



TRANSMITTAL LETTER

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Invasive Species Best Management Practices

INFORMATION AND SPECIAL INSTRUCTIONS:

The intent of the document is to provide PennDOT staff, as well as contractors working for the Department, Best Management Practices (BMPs) to help them address invasive species throughout the life of a project from design, through construction, and finally continuing ongoing maintenance. BMPs are methods or techniques found to be the most effective and practical in achieving an objective, such as preventing or minimizing the spread of invasive plants, while making optimal use of resources. Prevention BMPs that minimize invasive plant spread in transportation corridors can help:

- Reduce future maintenance needs and costs
- Reduce fire hazards
- Reduce herbicide use
- Enhance visibility, access and safety
- Limit the liability to PennDOT
- Maintain good public relations
- Protect existing wildlife habitat, native plant populations and beneficial insects.

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Pennsylvania Department of Transportation

Invasive Species Best Management Practices

Table of Contents

	<u>PAGE</u>
Chapter 1: Introduction	1
Legal Authority	2
FHWA Policy.....	3
PennDOT Policy (Highway Design)	3
Chapter 2: General Management Strategy and Guidance	3
Options for Incorporating Standard BMPs into all PennDOT Processes	4
Options for Incorporating BMPs into Design.....	4
Options for Incorporating BMPs into Construction.....	6
Options for Incorporating BMPs into Maintenance.....	8
Chapter 3: Common Invasive Species and Recommended BMPs	12
Common Invasive Plant Species and Recommended BMPs	13
Common Invasive Insect Species and Recommended BMPs.....	26
Common Invasive Non-plant Aquatic Species and Recommended BMPs	29
 Appendix A: Invasive Species Web Sites List	 32
Appendix B: Plant Structures.....	34
Appendix C: PFBC Biosecurity Protocols.....	36
Appendix D: Photograph and Drawing Credit List by Species	39

Chapter 1

INTRODUCTION

Invasive species represent one of the most significant ecological threats of the 21st century. Invasive species are exotic plants and animals that have been intentionally or accidentally introduced into native ecosystems. These invasive species displace native species and change the ecological structure of the invaded community, sometimes with dire consequences to native plants and animals. The problem attained national prominence in 1999 when President Clinton signed Executive Order 13112, which requires each federal agency to address the issue of invasive species.

The Pennsylvania Department of Transportation (PennDOT) has taken the initiative to address invasive species within its rights-of-way (ROWs) by preparing this guidance document. The intent of the document is to provide PennDOT staff, as well as contractors working for the Department, Best Management Practices (BMPs) to help them address invasive species throughout the life of a project from design, through construction, and finally continuing ongoing maintenance. BMPs are methods or techniques found to be the most effective and practical in achieving an objective, such as preventing or minimizing the spread of invasive plants, while making optimal use of resources. Prevention BMPs that minimize invasive plant spread in transportation corridors can help:

- Reduce future maintenance needs and costs
- Reduce fire hazards
- Reduce herbicide use
- Enhance visibility, access and safety
- Limit the liability to PennDOT
- Maintain good public relations
- Protect existing wildlife habitat, native plant populations and beneficial insects, as well as threatened and endangered species.

Effective implementation of BMPs will require a process of continuous learning. These voluntary BMPs were developed with the understanding that each situation and district has different needs, constraints and resources. The applicability and effectiveness of BMPs will vary with existing land uses, degree of human disturbance, the objectives of the land owners and the resources available for management activities.

Conducting a thorough pre-activity assessment will help to identify which tasks can spread invasive plants. Many of these BMPs may overlap with existing practices or standard mitigations, such as those for stormwater pollution prevention, erosion and sediment control, clean air regulations, pest quarantines or threatened and endangered species protections. Department staff are encouraged to incorporate the appropriate best management practices for each situation whenever they are practicable. Note that when noxious weeds are encountered in the ROW, certain actions may be required.

The intent of this manual is to bring awareness to invasive plants and the role that PennDOT can play in limiting the spread of these species along our rights-of-way and into

adjacent habitats. This document provides general information on the control of invasive species, a basic set of Best Management Practices (BMPs) to use as a start to addressing this issue, and a watch list of invasive species commonly identified in Pennsylvania ROWs with identification information. Finally, there are links to help staff find the information necessary to stay current and to develop detailed invasive species control plans for their District's responsibilities.

Be aware that "control of noxious weeds and establishment of native species" are activities that are eligible for federal funding under programs such as the National Highway Performance Program (NHPP) and Surface Transportation Program (STP).

The procedures herein are not an adjudication or regulation. There is no intent on the part of PennDOT to give the procedures in this guidance document weight or deference. This document establishes the framework within which PennDOT will exercise its administrative discretion to deviate from this document, if circumstances warrant. This guidance document is for informational purposes only; it is not regulatory.

Legal Authority

There are four sources of authority that provide legally binding direction with respect to the need to control, eradicate, or prevent invasive species presence in the ROWs of Pennsylvania; two are federal and two are state. To read the complete laws and executive orders, go to DCNR's web site on invasive species "[Laws and Regulations](#)". For a list of Noxious Weeds in Pennsylvania use the [Noxious Weed List](#) on Pennsylvania Code website. Noxious Weeds are a subset of invasive species.

The **Federal Noxious Weed Act** is a federal law which provides for the control and management of non-indigenous weeds that injure or have the potential to injure the interests of agriculture and commerce, wildlife resources, or the public health. **Executive Order 13112 of February 1999** is a federal executive order which defines an "invasive species" as an alien or nonnative species whose introduction does, or is likely to cause, economic or environmental harm or harm to human health. It outlines federal agency duties, establishes an Invasive Species Council and identifies their duties, and requires the preparation of a federal Invasive Species Management Plan. Finally, the executive order provides definitions related to the topic and judicial review and administration.

The **PA Noxious Weed Law** is a state law which provides a list of 13 plants that are illegal to propagate, sell, or transport in Pennsylvania (see pages 11 and 12). This list addresses agricultural weeds and, more recently, has included weeds of natural areas. **PA Executive Order 2004-1 is a state executive order which** was signed by Governor Ed Rendell on January 27, 2004; establishes the *Pennsylvania Invasive Species Council (PISC)*. The purpose of PISC is to advise the Governor on, and direct the development and implementation of, a state invasive species management plan; provide guidance on prevention, control, and rapid response initiatives; and facilitate coordination among federal, regional, state, and local efforts on invasive species work.

FHWA Policy

The [**FHWA Policy Statement on Invasive Alien Species**](#), dated April 22, 1999, overviews the federal efforts, including the Department of Transportation (DOT), to prevent and control the introduction of invasive species. It directs the Secretarial offices and operating administrations to implement E.O. 13112 by adhering to the policy that address roadside vegetation management issues on both construction activities and maintenance programs in a coordinated response against the introduction and spread of invasive species. The [**FHWA Guidance on Invasive Species**](#), dated August 10, 1999, gives a more detailed description of work items to be conducted to implement E.O. 13112 in terms of use of federal funds, FHWA National Environmental Policy Act (NEPA) analysis, state DOT activities and funded facilities, innovative design, coordinated research, training, interagency cooperation, and interagency committees. For Federally funded projects, these policies would be applicable.

PennDOT Policy (Highway Design)

PennDOT has been reviewing its highway design manuals as result of E.O. 13112 to include information on how to address invasive species in its work. [**Publication 13 M - Design Manual Part 2**](#) addresses re-vegetation of ROWs in Chapter 8 (Landscape Planting Design/Roadside Development) and Chapter 9 (Safety Rest Areas and Welcome Centers). [**Publication 408**](#), Section 800 (Roadside Development) in 804 and 808 addresses proper seed and plant selection and weed control. The U.S. Army Corps of Engineers and PA DEP may include invasive species conditions in their Chapter 404 and 105 permits. Invasive Species commitments should be tracked in the ECMTS. [**Publication No. 450 – Roadside/Landscape Development Construction Inspection Handbook**](#) serves as a reference and field guide to Project Inspectors to help assure landscape plants and other materials, as well as installation operations, are acceptable. This inspection work helps with assuring non-invasive materials are brought on-site by inspecting delivered landscape plants and seed mixes, and they also can avoid future infestation of invasive species during their post-construction inspection to assure no weeds are growing. [**Publication 23 – Maintenance Manual, Chapter 13**](#) and [**Penn State Roadside Vegetative Management Project**](#) both provide more detailed information for maintenance of ROWs, including mechanical and chemical control methods.

Chapter 2

GENERAL MANAGEMENT STRATEGY AND GUIDANCE

PennDOT should make the management of invasive species in the ROWs a routine part of its annual and daily work programs. By staying current on invasive species issues that impact PennDOT ROWs and working as a team throughout the life of a roadway, our roads can stay free of safety hazards and free of species that are a threat to spread through the travel corridors. This section lists a few general BMPs PennDOT may consider during design, construction, and maintenance on an annual basis. Note that the Department maintains a separate business license in each District for the application of herbicides only. All treatments should be coordinated with the Roadside Specialist who maintains the license for the District. Treatments to pests other than plant life should also be coordinated with the Roadside Specialist to ensure contractors hold the appropriate licenses.

G1 – Stay current on invasive species issues such as current laws and species lists known to the United States, and especially in Pennsylvania, by reviewing published information on websites (see Appendix), attending conferences and other trainings, and networking with other PennDOT staff and agencies on invasive species issues.

G2 – Know specific species that impact each District’s ROWs and how to identify these species or who they can contact to get assistance on identification of invasive species, such as PennDOT Central Office Environmental Policy and Development Section (EPDS) staff, District environmental staff, roadside staff and staff from jurisdictional agencies.

G3 – Know the most current and effective treatment and control methods to implement in these ROWs and where to go to get the most updated information, such as roadside staff, the Pennsylvania Department of Agriculture, or Penn State University.

G4 – Regularly revise PennDOT publications to include current invasive species prevention and control procedures.

G5 – Develop, test, and adopt native noninvasive seed mixes for use in roadside design.

G6 – Learn how to identify invasive species and take advantage of online tools such as the [iMAP Invasive search](#). Consider reporting invasive species if they are encountered in area outside of known infestation via iMAP or the Fish & Boat Commission’s [online reporting form](#).

Options for Incorporating Standard BMPs into all PennDOT Processes

To ensure PennDOT work addresses both federal and state laws on invasive species, use Best Management Practices (BMPs) in each phase of a PennDOT project. Consider the following BMPs during the design, construction, and maintenance phases of a roadway’s operational lifespan. Recognize that dealing with invasive species is an ongoing effort and these BMPs should continually be reviewed and revised as the industry develops new treatment information and as new invaders become known to Pennsylvania.

Options for Incorporating BMPs into Design

The first opportunity to address invasive species in a PennDOT ROW is during project design. Identify which species are currently present in a project area, note how to avoid or control the spread of these species in new construction, and design for re-vegetation of the ROW with native vegetation. Taking these steps will reduce the amount of time and money unnecessarily spent later in the life of the roadway for maintenance. The following are some BMPs to be considered for incorporation in project plans, specifications, and estimates (PS&E) packages.

FHWA policy (which complies with E.O. 13112) states that the DOT should determine the likelihood of introducing or spreading invasive species and a description of measures being taken to minimize their potential harm as part of any process conducted to fulfill agency responsibilities under NEPA. The actual NEPA analysis should include identification of any invasive terrestrial or aquatic animal or plant species that could do harm to native habitats within the project study area. In particular, BMPs D2, D3, D4, D5, and D6 comprise activities and commitments that should be documented during NEPA analysis.

D1 – Use current design publications on addressing invasive species in construction plan development.

D2 – Identify and map populations of invasive species (using the information in this guidance and various online resources) during the scoping field view and/or environmental studies associated with preliminary engineering. Avoid disturbing these areas during design and construction.

D3 – Design the project to minimize soil disturbance whenever possible. Invasive plants readily colonize areas of disturbed soil.

D4 – Design landscape plans to prevent introduction and growth of invasive species. When available, use a seed mix formula that has native plant species versus one with invasive or nonnative species.

D5 – Develop detailed species-specific control plans for any invasive species identified in the project area and include in the PS&E package.

D6 – Incorporate appropriate Construction BMPs related to invasive species management into the PS&E package.

D7 – For field activities during design, inspect and clean clothing, footwear and equipment for soils, seeds, plant parts, and invertebrates before and after activities. Acceptable methods of cleaning include but are not limited to the following:

- portable wash station that contains runoff from washing equipment (containment must be in compliance with wastewater discharge regulations)
- high-pressure air
- brushes, brooms, or other hand tools (used without water)

D8 – For field activities during design, if equipment must be used in a water body, clean the equipment by removing all plants and plant material, animals, and mud and thoroughly wash everything, including crevices and other hidden areas. Drain the equipment before leaving the area and allow time for the equipment to completely dry before contacting other waters.

D9 – For field activities during design, if equipment must be used in a water body *containing aquatic invasive species*, clean the equipment by following the species-specific PFBC Biosecurity Protocols attached in Appendix C.

D10 – Include language in the project-specific environmental commitments and mitigation tracking system (i.e., ECMTS; see Publication 10X appendix T) to monitor recent work sites for the emergence of invasive plants for a minimum of two years after project completion.

Options for Incorporating BMPs into Construction

Consider the existing flora and fauna in the project area during construction of new roadways or upgrades to existing roads. Knowing both the desirable and undesirable plants and animals in the area can go a long way in keeping our Pennsylvania ROWs both safe and beautiful. Incorporate the following BMPs when appropriate during construction.

C1 – Review the PS&E package prior to mobilization; locate and review all specifications that address invasive species.

C2 – Identify populations of invasive species in the construction ROW prior to the start of construction activities. Eliminate them when practicable (see C11), otherwise note invasive species areas by fencing or flagging them so they can be easy to identify during construction. Protect established, desirable, non-invasive vegetation to prevent disturbance.

C3 – Review species-specific control plan(s) included in the PS&E package and implement the control plans for invasive species encountered during construction. Should new invasive species be identified in the construction ROW that are not covered in the control plan(s), work with PennDOT Construction Site Managers/Engineers to develop a plan for any of these new invasive species encountered during construction.

C4 – Locate and use staging areas, including field offices that are free of invasive plants to avoid spreading seeds and other viable plant parts.

C5 – Minimize soil disturbance whenever possible. Invasive plants readily colonize areas of disturbed soil. Monitor recent work sites for the emergence of invasive plants for a minimum of two years after project completion when possible.

C6 – Stabilize disturbed soils as soon as possible by seeding and/or using mulch, hay, rip-rap, or gravel that is free of invasive plant material. Seeds of native species should be used whenever possible. Do not plant species on the [DCNR invasive plant list](#).

C7 – Materials such as fill, soil, topsoil, mulch, hay, rip-rap, and gravel should not be brought into project areas from sites where invasive plants are known to occur. If the absence of invasive plant parts in these materials cannot be

guaranteed, recent work sites should be monitored for the emergence of invasive plants for a minimum of two years after project completion when possible.

C8 – If work in areas containing invasive plants cannot be avoided, then the movement of construction equipment should be from areas not infested by invasive plants to areas infested by invasive plants whenever possible.

C9 – If equipment must be used in areas where invasive species occur, all clothing, equipment, machinery (including hydroseeding equipment), and hand tools should be cleaned of all visible soil and plant material before leaving the project site. Equipment should be cleaned at the site of infestation. Acceptable methods of cleaning include but are not limited to the following:

- portable wash station that contains runoff from washing equipment (containment must be in compliance with wastewater discharge regulations)
- high-pressure air
- brushes, brooms, or other hand tools (used without water)

C10 – If equipment must be used in areas containing Japanese knotweed, giant knotweed, or purple loosestrife, the aboveground plant material should be cut and properly disposed of prior to the start of work.

C11 – When invasive plants are treated, cut or removed for roadside construction, the spread of viable plant material must be avoided by rendering the plant material nonviable. Due diligence is required to avoid Threatened/Endangered species and to protect existing native plants. The following methods can be used to destroy plant material:

- **Drying/Liquefying**: For large amounts of plant material or for plants with rigid stems, place the material on asphalt, tarps, or heavy plastic and cover with tarps or heavy plastic to prevent the material from blowing away. For small amounts of plant material or for plants with pliable stems, bag the material in heavy-duty (3-mil or thicker) garbage bags. Keep the plant material covered or bagged for at least one month. Material is nonviable when it is partially decomposed, very slimy, or brittle. Once material is nonviable, it can be disposed of in a landfill or brush pile.

Recommended for: Japanese knotweed, giant knotweed, purple loosestrife.

- **Brush Piles**: Plant material from the most invasive plants can be piled on-site to dry out. However, when piling purple loosestrife, Japanese knotweed, and giant knotweed, care must be taken to pile stems so that cut surfaces are not in contact with the soil.

Recommended for: woody shrubs, trees, and vines; large quantities of purple loosestrife, Japanese knotweed, and giant knotweed.

NOT recommended for: any invasive plant with seeds or fruit attached, unless plants can be piled within the limits of the infestation.

- **Burying:** Plant material from most invasive plants can be buried a minimum of three feet below grade. This method is best used on a job site that already has disturbed soils.

Recommended for: most invasive plants.

NOT recommended for: Japanese or giant knotweeds, unless other options are not feasible and knotweeds can be buried *at the site of infestation at least five feet below grade.*

- **Burning:** Plant material should be taken to a designated burn pile. (All necessary permits must be obtained before burning.) Air Curtain Burners may be used were economically feasible.

Recommended for: any invasive plant, especially purple loosestrife, Japanese knotweed, and giant knotweed. Also effective with Emerald Ash Bore infested trees, gypsy moth egg masses and Marehail and Kochia, nuisances plants which have developed a herbicide resistance.

- **Herbicide:** Herbicide applications must be carried out by a certified applicator with a Pesticide Business License from the Pennsylvania Department of Agriculture, Bureau of Plant Industry.

Recommended for: any invasive plant, especially purple loosestrife, Japanese knotweed, giant knotweed Tree of Heaven and Canada Thistle.

C12 – Excavated material taken from sites that contain invasive species cannot be used away from the site of infestation until all viable plant material is destroyed. Excavated material from areas containing invasive species may be reused within the *exact* limits of the infestation.

C13 – Any excavated material that contains viable plant material and is not reused within the limits of the infestation must be stockpiled on an impervious surface until viable plant material is destroyed OR the material must be disposed of by burying a minimum of three feet below grade. Japanese knotweed and giant knotweed must be buried at least five feet below grade.

C14 – Whenever possible, excavation should be avoided in areas containing Japanese knotweed, giant knotweed, and purple loosestrife. If excavation does occur in these areas, see species-specific control plans in the PS&E package or developed by construction team.

C15 – Soil and other materials containing invasive species must be covered during transport.

C16 – If equipment must be used in a water body, clean the equipment by removing all plants and plant material, animals, and mud and thoroughly wash everything, including crevices and other hidden areas. Drain the equipment before leaving the area and allow time for the equipment to completely dry before contacting other waters.

C17 – If equipment must be used in a water body containing aquatic invasive species, clean the equipment by following the species-specific PFBC Biosecurity Protocols attached in Appendix C.

Options for Incorporating BMPs into Maintenance

Once a road is built, it still needs annual maintenance to keep it functioning safely and looking clean and beautiful. The following BMPs may be considered during maintenance activities to help control invasive species in PennDOT ROWs. For ease of presentation, they have been grouped by six main activity types.

Pre- and Post-Field Season Planning:

M1 – Develop a plan to identify and map new and existing areas of invasive species that will need to be treated/controlled the upcoming season; prioritize invasive species control schedules to treat areas of more aggressive species first. Mow invasive species (not listed in BMP M11) before August 7 or sooner if seed maturation is observed.

M2 – Have regular discussions of invasive species identification and management in staff planning and tailgate meetings.

M3 – Develop detailed species-specific control plans for invasive species identified in the District's maintenance areas. Include information specific to each species in terms of the best time to treat/control a species (for example, before seed matures in a plant species; before an insect matures, etc.). Note all methods that are effective in treating the species (for example, herbicide versus mowing for a plant), and note which work the best. Also note that PennDOT is not licensed to utilize insecticides on public right-of-way. Treatment and Control of insects or pests other than plants should be conducted by an appropriately licensed applicator.

M4 – Develop follow-up monitoring plans for treated areas to be conducted in future maintenance seasons. Plan for at least a two-year monitoring and add additional years based on monitoring findings. Include future maintenance costs in annual budgets.

Movement and Maintenance of Equipment:

M5 – If work in areas containing invasive species cannot be avoided, then the movement of maintenance and construction equipment should be from areas not infested by invasive plants to areas infested by invasive plants whenever possible. This is especially important during ditch cleaning and shoulder scraping activities.

M6 – Locate and use staging areas that are free of invasive plants to avoid spreading seeds and other viable plant parts.

M7 – If equipment must be used in areas where invasive species occur, all equipment, machinery (including hydroseeding equipment), clothing, and hand

tools should be cleaned of all visible soil and plant material before leaving the project site. Equipment should be cleaned at the site of infestation. Acceptable methods of cleaning include but are not limited to the following:

- portable wash station that contains runoff from washing equipment (containment must be in compliance with wastewater discharge regulations)
- high-pressure air
- brushes, brooms, or other hand tools (used without water)

M8 – If equipment must be used in areas containing Japanese knotweed, giant knotweed, or purple loosestrife, the aboveground plant material should be cut and properly disposed of (see M14 and M15) prior to the start of work. *If excavation occurs in these areas, see M16-22.*

M9 – If equipment must be used in a water body, clean the equipment by removing all plants and plant material, animals, and mud and thoroughly wash everything, including crevices and other hidden areas. Drain the equipment before leaving the area and allow time for the equipment to completely dry before contacting other waters.

M10 – If equipment must be used in a water body *containing aquatic invasive species*, clean the equipment by following the species-specific PFBC Biosecurity Protocols attached in Appendix C.

Mowing:

M11 – Avoid mowing tree-of-heaven, purple loosestrife, Japanese knotweed, and giant knotweed. Staking roadside populations of these plants as “do not mow” is one way to accomplish this. If these plants are cut, all plant material must be rendered nonviable and extra care should be taken to avoid spreading plant fragments.

M12 – Mow invasive species (not listed in BMP M11) before August 7 or sooner if seed maturation is observed.

M13 – Mowing equipment should be cleaned prior to transport or relocation (see M7). This is particularly important if mowing occurs after seed maturation (after August 1).

Disposal of Plants:

M14 – Make plant material nonviable after invasive plants are treated, cut or removed for roadside maintenance, construction, or control of plants activities. Due diligence is required to avoid Threatened/Endangered species and to protect existing native plants. The following methods can be used to destroy plant material.

- **Drying/Liquefying:** For large amounts of plant material or for plants with rigid stems, place the material on asphalt, tarps, or heavy plastic and cover with tarps or heavy plastic to prevent the material from blowing away. For small amounts of plant material or for plants with pliable stems, bag the material in heavy-duty (3-mil or thicker) garbage bags. Keep plant material covered or bagged for at least one month. Material is nonviable when it is partially decomposed, very slimy, or brittle. Once material is nonviable, it can be disposed of in a landfill or brush pile.
Recommended for: Japanese knotweed, giant knotweed, and purple loosestrife.
- **Brush Piles:** Plant material from most invasive plants can be piled on-site to dry out. However, when piling purple loosestrife, Japanese knotweed, and giant knotweed, care must be taken to pile stems so that cut surfaces are not in contact with the soil.
Recommended for: woody shrubs, trees, and vines; large quantities of purple loosestrife, Japanese knotweed, and giant knotweed.
NOT recommended for: any invasive plant with seeds or fruit attached, unless plants can be piled within the limits of the infestation.
- **Burying:** Plant material from most invasive plants can be buried a minimum of three feet below grade. This method is best used on a job site that already has disturbed soils.
Recommended for: most invasive plants.
NOT recommended for: Japanese or giant knotweeds, unless other options are not feasible and knotweeds can be buried *at the site of infestation at least five feet below grade.*
- **Burning:** Plant material should be taken to a designated burn pile. (All necessary permits must be obtained before burning.)
Recommended for: any invasive plant, especially purple loosestrife, Japanese knotweed, and giant knotweed. Also effective with Emerald Ash Bore infested trees, gypsy moth egg masses and Marestalk and Kochia, nuisances plants which have developed a herbicide resistance.
NOT recommended for: poison hemlock
- **Herbicide:** Herbicide applications must be carried out by a certified applicator with a Pesticide Business License from the Pennsylvania Department of Agriculture, Bureau of Plant Industry
Recommended for: any invasive plant, especially purple loosestrife, Japanese knotweed, giant knotweed Tree of Heaven and Canada Thistle.

M15 – Cover invasive species material during transport.

Soil Disturbance and Stabilization:

M16 – Minimize soil disturbance whenever possible. Invasive plants readily colonize areas of disturbed soil. Monitor recent work sites for the emergence of invasive plants for a minimum of two years after project completion.

M17 – Do not bring materials such as fill, soil, topsoil, mulch, hay, rip-rap, and gravel into project areas from sites where invasive plants are known to occur. If the absence of invasive plant parts in these materials cannot be guaranteed, monitor recent work sites for the emergence of invasive plants for a minimum of two years after project completion.

M18 – Stabilize disturbed soils as soon as possible by seeding and/or using mulch, hay, rip-rap, or gravel that is free of invasive plant material. Seeds of native species should be used whenever possible. Do not plant species on the noxious plant list.

Excavated Material:

M19 – Excavated material taken from sites that contain invasive plants cannot be used away from the site of infestation until all viable plant material is destroyed. Excavated material from areas containing invasive plants may be reused within the *exact* limits of the infestation.

M20 – Any excavated material that contains viable plant material and is not reused within the limits of the infestation must be stockpiled on an impervious surface until viable plant material is destroyed OR the material must be disposed of by burying a minimum of three feet below grade. Japanese knotweed and giant knotweed must be buried at least five feet below grade.

M21 – Whenever possible, excavation should be avoided in areas containing Japanese knotweed, giant knotweed, purple loosestrife, and phragmites. If excavation does occur in these areas, see species-specific control plans developed for these species. Review current information on invasive species to stay current on BMPs for species in your District.

M22 – Soil and other materials containing invasive species must be covered during transport.

Chapter 3

COMMON INVASIVE SPECIES AND RECOMMENDED BMPS

Watch List and Recommended BMPs for Invasive Plant Species

Invasive plants prevent the growth of native plants by crowding them out or producing chemicals that impact the native plants and can impact native wildlife by destroying habitat and causing loss of food sources. They impact water quality, agricultural fields, and recreation by their aggressive growth. They also impact ROWs by shading and weighing down woody vegetation with their growth, which can cause highway safety issues when wind- and snow-

damaged material fall onto the roads as well as by growing over roadway structures such as signs and guide rails, further impacting the road's safety.

The following 25 plants are either on the [PA Noxious Weed List](#) (noted with an *) and/or were noted as being problems in PennDOT ROWs by District Roadside Specialists. These plant species are known to be in ROWs and could be problematic if not controlled. PennDOT ROWs create long, linear habitats that serve as pathways for the spread of invasive plants into new regions and onto adjacent lands. Once established, invasive plants can affect the safety and maintenance of transportation infrastructure and wreak havoc on the natural environment.

For information on aquatic invasive plant species, review the **Pennsylvania's Field Guide to Aquatic Invasive Species (PA AIS)** developed by the Pennsylvania Sea Grant document as part of PA E.O. 2004-1 and PISC initiatives on its website at [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#). For information on invasive insects, review the [Pennsylvania Invasive Species Council Species Profiles for Insects and Other Invertebrates](#) webpage, or the [Pennsylvania DCNR Forest Pests Insects and Diseases](#) webpage.

Common Invasive Plant Species

Tree Species

Tree-of-Heaven (*Ailanthus altissima*)

Shrub Species

Exotic Bush Honeysuckles (*Lonicera sp.*)
Multiflora Rose (*Rosa multiflora*)*

Vine Species

Oriental Bittersweet (*Celastrus orbiculatus*)
Japanese Hop (*Humulus japonica*)
Mile-A-Minute (*Persicaria perfoliata*)*
Kudzu-vine (*Pueraria lobata*)*

Herbaceous Species

Nodding or Musk Thistle (*Carduus nutans*)*
Canada Thistle (*Cirsium arvense*)*
Bull or Spear Thistle (*Cirsium vulgare*)*
Poison Hemlock (*Conium maculatum*)
Japanese Knotweed (*Fallopia japonica*)
Giant Knotweed (*Fallopia sachalinensis*)
Goatsrue (*Galega officinalis*)*
Giant Hogweed (*Heracleum mantegazzianum*)*
Purple Loosestrife (*Lythrum salicaria*)*
Japanese Stiltgrass (*Microstegium vimineum*)
Eurasian Watermilfoil (*Myriophyllum spicatum*)

Curly-leaf Pondweed (*Potamogeton crispus*)

Shattercane (*Sorghum bicolor*)*

Johnson Grass (*Sorghum halepense*)*

Narrowleaf & Hybrid Cattails (*Typha angustifolia*, *Typha x glauca*)

Phragmites (*Phragmites australis*)

Algae Species

Didymo (*Didymosphenia geminata*)

Golden Alga (*Prymnesium parvum*)

Tree-of-Heaven (*Ailanthus altissima*)



Tree-of-heaven can grow anywhere in Pennsylvania ROWs and can grow up to 15 feet in one year from stumps of trees that are cut and will reach a height of 40 to 60 feet over a few years. This growth can obscure road signs and sight lines along ROWs. It is a weak-stemmed species that can threaten roadways by being blown down onto the road.

Key Identification Characteristics:

- Large (one to four feet in length) compound leaves composed of 11 to 25 smaller leaflets (with glandular teeth near the base) placed alternately on the stem.
- Small yellow-green flowers produced late in the spring in at the tip of the branches. They turn orange as the seeds begin to produce in late summer to early fall. The seeds are a flat, twisted, papery structure called a samara.
- All parts of these trees have a strong, offensive odor.

Pennsylvania Habitat: In disturbed woods, roadsides, fencerows, vacant lots, and railroad ROWs.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22. Spray to control root system for one year prior.

Link to More Information:

- [Plant Conservation Alliance’s Alien Plant Working Group](#)
- [USDA National Invasive Species Information Center](#)
- [DCNR Fact Sheet](#)

Exotic Bush Honeysuckles (*Lonicera sp.*)



Pennsylvania’s [Field Guide to Aquatic Invasive Species](#) lists five exotic bush honeysuckles as most problematic in our state. They grow in wet and upland habitats in ROWs. These problematic shrubs include Amur (*L. maackii*), Morrow’s (*L. morrowii*), Standish (*L. standishii*), Tatarian (*L. tatarica*), and Belle honeysuckle which is a Tatarian-Morrow’s hybrid cross. This growth can obscure road signs and sight lines along the ROWs and blocks drainage channels and swales.

Key Identification Characteristics:

- Leaves are oval to oblong or egg-shaped 1 to 2.6 inches in length and are opposite along the stem.
- Fragrant, pink or white (becoming yellow with age) flowers occur during May and are less than 1 inch long. Fruits are round berries (usually deep red, yellow, or orange in color) maturing in September to October.
- Stems are generally thornless, hairless, and shallow, with older stems having a shaggy-bark appearance and are often hollow.

Pennsylvania Habitat: In forest edges, disturbed woods, thickets, abandoned/old fields, pastures, roadsides, and other open, upland habitats, plus wetter habitats such as floodplains and stream banks.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 42
- [Plant Conservation Alliance’s Alien Plant Working Group](#)
- [Missouri Department of Conservation](#)
- [DCNR Fact Sheet](#)

Multiflora Rose (*Rosa multiflora*)



Multiflora rose was introduced in 1866 and has been used in erosion control, as “living fence,” as cover for wildlife, and has even been planted in highway medians to serve as crash barriers and to reduce automobile headlight glare. Its tenacious growth habit was eventually recognized as a problem to agricultural lands and native habitats; therefore it is now designated as a noxious weed in several states, including Pennsylvania.

Key Identification Characteristics:

- Multi-stemmed shrub, sometimes climbing vine-like, with arching stems and re-curved thorns on stems.
- Leaves divided into 5 to 11 sharply toothed leaflets; leaf stalks with fringed stipules (paired wing-like structures).
- Clusters of showy, fragrant, white to pinkish, one-inch wide flowers bloom in May. Small, bright red fruits called rosehips develop during the summer and remain on the shrub through the winter.

Pennsylvania Habitat: In disturbed woods, pastures, old fields, roadsides, and thickets.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [National Park Service: Multiflora Rose](#)
- [Plant Conservation Alliance’s Alien Plant Working Group](#)
- [Missouri Department of Conservation](#)
- [USDA National Invasive Species Information Center](#)
- [DCNR Fact Sheet](#)

Oriental Bittersweet (*Celastrus orbiculatus*)



Oriental bittersweet was introduced as an ornamental plant due to its colorful yellow and orange fruit and is still widely used today, further promoting its spread. It is an aggressive woody vine that climbs over native vegetation, smothering it and keeping sunlight from native plants. Its weight on trees can lead to uprooting and blow-over during high winds and heavy snow, creating a safety issue in our ROWs.

Key Identification Characteristics:

- Leaves are rounded, elliptical or ovate, with finely toothed edges and abruptly pointed tips; 2 to 5.1 inches long; and grow alternately and evenly around the stem.
- Female plants get small clusters of greenish flowers along the stem in May-June. Globular fruit capsules from July to October. The fruits turn yellow as they ripen and split at maturity to show three red-orange, fleshy seed coatings, each containing three to six seeds. Our native vine has flowers/fruits only on branch tips.
- Stems are light brown, 2 to 3.9 inches in diameter, and may be up to 60 feet long.

Pennsylvania Habitat: In disturbed woods, fields, fencerows, and edges, often in riparian corridors, growing over other plants or other structures.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide Pg. 58](#)
- [NPS Plant Conservation Alliance’s Alien Plant Working Group](#)
- [DCNR Fact Sheet](#)

Japanese Hop (*Humulus japonica*)

Japanese hop is a fast-growing, herbaceous, annual climbing vine that can form dense, almost solid stands that out-compete native vegetation. This dense growth can create safety hazards in ROWs due to covering trees and shrubs, causing them to break and fall over, as well as by covering signs and other roadway structures.

Key Identification Characteristics:

- Leaves are opposite on vines, 2 to 3.9 inch long, palmate with five to nine lobes and rough, serrated (knife-like) toothed edges. The key features are downward pointed prickles and down-curved bracts at the base of the leaves.
- Flowers lack petals and are green so are inconspicuous. They bloom in two-inch clusters in early to mid-summer, and seeds are in green hops.
- Stems are rough and covered in tiny, hooked hairs and can grow 8 to 35 feet in length.

Pennsylvania Habitat: In meadows, roadsides, and waste ground, often in riparian areas.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

[Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 48

[NPS Plant Conservation Alliance's Alien Plant Working Group](#)

[NPS Japanese Hop](#)

[DCNR Fact Sheet](#)

Mile-A-Minute (*Persicaria perfoliata*)

Mile-a-minute, also called asiatic tearthumb, is an herbaceous annual vine that is mostly prostrate and trailing that may reach 20 feet in length. It is native to India and eastern Asia. It was first discovered in the U.S. in the late 1930s in York, Pennsylvania. It is now common in many eastern Pennsylvania counties as well as Butler County. Aggressive growing vines cover roadside structures and native vegetation.

Key Identification Characteristics:

- Leaves are light green, very distinctive equilateral triangles. They are one to three inches in length and alternate on mostly prostrate long, thin, delicate stems. The stems contain circular, cup-shaped leaves at the nodes where the flower-fruit stalk meets the main stem.
- Flowers are small, white, and generally inconspicuous; fruits are attractive, deep metallic blue, berrylike fruits arranged in clusters. Seeds are glossy, black to deep red, hard, single seeds.
- Stems are delicate, thin, and reddish with downward-curved pointed barbs.

Pennsylvania Habitat: Open disturbed areas and roadsides along the edges of wetlands, woods, and streams.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

[Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 56

[NPS Plant Conservation Alliance's Alien Plant Working Group](#)

[USDA National Invasive Species Information Center](#)

[DCNR Fact Sheet](#)

Kudzu (*Pueraria lobata*)



Pennsylvania is the north limit of Kudzu, a climbing, semi-woody, perennial vine. This vine kills or degrades other plants by smothering them under a solid blanket of leaves, by girdling woody stems and tree trunks, and by breaking branches or uprooting entire trees and shrubs through the force of its weight. Kudzu causes safety hazards by covering signs and other roadway structures.

Key Identification Characteristics:

- Leaves are alternate and composed of three broad leaflets up to four inches across. The leaflets can be entire or deeply two- to three-lobed with hairy margins.
- Individual flowers are ½ inch long, purple, highly fragrant, and borne in long hanging clusters. The flowers bloom in summer; and brown hairy, flattened, seed pods, each with three to ten hard seeds, soon develop.
- Vines can grow 32 to 100 feet in length, with stems ½ to 4 inches in diameter.

Pennsylvania Habitat: In waste ground and woods edges.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [Florida Invasive Plant Education Initiative in the Parks](#)
- [NPS Plant Conservation Alliance’s Alien Plant Working Group](#)
- [Missouri Department of Conservation: Kudzu Control](#)
- <http://www.invasivespeciesinfo.gov/plants/multiflorarose.shtml>
- [DCNR Fact Sheet](#)

Nodding or Musk Thistle (*Carduus nutans*)



Musk, or nodding, thistle was introduced to the U.S. in the early 1800s. It is unpalatable to wildlife, therefore giving this plant a competitive edge over native vegetation. It often colonizes areas of disturbance such as landslides and flooding, both which occur in PennDOT ROWs.

Key Identification Characteristics:

- Leaves are dark green, coarsely lobed, with a smooth, waxy surface and a yellowish to white spine at the tip.
- The large, red-purple, disk-shaped flower heads contain hundreds of individual flowers and are 1½ to 3½ inches in length. The flowers bloom from May to August, and the flower heads drop to a 90-degree angle from the stem at maturity, hence the name. Each plant produces thousands of straw-colored seeds adorned with plume-like bristles.
- Mature plants range in height from 1½ to 6 feet tall and have multi-branched stems.

Pennsylvania Habitat: In pastures, roadsides, waste ground, and ballast.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [NPS Plant Conservation Alliance’s Alien Plant Working Group](#)
- [Missouri Department of Conservation: Musk Thistle Control](#)
- [DCNR Fact Sheet](#)

Canada Thistle (*Cirsium arvense*)



Canada thistle is declared a noxious perennial weed throughout the U.S. and has long been recognized as a major agricultural pest, costing tens of millions of dollars in crop losses annually and additional millions in dollars for control. This highly invasive thistle prevents the coexistence of other plant species through shading, competition for soil resources, and possibly through the release of chemical toxins poisonous to other plants. Due to its extensive root system, it is hard to control.

Key Identification Characteristics:

- Leaves are lance-shaped, irregularly lobed with spiny, toothed margins and are borne singly alternately along the stem.
- Rose-purple, lavender, or sometimes white flower heads with individual flowers 3/4 inch diameter. They grow in rounded, umbrella-shaped clusters from June to October. The small, dry, single-seeded fruits are 1 to 1 1/2 inches long and have a feathery structure attached to the seed base.
- The stems are erect, 1 1/2 to 4 feet tall, and branched, often slightly hairy, and ridged, with prickly leaves and creeping rootstocks.

Pennsylvania Habitat: In fields, pastures, roadsides and waste ground.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [NPS Plant Conservation Alliance’s Alien Plant Working Group](#)
- [Missouri Department of Conservation: Canada Thistle Control](#)
- [USDA National Invasive Species Information Center](#)
- [DCNR Fact Sheet](#)

Bull or Spear Thistle (*Cirsium vulgare*)



Bull, or spear, thistle is a widespread biennial thistle originally from Europe and Asia, but now introduced throughout North America. This thistle sometimes forms dense stands that reduce agricultural productivity and may also reduce tree seedling growth. Fortunately, this thistle is easier to control than other thistle species.

Key Identification Characteristics:

- Leaves are deeply lobed with coarse hairs on the leaf tops, making the leaf feel rough to the touch. The underside of the leaves have woolly hairs. The leaf bases extend down onto the stems, forming spiny wings along the stems.
- Flowers bloom from July to October and are pink-magenta in color. The flower heads are gumdrop in shape, and spines extend all around the base of the flower heads. Seeds are born on feathery structures.
- Stems are branching, erect, and two to six feet tall. This thistle is a biennial, meaning a basal rosette forms the first year and flowering stems the second year.

Pennsylvania Habitat: In pastures, meadows, and roadsides.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [King County Washington Noxious Weeds: Bull thistle](#)
- [DCNR Fact Sheet](#)

Poison Hemlock (*Conium maculatum*)



Because of its attractive flowers, poison hemlock was brought to the U.S. from Europe as a garden plant. Today, it grows throughout the U.S. The concern with this plant is due to all the parts (leaves, stem, fruit, and root) being very toxic to animals and extremely poisonous to humans; therefore, it is of concern as it spreads through our ROWs.

Key Identification Characteristics:

- Leaves are arranged alternately on the stem. They are divided and give the plant a coarse appearance. The base of the leaves are enlarged and sheathing the stem.
- Flowers are white and grow in small, erect clusters called umbels from May to July. Bracts beneath the umbel are entire. Each flower develops into a green, deeply ridged fruit that turns grayish brown.
- The stem is smooth, purple-spotted, and grows two to six feet tall.

Pennsylvania Habitat: In roadside ditches, floodplains and most woods, more in moist to wet habitats.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [USDA Agricultural Research Service](#)
- [DCNR Fact Sheet](#)

Japanese Knotweed (*Fallopia japonica*)



Japanese knotweed is a shrub-like herbaceous perennial that is nicknamed elephant ear bamboo because it has stems that resemble bamboo when mature. It grows quickly and aggressively, forming dense mats that crowd and shade out native plants. It can cause streambanks to shear off during flooding and create other ROW safety issues such as site hazards and by covering roadway structures. It spreads through rhizomes and from root fragments into new areas by natural means (wind and water) and man-made disturbances such as roadside clearing and equipment.

Key Identification Characteristics:

- Leaves are triangular to egg-shaped with pointed tips and grow alternately along the stem. Size average is 5.9 inches long and 3.1 to 3.9 inches wide. The leaf stems are often reddish colored. The leaf bases are almost straight across. (Differs from the heart-shaped base of the next species).
- Flowers in the summer with small, greenish to white flowers arranged in branched clusters that are 3.9 to 5.1 inches long. Small, winged fruits contain triangular seeds that are shiny and small (only about 0.1 inch long).
- Stems are smooth, stout, hollow, and can grow over 13 feet. The stem is swollen at the leaf joints. The base of the stem above each joint is surrounded by a thin membranous sheath.

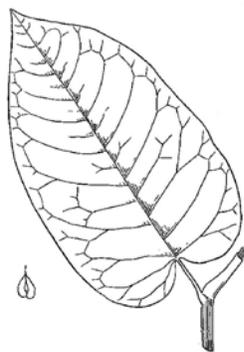
Pennsylvania Habitat: On river and stream banks, in rail and road ROWs, and waste ground.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 50
- [NPS Plant Conservation Alliance’s Plant Working Group](#)
- [USDA National Invasive Species Information Center](#)
- [DCNR Fact Sheet](#)

Giant Knotweed (*Fallopia sachalinensis*)



Once established, giant knotweed is very difficult to eradicate and creates similar problems in ROWs as Japanese knotweed – it is just much larger. It spreads through rhizomes and from root fragments into new areas by natural means (wind and water) and man-made disturbances such as roadside clearing and equipment.

Key Identification Characteristics:

- Leaves are rounded, can grow to one foot in length, and are placed alternately on stems. They have a heart-shaped base of the leaf with rounded lobes. There are thin, wavy hairs on the underside of the leaves.
- Flowers in late summer from leaf axils at the ends of the stems with small, greenish to creamy white flowers in short branched clusters. Fruits are three-sided, shiny, brown to black, egg-shaped seeds that have a paper-like texture.
- Smooth, hollow, jointed stems are swollen at the nodes, light green in color, and resemble bamboo shoots.

Pennsylvania Habitat: In disturbed sites like railroad embankments, ditches, old lots, and roadsides.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 44
- [USDA Forest Service](#)
- [DCNR Fact Sheet](#)

Goatsrue (*Galega officinalis*)



Goatsrue was introduced in the U.S. in the late 1800s and while not widespread in our state yet, it is on the Pennsylvania Noxious Weed list since all parts of the plant are toxic to livestock. This plant forms dense patches that begin in open, disturbed areas, including moist habitats in ROWs. It has deep, tough roots and produces seeds that can survive for 30 years in the soil.

Key Identification Characteristics:

- Leaves are pinnately compound, up to 8.7 inches long, with 11 to 17 elliptic to lanceolate leaflets (0.4 to 1.9 inches).
- Inflorescence is composed of 20 to 50 purple to white flowers, each about 0.4 inch long, arranged in terminal or axillary racemes beginning in June and continue through the growing season. Each flower produces a 0.8- to 1.6-inch pod that contains up to nine dull, mustard yellow seeds.
- Typically, stems are about three feet long at maturity, but they may be up to six feet long, and larger plants tend to recline on the ground with the tip ascending.

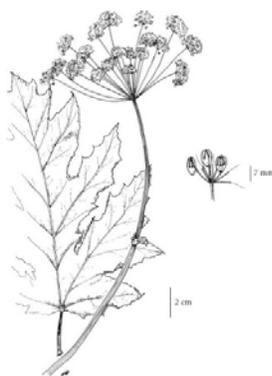
Pennsylvania Habitat: In moist open meadows and on stream banks.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [The City of Portland Oregon Environmental Services](#)
- [Invasive Plants Atlas of the United States](#)
- [DCNR Fact Sheet](#)

Giant Hogweed (*Heracleum mantegazzianum*)



Heracleum mantegazzianum

Giant hogweed is a member of the carrot or parsley family introduced to North America in the early 1900s as desirable plants for arboretums and gardens. However, it soon escaped cultivation and has become established in natural habitats. This tall, majestic plant is a public health hazard because its sap sensitizes the skin to UV Rays which can cause serious skin inflammation -a very bad sunburn- and long-term sun sensitivity. If sap gets into the eye, blindness can occur. ,Therefore it is on both the federal and Pennsylvania Noxious Weeds lists.

Key Identification Characteristics:

- Leaves are lobed, deeply incised, and up to five feet across.
- Flowers are numerous, small, and white, clustered into a flat-topped umbel up to 2½ feet across, and bloom in the summer. A dry, flattened, oval fruit that is tan with brown lines and about 3/8 inches long contains the seeds.
- Stems are hollow, ridged, two to four inches in diameter, and 8 to 14 feet tall with purple blotches and coarse, white hairs that are especially prominent in a circle around the stem at the base of the leaf stalks.

Pennsylvania Habitat: Cultivated and escaped along roadsides, ditches, waste areas, and woodlots.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [The City of Portland Oregon Environmental Services](#)
- [Pennsylvania Department of Agriculture Noxious Weed Alerts](#)
- [USDA Forest Service](#)
- [DCNR Fact Sheet](#)

Purple Loosestrife (*Lythrum salicaria*)



While purple loosestrife is an aesthetic plant sold by the landscaping industry, it can quickly become established and spread to form dense stands that restrict native wetland plants and alter the structural and ecological values of wetlands. It can also impact water flow in roadside ditches and create silt deposits.

Key Identification Characteristics:

- Leaves are opposite or whorled in groups of three, linear-shaped with smooth edges, and attached directly to the stem without a leaf stalk. They can be 1.6 to 3.9 inches long and sometimes covered in fine, downy hairs.
- Flowers are paired or clustered in 3.9- to 16-inch long spikes and bloom from July to September. Each flower has five to seven pink, purple-red, or magenta petals.
- Mature plants can have 1 to 50 square, woody stems growing from a large, central taproot. Stems are four- to six-sided, green to purple in color, and are often branching, giving the plant a bushy appearance.

Pennsylvania Habitat: In freshwater and brackish wetlands, riparian corridors, ditches, and other moist soil areas.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide Pg. 60](#)
- [NPS Plant Conservation Alliance’s Alien Plant Working Group](#)
- [USDA National Invasive Species Information Center](#)
- [DCNR Fact Sheet](#)

Japanese Stiltgrass (*Microstegium vimineum*)



Japanese stiltgrass was first identified in the U.S. in the first part of the 20th century. This plant is a severe threat to natural areas since it is adapted to low light conditions and it is most prevalent in disturbed, shaded floodplains that are prone to scouring and areas subject to mowing, tilling, and other soil-disturbing activities such as in utility corridors, lawns, gardens, and roadsides ditches.

Key Identification Characteristics:

- Leaves pale to bright green, one to three inches long, thin, alternate, lance-shaped flat blades and sparsely hairy on both surfaces. The mid-veins are whitish, shiny, and off-center, making the blade asymmetrical.
- Delicate spikes of flowers on slender tips from August to early-November. Flowers are tiny and arise terminally or in leaf axils. Dry fruits are produced soon after.
- Stalks are 2 to 3½ feet tall, often sprawling in habit, and distinctly divided by nodes.

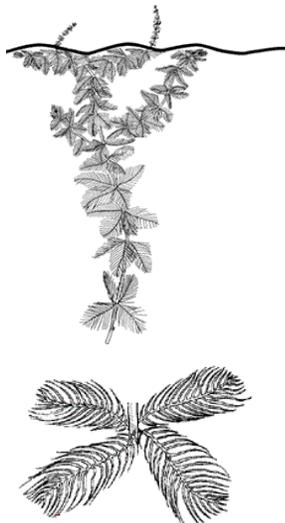
Pennsylvania Habitat: In moist or upland soils of forests, open woods, thickets, paths, clearings, fields, floodplains, wetlands, roadsides, ditches, utility corridors, and gardens.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [Global Invasive Species Database](#)
- [NPS Plant Conservation Alliance’s Alien Plant Working Group](#)
- [USDA National Invasive Species Information Center](#)
- [NPS: Japanese Stiltgrass](#)
- [DCNR Fact Sheet](#)

Eurasian Watermilfoil (*Myriophyllum spicatum*)



Eurasian watermilfoil is a submerged aquatic plant that is generally found in still to slow-moving water less than 20 feet deep and is extremely adaptable to thrive in a variety of conditions. It quickly forms thick, damaging mats in water of wide temperature range, and grows best in fertile, fine-textured sediments and high light conditions often associated with waterway crossings in our ROWs. *Plant fragments can easily spread this species.*

Key Identification Characteristics:

- Leaves are feathery whorls of three to six leaves openly spaced along the stem in 0.3 to 1.2 intervals. Leaves are threadlike, uniform in diameter, and have 12 to 24 pairs of leaflets. Note, there are a number of SAV species that are similar.
- Flowers grow in tiny whorls located on floral bracts atop slender spikes that rise above the water’s surface. They have either four petals or are without petals. Fruits are hard capsules that contain four seeds.
- Stems are slender and often curl on top of the water’s surface and thicken before blooming, doubling their width further down.

Pennsylvania Habitat: In lakes, ponds, and rivers in all regions of Pennsylvania.

BMPs: Design BMPs D1, D2, D6 to D10; Construction BMPs C1 to C3, C9, C16, C17; Maintenance BMPs M1 to M5, M7, M9, M14, M21, M22

Link to More Information:

- [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide Pg. 16](#)
- [NPS Plant Conservation Alliance’s Alien Plant Working Group](#)
- [Washington Invasive Species Council](#)
- [DCNR Fact Sheet](#)

Curly-leaf Pondweed (*Potamogeton crispus*)

Curly-leaf pondweed has a unique ability to form new plants under the ice in winter, making it one of the first nuisance plants to emerge in Pennsylvania in the spring. This allows the plant to out-compete native plants by growing in dense surface mats. When it dies off in mid-summer, it may create anoxic conditions and increase nutrient content that can cause harmful algae blooms. This plant can be a problem in waterway crossings in ROWs.

Key Identification Characteristics:

- Leaves are submerged, oblong, slightly translucent, olive-green to reddish brown with rounded tips and narrowing towards the base. They are alternately arranged and directly attached to the stem, with distinct wavy and fine-toothed edges (like lasagna noodles). They are 1.6 to 4 inches long and 0.2 to 0.4 inches wide.
- Flowers are small and tightly arranged at the end of slender, sometimes curved stalks and appear above the water surface from June to September. Fruits have a prominent cone-shaped beak and a bumpy, crown-like ridge.
- Stems are slightly flat, reddish-brown, one to three feet long, often branching as they grow, giving a bushy appearance.

Pennsylvania Habitat: In lakes, ponds, rivers and streams.

BMPs: Design BMPs D1, D2, D6 to D10; Construction BMPs C1 to C3, C9, C16, C17; Maintenance BMPs M1 to M5, M7, M9, M14, M21, M22

Link to More Information:

[Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 14

[USDA National Invasive Species Information Center](#)

[Minnesota DNR Invasive Aquatic Plants](#)

[Minnesota DNR Invasive Species Program](#)

[DCNR Fact Sheet](#)

Shattercane (*Sorghum bicolor*)

Shattercane is a wild type of grain and forage sorghum that is on the Pennsylvania Noxious Weed list. It is an annual that has seeds that can remain viable in the soil for two to three years. This plant is escaped from cultivation and could be present on ROWs and spread to agricultural areas via the roadside.

Key Identification Characteristics:

- Leaves are rolled in bud; blades are sparsely hairy at the base to hairless, 12 to 24 inches long, 1 to 4 inches wide, with a prominent mid vein. Blades have reddish-purple splotches. Leaf sheaths are hairless or sparsely hairy near the collar at maturity. Ligules are membranous, with a fringe of hairs on top, $\frac{1}{8}$ inch long.
- Inflorescence is a large, open, terminal panicle above the leaves with spikelets of paired fertile (long) and sterile (short) florets. Reddish black, rounded, flattened seeds are ellipsoid to ovoid and hairy; they often “shatter” before crop harvest, therefore the name. A summer annual plant.
- Stems are up to 13 feet tall, erect, and hairless with prominent nodes (like corn). Tillers are produced at the base.

Pennsylvania Habitat: Cultivated and spreading into waste grounds.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

[Michigan State University Integrated Pest Management](#)

[West Virginia University Extension Service](#)

[DCNR Fact Sheet](#)

Johnson Grass (*Sorghum halepense*)



Johnson grass is a very aggressive, perennial grass that is on the Pennsylvania Noxious Weeds List. It invades riverbank communities and disturbed sites, particularly fallow field and forest edges, where it crowds out native species and slows succession. This grass is a serious potential threat in many old fields where succession to forest communities is desired.

Key Identification Characteristics:

- Leaves are smooth. 6 to 20 inches long, and have a white or light green mid-vein.
- Panicles are large, loosely branched, purplish, and hairy. Spikelets occur in pairs or threes, and each has a conspicuous awn. Seeds are reddish-brown and nearly 1/8 inch long.
- Stems are three to six feet tall, pink to rusty red near the base. Rhizomes are stout and up to 3/4 inch in diameter.

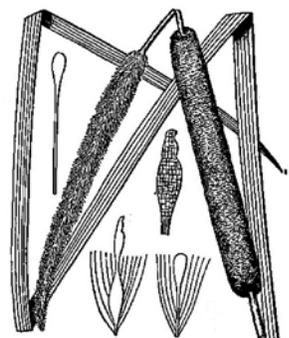
Pennsylvania Habitat: In moist to dry fields, roadsides, and serpentine barrens.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [West Virginia University Extension Service](#)
- [Missouri Department of Conservation: Johnson Grass Control DCNR Fact Sheet](#)

Narrowleaf and Hybrid Cattails (*Typha angustifolia, typha x glauca*)



Narrowleaf and hybrid cattails are aquatic perennials that form dense monocultures in wetland areas, eliminating habitat and replacing native plants important for waterfowl and wildlife. They are also thought to be allelopathic, meaning they produce chemicals which prevent the growth of other plant species, and this is more of a ROW concern to limit more desirable roadside vegetation success. The flower head of one plant can produce 250,000 seeds that can remain viable in the soil for up to 100 years. The seeds spread by wind and, once established, cattails can spread more through an extensive underground root system, making them difficult to control in ROWs.

Key Identification Characteristics:

- Leaves are three to six feet in height, 0.2 to 0.6 inch wide, flat, and originate at the base of the stem and spread outward as they rise.
- Flowers are dense, fuzzy, cylindrical spikes located at the end of the stem. Male flowers (staminate) are located above the female (pistillate) flowers by a 1.2- to 3.9-inch gap. They are green during bloom and turn dark brown during seed maturation. Fruits are cigar-shaped heads about 2 to 5.9 inches long that contains soft, downy seeds about 0.04 inch (1 mm) in size.
- Stems are light green, stiff, round in cross-section, and grow up to ten feet tall.

Pennsylvania Habitat: In wet meadows, shores, marshes, and ditches, often in calcareous or brackish habitats, increasingly found along roadways where salt is used.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 24
- [DCNR Fact Sheet](#)

Phragmites (*Phragmites australis*)



Phragmites (or common reed) is an aquatic perennial that, like cattails, form dense monocultures in wetland areas, eliminating habitat and replacing native plants important for waterfowl and wildlife. They are also thought to be allelopathic, meaning they produce chemicals which prevent the growth of other plant species, and this is more of a ROW concern to limit more desirable roadside vegetation success. The flower head of one plant can produce thousands of seeds annually; however, Phragmites can spread more through an extensive underground root system. Just fragments of the root can sprout a new plant, making them difficult to control in ROWs.

Key Identification Characteristics:

- Flowers are usually purple or golden bushy clusters (panicles) that grow 5.9-16 inches long in late July and August. As seeds matures flowers appear “fluffy”.
- Stems are light green and rigid, rough to the touch.
- Grow up to 15 feet tall.

Pennsylvania Habitat: Abundant along the borders of lakes, ponds, and rivers. Also in wet meadows, shores, marshes, and ditches, often in disturbed sites. It is tolerant to many different wetland conditions, especially in slightly saline environments. It does not tolerate rapidly moving water.

BMPs: Design BMPs D1 to D10; Construction BMPs C1 to C17; Maintenance BMPs M1 to M22

Link to More Information:

- [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 40
- [USDA Plant Fact Sheet](#)
- [USDA Plant Guide](#)
- [Maryland DNR Landowner’s Guide for the Control of Phragmites](#)
- [DCNR Fact Sheet](#)

Didymo (*Didymosphenia geminata*)



Didymo, or “rock snot”, is an invasive algae. Its large amounts of stalk material forms a thick brown mat, as thick as eight inches, smothering stream bottoms and blocking sunlight which eliminates habitat and threatens biodiversity. It is known to attach to rocks as well as plants. It is made up of microscopic diatoms, therefore, anything that comes in contact with Didymo has the possibility of spreading it.

Key Identification Characteristics:

- Tan, brown, white, or yellow in color (not green)
- Feels like wet wool (not slimy)
- Difficult to pull apart/detach from surface

Pennsylvania Habitat: Known to prefer cold water streams, however now is showing up in nutrient-rich streams and rivers. Prefers flowing water.

BMPs: Design BMPs D1, D2, D6, D9, D10; Construction BMPs C1-C3, C9, C16, C17; Maintenance BMPs M1-M5, M7, M9, M10, M14, M21, M22

Link to More Information:

- [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 130
- [PA Fish and Boat Commission](#)
- [USDA Species Profile](#)
- [DCNR Fact Sheet](#)

Golden Alga (*Prymnesium parvum*)

Golden alga is a fast growing, resilient, and microscopic algae. It is so small that over 2,000 golden alga cells may be present in a single drop of water. During an algal bloom, toxins are released to kill aquatic animals making it a threat to aquatic environments. It is hypothesized that one of the major ways the alga spreads is by being carried on industrial equipment.

Key Identification Characteristics:

- Golden alga is a microscopic flagellate
- During a bloom, water begins turning yellowish, yellowish-copper, or a brownish tea color and water may foam at the surface. Note that these conditions are not specific to golden alga blooms, they can come from other sources as well.

Pennsylvania Habitat: Can survive in a variety of environmental conditions; however, prefers waters with high salt and mineral content.

BMPs: Design BMPs D1, D2, D6, D9; Construction BMPs C1-C3, C9, C16, C17; Maintenance BMPs M1-M5, M7, M9, M10, M14, M21, M22

Link to More Information:

[Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 40

[Pennsylvania Sea Grant](#)

[PA Fish and Boat Commission Aquatic Invasive Species Action Plan](#)

Recommended BMPs for Invasive Insect Species

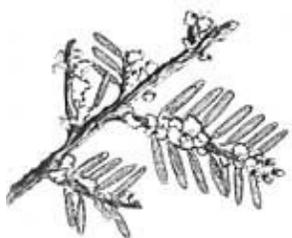
Non-native invasive insects have impacted the forests of Pennsylvania by altering the forest ecosystems. These invasive insects can also affect agricultural resources in the nursery/landscape sector. Since many of PennDOT ROWs contain tree species or are adjacent to forests, it is a concern when designing, constructing, and maintaining these ROWs. Care needs to be used to avoid or reduce the spread of these non-native invasive impacts throughout Pennsylvania along our road corridors.

The following four insect species were noted on the PA Invasive Species Council (PISC) website as insects that pose economic and safety concerns. These common invasive species could be spread through PennDOT ROWs and beyond due to the improper disposal of woody material removed from ROWs or by bringing infected materials into the ROWs, hence providing a travel corridor for the spread of these insects in and beyond Pennsylvania habitats.

Common Invasive Insect Species

Hemlock Woolly Adelgid (*Adelges tsugae*)
 Emerald Ash Borer (*Agrilus planipennis*)
 Asian Longhorned Beetle (*Anoplophora glabripennis*)
 Elongate Hemlock Scale (*Fiorinia externa*)

Hemlock Woolly Adelgid (*Adelges tsugae*)



The Hemlock Woolly Adelgid is a serious pest of the Eastern Hemlock and was first reported in Pennsylvania in the late 1960s. Since that time it has spread to both ornamental and native forest hemlocks in most of Pennsylvania. This insect sucks sap from the young branches which results in premature needle drop and branch dieback.

Key Identification Characteristics:

- Most obvious sign is masses of white, waxy, cottony, or wool-like tufts that cover the insects throughout their life. These masses are 3 mm or more in diameter and appear as flecks on twigs and at the base of the needles.
- Over-wintering females are oval, soft-bodied, blackish-gray, and about 1 to 2 mm in length.
- Females lay 110 to 300 eggs in early spring. The eggs are oblong, 0.25 mm long by 0.15 mm wide, and brownish-orange. Eggs hatch in early April to late June.
- The nymphs, called “crawlers,” are reddish-brown with a small white fringe near the front and 0.3 to 2 mm long.

Pennsylvania Habitat: In ornamental and forest Eastern Hemlock trees.

BMPs: Design BMPs D1, D2, D5, D9, D10; Construction BMPs C1 to C3, C9, C16; Maintenance BMPs M1 to M5, M7, M14, M21, M22

Link to More Information:

[Penn State University College of Agricultural Sciences: Entomology DCNR Forest Health Fact Sheet](#)

Emerald Ash Borer (*Agrilus planipennis*)



Gina Mikel, www.scientificillustrator.com

The emerald ash borer was first detected in western Pennsylvania in June 2007 followed by a quarantine of ash species which was imposed to slow the spread of the beetle. This beetle feeds exclusively on ash trees and usually kills the ash trees within three to four years of infestation.

Key Identification Characteristics:

- Adult beetle is metallic green in color and ½ inch long.
- The larvae are whitish and feed under the bark, which eventually girdles and kills branches and entire trees.
- Larvae leave “S”-shaped larval galleries under the bark and “D”-shaped exit holes in the tree bark.

Pennsylvania Habitat: Known to infest all ash species, including green, white, black, blue, and pumpkin ash, found in all types of wooded habitats.

BMPs: Design BMPs D1, D2, D5, D9, D10; Construction BMPs C1 to C3, C9, C16; Maintenance BMPs M1 to M5, M7, M14, M21, M22

Link to More Information:

[DCNR Bureau of Forestry Insects and Diseases](#)

Asian Longhorned Beetle (*Anoplophora glabripennis*)



Native to parts of Asia, the Asian longhorned beetle arrived in North America in 1996, thought to have been in the wooden packing material used in cargo shipments from China. The larvae of this beetle feeds in the stems and branches of many hardwood tree species. Continued feeding can lead to death of the branches and entire tree.

Key Identification Characteristics:

- Adults are large insects (with bodies ranging from 1 to 1½ inches in length), winged, and can fly short distances due to their size and weight. Active from mid-May to early August. They are shiny and black with white spots. Antennae are as long as four inches, and banded black and white.
- Signs of presence of this beetle are ball-point pen-like exit holes, 3/8 to 3/4 inches in diameter, often in the larger branches and crowns of the infested trees.
- Other signs are sap oozing from the exit holes with coarse sawdust or “frass” evident on the ground or lower branches.

Pennsylvania Habitat: In hardwoods including maple, box elder, alder, elm, birch, poplar and willows.

BMPs: Design BMPs D1, D2, D5, D9, D10; Construction BMPs C1 to C3, C9, C16; Maintenance BMPs M1 to M5, M7, M14, M21, M22

Link to More Information:

[DCNR National Invasive Species Information Center](#)

Elongate Hemlock Scale (*Fiorinia externa*)

No drawing available.

The elongate hemlock scale was accidentally introduced in 1908 to the U.S. from Japan and is a serious insect pest predominantly of hemlock species in both ornamental and forest trees in Pennsylvania. Feeding injury causes needles to drop, prematurely giving the crown of the infested tree a thin appearance. An infestation of this insect weakens trees, allowing successful attacks by secondary pests.

Key Identification Characteristics:

- Look for waxy covers of this species on the lower needle surface as well as on new cones. These waxy secretions may build into a mass of tangled strands and appear white, confusing the identification with the hemlock wooly adelgid.
- The female's waxy cover is flattened, elongated, light yellow brown to brownish orange, and about 1.5 mm long. The female's body, eggs, and crawler stage under this waxy covering is also yellow.
- The male's waxy cover is white and smaller in size. Adult males may look like tiny wasp parasitoids as they crawl across the needles. Adult male scales have one pair of wings.

Pennsylvania Habitat: Preferred hosts are eastern, Carolina, and northern Japanese hemlocks; fir; and spruce. Also feeds on cedar, Douglas-fir, pine, and yew species.

BMPs: Design BMPs D1, D2, D5, D9, D10; Construction BMPs C1 to C3, C9, C16, C17; Maintenance BMPs M1 to M5, M7, M14, M21, M22

Link to More Information:

[Penn State University College of Agricultural Sciences: Entomology](#)

Recommended BMPs for Invasive Non-plant Aquatic Species

This section will discuss four of the more common invasive non-plant aquatic species that could be encountered in water bodies and watercourses in PennDOT ROWs. These common invasive species are ones included in the **Pennsylvania's Field Guide to Aquatic Invasive Species (PA AIS)** developed by the Pennsylvania Sea Grant document as part of PA E.O. 2004-1 and PISC initiatives. These species could create economic and natural habitat issues if present in a bridge construction/maintenance site by disturbing them; thus they relocate to other waters. Aquatic plant species were included in the Invasive Plant Species Section above to avoid duplication. Fish, reptiles, pathogens, or algae species are also discussed in the PA AIS but are not included in this document. Information on these can be accessed at the website at [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#). Being aware of these other aquatic invasive species will be a benefit to PennDOT ROW work. Even reporting algae blooms in your area to your District's environmental staff can serve to reduce the spread of aquatic invasive species in our state.

Common Invasive Non-plant Aquatic Species

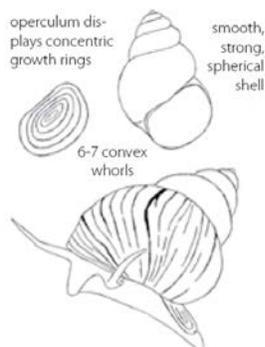
Chinese Mystery Snail (*Cipangopaludina chinensis*)

Asian Clam (*Corbiculata fluminea*)

Zebra Mussel (*Dreissena polymorpha*)

Rusty Crawfish (*Orconectes rusticus*)

Chinese Mystery Snail (*Cipangopaludina chinensis*)



The Chinese mystery snail is commonly sold for use in freshwater aquariums and garden ponds. These snails serve as vectors for transmitting parasites and diseases, and are a known host for some parasites that can infect humans. They can also clog water intake pipes and compete with native snails for food and resources.

Key Identification Characteristics:

- Shell is smooth, strong, and spherical with six to seven convex whorls separated by prominent sutures and fine vertical and horizontal lines that are slightly indented. It is 2.6 inches in height, dark-olive green in adults and lighter for juveniles. Some adults are greenish-brown, brown, or reddish-brown.
- The inner shell is white to pale blue.
- The outer lip of the shell is round or oval-shaped and black.
- The operculum ("trap door") has concentric growth rings and allows the snail to close the opening of the shell for protection.

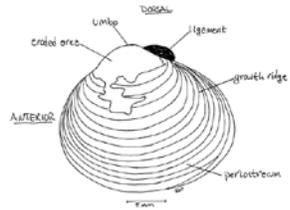
Pennsylvania Habitat: In shallow, quiet waters of lakes, ponds, marshes, irrigation ditches, and slower water portions of streams with some vegetation and muddy or sandy substrate.

BMPs: Design BMPs D1, D2, D6 to D10; Construction BMPs C1 to C3, C9, C16, C17; Maintenance BMPs M1 to M5, M7, M9, M10, M14, M21, M22

Link to More Information:

[Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 72

Asian Clam (*Corbiculata fluminea*)



The Asian clam was introduced to the west coast of the U.S. in 1924 but expanded to the eastern U.S. by the 1970s, impacting power plants, industrial water systems, and causing problems in irrigation canals and pipes. It also increases water clarity by filtering suspended matter which leads to excessive plant growth and altered nutrient and water quality regimes. This clam may also compete with native mollusks for food and habitat.

Key Identification Characteristics:

- Size is 1 to 2.6 inches long, it is thick and triangular-shaped with coarse concentric growth rings.
- Outer shell is typically yellow-green to brown (darker morphs can exist but usually in the southwestern U.S.)
- Inside of the shell is layered with light purple polished nacre, and the teeth are finely serrated.

Pennsylvania Habitat: Prefers running water with sand or gravel substrate bottom; therefore, can be found in streams, rivers, ponds, lakes, and man-made canals. While a freshwater species, it can withstand brackish waters and is also tolerant of degraded waters.

BMPs: Design BMPs D1, D2, D6 to D10; Construction BMPs C1 to C3, C9, C16, C17; Maintenance BMPs M1 to M5, M7, M9, M10, M14, M21, M22

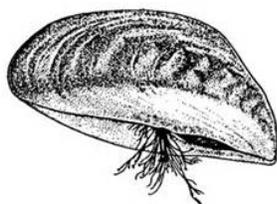
Link to More Information:

[Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 66

Zebra Mussel (*Dreissena polymorpha*)



Zebra Mussels



The economic impact of the zebra mussel is in the billions of dollars. Its clustering behavior clogs intake pipes and damages equipment at power and water facilities, making them very expensive to remove and control. They also harm fisheries, alter water quality, and increase the growth of harmful algae. They decrease food sources for native species by filtering large amounts of microscopic plants and animals from the water, and they accumulate contaminants in their tissues.

Key Identification Characteristics:

- The shell is “D”-shaped with alternative light and dark bands that can vary between brown, beige, and tan with white to yellow stripes or zigzagged patterns. Size is 0.8 to 1 inch in length, but can get up to 2 inches long.
- It sits flat on its ventral side due to a straight mid-ventral line and a prominent ridge. Sticky, thread-like projections located near the middle of the shell help it attach to hard substrates.

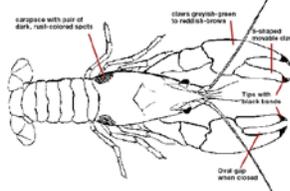
Pennsylvania Habitat: In lakes, rivers, reservoirs, ponds, and quarries, but they require calcium for shell production and water temperatures over 50 degrees F for reproduction. They attach to hard surfaces such as rocks, wood, concrete, steel, and even other organisms.

BMPs: Design BMPs D1, D2, D6 to D10; Construction BMPs C1 to C3, C9, C16, C17; Maintenance BMPs M1 to M5, M7, M9, M10, M14, M21, M22

Link to More Information:

[Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 84

Rusty Crayfish (*Orconectes rusticus*)



Rusty crayfish was first discovered in Pennsylvania in 1976 in the lower Susquehanna River. They reduce native crayfish populations by competing for food and daytime hiding locations. They are very aggressive and voracious eaters, destroying aquatic plant beds and reducing food, shelter, and spawning sites for other organisms, including valued sport fish.

Key Identification Characteristics:

- Adults are typically three to five inches long, with large, black tipped claws, smooth mouthparts, and are typically grayish-green to reddish-brown in color.
- The most distinguishing feature is a set of dark rusty orange spots on each side of the carapace; however, due to hybridization with native crayfish, these spots may not always be present or well developed.

Pennsylvania Habitat: Found in silt, clay, or gravel substrates and prefer areas with adequate rock, log, and debris cover; however, they can survive in a variety of habitats, including lakes, rivers, ponds, and streams. They are most active at temperatures above 46 degrees F.

BMPs: Design BMPs D1, D2, D6 to D10; Construction BMPs C1 to C3, C9, C16, C17; Maintenance BMPs M1 to M5, M7, M9, M10, M14, M21, M22

Link to More Information:

[Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#) Pg. 78

Appendix A – Invasive Species Web Sites List

USDA - <http://www.invasivespeciesinfo.gov/>

Invasive Plants - <http://www.invasivespeciesinfo.gov/plants/main.shtml>

List of Federal Noxious Weeds - <http://plants.usda.gov/java/noxious?rptType=Federal>

U.S. Department of Interior –

National Park Service - <http://www.nps.gov/plants/alien/pubs/midatlantic/midatlantic.pdf>

Bureau of Reclamation - <http://www.usbr.gov/mussels/prevention/docs/EquipmentInspectionandCleaningManual2010.pdf>

PA Department of Agriculture - Noxious, Invasive and Poisonous Plant Program, PA list of Noxious Weeds - http://www.portal.state.pa.us/portal/server.pt/gateway/PTARGS_0_2_24476_10297_0_43/http%3B/10.41.0.77/AgWebsite/ProgramDetail.aspx?name=Noxious-Invasive-and-Poisonous-Plant-Program&navid=12&parentnavid=0&palid=116&

PISC - Governor's Invasive Species Council of Pennsylvania - <http://www.invasivespeciescouncil.com/>

PA List of invasive Insects - http://www.invasivespeciescouncil.com/Profiles_Insects.aspx

PA DCNR - Invasive Species of PA - <http://www.dcnr.state.pa.us/conservationscience/invasivespecies/index.htm>

Invasive Laws and Regulations - <http://www.dcnr.state.pa.us/forestry/plants/invasiveplants/invasiveplanttutorial/invasivelaws/index.htm>

Forest Pests, Insects and Disease - <http://www.dcnr.state.pa.us/forestry/insectsdisease/index.htm>

Invasive Plants (Has Lists and Management Plans-Management plans are developed from a variety of sources such as Penn State) - <http://www.dcnr.state.pa.us/forestry/plants/invasiveplants/index.htm>

PA DEP - Pennsylvania Field Guide: Common Invasive Plants in Riparian Areas – <http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/streamreleaf/Docs/Invasive%20Plants.pdf>

PA Fish and Boat Commission - Aquatic Invasives - <http://www.fishandboat.com/ais.htm>

Penn State University - Roadside Vegetation Management Project (click on Publications to get fact sheets) - <http://plantscience.psu.edu/research/projects/vegetative-management>

Integrated Pest Management - <http://extension.psu.edu/ipm>

Weed Management - <http://extension.psu.edu/pests/weeds>

Aquatic Invasive Species of PA - <http://www.pserie.psu.edu/seagrant/ais/>

University of Pennsylvania - Invasive Plants - <http://www.paflora.org/invasive.php>

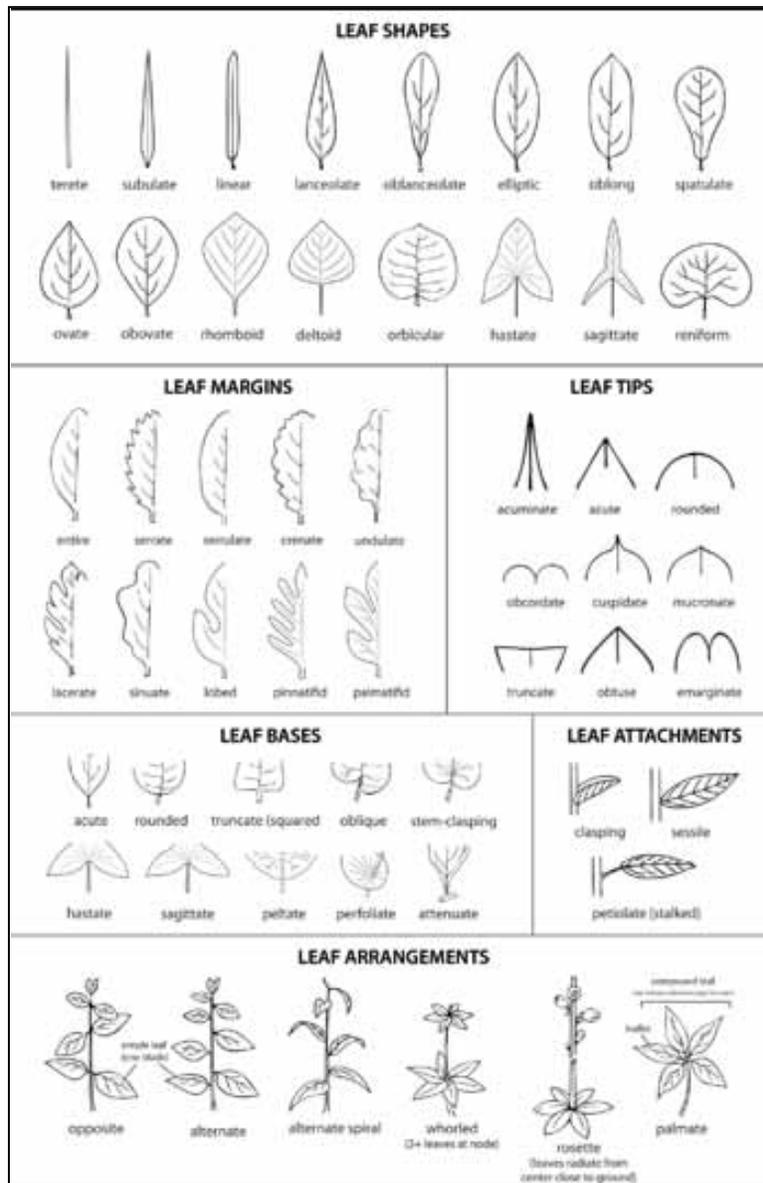
Bowman's Hill - Invasive Plants - <http://www.bhwp.org/resources/Invasive-Plants.htm>

Natural Biodiversity - Bio Bullies - <http://www.naturalbiodiversity.org/biobullies/index.shtml>

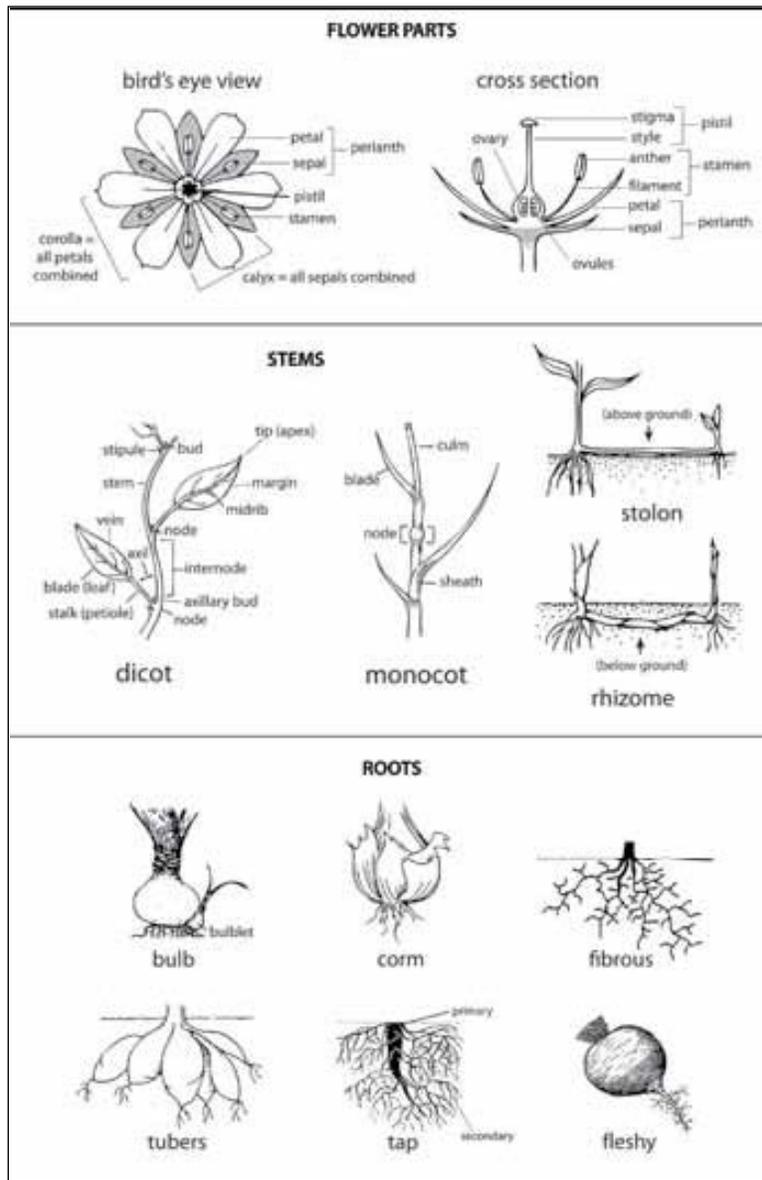
Weeding Invasives - <http://www.naturalbiodiversity.org/invasives.shtml>

iMAP Invasives - <http://imapinvasives.org/>

Appendix B – Plant Structures



Pg. 10 [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#)



From Pg. 11 [Pennsylvania Aquatic Invasive Species \(AIS\) Field Guide](#)

Appendix C – PFBC Biosecurity Protocols

(Excerpted from PA Fish & Boat Commission policy 2009-001)

A. Species-Specific Disinfectants and Procedures for Their Use

Note that many of these methods will be effective against multiple species – but when in doubt, always research which method is best for the particular species and equipment that is to be disinfected. Disinfection procedures for invertebrates are still being developed and evaluated. Thus, try to ensure successful disinfection – use the highest concentration disinfecting agent for the longest duration that won't adversely affect your gear. Always be aware of disposal procedures for disinfectant solutions in order to avoid accidentally polluting waterways!

Zebra/Quagga Mussel – *Dreissena spp.* (and most other invertebrates)

- Wash using a high temperature steam pressure washer at temperatures >200⁰ F or 100⁰C for 3 – 10 minutes depending on organism lifestage, density, etc. (e.g., thick clusters of adults will take longer to kill than a few scattered larvae)
- Wash in water at a minimum temperature of 120⁰ F (49⁰ C) (e.g., undiluted hot tap water) for at least 20 minutes (note: water must be maintained at 120⁰ F (49⁰ C) or above throughout process)
- Use of chlorine based disinfection procedures (see below) (precautions necessary)
- Equipment drying procedures (see below) – Note that it can take up to 21 days to kill adult zebra mussels by drying but most will die within one week (must be tested to confirm death)
- Phenol base cleaners (e.g., Lysol) – immersion in full strength for at least 2 minutes
- Ethanol (50%) – immerse for at least 2 minutes or use repeated flooding rinses of ethanol
- Salt solution (saturated salt solution diluted to 5%; e.g., 50 ml saturated salt solution in 950 ml water) – immersion for at least 30 minutes (exact exposure time depends on mussel life stage, density of mussels, etc.)
- Freezing solid for 1 – 24 hours depending on organism lifestage, density, etc.

Whirling Disease

- Wash using a high temperature steam pressure washer at temperatures >104⁰ F or 40⁰C.

Didymo – *Didymosphenia geminata*

(** minimum of 1 minute exposure to any one (1) of the following):

- Hot water: 140⁰F
- Dishwashing detergent: 5% solution (~1 cup detergent to 1 gallon of water) (“environmentally friendly” detergents are not considered effective)
- Salt solution: 5% solution (saturated salt solution diluted to 5%; e.g., 50 ml saturated salt solution in 950 ml water)
- Air: *Didymosphenia geminata* can survive for months in moist conditions. If complete drying isn't possible, restrict use of gear to a single waterway.

Boats and Other Equipment – “Check, Clean, Dry”

- Check: Look for and remove visible algae and plant material from boots, gear, or anything that has made contact with the water or sediments.
- Clean: Soak, scrub, and/or expose all equipment in one of the solutions described above for a minimum of 1 minute. Absorbent items like felt-soled waders require 30-40 minutes of soaking.
- Air Dry: Items must be dried “to touch,” and then allowed to dry for an additional 48 hours when possible.
 - *Didymosphenia geminata*. Dry: Items must be dried “to touch,” and then allowed to dry for an additional 48 hours when possible. Can survive for months in moist conditions. If complete drying isn’t possible, restrict use of gear to a single waterway.
 - Check trailers, trailer “bunks” with absorbent carpet, engines, paddles/oars, bilge areas, ropes, anchors, etc.

B. Disinfecting Solutions and Agents

Virkon: 0.5% (1:200) solution of Virkon Aquatic® sprayed on at an application rate of 300 ml per square meter. Virkon is available from Western Chemical. Contact number is 1-800-283-5292. PLEASE NOTE: Virkon Aquatic® is labeled for use only as a bactericide and viricide! Do not depend on its use against other AIS such as invertebrates (e.g. zebra mussel), plants, vertebrate species, etc. See above in Appendix 1 for other disinfection methods!

Chlorine: (NOTE: Chlorine, especially at high concentrations, is highly corrosive and causes degradation of plastics and rubber. Chlorine solutions must be neutralized with sodium thiosulfate prior to flushing.)

- 50% (1:1) household bleach (5.25% liquid sodium hypochlorite) dip, wipe, or spray; or
- 10% (1:9) household bleach (5.25% liquid sodium hypochlorite) immersion for 10 minutes; or
- 200 ppm [150 ml of household bleach (5.25% liquid sodium hypochlorite) /10 gal water or 35 g of granular 70% HTH® (pool chlorine)/26 gal water dip or spray (not for use on nets); or
- 20 ppm [15 ml of household bleach (5.25% liquid sodium hypochlorite)/10 gal water or 3.5 g of granular 70% HTH®/26 gal water complete immersion for 30 minutes.
- Household bleach (5.25% Chlorine) can be purchased with VISA through the PFBC’s cleaning supply contract (Grainger).
- HTH is granular chlorine (70% calcium hypochlorite) and can be purchased from a pool supply company.
- Sodium Thiosulfate should be available at a pool supply company or from a chemical supply company.

Quaternary Ammonium Compounds (follow manufacturer instructions)

- Roccal-D™; or
- BrightWater™; or
- Parvosol™, or
- Formula 409®, 1:2 dilution for soaking or full strength as a spray for 10 minutes.

Heated Water

- 200⁰F (93⁰C) poured on gear
- 140⁰F (60⁰C) complete immersion for 15 minutes (requires a consistent heat source)
- 113⁰F (45⁰C) complete immersion for 60 minutes (requires a consistent heat source)

Salt Solution

- Always start with a saturated salt solution and dilute with water to the desired concentration (e.g., 5% salt solution (saturated salt solution diluted to 5%; e.g., 50 ml saturated salt solution in 950 ml water)

Sunlight

- Complete drying in direct sunlight for a minimum of 4-6 hours. Because of the necessarily limited times involved, this method is only recommended for non-absorbent materials.

Freezing

- Items must be frozen for a sufficient duration to kill all AIS life stages – preferably 24 hours or longer.

Air Drying

- Items must be dried long enough to completely dehydrate the organism of concern (many AIS can survive for months in barely damp conditions!). When in doubt, always dry to touch and then continue drying for at least an additional 48 hours. More absorbent materials will take more time to dry thoroughly.

Rubbing Alcohol (Isopropyl)

- For wiping down small equipment.

Appendix D – Photograph and Drawing Credit List by Species

List of Common Invasive Plant Species:

Tree-of Heaven (*Ailanthus altissima*): Photograph is from the Invasive Plants video, produced by PennDOT, 2004; Drawing from Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. 3 vols. Charles Scribner's Sons, New York. Vol. 2:446.

Exotic Bush Honeysuckles (*Lonicera sp.*): Photograph is from (need citation and better photo); Drawing from Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. 3 vols. Charles Scribner's Sons, New York. Vol. 3:282.

Multiflora Rose (*Rosa multiflora*): Photograph by James H. Miller @ USDA-NRCS PLANTS Database / James H. Miller and Karl V. Miller. 2005. *Forest plants of the southeast and their wildlife uses*. University of Georgia Press., Athens; Drawing from Rhoads, A. F., and T. A. Block. 2000. *The Plants of Pennsylvania, First Edition*. University of Pennsylvania Press, Philadelphia. 620.

Oriental Bittersweet (*Celastrus orbiculatus*): Photograph is from the Invasive Plants video, produced by PennDOT, 2004; Drawing from Rhoads, A. F., and T. A. Block. 2000. *The Plants of Pennsylvania, First Edition*. University of Pennsylvania Press, Philadelphia. 340.

Japanese Hop (*Humulus japonica*): Photograph by Leslie J. Mehrhoff, University of Connecticut, Bugwood.org; Drawing from Rhoads, A. F., and T. A. Block. 2000. *The Plants of Pennsylvania, First Edition*. University of Pennsylvania Press, Philadelphia. 309.

Mile-A-Minute (*Persicaria perfoliata*): Photograph is from the Invasive Plants video, produced by PennDOT, 2004; Drawing from Bing Images, pick4.pick.uga.edu.

Kudzu-vine (*Pueraria lobata*): Photograph is from the Invasive Plants video, produced by PennDOT, 2004; Drawing from Rhoads, A. F., and T. A. Block. 2000. *The Plants of Pennsylvania, First Edition*. University of Pennsylvania Press, Philadelphia. 417.

Nodding or Musk Thistle (*Carduus nutans*): Photograph from ndweeds.homestead.com/Musk Thistle; Drawing Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. 3 vols. Charles Scribner's Sons, New York. Vol. 3:554.

Canada Thistle (*Cirsium arvense*): Photograph is from the Invasive Plants video, produced by PennDOT, 2004; Drawing from Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. 3 vols. Charles Scribner's Sons, New York. Vol. 2:553.

Bull or Spear Thistle (*Cirsium vulgare*): Photograph from apps.carelton.edu; Drawing from Strausbaugh, P. D., and E. L. Core. 19709-77. *F;ora of West Virginia, Second Edition*. Seneca Books, Inc., Granstville, West Virginia. 1008.

Poison Hemlock (*Conium maculatum*): Photograph from Photograph is from the Invasive Plants video, produced by PennDOT, 2004; Drawing Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions*. 3 vols. Charles Scribner's Sons, New York. Vol. 2:653.

Japanese Knotweed (*Fallopia japonica*): Photograph is from the Invasive Plants video, produced by PennDOT, 2004; Drawing from Strausbaugh, P. D., and E. L. Core. 19709-77. *Flora of West Virginia, Second Edition*. Seneca Books, Inc., Granstville, West Virginia. 338.

Giant Knotweed (*Fallopia sachalinensis*): Photograph from Bing Images, www.knotweed-uk.com; Drawing from Strausbaugh, P. D., and E. L. Core. 19709-77. *F;ora of West Virginia, Second Edition*. Seneca Books, Inc., Granstville, West Virginia. 338.

Goatsrue (*Galega officinalis*): Photograph from <http://www.portlandoregon.gov/bes/article/432917>; Drawing from Rhoads, A. F., and T. A. Block. 2000. *The Plants of Pennsylvania, First Edition*. University of Pennsylvania Press, Philadelphia. 408.

Giant Hogweed (*Heracleum mantegazzianum*): Photograph from <http://www.portlandoregon.gov/bes/article/432900>; Drawing from Google Images, <http://linnet.geog.ubc.ca/Images/Drawings/big/PDAP115020.jpg>.

Purple Loosestrife (*Lythrum salicaria*): Photograph is from the *Invasive Plants* video, produced by PennDOT, 2004; Drawing Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions. 3 vols.* Charles Scribner's Sons, New York. Vol. 2:581.

Japaneese Stiltgrass (*Microstegium vimineum*): Photograph from http://dnr.wi.gov/topic/Invasives/fact/imapges/Jstiltgrass_CEvans.jpg; Drawing from USDA-NRCS PLANTS Database/USDA NRCS. *Wetland flora: Field office illustrated guide to plant species*. USDA Natural Resources Conservation Service.

Eurasian Watermilfoil (*Myriophyllum spicatum*): Photograph from the Washington Department of Ecology by Alison Fox, University of Florida, Bugwood.org; Drawing from *Eurasian Watermilfoil. Robert Johnson, Cornell University. Ruthanna Hawkins, Cayuga Lake Watershed Network; Drawing, University of Florida, Center for Aquatic and Invasive Plants Line Drawing DVD Master. Used with permission.*

Curly- leaf Pondweed (*Potamogeton crspus*): Photograph by Chris Evans, River to River CWMA at website invasivespeciesinfo.gov/aquatics; Drawing Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions. 3 vols.* Charles Scribner's Sons, New York. Vol. 1:81.

Shattercane (*Sorghum bicolor*): Photograph from *Weeds of Nebraska and the Great Plains* published by Nebraska Department of Agriculture; Drawing from Rhoads, A. F., and T. A. Block. 2000. *The Plants of Pennsylvania, First Edition*. University of Pennsylvania Press, Philadelphia. 977.

Johnson Grass (*Sorghum halepense*): Photograph from Bing images, plants.ifas.ufl.edu; Drawing Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions. 3 vols.* Charles Scribner's Sons, New York. Vol. 1:121.

Narrowleaf & Hybrid Cattails (*Typha angustifolia, Typha x glauca*): Photograph by Nelson DeBarros @ USDA-NRCS PLANTS Database; Drawing Britton, N.L., and A. Brown. 1913. *An illustrated flora of the northern United States, Canada and the British Possessions. 3 vols.* Charles Scribner's Sons, New York. Vol. 1:69.

Phragmites (*Phragmites australis*): Photograph by Steve Dewey, Utah State University at http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_010286.pdf; Drawing USDA-NRCS PLANTS Database / Hitchcock, A.S. (rev. A. Chase). 1950. *Manual of the grasses of the United States*. USDA Miscellaneous Publication No. 200. Washington, DC.

Didymo (*Didymosphenia geminata*): Photographs by Tim Daley, PA DEP at http://www.fish.state.pa.us/water/habitat/ans/didymo/faq_didymo.htm.

Golden Alga (*Prymnesium parvum*): Photograph by Dr. Carmelo Tomas, University of North Carolina at Wilmington at <http://www.fish.state.pa.us/ais/ais-action-golden-alga.pdf>.

List of Common Invasive Insect Species:

Hemlock Woolly Adelgid (*Adelges tsugae*): Photograph from <http://na.fs.fed.us/fhp/hwa/images/branch.jpg>; Drawing from http://ento.psu.edu/extension/factsheets/images/hemlock-woolly-adelgid.jpg/image_mini.

Emerald Ash Borer (*Agrilus planipennis*): Photograph from Google Images, UGA 5343061 Adult EAB.preveiw.jpg; Drawing from www.scientificillustrator.com/art/insects/emerald-ash-borer.jpg Illustrator: Gina Mikel

Asian Longhorned Beetle (*Anoplophora glabripennis*): Photograph from **Adult** - Donald Duerr, USDA, Forest Service, Invasive.org; Drawing from <http://asian-longhorned-beetle.com/index.html>.

Elongate Hemlock Scale (*Fiorinia externa*): Photograph from Penn State Extension, hemlock-scale.jpg/imapge_preview; no drawing found.

List of Common Invasive Non-plant Aquatic Species:

Chinese Mystery Snail (*Cipangopaludina chinensis*): Photograph by Amy Benson at USGS.gov – website fact sheet; Drawing from pg. 72 of The Pennsylvania Field Guide to Aquatic Invasive Species by Sea Grant Pa., <http://www.pserie.psu.edu/seagrant/ais/>

Asian Clam (*Corbiculata fluminea*): Photograph by Noel M. Burkhead at U. S. Geological Services website fact sheet; Drawing from Bing Images – lanwebs.lander.edu.

Zebra Mussel (*Dreissena polymorpha*): Photograph from USGS website fact sheet; Drawing from Bing Images, en.wikipedia.org.

Rusty Crawfish (*Orconectes rusticus*): Photograph and drawing from Minnesota Sea Grant website at <http://www.seagrant.umn.edu/ais/rustycrayfish>.