berkeley, CA. Available at www.cal-ipc.org and data.gov;
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Invasive Species Management Resources

Natural Lands Trust. 2008. *Controlling Invasive Plants*.
https://conservationtools-production.s3.amazonaws.com/library_item_files/379/444/NLT_controlling_invasive_plants.pdf?AWSAccessKeyId=AKIAIQFJLILYGVDR4AMQ&Expires=1633665598&Signature=CwHM4aSZOUjyvLvzzKm2HDQryCM%3D

Pennsylvania Invasive Species Resources

Governor's Invasive Species Council

The Commonwealth of PA convenes an advisory panel that includes seven state agencies and non-governmental organizations. The Council serves as a state-wide group with a purpose of identifying invasive species of concern that could threaten natural or agricultural resources within the state. They maintain the a statewide invasive management plan and list of resources.
Website:https://www.agriculture.pa.gov/Plants_Land_Water/PlantIndustry/GISC/Pages/default.aspx

Mid-Atlantic Invasive Plant Council

MAIPC is a regional non-profit group comprised of members from six mid-Atlantic states and the District of Columbia. The group provides regional leadership to effectively address the theat of

invasive plants to the native flora, fauna, and natural habitats. They maintain non-regulatory invasive species lists for member jurisdictions and resources on identifying and controlling common invasive plants in the region.
Website: http://www.maipc.org

Pennsylvania Department of Conservation and Natural Resources

The state agency with the most knowledge and expertise of invasive plant management in forested ecosystems. They maintain a non-regulatory list of common invasive plants in state natural areas and information on the identification and control of common invasive plant species.
Website: https://www.dcnr.pa.gov/Conservation/WildPlants/InvasivePlants/Pages/default.aspx

Penn State Extension Resources

Maintains an extensive set of fact sheets on identification and management of common invasive plants in Pennsylvania.
Website: https://extension.psu.edu/forests-and-wildlife/forest-management/invasive-and-competing-plants

Appendix: List of understory native Plants observed at White's Woods in May 2021

Actaea pachypoda
Actaea racemosa
Adiantum pedatum
Ageratina altissima
Antennaria sp.
Arisaema triphyllum
Botrychium virginianum
Carex pensilvanica
Carex sp.
Chimaphila maculata
Circaea lutetiana
Claytonia virginiana
Conopholis americana
Dennstaedtia punctilobula
Dioscorea villosa
Diphasiastrum digitatum
Dryopteris intermedia
Erigeron sp.
Eurybia divaricata
Eurybia macrophylla
Galium aparine
Galium circaezans
Galium odoratum
Geranium maculatum
Geum canadense
Goodyera pubescens
Hamamelis virginiana
Hydrastis canadensis
Impatiens sp.
Juncus sp.
Lycopodium sp.
Maianathemum canadense
Onoclea sensibilis
Osmorhiza claytonii
Osmunda claytoniana
Osmundastrum cinnamomeum
Parthenocissus quinquefolia
Persicaria virginana
Phegopteris hexagonaptera
Podophyllum peltatum
Polygonatum biflorum

Polystichum acrostichoides
Potentilla canadensis
Prenanthes altissima
Prosartes languinosa
Prunella vulgaris
Pteridium aquilinum
Ranunculus abortivus
Sanicula sp.
Sassafras albidum
Silene virginica
Smilax rotundifolia
Solidago caesia
Symplocarpus foetidus
Thalictrum thalictroides
Thelypteris noveboracensis
Urtica dioica
Vaccinium pallidum
Viburnum acerifolium
Viola appalachiensis
Viola blanda
Viola pubescens
Viola rotundifolia
Viola sororia
Viola triloba