MARYLAND SEA GRANT REPRINT

Bushkill Township Invasive Species Management Program Handbook

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Publication Number
UM-SG-RO-2014-10

UNIVERSITY OF MARYLAND
SEA GRANT COLLEGE PROGRAM
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DECEMBER 2014

Presented to:
University of Maryland – Center for Environmental Science
Maryland Sea Grant

Prepared for:
Bushkill Township, Northampton County, Pennsylvania

Prepared by:
Hanover Engineering
Bethlehem, Pennsylvania

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Hanover Project 4180

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This project was supported by a grant from the Mid-Atlantic Panel on Aquatic Invasive Species (award #F12AP01037), as well as limited funding through Bushkill Township and in-kind assistance for Geographic Information Systems services from John R. Wilson.

Executive Summary

This Handbook was prepared to educate and engage Bushkill Township residents and municipal staff for the proper identification, mapping, and treatment of targeted invasive plant species which are impacting our local environment.

Bushkill Township is a 25-square mile municipality located in northern Northampton County in eastern Pennsylvania. The existing land-uses primarily include rural residential development and active agriculture, with limited commercial, industrial, and other uses. Bushkill Township also contains considerable State Gamelands along the Blue Mountain Ridge and the 1,168-acre Jacobsburg State Park and Environmental Education Center. Waterways within the Township are listed in Chapter 93, Title 25 of the Pennsylvania Code as High Quality-Cold Water Fishes and Exceptional Value. The Bushkill Creek is the primary waterway within the Township, flowing from northwest to southeast. A major tributary to Bushkill Creek is Sobers Run, a portion of which is designated as Exceptional Value. An unnamed tributary to the East Branch Monocacy Creek originates in the southwestern corner of the Township and flows south toward Bethlehem. Wetlands within the Township are all classified as Exceptional Value where directly or indirectly connected (significant nexus) to stream channels due to all streams being listed by the Pennsylvania Fish and Boat Commission to support the natural reproduction of wild trout. It should also be noted that the Township contains numerous vernal ponds, with the highest concentration being all along the foothill area of the Blue Mountain Ridge.

Centuries of land-use for agriculture and recent conversion for rural residential development, including considerable supporting local and regional infrastructure improvements, has resulted in widespread introduction and establishment of many invasive exotic plant species in both upland and wetland environments. These species continue to increase and spread, and are causing impacts on native species, aesthetics, and water quality.

The Bushkill Township Invasive Species Management Program has been designed to catalog/map obvious populations of targeted invasive exotic plant species along public roads and on public lands throughout the Township. A student intern from Lafayette College worked with Township staff to conduct field evaluations and mapping. Plant populations were mapped using a new Internet application (app) which can be viewed and

The primary goal of the project is to increase resident awareness and involvement in mapping and treating for targeted invasive exotic species, including purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), Japanese knotweed (*Polygonum cuspidatum*), and tree-of-heaven (*Ailanthus altissima*). These species create the most impact and are priorities for treatment and eradication. In the future, other plant species will be added to the list of targeted species within Bushkill Township.

The ultimate goal of this project is for landowners to eradicate these species from their properties, or at least control their spread. This Handbook provides concise, important, and effective information about the targeted species and their control, including regulatory concerns for treatment.

1.0 Introduction

What Are Invasive Plant Species?

Invasive plant species are most commonly non-native plants that cause, or are likely to cause, economic or ecological harm or harm to human health (Presidential Executive Order 13112). Some native plants can be invasive, but generally do not cause excessive harm, and therefore are not generally targeted for treatment or control. The term "non-native" means they have been introduced by human action, intentionally or accidentally, into a region outside their natural geographic range. Other common terms for "non-native" include "exotic, alien, and non-indigenous." Invasive species may be introduced to new areas through a variety of pathways, such as shipping of goods from outside areas, intentional trade of species (e.g. gardening and landscaping), , or incidentally by attachment to migratory animals or to transportation vehicles. "Aquatic nuisance species" are a sub-set of invasive species that impact aquatic ecosystems (U.S. Congress 1990).

Many nonnative species do not cause environmental harm, and in some cases are beneficial, as with the majority of agricultural and horticultural species. Prior to concern for the potential impacts of non-native species, some intentional introductions for agricultural and horticultural purposes escaped cultivation and spread into natural areas and other places where they were unwanted. These plants exhibited considerable competitive advantages over native species, such as early season growth and lack of natural controls (e.g. bacteria, disease, and grazing by hnative animal species). The result in many cases has been displacement of native species, plant and animal, as well as economic impacts to agriculture and silviculture. Where surface waters are involved, there have been considerable impacts on water quality caused by erosion, as well as impacts on recreation and aesthetics. Impacts on many sensitive wetland and upland environments have also decreased species diversity and have greatly affected many rare, threatened, and endangered species.

Why Should We Care?

Economic losses due to invasive species in the U.S. are estimated at over $120 billion (Pimentel et al. 2005), a cost which will continue to increase as species spread and new species are introduced. These costs include damages to crops and pasture land, impacts on forests and waterways, and human and animal diseases, as well as associated control and treatment costs.

Ecological harm caused by invasive species can include near extirpation of native species, as in the cases of chestnut blight, emerald ash borer, and hemlock wooly adelgid, and alteration of natural ecological communities, as with snakehead fish, zebra mussel, round-eyed gobie, purple loosestrife, and common reed (*Phragmites sp.*).

Throughout evolutionary history, organisms have moved around the planet gradually, modifying their native ranges and adapting to meet new conditions. However, human actions in North America since the time of Columbus have transplanted species from their native ranges into new habitats at dramatically increasing rates with resulting establishment in new habitats. Some of these established transplants have become invasive. Unchecked, invasive species propagate and

spread to the detriment of native species which have not evolved competitive strategies or immunity to compete with the newly introduced species (Virginia Invasive Species Working Group, 2012).

Controlling and managing invasive species is a significant management goal in Bushkill Township and the watersheds of the Bushkill and Monocacy Creeks. Invasive plants are usually non-native plants that have no natural enemies. These invasive non-native species overrun the native communities into which they are introduced. Only about 10% of introduced plants become invasive, but once these plants become established, they are difficult to eliminate. Invasive species alter the natural ecology of an area by outcompeting and eliminating native species, displacing native plants and animals, destabilizing soils, and altering natural aesthetics of the landscape. In our region, the following species are common and should be actively managed: purple loosestrife, Japanese knotweed, multiflora rose, tree-of-heaven, garlic-mustard, bush honeysuckle, Japanese barberry, and common reed. If left unchecked, these populations could dramatically and irreversibly impact thousands of acres of upland, wetland, and riparian habitats.

Educational programs are offered through Jacobsburg Environmental Education Center and the Bushkill Stream Conservancy, with additional training available locally through The Nature Conservancy office in Long Pond. Bushkill Stream Conservancy has developed a powerpoint presentation and has held public seminars to educated the general public about invasive plant species, their respective impacts, and their management.

Currently, there is no active management program within the region, however, and efforts are far outweighed by the ongoing introduction and spread of the problematic invasive plants. Management efforts have been undertaken at Jacobsburg State Park and the Graver Arboretum where maintaining native plant assemblages is a particular focus. Additionally, some citizens have implemented management and control practices on their own private property to eradicate unwanted invasive, exotic species.

The Bushkill Stream Conservancy and The Nature Conservancy are both in the process of developing invasive plant management programs. These programs should focus on the most highly environmentally sensitive areas such as Moorestown Wetlands, Rissmillers Woods, and Knechts Ponds, but should also include all other watershed areas as part of a comprehensive management strategy to control the introduction and spread of invasive and exotic plant species.

The Bushkill Stream Conservancy has developed an invasive and exotic species monitoring program that integrates Global Positioning Systems (GPS) locating of sites with their new Geographic Information Systems (GIS) database. This program is still new, but has proven to be highly effective as a tool for mapping and monitoring invasive species. The GIS allows excellent mapping that is tied to data regarding species, aerial coverage, suggested control methods, and photographs of the sites.

Monitoring is also recommended to gain long-term control, as most of the species that are treated will require several growing seasons worth of treatment efforts to gain full eradication.

Monitoring results should be included in the GIS database to allow for more efficient and effective cataloguing of efforts and successes.

1.1 Goals and Objectives

The primary goal of the project is to increase resident awareness and involvement in mapping and treating for targeted invasive exotic species, including purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), Japanese knotweed (*Polygonum cuspidatum*), and tree-of-heaven (*Ailanthus altissima*). These species create the most impact and are priorities for treatment and eradication. In the future, other plant species will be added to the list of targeted species within Bushkill Township.

The ultimate goal of this project is for landowners to eradicate these species from their properties, or at least control their spread. This Handbook provides concise, important, and effective information about the targeted species and their control, including regulatory concerns for treatment.

Objectives identified for implementation of the Bushkill Township Invasive Species Management Program are:

1. Map populations of targeted invasive species on public lands and along roadways.
2. Develop an Internet-based Mobile Application (App) to support identification, mapping, and treatment by residents.
3. Develop a handbook for residents to use for implementation of the Bushkill Township Invasive Species Management Program.

1.2 Bushkill Township

Bushkill Township is a 25-square mile municipality located in northern Northampton County in eastern Pennsylvania (see Figure 1.1). The existing land-uses primarily include rural residential development and active agriculture, with limited commercial, industrial, and other uses. Bushkill Township also contains considerable State Gamelands along the Blue Mountain Ridge and the 1,168-acre Jacobsburg State Park and Environmental Education Center.

Water resources within Bushkill Township are extremely important to the local economy and well-being of the watershed residents. The many small and large streams are the central components of the Lehigh Valley ecology. The Bushkill Creek and its tributaries drain from the Kittatinny Mountains to the Delaware River, creating an interconnected web of greenways and unique natural areas (see Figure 1.2). The headwaters of an unnamed tributary to the East Branch Monocacy Creek also begin in the southwestern corner of the Township, flowing south toward the City of Bethlehem. The various water features in the watershed are described in the following paragraphs. A Glossary of Watershed Terms is provided in Appendix A.

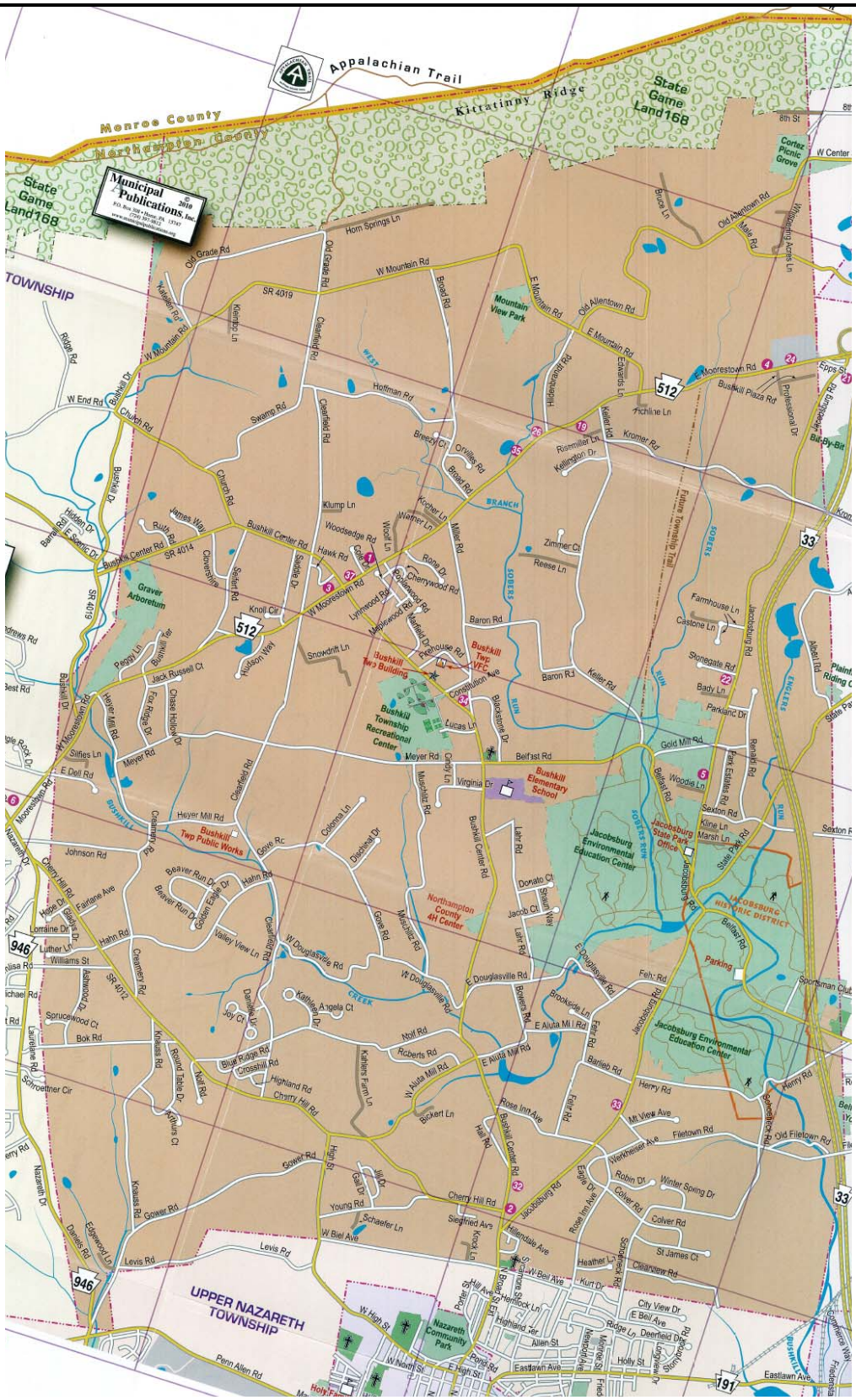


Figure 1.1	**Map of Bushkill Township Northampton County, Pennsylvania (Municipal Publications, Inc., 2010)**

The many small streams that form the beginning of Bushkill Creek originate at the base of Blue Mountain in northern Moore and Bushkill Townships. The mainstem of the Bushkill Creek flows in a southeasterly direction through rolling farmland and residential areas in Bushkill Township, passing through Jacobsburg State Park before entering the farmlands and developed areas of Palmer and Forks Townships. The Bushkill Creek eventually empties into the Delaware River just north of the Route 22 Bridge in Easton, a much more urbanized area than the upper watershed.

Four major tributaries join Bushkill Creek: Sobers Run in Bushkill Township, that drains the north-central part of the watershed; Little Bushkill Creek in Plainfield Township, that drains the northeastern section of the watershed; Schoeneck Creek in Nazareth and Palmer Townships, that drains the western portion of the watershed; and Spring Brook that drains a very small portion of the lower watershed in the City of Easton.

Bushkill Creek is classified as a High Quality Cold Water Fishery (HQ-CWF) stream. Groundwater recharge along the wooded slopes of Blue Mountain provides a critical source of high quality baseflow to the headwaters of Bushkill Creek in Bushkill, Plainfield, and Moore Townships. The southern end of Bushkill Creek is stocked with brown and rainbow trout, while the northernmost headwater streams support thriving populations of native brook trout. Bushkill Creek is listed by the Pennsylvania Fish and Boat Commission as a Class A Wild Trout Fishery from Tatamy through the City of Easton to the confluence with the Delaware River, making protection of the upper watershed a critical priority. The adjacent Monocacy Creek to the immediate west has very similar designations and is of equal importance, regionally, also warranting protection of headwater streams and wetlands.

Sobers Run, having a 10-square mile watershed entirely within Bushkill Township, is currently classified as a HQ-CWF, with the upper main stem classified as Exceptional Value (EV). Documentation is under final review to determine whether the EV classification may be given to the remainder of the Sobers Run, including its primary tributary, West Branch Sobers Run.

Wetlands are most common in the Bushkill Creek watershed along the foothill areas of the Blue Mountain (aka Kittatinny Ridge), although several other wetland complexes and vernal ponds exist south of that area. Many of these wetland areas are considered “Outstanding Natural Areas,” based on a 1999 Natural Areas Inventory of Northampton and Lehigh Counties by the Pennsylvania Science Office of the Nature Conservancy. Knechts Ponds and Moorestown Wetlands, both in Bushkill Township, fall into that category. Wetlands within the watersheds of local streams help to buffer impacts associated with stormwater runoff while providing important wildlife habitat.

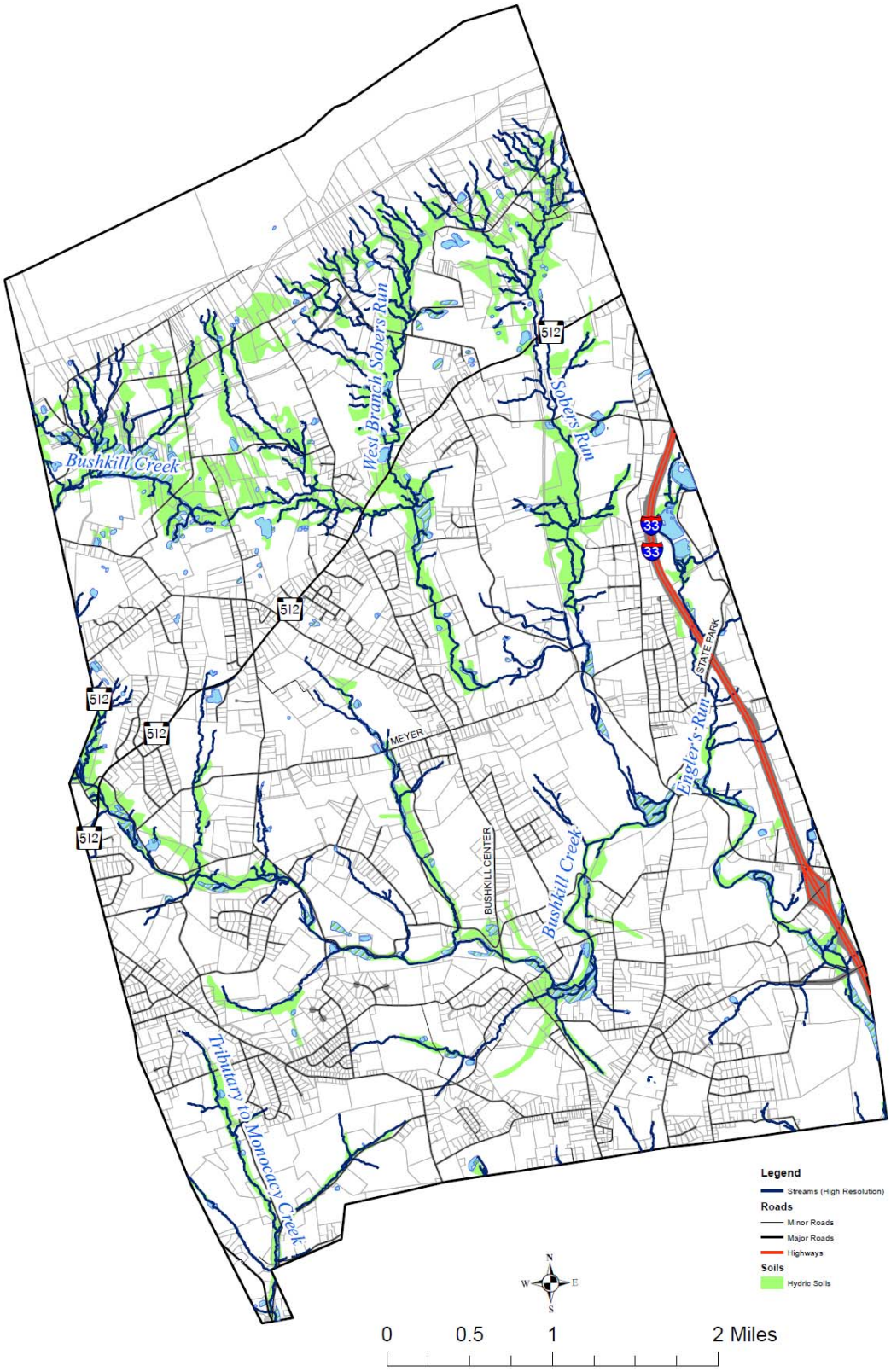


Figure 1.2	**Water Resource Map of Bushkill Township Northampton County, Pennsylvania Northampton County GIS Mapping (LVPC, 2014)**

2.0 Bushkill Township Invasive Species Management Program

2.1 Plan Strategies

This Program is geared toward practical application by the Township staff and residents to control targeted invasive plant species which may occur on their respective land. Targeted invasive species include purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), Japanese knotweed (*Polygonum cuspidatum*), and tree-of-heaven (*Ailanthus altissima*). These species create the most impact and are priorities for treatment and eradication. In the future, other plant species will be added to the list of targeted species within Bushkill Township.

During the summer of 2014, Bushkill Township worked with Lafayette College to identify and catalog the locations of these targeted species along public roads and on public lands (see Figure 2.1), using an Internet-based Mobile Application (App) developed by Hanover Engineering. The App was tested and finalized for use by Township staff and residents to continue cataloging new locations of these plants on Township lands and private properties, respectively. The App is available at http://arc.hanovereng.com/btis, and contains instructions for use, photographs of plans, information sheets for plants, and an interactive mapping program. Users may find their current location using the App and may catalog any of the target species with simple keystrokes for location, size, and density of plant populations observed. Data are maintained on a server at Lafayette College through an ongoing partnership with the College for watershed-based activities. Use of the App is intended to also provide current information to users on proper plant identification and treatment, as well as to educate about the spread of these species and to be an engaging platform to stimulate interest and implementation of the Program.

This Handbook is intended to introduce the Bushkill Township Invasive Species Management Program and to provide users with a simple and concise reference for implementation and for proper identification and treatment of invasive species on their respective properties.

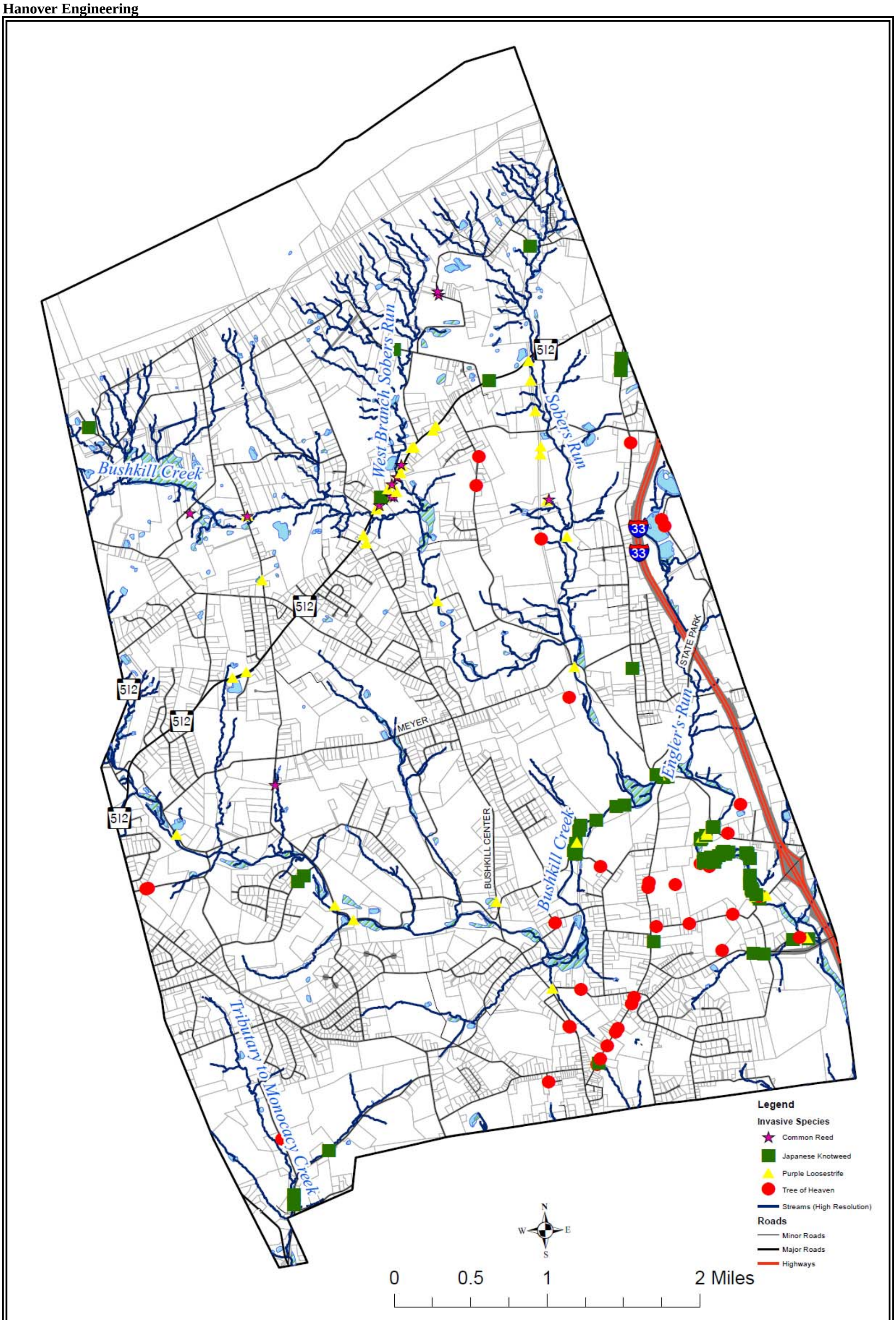


Figure 2.1

Current Mapping of Targeted Invasive Species in Bushkill Township
Northampton County, Pennsylvania
Northampton County GIS Mapping (LVPC, 2014)

2.2 Coordination

Invasive species management, in its entirety, is a very involved and complicated issue. There are many entities involved in different aspects, from landowners to government agencies, as well as environmental organizations, farmers, and the horticulture industry. The various stakeholders all have different objectives and positions, and are not always in perfect agreement. To further complicate matters, there are Local, State, and Federal regulations which may affect invasive species management practices.

The Bushkill Township Invasive Species Management Program is intended to help Township landowners and staff to best address certain target species which have been determined to be particularly damaging within Bushkill Township. The goal of the Program and this Handbook is to make the process simple, clear, and effective, so that species are identified, mapped, and treated. The following sections address the most common elements for successful management of the targeted invasive species, so that landowners and Township staff feel comfortable taking proper and legal action.

2.3 Prevention

Prevention of introduction of invasive exotic species should always be the top priority for all landowners, as it is the most effective and inexpensive means for maintaining natural plant communities. Prevention should be accomplished in two basic ways. The first is to maintain natural areas free of disturbance to existing vegetation and soils, since most invasive plant species easily colonize and spread in disturbed conditions. The second is to prevent invasive species from spreading once established. All landowners should become familiar with invasive species, especially those targeted by this Program, and should monitor their properties to ensure "early detection" (see Section 2.4, below) and treatment.

2.4 Early Detection and Reporting

Early detection and treatment is generally effective and relatively easy for eradication of unwanted invasive plant species. Properly identifying an invasive plant before it has time to spread and/or produce seed, with "rapid response" (see Section 2.6, below) for treatment using recommended methods (see Section 2.7, below, and Appendix C) will usually result in successful eradication. Catching and treating the problem early can generally be accomplished without any major disruption to the surrounding native vegetation or soils, and greatly minimizes the chance for reintroduction into that area, post-treatment.

Routine monitoring, such as annual or biannual monitoring of property, is recommended for all landowners as the best means for early detection and cost-effective treatment. Time and cost commitments for simple monitoring and treatment of any individual plants observed are generally minimal and highly successful. If plants are allowed to grow and spread, however, or if larger populations are encountered, treatment is generally much more difficult, time-consuming, and costly.

2.5 Mapping and Reporting

Invasive species observed should always be reported, regardless of treatment efforts implemented by landowners, so that these areas are cataloged and mapped for future reference, as well as targeted by landowners, interest groups, and the Township for treatment. Mapping information also helps others understand the patterns for establishment and spread of these harmful species. Currently, there are two good repositories for mapping of invasive species that can be accessed and used by the public

Bushkill Township's Internet App can be easily used by anyone to report and map invasive species populations and may be accessed at http://arc.hanovereng.com/btis. This App was specifically developed for use by Township residents and staff as part of the Bushkill Township Invasive Species Management Program. The App can be used on any handheld mobile device, such as smart-phones and tablets, to learn about and map targeted invasive plant species within the Township. The list of targeted invasive species is provided on the home page of the App, with identification information, photographs, and mapping instructions provided. The App allows users to find their current location on the mapping using Global Positioning Systems technology with the simple touch of a button. Using this functionality, a user can then mark the location of invasive species they observe, noting the general size of its coverage at that site. Once a site is marked on the map, the information is reviewed by the Township and will remain mapped indefinitely. The App also provides users with considerable information about the targeted species on fact sheets, including optimal treatment recommendations and methods that landowners can use on their own properties.

Reports of invasive species can also be filed with iMap Invasives, a similar statewide Internet-based mapping application which can be accessed at http://imapinvasives.org/paimi/map/. Having good mapping of invasive species serves many purposes, including obtaining funding and/or assistance for treatment when available, as well as support for State and Federal programs related to invasive species management.

2.6 Rapid Response and Regulations

Rapid response simply refers to treatment of invasive plant populations as soon as possible after identification and reporting. The information for proper treatment of species targeted by this Program is included in Appendix C. The most common methods for treatment are described below in greater detail in Section 2.7.

Regulations applicable to many treatment methods can be fairly confusing, but with a couple general rules, landowners can treat invasive species without breaking any laws. As a general rule, wetlands and waters (e.g. streams, ponds, springs, etc.) should never have any excavation or fill placed as part of treatment activities. Use of commercially available herbicides is allowable by landowners on their own property without formal certification as a Pesticide Applicator as along as application follows the product label and there is no direct contact with surface water of any kind, including by overspray. A landowner may apply an approved aquatic herbicide to water without formal certification as a Pesticide Applicator but with proper approval from the

Pennsylvania Fish and Boat Commission. Care should always be taken to treat only targeted plant species, and to not treat surrounding native plants.

Note: Use of approved herbicides may be required for some species which do not respond to other treatment methods. Approved herbicides are rigorously tested and deemed safe for use when strictly applied in accordance with the product label. See Appendix C and product labels, accordingly.

2.7 Control and Management

For the purposes of the Bushkill Township Invasive Species Management Program, control and management strategies are primarily geared toward implementation by private landowners on their own property and by the Township Public Works Department on Township property, with a lesser emphasis on commercial control and management options. Regulatory requirements for environmental, health, and safety are discussed in this document, especially for targeted species with fact sheets in Appendix C. Under all circumstances, it is the responsibility of the landowner or applicator to ensure full compliance with all applicable environmental, health, and safety regulations and requirements related to their particular actions and activities taken to control and manage invasive species. The following subsections include additional discussion related to various control and management methods.

2.7.1 Control Methods

Invasive species, by their very nature, are problematic to control and manage. These species spread easily and quickly through various means and as a result require landowners to be equally diligent in their actions. Eradication is commonly the goal for a landowner, although ongoing active management may be more realistic for the more-problematic species. Different species generally require different methods and/or combinations of different methods to optimize control effectiveness. Knowing the enemy is half of the battle – understanding the control methods available is the other half.

Primary control methods fall into three basic categories including biological, physical, and chemical. These categories are broad and each includes various techniques, applications, and alternatives, many of which are discussed below. **Fact sheets included in Appendix C for specific invasive species targeted within Bushkill Township include species-specific recommendations for optimal treatment.**

Biological Control Methods

Various biological control methods have become available for control and management of invasive plant species. As a rule, there is considerable scientific evaluation conducted on biological alternatives in an effort to protect against unintended consequences and collateral damage.

Herbivory – Animals such as insects or grazing farm animals are introduced into an infested area to damage or control growth and spread of the target species. In some cases, this application is very focused, with only the target species being damaged. In other cases, herbivores are less selective and damage both target and non-target species. Based on experience, herbivory exhibits variable effectiveness and does not result in eradication of target species. Where host-specific damages are the intent and are successful in causing considerable damage to the host (e.g. target species), the host species commonly loses some degree of its competitive edge and less dominant, or even non-dominant in the immediate landscape. Use of herbivory may also be employed as a natural or inexpensive means of hedging back spreading invasive plant populations, as well as a preliminary step in the treatment process to weaken plant root stocks prior to treatment with a chemical herbicide.

Predation – Similar to herbivory, predatory animals may be introduced to control targeted invasive animal species. This is not a common practice used by most landowners, but is a potential option for treatment and control of some species.

Habitat Modification – Invasive species, like all other species, prefer certain habitats in which to grow and thrive. Commonly, disturbed areas provide for easy establishment and optimal growing conditions for most invasive species. Planting native species that have characteristics to outcompete targeted invasive species may be a highly effective means for long-term control and restoration of natural, native habitats. For example, planting a disturbed area with a high density of native conifers should create a condition in which many lower-growing herbaceous and shrub invasive species will not grow and/or become dominant. The tall conifers will out-compete the target invasive species for light, space, water, and nutrients. In many cases, native herbaceous and shrub species will still grow under the dense and dark conifer canopy, and native animals will use this area as valuable habitat.

Physical Control Methods

Pulling (by hand or mechanical) – Removal of the plant by hand- or machine pulling may be very successful for some species, especially when all roots can be removed. Hand-pulling is the most simplistic means and may work for smaller plants or poorly rooted plants. For larger plants and more tenacious roots, hand tools for pulling may be used, and in worst cases machines may be used. Many invasive species are very hearty, however, and can regrow from even tiny segments of roots left behind. Under all pulling scenarios, follow-up inspections should be conducted, and in some cases other treatment methods should be used to complement.

Mowing/Cutting – This technique may be successful in killing plants that will not regrow from roots, such as some annuals, or may be used to weaken plants before other methods are then applied. As an example, Japanese knotweed is often cut prior to an application of herbicide to steam or to smaller regrowth. Tree-of-heaven is often cut, with an immediate application of herbicide to the remaining stump to kill roots before re-sprouting occurs.

Solarization – For small patches of invasive plant species growing in areas open to full sunlight, a dark tarp or plastic may be applied to cover the plants to use high temperatures from solar

radiation to kill plants and their roots. Generally, plants are cut to ground level, with proper disposal of cut parts to avoid spreading. The dark tarp or plastic is laid on the ground to cover plant crowns, rhizomes, roots, etc. and properly anchored. This technique is best used during the summer months when sunlight is strongest. The cover should remain in place for at least a couple weeks to ensure adequate success. Immediately following removal of the cover, the area should be seeded with a native plant seed mix with cover crop (e.g. annual ryegrass, oats, etc.) to establish coverage by desirable native species to help prevent reestablishment by non-native species which commonly colonize disturbed soils. The area should be monitored for the remainder of the growing season to ensure the target invasive species does not return and that no other invasive species become established. Early detection of any target or non-target invasive plants should lead to immediate treatment using methods such as hand-pulling or carful application of appropriate herbicide,

Freezing – Freezing is a technique that may work for some aquatic species and more southern species which may not tolerate harsher northern climates. Most commonly, freezing is used along pond and lake shorelines, where water can be drawn down under a State permit from the Pennsylvania Fish and Boat Commission, to expose the shoreline to freezing temperatures during winter months. As long as soils along the shoreline are also drained of water and are non-saturated, freezing may successfully kill the target species, including crowns, roots, and tubers. The decision to use this technique should account for unintended consequences of killing other non-target plants.

Drying – Drying is a practice that may be used to control certain invasive wetland or aquatic plants which get into managed facilities that are not regulated as wetlands, such as stormwater basins or treatment constructed wetlands, or sometimes in bottomlands that are wet but not classified as wetlands. This technique may also be used in some ponds and lakes where permitted water drawdown is possible for extended periods sufficient to dry bed or shoreline soils. In such instances, it may be possible to temporarily alter the hydrology of such systems, removing the water that keeps the soils saturated or moist and thereby killing the targeted invasive wetland or aquatic plants. The decision to use this technique should account for unintended consequences of killing other non-target plants.

Chemical Control Methods

Herbicide Application – Numerous approved chemical herbicides are available on the open market which may be used effectively for the treatment of invasive species. Different herbicides and application methods generally work for different species, and therefore research for species-specific applications should be conducted prior to any such treatment. Additionally, all applications should be made strictly in accordance with the product label on the selected herbicide. Any application made directly to surface water, including overspray, requires approval of a permit from the Pennsylvania Fish and Boat Commission. Application to private property by the respective landowner does not require certification as a Pesticide Applicator. Application on publicly owned land requires certification as a Pesticide Applicator, including by Township staff. See Appendix C for more information about herbicides which may be used for targeted invasive plant species in Bushkill Township.

Soil pH Adjustment – Different plants may grow better or worse in different soil pH values. For species that like acidic soils, lime may be added to raise the pH to become more basic. For species that like more basic soils, several soil amendments are commercially available which may be applied in accordance with the manufacturer's recommendations, such as elemental sulfur, iron sulfide, aluminum sulfate, etc. It is recommended to have soils pH tested prior to adding such amendments in order to know how much amendment to use to get to a certain pH.

Nutrient Management – Controlling the amount of nutrients in the soil or water may help to discourage growth and spread of invasive species, and may also promote colonization by native species and Habitat Modification (see description under Biological Control Methods, above).

3.0 References

Bushkill Stream Conservancy, 2000. Bushkill Creek Watershed Management Plan Goals and Recommendations. 12 pages.

Groenendall and Jones, 2001. Two Rivers Area Watershed Conservation Management Plan. (Addenda #1 of this document is the 2000 Bushkill Creek Watershed Management Plan Goals and Recommendations).

Halma, R., and C.S. Oplinger, 2001. The Lehigh Valley a Natural and Environmental History. The Pennsylvania State University Press, 375 pages.

Heritage Conservancy, 2004. Lehigh & Northampton Counties Riparian Buffer Assessment.

Lehigh Valley Planning Commission, 2004. Natural Features Plan Northampton County. Map prepared for the Northampton County Open Space and Natural Areas Program.

Lehigh Valley Planning Commission, 2004. Northampton County Open Space and Natural Areas Program.

New Hampshire Department of Environmental Services, 2014. It's Your Choice: Invasive Plant Control Options for Landowners.

The Nature Conservancy, 1999. A Natural Areas Inventory of Lehigh and Northampton Counties.

Penn State. Vegetation Management. Department of Horticulture. College of Agricultural Sciences. 2008. Invasive Plant Species Management – Quick Sheets.

United States Department of Agriculture Soil Conservation Service (SCS), 1974. Soil Survey of Northampton County Pennsylvania.

Urban Research and Development Corporation (URDC), 2004. Draft Two Rivers Area Greenways Plan.

Virginia Invasive Species Working Group. 2012. Natural Heritage Technical Document 12-13. Richmond, VA. 55 pages.

Wildlands Conservancy, 1991. Bushkill Stream Greenway Project.

APPENDIX A

GLOSSARY

aquatic nuisance species are a sub-set of invasive species that impact aquatic ecosystems (U.S. Congress 1990).

black list species are potential invasive species identified as of special concern and for which planning and education has been conducted to strengthen early detection and rapid response efforts.

ecosystem (or ecological system) all the living organisms and the nonliving components within a given area of the Earth.

invasive species are non-native plant, animal, or microbial species that cause, or are likely to cause, economic or ecological harm or harm to human health (Presidential Executive Order 13112). Established invasive species are present in a specific region of interest to the extent that eradication is not feasible. Potential invasive species are considered to have high likelihood of becoming invasive in a specific region, are not yet established, and their establishment may be prevented through early detection and rapid response efforts.

native (or indigenous) species have evolved within a specific geographic region or expanded their range naturally, i.e., without the benefit of intentional or accidental human transport.

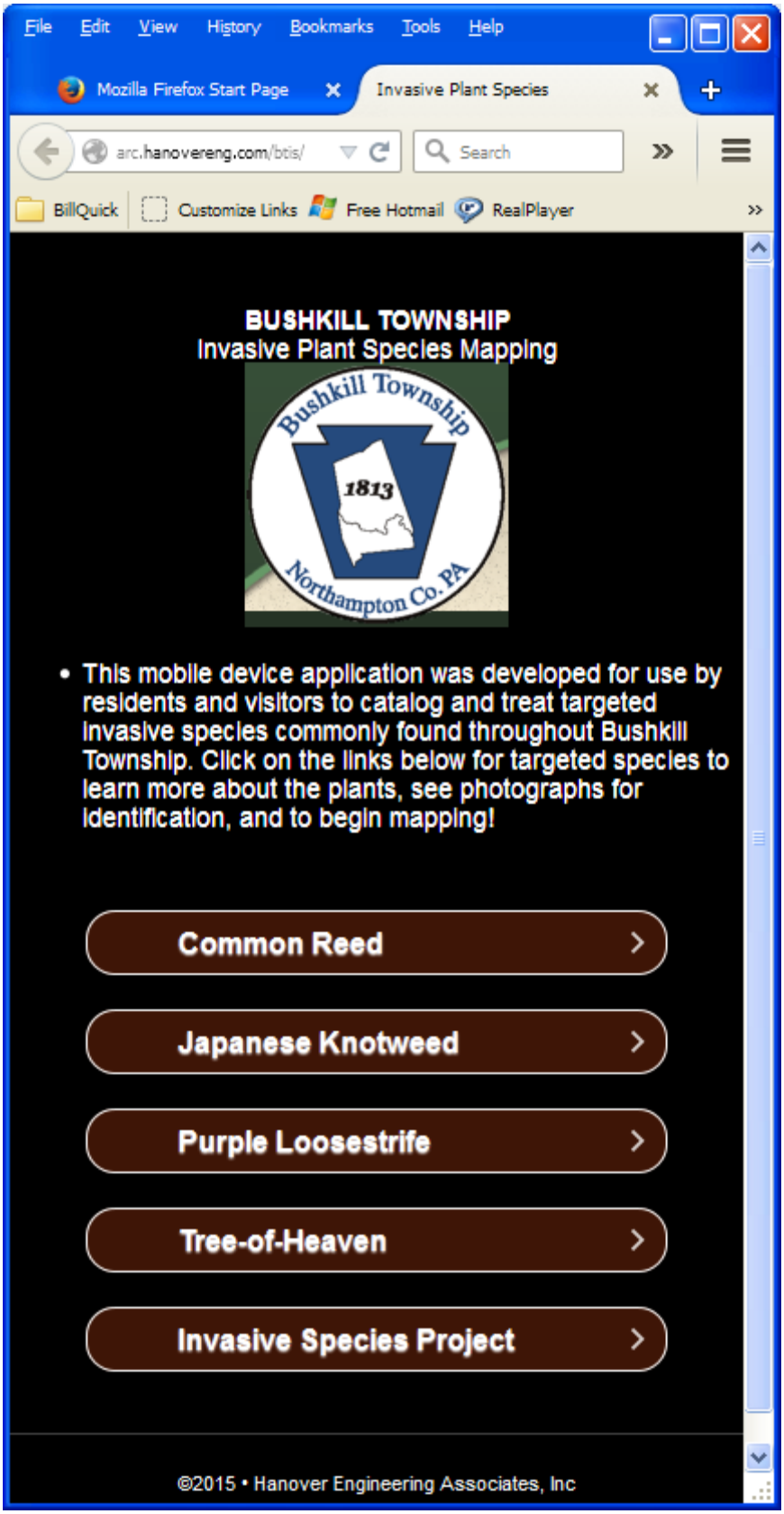
non-native (or alien, exotic, or nonindigenous) species have been transplanted from their native range by intentional or accidental human action.

pathway (or vector) is the artificial means by which species are transported from their native range into new regions. Ballast water, shipping containers, tourist luggage are examples of species pathways.

risk assessment is “a process for organizing and analyzing data, assumptions, and uncertainties to evaluate the likelihood of adverse ecological effects that may occur or are occurring as a result of exposure to one or more stressors.” (Source: “Ecological Risk Assessment in the Federal Government,” 1999, CENR/5-99/001)

APPENDIX B

MOBILE APPLICATION FOR INVASIVE SPECIES MANAGEMENT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BUSHKILL TOWNSHIP
Invasive Plant Species Mapping
Bushkill Township
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Northampton Co. PA
• This mobile device application was developed for use by residents and visitors to catalog and treat targeted invasive species commonly found throughout Bushkill Township. Click on the links below for targeted species to learn more about the plants, see photographs for identification, and to begin mapping!
Common Reed
Japanese Knotweed
Purple Loosestrife
Tree-of-Heaven
Invasive Species Project
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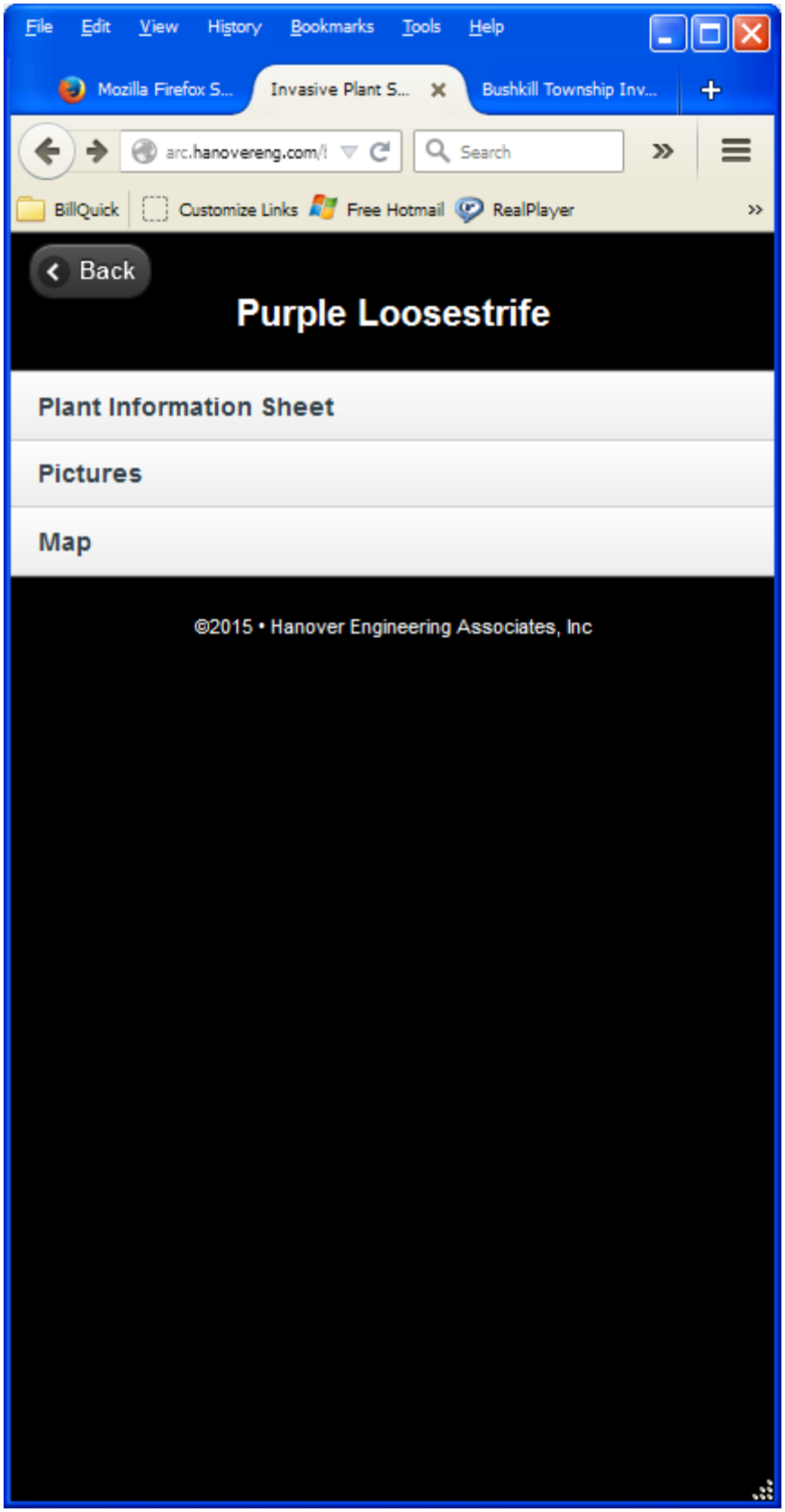
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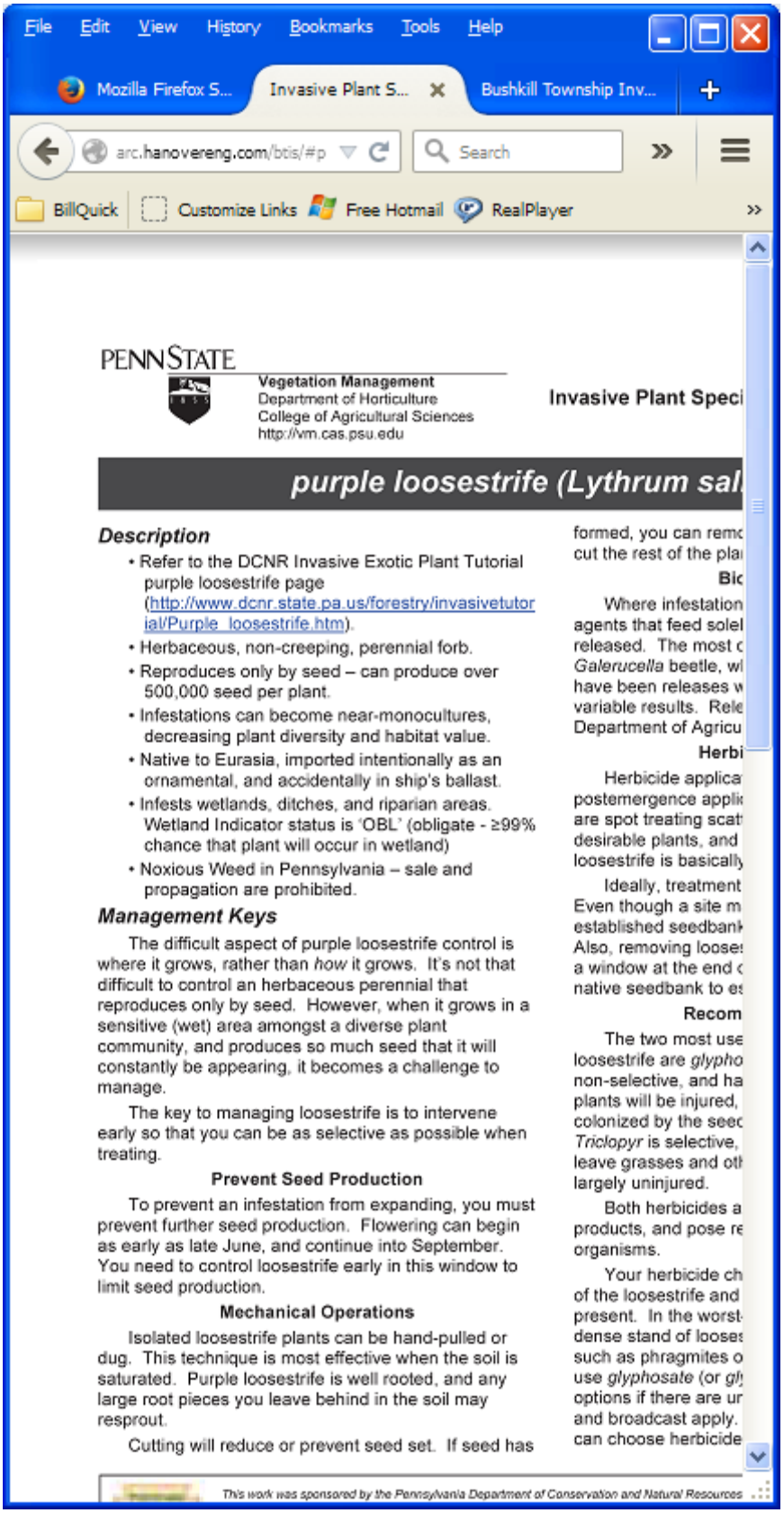

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Invasive Plant Speci

purple loosestrife (Lythrum sal

Description

- Refer to the DCNR Invasive Exotic Plant Tutorial purple loosestrife page (http://www.dcnr.state.pa.us/forestry/invasivetutorial/Purple_loosestrife.htm).
- Herbaceous, non-creeping, perennial forb.
- Reproduces only by seed – can produce over 500,000 seed per plant.
- Infestations can become near-monocultures, decreasing plant diversity and habitat value.
- Native to Eurasia, imported intentionally as an ornamental, and accidentally in ship's ballast.
- Infests wetlands, ditches, and riparian areas. Wetland Indicator status is 'OBL' (obligate - ≥99% chance that plant will occur in wetland)
- Noxious Weed in Pennsylvania – sale and propagation are prohibited.

Management Keys

The difficult aspect of purple loosestrife control is where it grows, rather than *how* it grows. It's not that difficult to control an herbaceous perennial that reproduces only by seed. However, when it grows in a sensitive (wet) area amongst a diverse plant community, and produces so much seed that it will constantly be appearing, it becomes a challenge to manage.

The key to managing loosestrife is to intervene early so that you can be as selective as possible when treating.

Prevent Seed Production

To prevent an infestation from expanding, you must prevent further seed production. Flowering can begin as early as late June, and continue into September. You need to control loosestrife early in this window to limit seed production.

Mechanical Operations

Isolated loosestrife plants can be hand-pulled or dug. This technique is most effective when the soil is saturated. Purple loosestrife is well rooted, and any large root pieces you leave behind in the soil may resprout.

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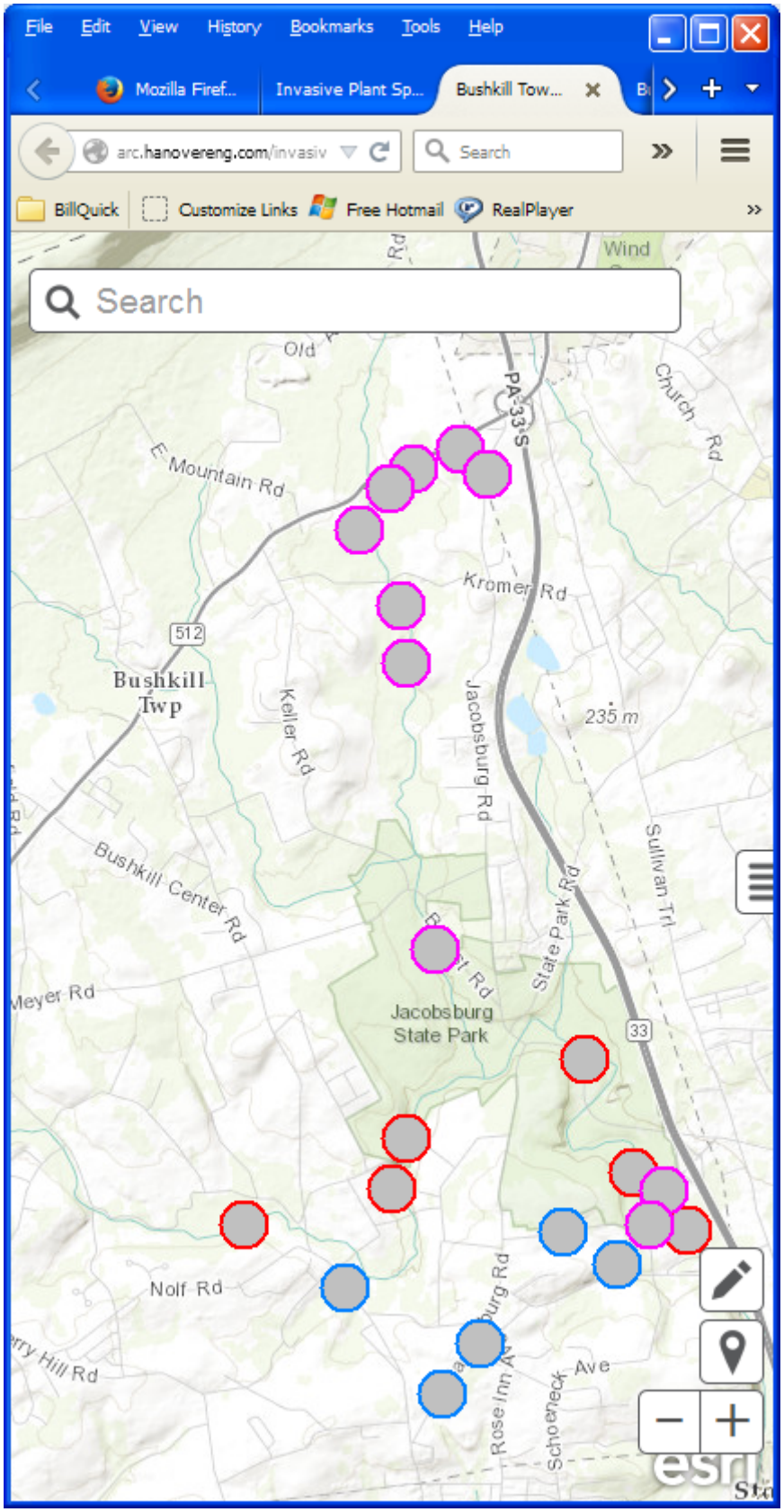
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APPENDIX C

FACT SHEETS FOR TARGETED INVASIVE SPECIES

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purple loosestrife (*Lythrum salicaria*)

Description

- Refer to the DCNR Invasive Exotic Plant Tutorial purple loosestrife page (http://www.dcnr.state.pa.us/forestry/invasivetutorial/Purple_loosestrife.htm).
- Herbaceous, non-creeping, perennial forb.
- Reproduces only by seed – can produce over 500,000 seed per plant.
- Infestations can become near-monocultures, decreasing plant diversity and habitat value.
- Native to Eurasia, imported intentionally as an ornamental, and accidentally in ship's ballast.
- Infests wetlands, ditches, and riparian areas. Wetland Indicator status is 'OBL' (obligate - ≥99% chance that plant will occur in wetland)
- Noxious Weed in Pennsylvania – sale and propagation are prohibited.

Management Keys

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Prevent Seed Production

To prevent an infestation from expanding, you must prevent further seed production. Flowering can begin as early as late June, and continue into September. You need to control loosestrife early in this window to limit seed production.

Mechanical Operations

Isolated loosestrife plants can be hand-pulled or dug. This technique is most effective when the soil is saturated. Purple loosestrife is well rooted, and any large root pieces you leave behind in the soil may resprout.

Cutting will reduce or prevent seed set. If seed has formed, you can remove the flowers for disposal, then cut the rest of the plant to the ground.

Biological Control

Where infestations are extensive, biological control agents that feed solely on purple loosestrife can be released. The most common agent released is the *Galerucella* beetle, which feeds on the foliage. There have been releases within the State Park system with variable results. Releases are coordinated with the PA Department of Agriculture and USDA-APHIS.

Herbicide Applications

Herbicide applications against loosestrife will be postemergence applications. The two basic scenarios are spot treating scattered loosestrife growing among desirable plants, and near-monocultures where loosestrife is basically the only plant present.

Ideally, treatment needs to occur before seed set. Even though a site may be heavily infested with an established seedbank, adding more seed is never good. Also, removing loosestrife earlier in the season provides a window at the end of the growing season for the native seedbank to establish.

Recommended Herbicides

The two most useful herbicides to manage loosestrife are *glyphosate* and *triclopyr*. *Glyphosate* is non-selective, and has no soil activity. All contacted plants will be injured, but openings will be quickly colonized by the seedbank and uninjured propagules. *Triclopyr* is selective, with minimal soil activity and will leave grasses and other monocots (sedges, rushes) largely uninjured.

Both herbicides are available as aquatic-labeled products, and pose reduced risk to non-target organisms.

Your herbicide choice will be based on the density of the loosestrife and the desirable species that are present. In the worst-case scenario where you have a dense stand of loosestrife and other invasive species such as phragmites or narrowleaf cattail, you need to use *glyphosate* (or *glyphosate* plus *triclopyr* to cover all options if there are undesirable woody species present) and broadcast apply. If the loosestrife is sparse, you can choose herbicides based on the desirable species

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that are present. If the desirable species are mostly monocots, *triclopyr* will be a more selective option.

Aquatic or Terrestrial Application?

The presence of widespread standing water or saturated soil render an application 'aquatic'. These conditions require the applicator to be certified for aquatic applications (Applicator Category 9) AND to get a permit from the PA Fish & Boat Commission to make the aquatic application. Time your applications for drier periods. Isolated standing water or saturated soil does not require a permit.

Follow-up Treatments

Due to the vast amounts of seed that loosestrife drops, it will always reappear on a site once it has become established. Purple loosestrife is not a species that you control, declare victory, and walk away. Once you have eliminated the original infestation, you will need to spot-treat new plants as they arise, on an ongoing basis. However, by keeping purple loosestrife in check and encouraging a native plant community, you will be providing the best habitat possible under the circumstances.

Figure 1. The management calendar for purple loosestrife emphasizes treatment before seed set. When seed is present it should be removed and destroyed prior to herbicide treatment, cutting, or pulling/digging.

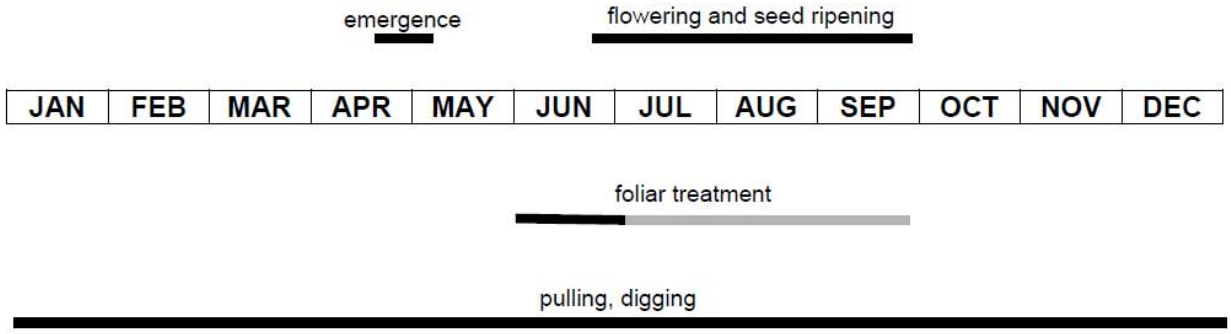

Table 1. Prescriptions for controlling purple loosestrife emphasize preventing seed set. Waiting until bloom stage will likely result in some production. Learn to identify loosestrife without flowers and implement controls prior to bloom.

timing	treatment	product rate	comments
any time	pulling or digging	n/a	When plant numbers are small, purple loosestrife can be pulled or dug. Loosestrife does not have a creeping root system, but leaving large pieces of root may result in regrowth – similar to dandelion or other taprooted perennials. Purple loosestrife is well rooted, so this should be done in saturated conditions.
June - September	foliar treatment with 'Garlon 3A'	2 qts/ac	'Garlon 3A' is a water-soluble formulation of *triclopyr* that is active against dicot weeds, and safe to most monocots (grasses, sedges, rushes, etc). It has aquatic labeling, and little soil activity. Use an aquatic-labeled surfactant such as 'Timerland 90'. If plant numbers are small, remove inflorescences and destroy them after flowering begins to reduce addition to the seedbank. In larger, established infestations this is not practical.
June-September	foliar treatment with *glyphosate* 'Aquaneat' or 'Glyphomate 41'	 3 qts/ac or 4 qts/ac	These *glyphosate* products are aquatic-labeled. 'Aquaneat' requires additional surfactant ('Timberland 90'), while 'Glyphomate 41' has surfactant pre-mixed. *Glyphosate* will injure all contacted plants. Sparse loosestrife should be spot-treated, while dense stands can be broadcast-treated. If plant numbers are small, remove inflorescences and destroy them after flowering begins to reduce addition to the seedbank. In larger, established infestations this is not practical.

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Invasive Plant Species Management

QuickSheet 2

common reed (Phragmites australis)

Description

- Common reed is usually known simply as 'phragmites'.
- Refer to the DCNR Invasive Exotic Plant Tutorial phragmites page (http://www.dcnr.state.pa.us/forestry/invasivetutorial/common_reed.htm)
- Herbaceous, rhizomatous, perennial, cool-season grass.
- Grows in tall (6 to 12-plus feet), dense stands that exclude almost all other vegetation.
- The invasive form of phragmites is an exotic genotype likely introduced via ship ballast. There is a native form that is less common.
- Grows in tidal and non-tidal marshes, other wet areas, and will persist in terrestrial settings when introduced via rhizome fragment.

Management Keys

Due to its sheer size and persistence, phragmites is difficult to control, but as long as you are willing to invest the effort and follow a few guidelines, it can be successfully suppressed.

Target the Rhizomes

To eliminate phragmites, you have to injure the rhizomes. This is most effectively done with systemic herbicides.

Timing is Key

Systemic herbicides are most effective when applied later in the growing season. This is when the foliage is sending sugars produced through photosynthesis to the roots and rhizomes. Systemic herbicides are moved in the same direction through the plant as the sugars.

Applications made too early in the season or too soon after cutting do not translocate to the rhizomes, and only injure the shoots.

Do Not Disturb

After herbicide treatment, it is important that you do not disturb the rhizome system through any type of excavation or vehicle rutting.

Cutting Helps

Cutting alone is not an effective suppression approach. However, cutting prior to an herbicide treatment will make the application easier. Cutting reduces the size and density of the regrowth, and eliminates the persistent stems from the previous season.

A point to consider is that it may be easier to simply spray the phragmites rather than cut it.

Be Patient

Wait 8 weeks after cutting before applying herbicide. If you apply too soon after cutting, the herbicide will not be translocated to the rhizomes.

Recommended Herbicides

Imazapyr ('Habitat' is an aquatic-labeled formulation) is regarded as the most effective herbicide against phragmites. However, *imazapyr* has considerable soil activity. Application near desirable trees and situations where you are relying on the seedbank for revegetation is not recommended.

Glyphosate is probably less effective than *imazapyr*, but has a greater 'comfort level'. *Glyphosate* is the active ingredient the many 'Roundup' products that are available for agricultural, professional, and homeowner use. As of this writing, the *glyphosate* products available on the PA statewide herbicide contract are 'Aquaneat' and 'Glyphomate 41'. Both of these products have aquatic labeling.

Glyphosate has several advantages:

- it *is* effective
- it has low toxicity to non-target organisms
- it has no soil activity
- it's relatively inexpensive

A new option still being evaluated is the herbicide *imazamox* ('Clearcast'). Operational results to date suggest it is very active against phragmites. It has less soil activity than *imazapyr*, and may be less injurious than *glyphosate* to many species that would be contacted during spray operations.

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Where's the Water?

If standing water is present, a spray application requires the presence of an applicator certified for aquatic application, and a permit from the PA Fish & Boat Commission. It's easier to wait for drier conditions so that a permit is not required.

Be Persistent

There are two phases of phragmites management – control and maintenance. The control phase takes two seasons, and includes at least two operations in year-one (e.g. cut and treat, or treat twice) and at least one operation in year-two.

After your control efforts have nearly eliminated phragmites, you need to periodically monitor the sites and treat any signs of new growth to prevent re-infestation.

Figure 1. The management calendar for phragmites emphasizes late-season applications of the herbicide glyphosate to maximize injury to the rhizomes.

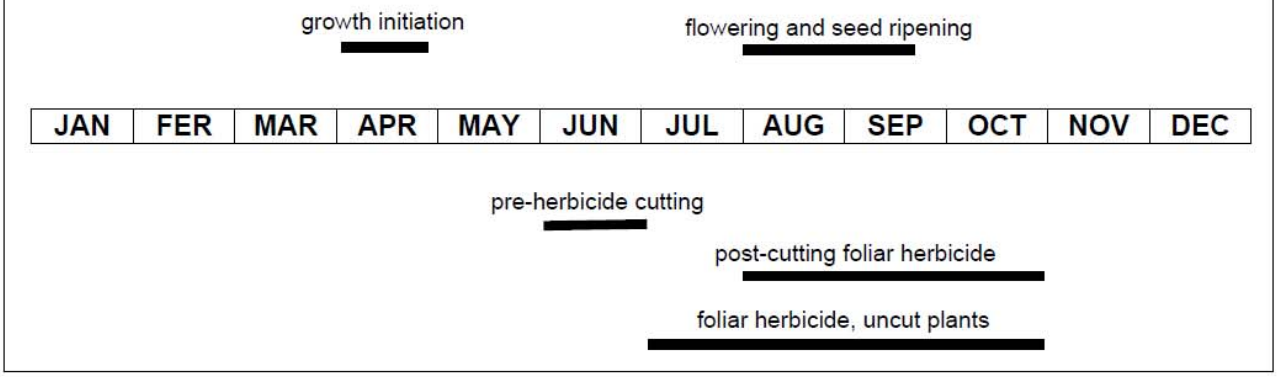

Table 1. Prescriptions for elimination of phragmites stress proper timing of operations to maximize injury to rhizomes. Improper timing (impatience) will result in treatments that provide 'topkill' (shoot injury) but no net effect.

timing	treatment	product rate	comments
June	cutting prior to foliar herbicide application	n/a	Cutting in June results in shorter, less dense regrowth. It also eliminates the persistent stems from previous seasons. This makes a subsequent herbicide application easier. However, cutting is very laborious – unless you have a small infestation or a mower that won't get stuck or leave damaging ruts, it may easier to spray twice rather than to manually cut and spray.
anytime	cutting	n/a	Repeated cutting does not eliminate phragmites, but it does slow its growth and lateral spread significantly. Where phragmites is adjacent to mowed areas, it should be included in the mowing regimen (conditions permitting). If you are going to treat phragmites with a systemic herbicide, stop mowing 8 weeks prior to application.
At least 8 weeks after mowing, or to uncut phragmites after July 1	'Aquaneat' or 'Habitat' or 'Clearcast'	7.5 pints/acre or 5 pints/acre or 4 pints/acre	Use any of these products to treat regrowth, waiting eight weeks after the cutting to treat, or treat uncut phragmites after July 1. Phragmites will usually remain green into late October, allowing time for a follow-up application as well. 'Habitat' (*imazapyr)* has significant soil activity and should not be used over the root system of desirable trees
fall follow-up, while foliage is still green	'Aquaneat'	7.5 pints/ac	Phragmites can be treated as late as early November in some locations. Use an aquatic-labeled *glyphosate* product for the follow-up treatment if 'Habitat' or 'Clearcast' were used for the initial treatment.
after herbicide treatment	STAY OUT	n/a	Do not disturb the rhizome system after herbicide application. Where rhizomes are severed due to mechanical injury, you will likely observe more resprouting.

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Japanese knotweed (Polygonum cuspidatum)

Description

- Refer to the DCNR Invasive Exotic Plant Tutorial knotweed page (http://www.dcnr.state.pa.us/forestry/invasivetutorial/japanese_knotweed.htm), which describes Japanese knotweed and giant knotweed (*Polygonum sachalinense*).
- Herbaceous, rhizomatous, perennial dicot.
- Dioecious – male and female flowers on separate plants.
- Grows in tall (6 to 10-plus feet), dense stands that exclude almost all other vegetation.
- Native to East Asia, imported as an ornamental in the late-1800's.
- Grows almost anywhere, from acidic spoil in full sun to fertile, shaded alluvial soils along rivers and streams.

Management Keys

Japanese knotweed is difficult to control, but as long as you are willing to invest the effort and follow a few key guidelines, it can be successfully suppressed.

Target the Rhizomes

To eliminate knotweed, you have to injure the rhizomes. This is most effectively done with systemic herbicides, when the plant canopy is exporting sugars to the rhizomes for growth and storage.

Timing is Key

Systemic herbicides are most effective when applied later in the growing season (Figure 1). This is when the foliage is sending sugars produced through photosynthesis to the roots and rhizomes. Systemic herbicides are moved in the same direction through the plant as the sugars.

Applications made too early in the season or too soon after cutting do not translocate to the rhizomes, and only injure the shoots.

Cutting Helps

Cutting alone is not an effective suppression approach. However, cutting prior to an herbicide application can be very helpful. If you wait until about June 1 to cut, and wait 8 weeks to treat, you will find that the knotweed regrowth is much shorter than when it was cut. Typically, knotweed regrows 2 to 4 feet tall.

When knotweed is growing near water, cutting is useful because it is easier to treat the shorter regrowth without getting spray solution into the water.

If the knotweed is not near water, you have to decide if cutting the knotweed is a good use of your finite time and effort. Treating intact knotweed towering over your head is a lot like work, but cutting may be even more work.

Be Patient

Wait 8 weeks after cutting before applying herbicide. If you apply too soon after cutting, the herbicide will not be translocated to the rhizomes.

Recommended Herbicides

We recommend the herbicide *glyphosate*. *Glyphosate* is the active ingredient in the many 'Roundup' products that are available for agricultural, professional, and homeowner use. As of this writing, the *glyphosate* products available on the PA statewide herbicide contract are 'Aquaneat' and 'Glyphomate 41'.

Glyphosate has several advantages:

- it's effective
- it has low toxicity to non-target organisms
- it is available in aquatic-labeled formulations
- it has no soil activity
- it's relatively inexpensive

The herbicide *imazapyr* ('Arsenal Powerline', 'Habitat') is effective against knotweed, but has considerable soil activity and can injure nearby trees through root absorption.

The herbicide *triclopyr* ('Garlon 3A') is recommended in some accounts, but our research has shown that rates up to 4 quarts/acre had no visible effect on the following year's growth.

Be Persistent

There are two phases of knotweed management – control and maintenance. The control phase takes two seasons, and includes at least two operations in year-one (e.g. cut and treat, or treat twice) and at least one application in year-two.

After your control efforts have nearly eliminated the knotweed, you need to periodically monitor the sites

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and treat any signs of new growth to prevent re-infestation.

After the Knotweed

If you remove the knotweed early in its infestation, you probably will not need to establish replacement vegetation.

When a knotweed infestation is well established, you may need to suppress the vegetation that follows as well, and establish desirable plants in that space. If you are planning on replanting the area, BE PATIENT. If you plant desirable vegetation before the knotweed is completely suppressed, it will be much harder to manage the remnant knotweed without injuring the desirable plants.

Figure 1. The management calendar for Japanese knotweed emphasizes late-season applications of the herbicide glyphosate to maximize injury to the rhizomes.

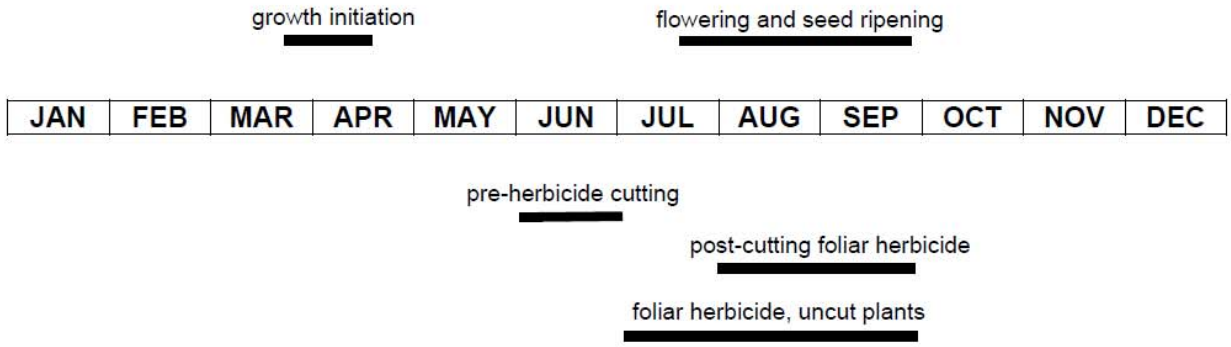

Table 1. Prescriptions for controlling Japanese and giant knotweed stress proper timing of operations to maximize injury to rhizomes. Improper timing (impatience) will result in treatments that provide 'topkill' (shoot injury) but little net effect.

timing	treatment	product rate	comments
June	cutting prior to foliar herbicide application	n/a	Cutting in June results in shortened regrowth and elimination of persistent stems from the previous season. This is a particular advantage in riparian settings, where knotweed will hang over the water. In this situation, it is impossible to treat without contacting the water with herbicide solution (therefore requiring a permit and an aquatic-certified applicator). Cutting will result in regrowth that is 2 to 4 ft. tall, which can be treated using a backpack sprayer (as opposed to a high volume application with a handgun), and without contacting the adjacent water.
anytime	cutting	n/a	Cutting does not eliminate knotweed, but it does slow its growth and lateral spread significantly. Where knotweed is adjacent to mowed areas, it should be included in mowing regimen. If you are going to treat the knotweed with a systemic herbicide, stop mowing 8 weeks prior to application.
At least 8 weeks after mowing	'Aquaneat' or 'Glyphomate 41'	4 qts/acre or 5.7 qts/acre	Use either of these *glyphosate* products to treat knotweed regrowth, waiting eight weeks after the June cutting to treat. The product rates differ because the glyphosate concentration differs. The application rates provide 4 lbs of *glyphosate*-acid per acre. Applications of 'Aquaneat' will require an additional surfactant (e.g. 'Timberland 90'). No additional surfactant is needed with 'Glyphomate 41'. Work at the early end of the operational windows so you can make a 'touch-up' application with the same treatment in September, before a killing frost.
July 1 to mid-September	'Aquaneat' or 'Glyphomate 41'	4 qts/acre or 5.7 qts/acre	Treatment to uncut knotweed should be delayed until after July 1. Unless the knotweed patches are small, this will need to be a high volume application. It is very difficult to get thorough coverage of dense vegetation that is over your head. Follow-up in September to treat misses and resprouts.

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Tree-of-heaven (Ailanthus altissima)

Description

- Tree-of-heaven is commonly known as 'ailanthus'.
- Refer to the DCNR Invasive Exotic Plant Tutorial ailanthus page (http://www.dcnr.state.pa.us/forestry/invasivetutorial/tree_of_heaven.htm).
- Fast growing, weak-wooded, clonal (root suckering) tree.
- Dioecious – male and female flowers on separate plants.
- Individual stems are relatively short-lived, but they can reach heights of 80 ft.
- Grows in dense clones where ailanthus stems occupy all layers, from understory to canopy.
- Native to East Asia, imported as an ornamental and urban street tree in the late-1700's.
- Grows almost anywhere, from sidewalk cracks or spoil in full sun to fertile, shaded alluvial soils along rivers and streams.

Management Keys

Due to its size and vigor, and extensive spreading root system, ailanthus can be difficult to control. As long as you are willing to invest the up-front effort and follow a few key guidelines, it can be successfully suppressed.

Target the Roots

To control ailanthus, you have to injure the root system. This is most effectively done with systemic herbicides, when the plant canopy is exporting sugars to the roots for growth and storage.

Timing is Key

Systemic herbicides are most effective when applied later in the growing season (Figure 1). For ailanthus, we recommend waiting until July 1 to initiate treatment. This is when the foliage is sending sugars produced through photosynthesis to the roots. Systemic herbicides are moved in the same direction through the plant as the sugars.

Applications made too early in the season do not translocate to the roots, and only injure the aboveground growth.

Management Approach

You need a program to manage ailanthus, not occasional bursts of activity. Ailanthus management falls into two phases – control and maintenance. The control phase will require two growing seasons, and the maintenance phase will be ongoing.

Anticipate three treatments during the control phase, and at least biennial treatments during the maintenance phase. If you are successful during the control phase, very little effort is required during the maintenance phase to prevent reinfestation.

Mechanical Operations

Cutting ailanthus is often necessary to remove potentially hazardous stems, but it is not usually useful as a control measure. You should only cut ailanthus if you are planning on treating the resulting resprouts. In situations where you want to remove ailanthus stems, it is better to cut *after* you have treated with herbicides.

Herbicide Applications

Ailanthus can be effectively treated with foliage or stem treatments. Tall, dense growth is best treated with a high volume ('spray to wet') application, while smaller stems can be treated with a low volume approach.

Effective stem treatment methods include basal bark and 'hack and squirt'. Basal bark treatments use a concentrated mixture of herbicide in oil, applied to the complete circumference of the lower 12 to 18 inches of the stem. The 'hack and squirt' method uses concentrated herbicide solution applied to spaced cuts around the perimeter of the stem. It is critical that the stem cuts are spaced so the applied herbicide can translocate to the roots. If you completely girdle the stem, the herbicide can only move up in the stem, and you will not injure the roots or the stem below the girdle.

Dense, or extensive infestations should be treated initially with a foliar application. The 'clean-up' application can be stem treatment, or foliar, depending on the size of the remaining stems. Large, tall stems are easier to treat with stem treatment, while smaller stems are easier to treat with a foliar application.

This work was sponsored by the Pennsylvania Department of Conservation and Natural Resources, Bureau of State Parks (PA DCNR).
By Art Gover, Jon Johnson, Kirsty Lloyd, and Jim Sellmer, 2008. The contents of this work reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the PA DCNR or The Pennsylvania State University at the time of publication.

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Recommended Herbicides

There are many herbicides available that are very effective against ailanthus, but we recommend using *glyphosate* and *triclopyr*. For foliar applications, we recommend a mixture of these herbicides (Table 1). Either herbicide can be used for hack-and-squirt treatments, and *triclopyr* is available in oil soluble formulations for basal bark applications.

What about Stump Treatment?

If you need to cut down ailanthus for immediate safety reasons, by all means do so and treat the stump. However, cutting the stems and treating the stumps does not provide effective control of the roots. When you remove the top, there is no more downward flow of sugars to the roots. Stump treatment of ailanthus will keep the stump free of sprouts, but it will not prevent root suckering.

If you want to cut ailanthus, treat it first, and then wait until the dormant season to cut it down. You should cut it before the next growing season because standing dead ailanthus decays quickly. If you leave it stand too long, you may be faced with considerable hazard while trying to remove the ailanthus.

Figure 1. The management calendar for ailanthus emphasizes late-season treatment to maximize injury to the roots.

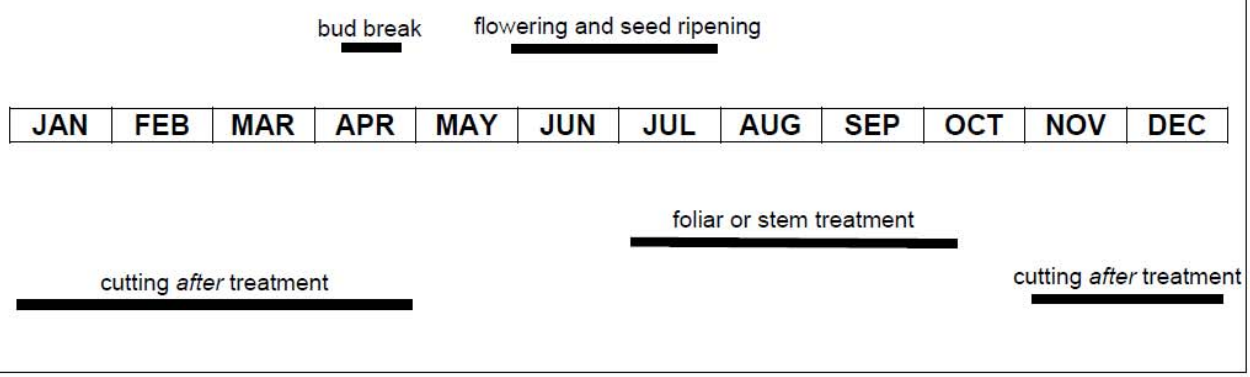

Table 1. Prescriptions for controlling ailanthus stress proper timing of operations to maximize injury to the roots. Improper timing will result in treatments that provide 'topkill' (shoot injury) but little net effect.

timing	treatment	product rate	comments
July 1 to fall color	foliar application of 'Aquaneat' plus 'Garlon 3A'	 3 qts/acre plus 1 qt/acre	The combination of *glyphosate* and *triclopyr* provides a broad-spectrum treatment that is effective against ailanthus and other woody species that should be targeted as well during the application. This is a non-selective mixture, but it has little soil activity, poses low risk to non-target organisms, and both products have aquatic labeling. A surfactant needs to be added. If the *glyphosate* product 'Glyphomate 41' is used instead (4.25 qts/acre), no additional surfactant is needed.
July 1 to fall color	basal bark application 'Pathfinder II'	 ready-to-use	'Pathfinder II' is an oil-based formulation of *triclopyr* that can be used for basal stem applications. Treat the entire circumference of the lower 12 to 18 inches to wet the stem without runoff. This technique is laborious, and is best suited for treating small infestations or as a follow-up to a foliar application.
July 1 to fall color	hack-and-squirt 'Aquaneat' or 'Glyphomate 41' or 'Garlon 3A'	 undiluted or 1:1 with water	These are water-based formulations useful for hack-and-squirt treatments. It is essential to space the cuts so there is intact bark between the cuts. If you completely girdle the stem, the herbicide cannot translocate to the roots. A simple guideline for number of cuts is 'inches in diameter plus one'. This is a laborious treatment best suited for low stem numbers, and stems at least 1-inch in diameter. Treat immediately after cutting, filling the cut with herbicide mixture.

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