

Invasive Plant Management for Land Managers

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INVASIVE PLANT MANAGEMENT FOR LAND MANAGERS

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What is an Invasive Species?

People have been moving plants around the world for centuries. Most countries now rely on plants from other regions of the world for food, construction materials, ornamental plants and fibers. Organisms that have been moved from their native habitat to a new location are referred to as "non-native," "non-indigenous," "exotic," or "alien" to the new environment. Most U.S. food crops are non-native species and their beneficial value is obvious. A small percentage of non-natives, however, cause serious problems in their new environments and are collectively known as "invasive species."

How Did They Get Here?

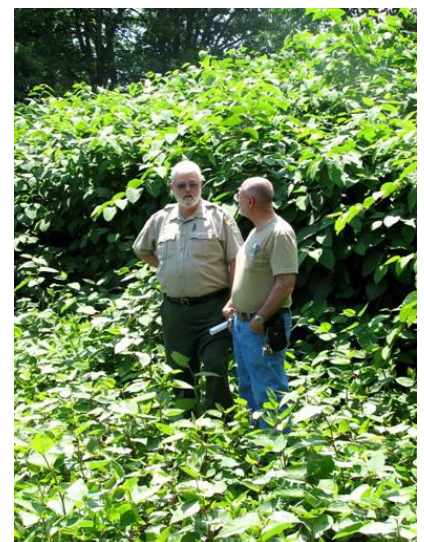
Non-native species have been introduced into the U.S. in a variety of ways. Some non-native species, intentionally introduced for beneficial purposes, later turn out to be invasive. Examples include purple loosestrife, which was sold as an ornamental plant, as well as Japanese knotweed, which was introduced for erosion control. Yet many of the non-native species that later become invasive were unintentionally introduced; they move as unknown stowaways and hitchhikers when people and their products are transported by air, water, rail or road. Examples of invasive plant species unintentionally introduced into the U.S. include mile-a-minute vine and Japanese stiltgrass.

Why Are They a Problem?

The most important aspect of how a non-native plant does or does not become invasive is how it responds to a new environment. An **invasive** plant displays rapid growth and spread, allowing it to establish over large areas. Free from the vast and complex array of natural controls present in their native lands, including herbivores, parasites and diseases, invasive plants may experience rapid and unrestricted growth in new environments. Their phenomenal growth allows them to overwhelm and displace existing vegetation and form dense monocultures.

What Makes a Non-Native Plant Become Invasive?

- Ability to grow in many conditions
- Rapid growth
- Ability to exploit and colonize disturbed ground
- Ability to thrive in high nutrient conditions (i.e. excess fertilizers)
- Reproduce rapidly by roots and shoots. If spread by seed, produce numerous seeds that disperse and sprout easily
- Having roots and rhizomes with large food reserves
- Ability to survive and reproduce under adverse conditions
- Having high photosynthetic rates - "greening up" earlier in the spring than natives gives these plants a competitive advantage
- Lack of natural predators, pathogens and parasites



DCNR employees in a Japanese knotweed patch



Impacts of Invasive Plants

Invasive plant species are a considerable threat to biodiversity. Once these species are well established it is sometimes impossible to remove them. When removal is possible, it comes at a high cost financially and ecologically. For instance, researchers at Cornell University estimate that invasive species are costing Americans more than \$130 billion every year. Even controlling a single unwanted invader can carry a price tag in the millions.

In some cases, invasive plants are driving our rarest species closer to extinction. According to the U.S. Fish and Wildlife Service, an estimated 42 percent of the nation's endangered and threatened species have declined as a result of encroaching invasive plants and animals. Recent research has shown that some invasive species can cause the populations of even common species to collapse.

Ecological impacts

- Changes in the availability or quantity of water or nutrients
- Changes in light availability to plants in the ground layer and shrub layer or to plants and animals in lower depths of lakes and streams
- Toxicity
- Allelopathy (when one plant produces chemicals that are toxic to other plants)
- Reduction or elimination of localized or specialized native plant communities
- Disruption of insect-plant associations necessary for seed dispersal of native plants
- Disruption of native plant-pollinator relationships
- Reduction and elimination of host plants for native insects and other wildlife
- Serving as host reservoirs for plant pathogens and other organisms that can infect and damage desirable native and ornamental plants
- Replacing nutritious native plant foods with lower quality sources
- Killing trees and shrubs through girdling
- Preventing seedling establishment of native trees and shrubs
- Changes in the rate of soil erosion
- Changes in the frequency of wildfire
- Changes to natural ecological processes, such as plant community succession
- Genetic dilution - incidence of cross-breeding with native species, alters the natives' genetic make-up



Mile-a-minute vine



Laws and Regulations

There are several laws and regulations that address the control, eradication, or prevention of invasive plant species. New legislation or changes to current legislation have an important impact on how we can deal with invasive plant problems. For the benefit of those using this site, we will discuss only a few of the most pertinent pieces of legislation. For a full review of national and state laws and regulations, see the National Invasive Species Center website: www.invasivespeciesinfo.gov.

Federal Noxious Weed Act

Visit USDA Plant Database for a complete list of federal noxious weeds (<https://plants.usda.gov/java/noxious?rptType=Federal>).

Overview: The Act 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.

Policy: Congress found that noxious weeds interfere with the growth of useful plants, clog waterways, interfere with navigation, cause disease and generally are detrimental to agriculture, commerce and the public health. Congress determined that regulation of transactions in and movement of noxious weeds was necessary.

Selected Definitions: Noxious weed: any living stage (including seeds and reproductive parts) of a parasitic or other plant of a kind which is of foreign origin, is new to or not widely prevalent in the U.S., and can directly or indirectly injure crops, other useful plants, livestock, poultry or other interests of agriculture, including irrigation, navigation, fish and wildlife resources, or the public health. Undesirable plants: species classified as undesirable, noxious, harmful, exotic, injurious, or poisonous under state or federal law, but not including species listed as endangered by the Endangered Species Act, or species indigenous to the area where control measures are to be taken. Secretary: the Secretary of Agriculture or a designee. Move: deposit for transmission in the mails, ship, offer for shipment, offer for entry, import, receive for transportation, carry, or otherwise transport or move, or allow to be moved. Integrated management system: a system for planning and implementing a program, using an interdisciplinary approach, to select a method for containing or controlling undesirable plant species, using all available methods, including education, preventive measures, physical or mechanical methods, biological agents, herbicide methods, cultural methods, and land management practices such as manipulation of livestock, wildlife grazing strategies or improving wildlife or livestock habitat.

Movement of Noxious Weeds into or Through the U.S.: No person may import or move any noxious weed identified by regulations of the Secretary into or through the U.S. except in compliance with the regulations, which may require that permits be obtained. No person may knowingly sell, purchase, barter, exchange, give or receive any noxious weed moved in violation of these provisions or deliver or receive for transportation any advertisement to sell, purchase, barter, exchange, give or receive a noxious weed whose movement is prohibited.

The Secretary may promulgate inspection and quarantine regulations to prevent the dissemination of noxious weeds. The Secretary may temporarily quarantine any state, territory or district or any portion, and may prohibit the interstate movement of any products from the quarantined area. Quarantine regulations expire 90 days after promulgation unless the Secretary determines, after a public hearing, that a quarantine and regulations are necessary to protect agriculture, commerce, wildlife resources, or the public health.

The Act empowers the Secretary to seize, quarantine, treat, destroy or dispose of any product or article infested by a noxious weed as an emergency measure to prevent dissemination. The owner of destroyed property may recover compensation for the lost property if legal action is taken within one year after the loss and the owner establishes that the Secretary's action was not authorized by the Act.

Enforcement: The Act authorizes the Secretary's inspectors to stop and inspect, without warrant, any product, article, or means of conveyance moving into the U.S., or with probable cause, through the U.S. Inspectors may enter premises with a warrant to perform inspections or other actions necessary under the Act. A person who knowingly violates the Act or any regulation under the Act will be guilty of a misdemeanor and may be punished by a fine, imprisonment not exceeding one year, or both.

Regulations: The Secretary may promulgate regulations to carry out provisions of the Act. Regulations identifying plants as noxious weeds may be promulgated only after publication of notice and, when requested, a public hearing. A plant may be deemed a noxious weed if it falls within the Act's definition of a noxious weed and if there is a reasonable expectation that its dissemination will injure, to a serious degree, agriculture, navigation, fish and wildlife resources, or the public health.

Federal Executive Order 13112

By the authority vested in me as President by the Constitution and the laws of the United States of America, including the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 *et seq.*), Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended (16 U.S.C. 4701 *et seq.*), Lacey Act, as amended (18 U.S.C. 42), Federal Plant Pest Act (7 U.S.C. 150aa *et seq.*), Federal Noxious Weed Act of 1974, as amended (7 U.S.C. 2801 *et seq.*), Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*), and other pertinent statutes, to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause, it is ordered as follows:

Section 1. *Definitions.*

- (a) "Alien species" means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.
- (b) "Control" means, as appropriate, eradicating, suppressing, reducing, or managing invasive species populations, preventing spread of invasive species from areas where they are present, and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.
- (c) "Ecosystem" means the complex of a community of organisms and its environment.
- (d) "Federal agency" means an executive department or agency, but does not include independent establishments as defined by 5 U.S.C. 104.
- (e) "Introduction" means the intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity.
- (f) "Invasive species" means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.
- (g) "Native species" means, with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.
- (h) "Species" means a group of organisms all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves, and show persistent differences from members of allied groups of organisms.
- (i) "Stakeholders" means, but is not limited to, State, tribal, and local government agencies, academic institutions, the scientific community, nongovernmental entities including environmental, agricultural, and conservation organizations, trade groups, commercial interests, and private landowners.
- (j) "United States" means the 50 States, the District of Columbia, Puerto Rico, Guam, and all possessions, territories, and the territorial sea of the United States.

Sec. 2. Federal Agency Duties. (a) Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law,

(1) identify such actions;

(2) subject to the availability of appropriations, and within Administration budgetary limits, use relevant programs and authorities to: (i) prevent the introduction of invasive species; (ii) detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner; (iii) monitor invasive species populations accurately and reliably; (iv) provide for restoration of native species and habitat conditions in ecosystems that have been invaded; (v) conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species; and (vi) promote public education on invasive species and the means to address them; and

(3) not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.

(b) Federal agencies shall pursue the duties set forth in this section in consultation with the Invasive Species Council, consistent with the Invasive Species Management Plan and in cooperation with stakeholders, as appropriate, and, as approved by the Department of State, when Federal agencies are working with international organizations and foreign nations.

Sec. 3. Invasive Species Council. (a) An Invasive Species Council (Council) is hereby established whose members shall include the Secretary of State, the Secretary of the Treasury, the Secretary of Defense, the Secretary of the Interior, the Secretary of Agriculture, the Secretary of Commerce, the Secretary of Transportation, and the Administrator of the Environmental Protection Agency. The Council shall be Co-Chaired by the Secretary of the Interior, the Secretary of Agriculture, and the Secretary of Commerce.

The Council may invite additional Federal agency representatives to be members, including representatives from subcabinet bureaus or offices with significant responsibilities concerning invasive species, and may prescribe special procedures for their participation. The Secretary of the Interior shall, with concurrence of the Co-Chairs, appoint an Executive Director of the Council and shall provide the staff and administrative support for the Council.

(b) The Secretary of the Interior shall establish an advisory committee under the Federal Advisory Committee Act, 5 U.S.C. App., to provide information and advice for consideration by the Council, and shall, after consultation with other members of the Council, appoint members of the advisory committee representing stakeholders. Among other things, the advisory committee shall recommend plans and actions at local, tribal, State, regional, and ecosystem-based levels to achieve the goals and objectives of the Management Plan in section 5 of this order. The advisory committee shall act in cooperation with stakeholders and existing organizations addressing invasive species. The Department of the Interior shall provide the administrative and financial support for the advisory committee.

Sec. 4. Duties of the Invasive Species Council. The Invasive Species Council shall provide national leadership regarding invasive species, and shall:

(a) oversee the implementation of this order and see that the Federal agency activities concerning invasive species are coordinated, complementary, cost-efficient, and effective, relying to the extent feasible and appropriate on existing organizations addressing invasive species, such as the Aquatic Nuisance Species Task Force, the Federal Interagency Committee for the Management of Noxious and Exotic Weeds, and the Committee on Environment and Natural Resources;

(b) encourage planning and action at local, tribal, State, regional, and ecosystem-based levels to achieve the goals and objectives of the Management Plan in section 5 of this order, in cooperation with stakeholders and existing organizations addressing invasive species;

(c) develop recommendations for international cooperation in addressing invasive species;

- (d) develop, in consultation with the Council on Environmental Quality, guidance to Federal agencies pursuant to the National Environmental Policy Act on prevention and control of invasive species, including the procurement, use, and maintenance of native species as they affect invasive species;
- (e) facilitate development of a coordinated network among Federal agencies to document, evaluate, and monitor impacts from invasive species on the economy, the environment, and human health;
- (f) facilitate establishment of a coordinated, up-to-date information-sharing system that utilizes, to the greatest extent practicable, the Internet; this system shall facilitate access to and exchange of information concerning invasive species, including, but not limited to, information on distribution and abundance of invasive species; life histories of such species and invasive characteristics; economic, environmental, and human health impacts; management techniques, and laws and programs for management, research, and public education; and
- (g) prepare and issue a national Invasive Species Management Plan as set forth in section 5 of this order.

Sec. 5. *Invasive Species Management Plan.* (a) Within 18 months after issuance of this order, the Council shall prepare and issue the first edition of a National Invasive Species Management Plan (Management Plan), which shall detail and recommend performance-oriented goals and objectives and specific measures of success for Federal agency efforts concerning invasive species. The Management Plan shall recommend specific objectives and measures for carrying out each of the Federal agency duties established in section 2(a) of this order and shall set forth steps to be taken by the Council to carry out the duties assigned to it under section 4 of this order.

The Management Plan shall be developed through a public process and in consultation with Federal agencies and stakeholders.

(b) The first edition of the Management Plan shall include a review of existing and prospective approaches and authorities for preventing the introduction and spread of invasive species, including those for identifying pathways by which invasive species are introduced and for minimizing the risk of introductions via those pathways, and shall identify research needs and recommend measures to minimize the risk that introductions will occur. Such recommended measures shall provide for a science-based process to evaluate risks associated with introduction and spread of invasive species and a coordinated and systematic risk-based process to identify, monitor, and interdict pathways that may be involved in the introduction of invasive species. If recommended measures are not authorized by current law, the Council shall develop and recommend to the President through its Co-Chairs legislative proposals for necessary changes in authority.

(c) The Council shall update the Management Plan biennially and shall concurrently evaluate and report on success in achieving the goals and objectives set forth in the Management Plan. The Management Plan shall identify the personnel, other resources, and additional levels of coordination needed to achieve the Management Plan's identified goals and objectives, and the Council shall provide each edition of the Management Plan and each report on it to the Office of Management and Budget. Within 18 months after measures have been recommended by the Council in any edition of the Management Plan, each Federal agency whose action is required to implement such measures shall either take the action recommended or shall provide the Council with an explanation of why the action is not feasible. The Council shall assess the effectiveness of this order no less than once each 5 years after the order is issued and shall report to the Office of Management and Budget on whether the order should be revised.

Sec. 6. *Judicial Review and Administration.* (a) This order is intended only to improve the internal management of the executive branch and is not intended to create any right, benefit, or trust responsibility, substantive or procedural, enforceable at law or equity by a party against the United States, its agencies, its officers, or any other person.

(b) Executive Order 11987 of May 24, 1977, is hereby revoked.

(c) The requirements of this order do not affect the obligations of Federal agencies under 16 U.S.C. 4713 with respect to ballast water programs.

(d) The requirements of section 2(a)(3) of this order shall not apply to any action of the Department of State or Department of Defense if the Secretary of State or the Secretary of Defense finds that exemption from such requirements is necessary for foreign policy or national security reasons.

William Clinton

February 3, 1999

PA Noxious Weed Law

The Pennsylvania Noxious Weed Law, updated in 2012, states that it is illegal to propagate, sell or transport the following noxious weeds in Pennsylvania:

- (1) *Cannabis sativa*, commonly known as marijuana.
- (2) The *Lythrum salicaria* Complex: Any nonnative *Lythrum* including, *Lythrum salicaria* and *Lythrum virgatum*, their cultivars and any combination thereof.
- (3) *Cirsium arvense*, commonly known as Canadian thistle.
- (4) *Rosa multiflora*, commonly known as multiflora rose.
- (5) *Sorghum halepense*, commonly known as Johnson grass.
- (6) *Carduus nutans*, commonly known as musk thistle.
- (7) *Cirsium vulgare*, commonly known as bull thistle.
- (8) *Datura stramonium*, commonly known as jimson weed.
- (9) *Polygonum perfoliatum*, commonly known as mile-a-minute.
- (10) *Puerria lobata*, commonly known as kudzuvine.
- (11) *Sorghum bicolor* cv. *drummondii*, commonly known as shattercane.
- (12) *Heracleum mantegazzianum*, commonly known as Giant Hogweed.
- (13) *Galega officinalis*, commonly known as Goatsrue.

This list was initially developed to identify agricultural weeds and more recently has included weeds of natural areas. Any changes or expansions of this list require an act of the Pennsylvania Legislature.

For additional information on the PA Noxious Weed Law or noxious weeds, go to the Pennsylvania Department of Agriculture website, <http://www.agriculture.state.pa.us/> and search under "noxious weed."

PA Executive Order 2004-1

Because of the significant impact of invasive species on the commonwealth, on January 27, 2004, Pennsylvania's Governor signed an executive order that established the *Pennsylvania Invasive Species Council* (PISC). The purpose of the council 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.

The Secretary of Agriculture and members chair the council include heads or their designees of six Pennsylvania agencies responsible for the conservation of agricultural and natural resources and the protection of public health (Dept. of Conservation and Natural Resources, Dept. of Environmental Protection, Dept. of Health, Dept. of Transportation, Fish and Boat Commission and Game Commission). In addition, members of the public representing agriculture and natural resource organizations and educational institutions conducting invasive species research and outreach were also appointed by the governor. These groups include The Nature Conservancy, the Pennsylvania Landscape and Nursery Association and Penn State University, among others.

The main task of the Pennsylvania Invasive Species Council (www.invasivespeciescouncil.com) was to develop a comprehensive state management plan. A list of all council members and their designees can also be found on the website, along with meeting minutes, upcoming events, and other information.



Prevention and Early Detection

The most effective, economical and ecologically-sound approach to managing invasive plants is to prevent their invasion in the first place. Often limited resources are directed to fight firmly established infestations, but by that stage management is expensive and eradication is probably impossible. Certainly, it is necessary to manage infestations to limit the spread of invasive plants into non-infested areas. However, limited resources might be spent more efficiently on proactive invasive plant management that controls existing infestations but also focuses strongly on prevention or early detection of new ones.



Prevention and Early Detection Guidelines

Plant invasions often follow a typical pattern. Seeds or plant fragments arrive by various mechanisms and become established; however, the persistence of these new individuals is tenuous because of unsuitable habitat or low population levels. If the plant invaders persist, it takes some time (the lag phase) for the population to increase in size. Only after a time specific to species and habitat has elapsed does the population suddenly expand. Control efforts are most cost-effective and likely to succeed during this lag phase. Thus the early detection of newly arriving exotic plant species is an

important component of a control program. Unfortunately, these newly establishing populations are rare and consequently difficult to detect.

Prevention and early detection activities can be focused at different scales. A land manager of a 2,000-acre state park may be limited to focusing prevention efforts on that specific landscape. Invasive species may be well established in other parts of the region or state, but may be new to the 2,000-acre state park. On the other hand, land managers may work beyond the borders of their state forest or state park. Having this larger focus will result in greater success in keeping unwanted species off protected natural lands.

Prevention techniques may include:

- Checking soil, mulch, or other materials that may be brought to a new site for invasive plant presence.
- Cleaning equipment, gear and clothing when moving between sites where invasive plants may be present. The US Department of the Interior Bureau of Reclamation's manual, *Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species*, is a helpful resource (<https://www.usbr.gov/mussels/prevention/docs/EquipmentInspectionandCleaningManual2012.pdf>)
- Moving your activities from the least infested site to the most infested site to avoid bringing in invasive plant propagules to a new area.
- Use certified seed for restoration, landscaping, and lawns to decrease bringing in unwanted invasive plant seed. See the Seed Program website of the PA Department of Agriculture, which manages seed regulation, inspection and certification (<http://www.agriculture.pa.gov/Protect/PlantIndustry/Seed/Pages/default.aspx>).

Watch List Species

Another focus for prevention and early detection activities is on species that are not yet well-established in Pennsylvania or a region of Pennsylvania (e.g., eastern PA or western PA). In addition to known species, there are a number of species that experts believe may be future problems for Pennsylvania's natural areas. These species have been observed acting invasively in natural settings in other parts of the Mid-Atlantic region. Of greatest concern are invasions in bordering states with similar habitats. These species are included on the DCNR Watch List and should be a major focus of any EDRR efforts in the state. Recording the presence of these species on shared networks like EDDMapS allows other concerned land managers to view the introduction of a new invasive plant.

Getting Started on EDRR

Early detection of non-native species should be based on a system of regular surveys to find newly established species. However, not all species will become established, and only a small percentage of those that do will become invasive, presenting threats to biodiversity and the economy. Thus, some surveys will need to focus on specific target species known to be invasive under similar conditions or species that have been successfully eradicated before.

In addition, site-specific surveys looking for non-native species in general can be carried out. They should be targeted at key sites, e.g. areas of high conservation value, within the range of highly endangered species, and at high-risk entry points such as airports and harbors (logging roads, trail heads, parking lots). The drawback of these general surveys is that only well-trained staff will be able to identify non-native species in many taxonomic groups.

A crucial part of early detection is a contingency plan, which determines the action to be taken when a non-native species is found. Given the diversity of potential new incursions, an initial plan will be rather general. It should summarize the stakeholders and experts



DCNR staff EDRR training

who need to be contacted for a more detailed action plan. Contingency plans targeted at specific high-risk species can be very efficient, with an exact schedule for what to do.

Please refer to the Monitoring and Evaluation Section for important information on monitoring for potential new invasive species.

Resources

1. Manager's Tool Kit: Early Detection and Rapid Response: This website includes many links regarding invasive species and EDRR management. <https://www.invasivespeciesinfo.gov/toolkit/detection.shtml>.
2. *General Guidelines for the Establishment & Evaluation of Invasive Species Early Detection and Rapid Response Systems, version 1 June 2003* from The National Invasive Species Council. <http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1017&context=natinvasive>
3. The U.S. Department of The Interior's National Invasive Species Council hosts a website for Early Detection and Rapid Response: <https://www.doi.gov/invasivespecies/edrr>.
4. *Safeguarding America's Lands and Waters from Invasive Species*: Guidelines developed by the Department of the Interior and the National Invasive Species Advisory Committee's Early Detection and Rapid Response subcommittee for land managers. https://www.doi.gov/sites/doi.gov/files/uploads/national_edrr_framework_2016.pdf
5. Early Detection and Rapid Response website on Invasive.org, the Center for Invasive Species and Ecosystem Health's site: <https://www.invasive.org/edrr/>.
6. *Early Detection of Invasive Species: Surveillance, Monitoring and Rapid Response, Eastern Rivers and Mountains Network Summary Report 2010*: The National Park Service has developed this document for resource managers, scientists and the public. https://science.nature.nps.gov/im/units/ermn/assets/docs/monitoring/ERMN_2170272_ISED_Keefer_NPS_ERMN_NRDS_2011_150.pdf
7. Visit DCNR's factsheets on avoiding transporting invasive plant hitchhikers during your recreational activities can be viewed on DCNR's Invasive Plants Page. <http://www.dcnr.state.pa.us/forestry/plants/invasiveplants/index.htm>

Contract and Bid Language

For all projects, general prevention measures can have a great effect on keeping invasive plants out. The following activities will help with preventing the introduction or spread of invasive plants and you can build them into your contract as requirements by the operator:

- Inventory the site for presence of invasive species prior to disturbance. If invasive plants are present, pre-treat with appropriate control methods to ensure they won't spread during project activities.
- Wash all equipment prior to bringing it on site to be sure it is free of any soil or plant parts from previous work areas. Equipment may be inspected before entering a site to be sure it is clean and ready for use. Truck powerwash stations may be used to clean equipment; provide addresses or locations of the facilities in your area.
- Be sure to require only weed-free soil, mulch, gravel and other materials used in the project. Often, invasive plants can be introduced through the materials brought onto the site. You can inspect source materials for presence of invasive species or use reliable sources. Mulching with straw rather than hay can reduce the chance of unintended invasive species introductions.
- Seed all disturbed areas and exposed soil with suitable mixes that do not contain invasive species and are suitable for soil and erosion control. Depending on what the long-term use of the site may be, you can incorporate native grasses and herbaceous plants to occupy the site and provide wildlife habitat. Keep in mind that invasive species contamination can occur during seeding activities and be sure the equipment being used to spread seed is clean and free of any previously-used seed "hitch-hikers".
- Monitor the site while it is being revegetated to ensure desired species are growing and invasive species have not come in. If invasive plants are present, treat with early detection methods.

Depending on your project, you may be able to require the contractor or operator to do long-term inspections of the site to be sure desired vegetation is growing and invasive species are not introduced. This can be done where the contractor may have benefits gained on the site even after construction is complete, such as oil or gas development projects or rights-of way. Requiring the contractor to monitor the site for invasive plants and treat any invasive plants that may appear for a length of time after construction, say five years, may help in keeping these unwanted plants from establishing. This can be as detailed as requiring annual formal monitoring with reporting to simply requiring treatments when you notice invasive plants on the site.



Management Tools

After you assess which invasive plant species to target for management, the next step is to evaluate options for control. There are a number of tools available. They include everything from manually or mechanically removing plants to using biocontrol methods or chemicals. Understanding the biology of the targeted plant, as well as its population size, degree of threat and tools that have proven successful by other practitioners should all play in to your decision of what tools to use. In most cases, more than one tool will be necessary to control your target.

Manual Tools

Hand-pulling or the use of mechanized tools, including mowers, chippers, tractors, or weed pullers, do not involve the use of chemicals. They can be effective for certain species or areas, especially in sensitive habitats where herbicides are not desirable.

Mowing and Cutting

Mowing and cutting can reduce seed production and restrict weed growth, especially in annuals cut before they flower and set seed. However, some species re-sprout vigorously when cut, so be sure to consider the biology of the plant before cutting.

How To

Mowing and cutting are often used as primary treatments to remove aboveground biomass, in combination with prescribed burning or herbicide treatments. It is important to collect the cut plant fragments to prevent roots and seeds from washing or blowing into uninfested areas when they can re-sprout. The timing of this control is key – be sure to remove the plant before they set seed, otherwise you will have to start over again next year.



Two methods of mechanical removal. Left, brush hog mowing small shrubs. Right, DCNR employees using string trimmers.

Girdling

Girdling is one form of cutting that is often used to control trees or shrubs that have a single trunk. It involves cutting away a strip of bark several centimeters wide all the way around the trunk. The removed strip must be cut deep enough into the trunk to remove the vascular cambium, or inner bark, which is the thin layer of living tissue that moves sugars and other carbohydrates between areas of production (leaves), storage (roots), and growing points. This inner cambium layer also produces all new wood and bark.

How To

To girdle a tree, cut parallel lines approximately three inches or more apart around the circumference of the tree. The cuts can be made using a knife, ax or saw, and should be slightly deeper than the cambium. Strike the trunk sharply between the cuts using the back of an ax or other blunt object. The bark should come off in large pieces and prevent the tree from any further growth. It is important not to cut too deeply into the trunk because this could cause the tree to snap and fall in high winds. To determine the depth of the cambium, make two short test cuts and strike the bark between the cuts. After several strikes the bark should come off intact, exposing the cambium and wood (xylem) below.

Girdling is typically less labor intensive than cutting and removal of a tree, is inexpensive and kills only the targeted plant. It also leaves no residue except the standing trunks. In addition, a dead standing tree (snag) can provide valuable wildlife habitat, and if left to decay, allows the nutrients of the tree to be returned to the system, rather than being removed and deposited elsewhere. A few species, notably tree of heaven (*Ailanthus altissima*), should not be girdled because they respond by producing many fast-growing root and stem sprouts. Therefore, before girdling, find out if the target species responds by re-sprouting. If so, use another control technique, such as cut stump or hack and squirt herbicide applications.

Proper Disposal

All plant material should be bagged and properly disposed of. Composting is not recommended for most invasive plants because the seeds may still be able to germinate. You may want to place the plant material in a heavy-grade plastic bag and leave in the sun for several weeks. This will help kill the seeds. Then composting that material becomes a viable option.

Pulling

Pulling can be effective against some shrubs, tree saplings and herbaceous plants but it is not as effective against many perennial invasive plants with deep underground stems and roots that are often left behind to re-sprout.

How To

Minimize soil disturbance by pulling out plants slowly and carefully, and replace soil to disturbed areas where possible. Pull low to the ground to remove as much root material as possible. It helps to pull when soil is moist. Trampled and disturbed areas can provide optimal germination sites for many invasive plants. Minimize trampling by limiting the number of people in the site and the amount of time spent there. Whenever pulling is used, it is wise to wear gloves, a long-sleeved shirt and long pants because some plants can cause moderate to severe skin irritation, especially when their stems and leaves are crushed and broken.

The advantages of pulling include its small ecological impact, minimal damage to neighboring plants and low (or no) cost for equipment or supplies. Pulling is extremely labor intensive, however, and is effective only for relatively small areas, even when abundant volunteer labor is available.



DCNR employee using a Weed-Wrench™ to remove Japanese barberry.

Tools

A garden spade can be used to remove shallow rooted plants. For those with deeper roots, several tools are available including the Root Talon and the Weed Wrench™. The Root Talon is low-cost and lightweight tool shaped like a pick-ax with a plastic handle and metal head. It has a specialized claw and gripping device that allow the user to grab the plant stem and provide leverage to pull-up and remove the plants. The Root Talon is not effective against deep-rooted plants because it does not provide enough leverage.

The Weed Wrench™ provides more leverage than the Root Talon. Its all-steel frame is capable of withstanding more strain than the plastic handle of the Root Talon. It comes in four sizes. Larger Weed Wrenches provide more leverage and pulling power, but it is best to choose the smallest size needed because larger Weed Wrenches are heavy and can be difficult to carry and use in remote sites.

Proper Disposal

All plant material should be bagged and properly disposed of. Composting is not recommended for most invasive plants because the seeds may still be able to germinate. You may want to place the plant material in a heavy-grade plastic bag and leave in the sun for several weeks. This will help kill the seeds. Then composting that material becomes a viable option.

Prescribed Burning

Fire has been used since ancient times by humans to manage vegetation. In modern times, prescribed burns, or controlled fires set by humans, are used to reduce hazardous fuel loads, restore historical disturbance regimes, improve forage habitat for game and livestock species, and promote biodiversity. This last point includes the use of prescribed fires in invasive species management.

Planning and Implementing Prescribed Burns

In planning a prescribed burn, there must be an Agency Administrator, who has the final responsibility of prescribed burns on their land. Examples include: District Forester, Park Superintendent, Regional Land Manager, and the landowner if the burn is on private lands. The Agency Administrator is responsible for:

- Appointing a plan writer who develops and obtains approval for the burn plan.
- Reviewing and approving a specific prescribed burn plan for each site, which includes considerations of the availability of resources, training and qualifications of personnel, safety, budget limitations, and project review.
- Appointing a qualified Burn Boss to implement the burn plan. Duties of the Burn Boss include ensuring that resources are available, determining that fuel and weather conditions are within acceptable parameters according to the plan, managing the activity and resources during the burn, and conducting the burn effectively and safely.
- Ensuring that proper notifications are made as outlined in the PA Prescribed Fire Standards



Using a drip-torch in a prescribed burning event.

Under the Pennsylvania's Prescribed Burning Practices Act (Act 17 of 2009), the Department of Conservation and Natural Resources developed standards for planning and conducting prescribed fires in the Commonwealth, which include

minimum qualifications and training requirements, as well as required content for prescribed burn plans. Pennsylvania's Prescribed Fire Standards, which cover in detail the essential planning and implementation procedures for prescribed fires, can be found at [here](#).

Education of the public is also important in successful implementation of prescribed burn plans. Opposition to a prescribed burning from the public can be strong, even if the project is potentially beneficial, so the responsible party (lead agency) should do their best to provide information to the cooperators, neighbors and community. This can be best achieved by encouraging participation in the planning process and accepting feedback from interested individuals. Concerns need to be addressed and, as necessary, mitigated.

Control of Invasive Plants with Prescribed Fire

Proper timing is essential for effective use of prescribed fires. Therefore, the life histories of the various types of invasive plants, as well as those of the surrounding native plants in the community, must be considered when planning the burn. Long-term suppression for all types of invasive plants also requires reduction or depletion of the seed bank, so it is important to understand the timing of seed maturation, mechanisms of new seed recruitment, and the longevity of existing seeds in the soil. Understanding these aspects of invasive plant biology is important in developing prescribed burning plans as well as more integrated approaches to management.

Annuals

To control annuals effectively, it is critical to either destroy the seeds with fire before they germinate or to kill the plant before the seeds mature. Prescribed burns have been used effectively on invasive grasses such as downy brome and the annual forb weed yellow starthistle.

Biennials

Prescribed burning is generally not successful for control of biennials because the life cycle of biennial plants creates uneven-aged stands. Only those plants that have flowered in the second year of growth are susceptible to fire mortality; one-year-old plants in the basal rosette stage (ground-level grouping of leaves) are protected from grassland fire damage and can survive to produce seeds the second year. To obtain better results, initiate the burn later in the spring before the bolted plants have set and dispersed seed.

Since the strategy with biennials is to decrease the existing seed bank and prevent new seed set and off-site recruitment, multiple year burns can be used to eventually deplete the seed bank. More intense burns give better control of bolting plants, but control is still difficult when the stands are uneven-aged.

In the eastern United States, prescribed burning has been used to control garlic mustard effectively. However, in areas where the thatch and litter layer were damp, plants survived. Sequential burns under drier conditions were more effective in reducing garlic mustard cover and spread rate. Although burning has been shown to suppress sweet-clovers, garlic mustard and other biennial species, combining burns with timely herbicide treatment would probably be even more effective.

Herbaceous Perennials

In most cases, successful control of perennial forbs involves integration of multiple control options, such as prescribed burning and herbicide application. Typically, controlled fires or wildfires promote invasive perennial forbs. For example, spotted knapweed seeds are dispersed soon after they mature and neither spring nor fall burns have been successful in the control of this species. While timing of burning may be critical to management of herbaceous perennial forbs, in some cases, regardless of the timing, control failed and invasive species generally increased in abundance.

Woody Species

Most woody species are difficult to control with prescribed burning. For example, Japanese honeysuckle, tree-of-heaven and Russian-olive actually benefit from fire because they readily re-sprout from the base following fire or mechanical damage. However, other shrub and tree species can be controlled using prescribed burns.



A prescribed fire

In the eastern and mid-Atlantic states, prescribed burning for invasive plants is conducted during the dormant season and is generally unsuccessful due to re-sprouting from rootstocks. It is theorized that growing season burns will be more effective since non-structural carbohydrate reserves are lowest at this time, and a prescribed burn could potentially deplete the energy reserves of the plant's root system, making it more susceptible to subsequent burns or other control measures.

Another strategy is to take advantage of the stimulation of seed germination following a fire: the above ground growth of a plant can be cut in summer or fall and allowed to dry on-site. Once dried, the site can be burned; this initial fire is usually intense because of the dried material and will stimulate greater-than-normal seed germination in the next season. The cut and burn strategy is repeated, and the second burn provides control of the new large batch of young seedlings. However, it will likely require several more years of follow-up control efforts to assure near-elimination of invasive plants at some sites.

Prescribed Fire and Integrated Management Strategies

Repeated burnings that completely manage an invasive species population are rare. Therefore, other management strategies can and should be used with prescribed fire in an integrated approach.

First, a word of caution: prescribed fire, even if it is done repeatedly to deplete the seed bank, is not effective on all invasive species and types of ecosystems. For example, repeated burnings can create shorter fire intervals that can be detrimental to some fire-sensitive native plants. Increasing fire frequencies can also alter an ecosystem's rate of soil formation and erosion and patterns of nutrient cycling. Thus, the effects of fire on plant populations and communities must be considered; a fire regime that aims to reduce invasive species cover can create a disturbed environment that may encourage infestation of other invasive species. Repeated burnings that completely manage an invasive species population are rare. Therefore, other management strategies can be used with or without prescribed fire in an integrated approach.



Vegetation resprouting after a fire

Pre-Treatment Burning

In cases where fire alone cannot provide sufficient control, it can be used to dramatically enhance other control methods, such as chemical or mechanical control methods. The initial burn can be used to stimulate seed germination and thus deplete the seed bank faster than one control method alone. The new seedlings can then be killed with chemical or mechanical methods. Prescribed burning can also be used to clear away invasive species in areas of high density; this can provide more access for additional treatments. For example, litter or thatch removal can improve deposition of herbicide on a target surface. This method is also effective for dealing with vine species, such as kudzu and Japanese honeysuckle, but be careful that the fire does not spread into the tree canopy for vines wrapped around tree trunks.

Post-Treatment Burning

For annuals, where the invasive infestation is heavy and there is not adequate fuel for ideal burn timing, an herbicide treatment the previous year can increase the grass population and facilitate a complete burn the second year. However, when using this strategy, it is important to use a third year control option since burning can stimulate germination of some invasive plants. A similar strategy can apply to woody species; top vegetation can be killed by herbicides and a subsequent burn can kill the root systems. Prescribed fire can also be used after mechanical or chemical methods to remove the dead biomass and stimulate recovery or re-vegetation of infested site with more desirable species.

Tools Used in an Integrated Control Strategy

Mechanical Control

Mechanical methods of control consist of removing or damaging above- or below-ground biomass, including stems, new shoots and roots. Mechanical control methods includes hand-pulling, mowing shredding, roller chopping, clipping (wood cutting) and chaining. These treatments increase the amount of dried and thus the effectiveness of burning. Mechanical control methods should be limited to fairly gentle terrain accessible to the equipment used, such as bulldozers and tillage equipment.

Chemical Control

Most integrated approaches that include prescribed burning also incorporate an herbicide treatment either before or after the burn. Before a burn, these treatments can increase fuel loads, and after a burn they can be used to control re-sprouting vegetation.

Biological Control

Biological control programs for invasive plants often do not eradicate the target plant but exert sufficient environmental stress to reduce invasive plant dominance and spread. Burn timing can be critical to the survival of biological control agents and should be carefully considered. Burning a site when the control agent is inactive (for example, burning in spring and fall for a summer-active control species) can increase the population of the control agent. However, in most situations, prescribed fire's direct effect is damaging to biological control agents. Despite this, biological control and prescribed fire is still a sound integrated approach since insects and pathogens are mobile and can re-occupy a treated site. A combination of these methods can further stress the invasive species and reduce its dominance.

Soil Covers

Because invasive plants are some of the first species to appear in exposed or disturbed soil, the use of a soil covering, like mulch or plastic, can suppress the growth of some invasive plants while minimizing the risk to non-target native species.

Mulching

Mulching can be used on relatively small areas to control invasive plants, but the technique will often stunt or stop growth of desirable native species too. Mulching cannot control some perennial weeds because their extensive food reserves allow them to continue to grow up through the mulch.

How To

Cover the ground seedlings with several inches of mulch (straw, grass clippings, wood chips, etc.) or other type of ground cover (newspaper). This prevents some weed seeds and seedlings from receiving sunlight necessary to survive and grow. While it may not eliminate the invasive plant entirely, it has been shown to suppress flowering rates in plants like Canada thistle.

Soil solarization

This technique involves placing a plastic cover over the soil surface to trap solar radiation and cause an increase in soil temperatures to levels that kill plants, seeds plant pathogens and insects. However, this technique can cause significant biological, physical and chemical changes in the soil that can last up to two years, and deter the growth of desirable native species.

This method has not been used extensively for invasive plant control in natural settings. The effectiveness of soil solarization depends, in part, on how susceptible invasive seeds are to temperature increases. It is most effective against winter annual weeds that germinate under cool conditions. Summer annuals and other species adapted to higher temperatures, which germinate during warmer parts of the year, are less susceptible.

Soil solarization is most effective during the summer months, and may be less effective in cooler climates. The higher the temperature, the more quickly a kill is achieved. Solarization is effective only if done in wet soil. Where soils are typically dry, they must first be irrigated.

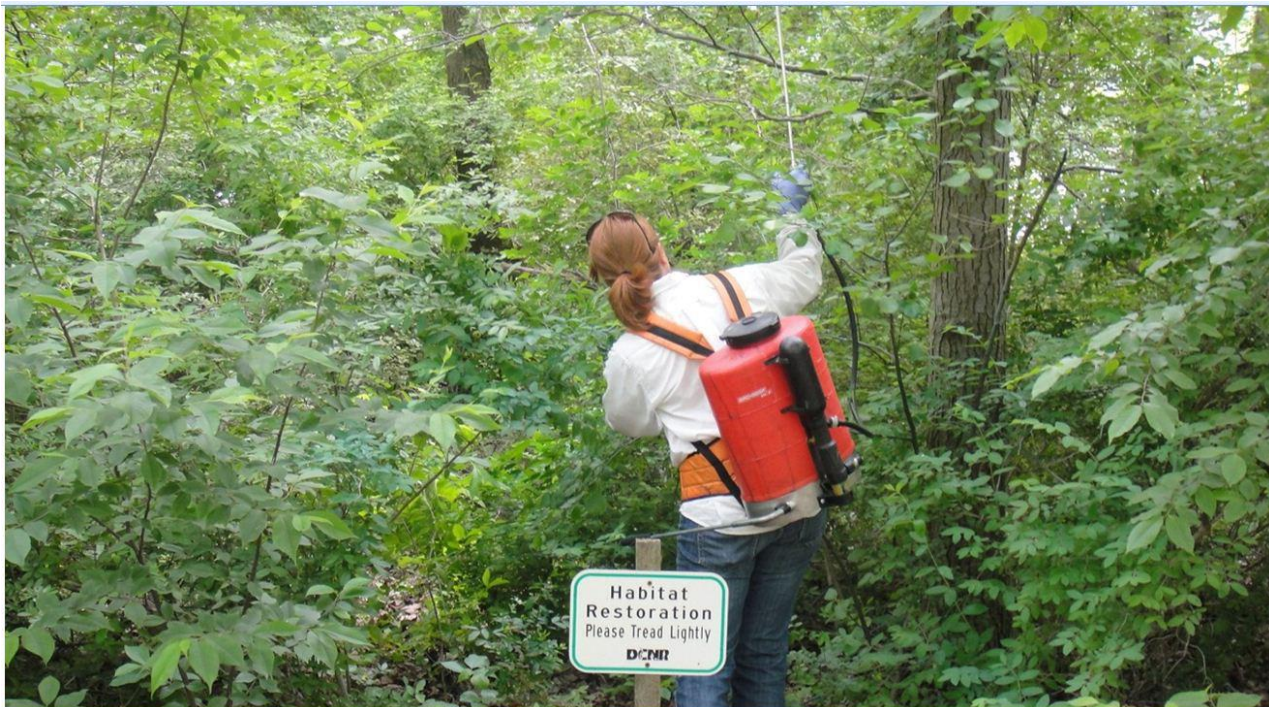
How To

Polyethylene plastic film is the most useful for soil solarization. Clear and black films both trap infrared radiation that is re-radiated from the soil surface, therefore keeping the soil hot. Transparent film allows more radiation to reach the soil than black films, as it lets visible light in, causing even greater temperature increases. Because black films exclude visible light however, they stop photosynthesis, which can be enough to kill some young annuals and perennials given sufficient time. Double layers of film have been found to increase soil temperatures by three to 10 degrees over single layers.



Black plastic covering the soil

Chemical Control



A DCNR employee spot-treating invasives with chemical herbicide.

These guidelines are designed to ensure that you carefully consider the overall impacts of herbicide use on the invasive plant, native species and the ecological system. Base all decisions whether to treat invasive plants with herbicides instead of other methods on the management goals for the site. Herbicides should only be used when one is confident the treatments will meet management and conservation goals, while ensuring protection of the applicators, water sources, wildlife and other values.

Determining the right course of action in invasive species management can be difficult. For many land managers, whether to apply herbicides is a decision that is not taken lightly. Herbicides should be used as a last resort, when other attempts have failed, and action is imperative. However, for the control of some tenacious species like tree of heaven, herbicide use is required for effective control.

How to Know When to Use Herbicide or Another Control Option

- Determine whether invasive plants threaten conservation targets or management goals on the site. Use herbicides (versus other control methods) only if confident they can be used safely and will do more conservation good than harm.
- Develop safety protocols for storing, mixing, transporting, handling spills and disposing of unused herbicides and containers before obtaining herbicides.
- Follow all federal, state and local regulations regarding herbicide use. You **MUST** read and follow product labels. It is a violation of federal law to use an herbicide in a manner inconsistent with its label.
- Contact your state Department of Agriculture for information about state and local regulations regarding applicator permits and posting requirements.
- Check with the legal staff for your program (State or Regional Office) before obtaining herbicides if you have any questions about regulations or liability issues.
- Applicators **MUST** wear all protective gear required on the label of the herbicide they are using. Provide all safety and protective gear requested by the employee applying the herbicide.

Herbicide Properties to Consider

- Effectiveness against the target species (not all herbicides will control invasive plant species the same)

- Mechanisms of dissipation (persistence, degradation and likelihood of movement via air or water to non-target organisms)
- Behavior in the environment (in soils, water and vegetation)
- Toxicity to non-target organisms (including soil organisms)
- Application considerations
- Safety
- Human toxicology

In general for work in natural areas, it is best to select compounds that are:

- Effective against the invasive
- Not likely to drift, leach to groundwater or wash into streams
- Nontoxic to people and other organisms
- Not persistent in the environment
- Easy to apply.



Targeted application of herbicide on a cut stump.

In some circumstances, a single application of a more toxic or persistent chemical is effective in killing the invasive plant, and may be preferable over a less persistent, less toxic compound that must be applied repeatedly. Strive to do the job with the smallest total negative impact to the environment.

Application Methods

Herbicides can be applied in a variety of ways. The most appropriate application method is determined by assessing the species being treated, the herbicide being applied, the skills of the applicator and the conditions at the application site. Standard application techniques can sometimes be modified to effectively meet natural resource and invasive plant management goals.

Site Selection

Site conditions also should be considered before choosing an application method. Consider accessibility, proximity to open water, depth to groundwater, the presence of rare species and other conservation targets, and the site's sensitivity to trampling that could occur when the herbicide is being applied.

Record Retention

When using herbicides, it is critical (and, in some cases, required by law) to keep records of all the species and sites that are treated, the amounts and types of herbicide used and the dates of application. This information will be important in evaluating the project's success, improving methodology and identifying mistakes. In addition, it documents the procedure for future site managers and biologists. Records of abundance/condition of the targeted invasive plants and nearby desirable plants before and after treatment will also be valuable in evaluating the effectiveness of the herbicide.



Using a drip-torch in a prescribed burning event.

Foliar Applications

These methods apply herbicide directly to the leaves and stems of a plant. An adjuvant or surfactant is often needed to enable the herbicide to penetrate the plant cuticle - a thick, waxy layer present on leaves and stems of most plants. Foliar application methods can range from very specific spot treatments through spray or wick equipment or more general broadcast spraying with hoses or boom applicators attached to a tractor or other motorized equipment. Spot applications are preferred when possible to ensure non-target specimens are not treated with herbicides and to cut back on the amount of chemical applied.

- A. Spot applicators - Spray herbicide directly onto target plants only, and avoid spraying other desirable plants. These applicators range from motorized rigs with spray hoses to backpack sprayers, to hand-pumped spray or squirt bottles.
- B. Wick (wipe-on) applicators - Use a sponge or wick on a long handle to wipe herbicide onto foliage and stems. Use of a wick eliminates the possibility of spray drift or droplets falling on non-target plants. However, herbicide can drip or dribble from some wicks.
 - 1. "Paint sticks" and "stain sticks" sold at local hardware stores have been used successfully for wick application. These sticks have a reservoir in the handle that can hold herbicide, which soaks a roller brush at the end of the handle. The brush is wiped or rolled across leaves and stems.
 - 2. The "glove of death" is a technique for applying herbicide in an otherwise high quality site. Herbicide is sprayed directly onto a heavy cotton glove worn over a thick rubber/latex (or nitrile) glove. The wearer of the glove can then apply the herbicide with total precision and little or no runoff.
- C. Boom applicator - A boom, a long horizontal tube with multiple spray heads, is mounted or attached to a tractor, ATV (or other four-wheel drive vehicle), helicopter, or small plane. The boom is then carried above the weeds while

spraying herbicide, allowing large areas to be treated rapidly with each sweep of the boom. Offsite movement due to vaporization or drift and possible treatment of non-target plants can be of concern when using this method.

Basal Bark

This method applies a six to 12 inch band of herbicide around the circumference of the trunk of the target plant, approximately one foot above ground. The width of the sprayed band depends on the size of the plant and the species' susceptibility to the herbicide. The herbicide can be applied with a backpack sprayer, hand-held bottle or a wick. Ester formulations are usually best for basal bark treatments, as esters pass through the bark more readily than salts. Esters can be highly volatile, however, so basal bark treatments should be performed only on calm, cool days. During summer, treatment is best carried out in the mornings, which tend to be cooler. The basal bark treatment works best on young trees with smooth bark. It is usually not effective against older plants with thick corky bark.



Basal bark treatment

Hack and Squirt

The hack and squirt method is often used to treat woody species with large, thick trunks and bark. The tree is hacked with a small ax or hatchet, or drilled with a power drill or other device. Herbicide is then immediately applied to the exposed wood with a backpack sprayer, squirt bottle, syringe or similar equipment. Because the herbicide is placed directly onto the thin layer of growing tissue in the trunk (the cambium), an ester formulation is not required.

Injection

Herbicide pellets can be injected into the trunk of a tree using a specialized tool such as the EZ-Ject Lance[®]. The lance's five-foot-long, metal tube has "teeth" on one end that grip the trunk of the tree. A sharp push on the other end of the tube sends a brass capsule of herbicide into the tree trunk. It is a convenient way of applying herbicide and requires minimal preparation, little exposure to the chemical and easy clean up.

However, there are some serious drawbacks to this method. The lance and capsules are expensive and full-sized lances can be unwieldy, particularly in thickets. The lance is difficult to thrust with enough power to drive the capsules far enough into thick barked trees to be effective. A large number of capsules placed close together are often necessary to kill large trees.

Cut-Stump

This method is often used on woody species that normally re-sprout after being cut. The tree or shrub is cut, and herbicide is immediately applied to the exposed cambium (living inner bark) of the stump. The herbicide must be applied to the entire inner bark (cambium) within minutes after the trunk is cut. The outer bark and heartwood do not need to be treated since these tissues are not alive, although they support and protect the tree's living tissues.

Herbicide can be applied to cut stumps in many ways, including spray and squirt bottles, or even paint brushes. Care must be taken to avoid applying too much herbicide, causing the chemical to run-off the stump and onto the ground. Herbicide can also dribble from bottles or brushes, potentially falling onto non-target plants or the ground.

Sometimes even treated stumps will re-sprout, so it is important to check regularly (two to six months) for at least a year. Depending on the vigor of the re-sprouts, these can be treated by cutting, basal bark applications or foliar applications. Even when foliar applications are a necessary follow-up treatment, applying herbicide to the re-sprouts is usually easy and requires minimal chemical use.

The cut stump treatment allows for a great deal of targeted control of invasive plants with a low probability of affecting non-target species or contaminating the environment. It also requires only a small amount of herbicide to be effective.



Cut-stump method

Safe Use

Herbicides can be dangerous if not handled properly. The health and safety of the applicator are the primary concern during herbicide treatments. Applicators **MUST** wear all protective gear required on the label of the herbicide they are using. Any additional safety and protective gear requested by the applicators must be provided. After using herbicides, be sure to adequately clean gear and properly store or dispose of extra chemicals.

Personal Protective Equipment (PPE)

Herbicide labels indicate the minimum protective equipment required. This may vary by application technique. Cotton, leather, canvas and other absorbent materials are not chemical resistant, even to dry formulations.

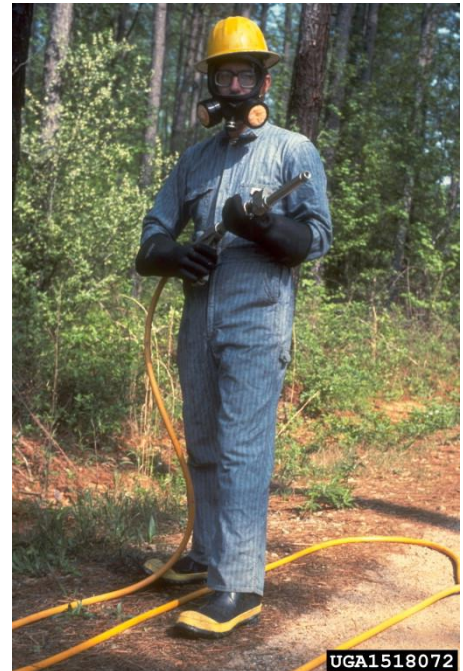
- Always wear at least a long-sleeved shirt, long pants, sturdy shoes or boots, and socks. The more layers of fabric and air between you and the pesticide, the better the protection.
- Hands and forearms usually receive the most pesticide exposure. Wear chemical-resistant gloves, and tuck shirt sleeves into gloves. Gloves should reach up the forearm, with cuffs to catch runs and drips.
- Canvas, cloth and leather shoes or boots are almost impossible to clean adequately. Wear chemical-resistant rubber boots that come up at least halfway to the knee if the lower legs and feet will be exposed to herbicides or residues.

Avoiding Contamination

- Wear chemical-resistant gloves (rubber or plastic such as butyl, nitrile or polyvinyl chloride are common types).
- Make sure gloves are clean, in good condition, and worn properly. Replace gloves often. Wash and dry hands before putting on gloves. Wash gloves before removing them.
- Wash hands thoroughly before eating, drinking, using tobacco products or going to the bathroom.
- Cuff gloves if pesticide is expected to run down towards the sleeves. Tuck sleeves into gloves.

Eye and Respiratory Protection

- PPE labeling might require goggles, face shields or safety glasses with shields. Some formulas or handling activities pose more risks to eyes than others. Dusts, concentrates and fine sprays have the highest risk of causing pesticide exposure.
- There are many types of dust-mist masks and respirators, all of which must fit and be used properly to be effective.
- Respiratory protection is most important in enclosed spaces or when the applicator will be exposed to pesticides for a long time.
- Pesticides that can volatilize require the use of respirators. Check label requirements.



Full personal protective equipment (USDA Forest Service - Region 8 - Southern, USDA Forest Service, Bugwood.org)

Personal Clean-up After Herbicide Use

- Wash gloves and footwear (if possible) with detergent and water before removing them.
- Change clothing and put clothes used during application in a plastic box or bag, and keep it away from children or pets. Use a mild liquid detergent and warm water to wash your hands, forearms, face and any other body parts that may have been exposed to pesticides.

Laundry

- Do not wash work clothing and personal protective equipment in the same wash water with the family laundry. Handle with care and wash your hands after loading the machine.
- If you have chemical-resistant items, follow the manufacturer's washing instructions. Wash boots and gloves with hot water and liquid detergent. Wash twice, once outside and once inside. Air-dry boots and gloves.
- Rinse clothes in a machine or by hand.
- Wash in plenty of water for dilution and agitation.
- If using a washing machine, using heavy-duty liquid detergent in hot water for the wash cycles.
- After washing the clothes, run the washer through one complete cycle with detergent and hot water, but no clothing, to clean the machine.
- Hang items to dry if possible in plenty of fresh air. Do not hang in living areas.
- Using a clothes dryer is acceptable, but over time the machine may become contaminated with pesticide residues.

Emergency Precautions and Equipment

Applicators must have easy access to emergency decontamination and first aid kits whenever they are applying herbicides, even if they are out in the field. All applicators should have access to an eyewash kit and at least two gallons of clean water.

Decontamination kits are available from many suppliers or can be assembled independently. Rubber buckets or tubs with tight sealing lids are convenient for homemade kits and should include:

- Two (or more) 1 gallon containers filled with potable water,
- Eyewash kits or eyewash bottles with buffered isotonic eyewash,
- Hand or body soap (bring enough for all workers to thoroughly wash their hands when in the field),
- Paper or other disposable towels,
- A full tyvek coverall with foot covers,
- A map and directions to the nearest medical facilities. Such maps should be posted in prominent locations at all preserve offices and work buildings. Include a copy as an Appendix to your weed control plan.

Posting Treated Areas

Federal requirements for posting treated areas, if any, are listed on the herbicide label. Glyphosate, triclopyr and most other herbicides used in natural areas have no federal posting requirements. Some municipalities and counties have stricter requirements. Always keep treated areas off limits to the public at least until the herbicide dries. Treated areas may be kept off limits for longer periods if the herbicide is persistent in the environment.

When posting areas that are accessible to the public (trails, visitor centers etc.), place notices at the usual points of entry or along the perimeter of treated sites. The posting should include a notice that the area has or will be treated, the name of the herbicide used, the date of the treatment, appropriate precautions to be taken, the date when re-entry is judged to be safe and a phone number for additional information. The notices should be removed after it is judged safe to re-enter the area.



Safe Storage and Disposal

Herbicides must be stored and disposed of in certain ways to protect both human health and the environment.

Storing Herbicides

Store herbicides in a well ventilated, cool, dry area where food and drinks are never stored or prepared. Most pesticides should not be stored for any length of time below 40° F. The floor should be concrete or lined with plastic or other impermeable material to prevent leaks from reaching the soil.

The area should be inaccessible to the public and locked except when chemicals are being removed or returned.

Containers should be labeled to indicate the following: contents (ratio of herbicide, surfactant, water, etc.), date mixed and approximate volume remaining when placed in storage. The containers must be stored carefully and never stacked.

Heavy plastic garbage bags, a shovel and a soil absorbent (e.g., cat litter) must be available for use in cleaning-up small leaks or spills.



Proper signage of storage buildings (USDA Forest Service - Region 8 - Southern, USDA Forest Service,

Mixing Herbicides

Use extreme caution when mixing herbicides. Dermal exposure to a small amount of a concentrated herbicide can be equivalent to the exposure received after a full day of working in a treated field. Before mixing any herbicide, read the label. Herbicide labels are legal documents and users are obligated to read and obey them.

Establish a mixing area. Herbicides should be mixed only in pre-designated areas - preferably either in an industrial sink near the storage site or in an area near the treatment site(s) in which damage from small spills or other herbicide contamination would be minimal. Field mixing sites should have relatively few native or other desirable species, not be susceptible to erosion or runoff, and rarely, if ever, be visited by the public or preserve staff. In addition, mixing sites should provide easy access for containment and clean up of spills.

Prior to mixing, determine the order that chemicals will be added to the mix. Generally, adjuvants are added prior to the herbicide, but consult the label for specific instructions. When mixing, start by filling the spray tank or other mixing vessel half to three-quarters full with water. The water should be clean and clear to prevent contamination of the mixture or clogging of tank nozzles and hoses. The water should have a neutral or slightly acidic pH, as alkaline water can cause the pesticide to breakdown prior to application. Add a buffer or acidifier to the water if necessary.

Carefully measure the herbicide concentrate and add it to the tank water. Small measuring errors can lead to large errors in the amount of pesticide applied. Be aware of if you are using the active ingredient (a.i.) or acid equivalent (a.e.) of the herbicide. The measuring container should be rinsed and the rinsate added to the tank solution. The container of liquid herbicides should be triple rinsed with ¼ container volume of water. Add rinsate to the tank solution or store it in a separate container labeled "WATER AND RINSATE FOR HERBICIDE ONLY, NONPOTABLE"

Transporting Herbicides

Herbicides should be transported in tightly sealed containers placed in a well-constructed and watertight carrying box or bucket. A good container will prevent leaks in vehicles, onto applicators, or to the environment. Each program should develop techniques and use materials that will best serve the needs of a particular site or circumstance. In some cases, you may want to carry only a small amount of herbicide to treat weeds encountered while conducting daily activities in the field.

Container Disposal

Use the state herbicide container recycling program where available. If no specific chemical container recycling program is available, puncture the empty container to prevent anyone from using it as a container again, and then dispose of or destroy it. In most areas, small numbers of empty, triple-rinsed containers can be disposed in the trash for pick-up or taken to the local dump, unless the label states otherwise. Some jurisdictions require containers to be burned, while others prohibit burning pesticide containers. If the herbicide label states that the container may not be disposed of in regular sanitary landfills, call your county or municipal waste department for information on Hazardous Material Collection dates.

Different Formulations

An herbicide formulation is the total marketed product, and is typically available in forms that can be sprayed on as liquids or applied as dry solids. It includes the active ingredient(s), any additives that enhance herbicide effectiveness, stability or ease of application such as surfactants and other adjuvants, and any other ingredients including solvents, carriers or dyes. The application method and species to be treated will determine which formulation is best to use. In most cases, manufacturers produce formulations that make applications and handling simpler and safer. Some herbicides are available in forms that can reduce risk of exposure during mixing, such as pre-measured packets that dissolve in water, or as a liquid form already mixed with surfactant and dye.

Sprayable or Liquid Formulations

- Water-soluble formulations: soluble liquids (SL), soluble powders or packets (SP), and soluble granules (SG). Only a few herbicidal active ingredients readily dissolve in water. These products will not settle out or separate when mixed with water.
- Emulsifiable formulations (oily liquids): emulsifiable concentrates (E or EC) and gels (GL). These products tend to be easy to handle and store, require little agitation, and will not settle out of solution. Disadvantages of these products are that most can be easily absorbed through the skin and the solvents they contain can cause the rubber and plastic parts of application equipment to deteriorate.
- Liquid suspensions (L for liquid or F for flowable) that are dispersed in water include: suspension concentrates (SC), aqueous suspensions (AS), emulsions of water-dissolved herbicide in oil (EO), emulsions of an oil-dissolved herbicide in water (EW), micro-encapsulated formulations (ME), and capsule suspensions (CS). All these products consist of a particulate or liquid droplet active ingredient suspended in a liquid. They are easy to handle and apply, and rarely clog nozzles. However, they can require agitation to keep the active ingredients from separating out.
- Dry solids that are suspended in water: wettable powders (W or WP), water-dispersible granules (WDG, WG, DG), or dry flowables (DF). These formulations are some of the most widely used. The active ingredient is mixed with a fine particulate carrier, such as clay, to maintain suspension in water. These products tend to be inexpensive, easy to store, and are not as readily absorbed through the skin and eyes as ECs or other liquid formulations. These products, however, can be inhalation hazards during pouring and mixing. In addition, they require constant agitation to maintain suspension and they may be abrasive to application pumps and nozzles.

Dry Formulations

- Granules (G) - Granules consist of the active ingredient absorbed onto coarse particles of clay or other substance, and are most often used in soil applications. These formulations can persist for some time and may need to be incorporated into the soil.
- Pellets (P) or tablets (TB) - Pellets are similar to granules but tend to be more uniform in size and shape.
- Dusts (D) - A dust is a finely ground pesticide combined with an inert or inactive dry carrier. They can pose a drift or inhalation hazard.

Salts Versus Esters

Many herbicidally-active compounds are acids that can be formulated as a salt or an ester for application. Once the compound enters the plant, the salt or ester cation is cleaved off allowing the parent acid (active ingredient) to be transported throughout the plant. When choosing between the salt or ester formulation, consider the following characteristics:

Salts

- Most salts are highly water soluble, which reduces the need for emulsifiers or agitation to keep the compound suspended.
- Salts are not soluble in oil.
- Salts generally require a surfactant to facilitate penetration through the plant cuticle (waxy covering of leaves and stems).
- Salts are less volatile than esters.
- Salts can dissociate in water. In hard water the parent acid (i.e. the active ingredient) may bind with calcium and magnesium in the water, precipitate out, and be inactivated.

Esters

- Esters can penetrate plant tissues more readily than salts, especially woody tissue.
- Esters generally are more toxic to plants than salt.
- Esters are not water soluble and require an emulsifying agent to remain suspended in water-based solvents.
- Esters have varying degrees of volatility.



Reading the label (USDA Forest Service - Region 8 - Southern, USDA Forest Service, Bugwood.org)

Active Ingredient (AI) versus Acid Equivalent (AE)

Labels on herbicide containers and instructions for mixing herbicides sometimes use units of herbicide active ingredient (AI) or acid equivalent (AE). The herbicide may be sold in different concentrations, but units of a.i. or a.e. provide standard measures, so the mixing instructions can apply in all cases. In order to follow these instructions, you will need to determine how many AI or AE are in an ounce, or quart or liter, of the concentrate on hand.

The AI of an herbicide formulation is responsible for its herbicidal activity or ability to kill or suppress plants. The AI is always identified on the herbicide label by either its common name or chemical name, or both. Herbicide formulations available for sale commonly contain other so-called "inert" compounds too.

The AE of an herbicide is just the acid portion of the AI, and it is this acid portion that is responsible for herbicidal effects. The acid portion (or parent acid) is generally associated with other chemical compounds to form a salt or an ester, which is more stable and better able to move through a plant's waxy cuticle, and into the plant. The salt or ester is the AI.

Weak acid herbicides are formulated as salts or esters through the addition of a salt or ester molecular group to the parent acid molecule. This allows the herbicide acid to mix properly with adjuvants and enhances the compound's ability to move into plant tissue. Once the herbicide enters the plant, the salt or ester group is cleaved off the parent molecule, allowing the acid to affect the plant.

Because the salt or ester molecular group can vary dramatically in size, a measure of the percent AI, especially in the case of a weak acid herbicide, does not adequately reflect the percentage of acid in the formulation. Thus, the AE is used to determine the amount of the product to be applied.

Product labels for weak acid herbicides will list the product's percentage of active ingredient, as well as other inert ingredients, at the top of the label. The percentage of acid equivalent in the formulation is usually listed below these percentages in a separate table or paragraph.

Adjuvants

An adjuvant is any material added to a pesticide mixture that facilitates mixing, application or pesticide efficacy. An adjuvant enables an applicator to customize a formulation to be most effective in a particular situation. Adjuvants include surfactants, stickers, extenders, activators, compatibility agents, buffers and acidifiers, deposition aids, de-foaming agents, thickeners and dyes.

Surfactants

Surfactants are the most important adjuvants. They are chemical compounds that facilitate the movement of the active herbicide ingredient into the plant. They may contain varying amounts of fatty acids that are capable of binding to two types of surfaces, such as oil and water.

Biocontrol

Biological control is the use of animals, fungi or other microbes to feed upon, parasitize or otherwise interfere with a targeted invasive species. Successful biocontrol programs usually significantly reduce the abundance of the invasive, but in some cases, they simply prevent the damage caused by the species without reducing overall abundance. Biocontrol is often viewed as a progressive and environmentally friendly way to control pest organisms because it leaves behind no chemical residues that might have harmful impacts on humans or other organisms, and when successful, it can provide essentially permanent, widespread control with a very favorable cost-benefit ratio.

Successful biocontrol projects reduce the abundance or impacts of the targeted species to acceptable levels across large areas. Use of biocontrol agents should be approached with caution, however, due to concerns that biocontrol agents may attack and damage populations of non-target native species. If a biocontrol agent does in fact attack any native non-target species, its persistence and ability to spread to areas far from release sites become serious liabilities. While biocontrol offers great promise, it will provide long-term benefits to natural areas and biodiversity preservation only if it is practiced carefully and its potential risks are fully recognized and addressed.



Mile-a-minute weevils being released.

There is also concern about releases of biocontrol agents among some conservationists precisely because the agents are themselves non-native introductions. In some cases the agents may carry additional non-native parasite and commensal species. There has been at least one case in the past decade in which a biocontrol release unintentionally included a second non-native look-alike species that has now become established. Intentional introductions of non-native biological

control agents may, however, contribute to global biodiversity by significantly reducing large populations of targeted non-native organisms that would otherwise reduce or threaten populations of native species.

Of course, it must be recognized that all courses of action against invasive organisms, including that of taking no action, carry some risk to valued, non-targeted organisms. If no action is taken, the invasive may continue to spread and reduce or eliminate valued native species, and in the worst cases, drastically alter community and ecosystem functioning.

Species with Existing Biocontrols

<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	bull thistle
<i>Conium maculatum</i>	poison hemlock
<i>Eichhornia crassipes</i>	water hyacinth
<i>Hydrilla verticillata</i>	hydrilla
<i>Lythrum salicaria</i>	purple loosestrife
<i>Pistia stratiotes</i>	water lettuce
<i>Polygonum perfoliatum</i>	mile-a-minute

Species with Biocontrols Being Researched

<i>Acroptilon repens</i>	Russian knapweed
<i>Alliaria petiolata</i>	garlic mustard
<i>Ligustrum spp.</i>	privets
<i>Phragmites australis</i>	common reed
<i>Pueraria montana var. lobata</i>	kudzu
<i>Rhamnus cathartica</i>	common buckthorn
<i>Frangula alnus</i>	glossy buckthorn

Obtaining and Releasing Biocontrol Agents

It is best to obtain biocontrol agents locally, if possible, as this will minimize losses in storage and transport and increase the likelihood that the agents can survive in the local environment. It is also wise to start lining up a supply of agents several months before you will need them. The USDA's Animal and Plant Health Inspection Service (APHIS) issues permits that relate to the importation and testing of biocontrol agents. To learn more about their program and find contact information for staff within the program, visit their Biological Control Program

(<https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/biological-control-program>)



Mile-a-minute weevils

Biocontrols on State Park and State Forest Lands

To control mile a minute (*Polygonum perfoliatum*), the weevil, *Rhinoncomimus latipes Korotyaev*, has been released at many parks over several years, including Boyd Big Tree and Ibberson conservation areas, and Bald Eagle, Caledonia, Codorus, French Creek, Kings Gap, Memorial Lake, Nockamixon, Sam Lewis, Sinnemahoning, Susquehannock, Swatara, and Tyler state parks.

For purple loosestrife (*Lythrum salicaria*) control, *Galerucella* beetles (either *G. calmariensis* or *G. pusilla*) were released at Codorus. These beetles can be found at many other state parks, as well on some of the islands on the Susquehanna River that are managed by the Bureau of Forestry.

Hemlock wooly adelgid (*Adelges tsugae*) is being controlled with *Sasajiscymnus tsugae* and *Laricobius nigrinus* beetles. They were released at many parks over the past several years, showing various degrees of success. A couple of the sites are Blue Knob and Jacobsburg. A fungus is also being researched as potential biocontrol.

Emerald Ash Borer parasitoids will be released at Greenwood Furnace and Shawnee state parks in 2012-13.

Weevils for Eurasian water milfoil were released at Gifford Pinchot State Park. They were unsuccessful in establishing, possibly due to the turbidity of the lake. Due to the cost, they have not been trialed in any other body of water.

To control mile a minute (*Polygonum perfoliatum*), the weevil, *Rhinoncomimus latipes Korotyaev*, has been released at many forests over several years, including Michaux, Buchanan, Tuscarora, Rothrock, Gallitzin and Susquehannock state forests.

Grazing

Grazing can either promote or reduce invasive plant abundance at a particular site. By itself, grazing will rarely, if ever, completely eradicate invasive plants. However, when grazing treatments are combined with other control techniques, such as herbicides or biocontrol methods, severe infestations can be reduced and small infestations may be eliminated. Grazing animals may be particularly useful in areas where herbicides cannot be applied or are prohibitively expensive. Animals can also be used as part of a restoration program by breaking up the soil and incorporating in seeds of desirable native plants.

When not properly controlled, however, grazing or other actions of grazing animals (wallowing, pawing up soil) can cause significant damage to an ecosystem and promote the spread and survival of invasive plants. Overgrazing can reduce native plant cover, disturb soils, weaken native communities and allow invasive plants to invade. In addition, animals that are moved from pasture to pasture can spread invasive plant seeds.

In general, the specific invasive and desirable native plants will determine the number and species of animal grazers and the duration and frequency of grazing. A grazing plan should be developed in situations where prescribed grazing is desirable, and this plan must be tailored to fit the specifics of the site.



Species to Use for Grazing

Cattle, goats, sheep and even geese may be used to control invasive plants. Cattle will graze invasive grasses, can trample inedible weed species, and can incorporate native seeds into soil. Horses can also be used to control invasive grasses, but horses tend to be more selective than cattle. Geese are also useful for the control of invasive grasses, but are more subject to predation than other animals.

Sheep and goats prefer broadleaf herbs and have been used to control plants like Russian knapweed (*Acroptilon repens*). These animals appear to be able to neutralize the phytochemicals toxic to other animals that are present in these and other forbs. Goats can control woody species because they can climb and stand on their hind legs, and will browse on vegetation other animals cannot reach. Goats additionally, tend to eat a greater variety of plants than sheep.

Plant availability, hunger and previous experience can determine a grazer's selection of food plants. Differences in vegetation quality may cause an animal to eat one species in one situation and to ignore the same species in another. A period of adjustment is generally required to get a grazing animal to eat a new type of forage. It is therefore helpful to find animals previously experienced with the target invasive.

Finding grazing animals to use for invasive control can be a problem. Land managers are sometimes forced to make use of the animals available in the immediate area, especially since transportation costs can be excessive.

Timing and Duration of Grazing

Animals should be brought into an infested area at a time when they will be most likely to damage the invasive species without significantly impacting the desirable native species. Grazing during seed or flower production can be especially useful. On the other hand, some weeds are palatable only during part of the growing season. For example, cheatgrass (*Bromus tectorum*) is preferred in spring before seed heads develop, but avoided by cattle once it has begun to set seed because the seed heads have stiff awns that can puncture the mouth and throat tissue of livestock. Grazing will often result initially in an increase in stem density and root buds, but repeated grazing should lead to reduced stem densities in the longer term.

Grazing should be closely monitored and the animals promptly removed when the proper amount of control has been achieved and before desirable native species are impacted. Consequently, land managers must be flexible and have control over herd movements. Lack of control can result in overgrazing of desirable species, which can enhance infestations or allow new invasive species to become established. The necessary flexibility is not always possible with commercial herds.

In most cases, several years of intensive grazing followed by annual brief periods of grazing by the same grazing species is required to gain and maintain control of an infestation.



Animal Fencing and Movement

The containment and movement of grazers within and between infested areas is necessary for the successful implementation of an appropriate grazing plan. Temporary fencing, including electric net fences, erected to contain animals in a particular area may be suitable for goats and sheep, but is often inadequate for larger animals like cows and horses. More stable and expensive barbed wire fencing may be required to contain these larger animals. Salt licks have been used successfully to concentrate animal impact in a particular area.

A herder is usually required to move goats and sheep between pastures or infestations and to ensure that the animals concentrate grazing on the appropriate species. Cattle must be moved periodically, but generally do not require a herder. Goats have been tied to stakes within infested areas to concentrate their activity and eliminate the need for full-time herders. "Open" herding is usually more beneficial than "close" herding, where animals are kept close together causing much of the forage to be trampled.

Controlling Seed Dispersal

Seeds of spotted knapweed (*Centaurea maculosa*) and other species can pass through the digestive tract of animals and remain viable. Animals that are removed from an infested area should not be transported to weed-free areas until all seeds have passed through their digestive tracts (five to nine days). Invasive seeds can also be transported to new areas in animal hair. Care and precaution should be taken when moving animals from infested areas.

Pennsylvania Example of Controlled Grazing

Kings Gap Environmental Education Center

500 Kings Gap Road, Carlisle, PA 17015

Scott Hackenburg, Center Manager, (717) 486-5031, shackenbur@pa.gov

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The Pine Plantation Day-Use Management Area is a 70-acre unit located in the northern part of Kings Gap Environmental Education Center. As the trees in the Pine Plantation age and die, the forest floor is no longer completely shaded by the dense canopy of the pines. These openings in the canopy allow plants to grow in the understory. The management goal is to maintain the Pine Plantation Day-Use Area in a manner that will provide a forest habitat that will offer wildlife cover for a variety of woodland species as well as serve as an area for environmental education programs and low impact recreational pursuits such as hiking and cross country skiing.

As the canopy opens in the Pine Plantation, invasive plants are thriving. Recently the populations of these non-native invasive plants have become very dense and are out-competing the native plants, disrupting the natural succession of the forest. The non-native invasive plants include multiflora rose, oriental bittersweet, honeysuckle vine, shrub honeysuckle, tree of heaven, privet, garlic mustard, Japanese stiltgrass and mile-a-minute weed.

To sustain a viable and healthy forest ecosystem, Kings Gap is implementing a systematic approach called Integrated *Vegetation* Management. As part of the integrated strategy, Kings Gap will use a combination of different control methods, including chemical, biological, and mechanical practices, to control the invasive species and encourage growth of desirable native plants.



Goals

1. Control the spread of mile-a-minute weed by removing seedlings inside the treatment area before they produce seeds
2. Decrease vegetative growth of multiflora rose, blackberry and bittersweet in order to make treatment area more accessible for follow-up treatments
3. Increase multiflora rose susceptibility to rose rosette disease by stressing plants through defoliation

Pre-Treatment

To establish baseline data, a series of photographs were taken before the goat grazing begins. These pictures reflect the quantity and density of the invasive plants in the treatment area, as well as the current state of the desirable plant species.

Fencing

The goats were contained using electric netting, which is designed to keep goats in and predators out. This fence is 42 inches high and comes in rolls 164 feet each. They ordered four rolls for a total of 656 linear feet, which enclosed one area of 25,000 to 32,000 square feet (approximately 0.6 - 0.7 acre). In order to use an electric fence, existing vegetation must be cleared to the ground. They cleared an eight-foot swath around the perimeter of the treatment area, two feet for the fence (one foot on either side) plus a six-foot wide access route for the Gator, allowing the fence to be monitored and maintained daily by driving the Gator around the perimeter. The vegetation removal was done by hand using loppers and chain saws, and with a Fecon brush clearing machine.

Goats

For most effective control of mile-a-minute, they placed the goats inside the treatment area beginning June 1, 2011. They used six goats, leased from local farmers: Sandy Miller, whose farm is located in Newburg, Pa. and Bill Yocum, in Carlisle, Pa. Goats from both of these farms have experience grazing in forested areas. Because the forest provides adequate shade, a shelter for the goats was not needed. They provided fresh water and monitored the goats daily. The goats grazed for approximately 30 days. The amount of time is dependent on grazing rate, which varies with individual goats and the amount and type of vegetation available. Kings Gap staff monitored the grazing rate and removed the goats from the treatment area when the targeted vegetation was eaten and the goats had begun to feed on the twigs and bark of woody plants. When the grazing period ended, the goats were returned to their owners.

Post Treatment

Immediately after removing the goats from the treatment area, they evaluated the results and took a second series of photographs, showing the impact that the goats had on both invasive plants and desirable vegetation. Following this, the fence was removed and stored for future use. The eight-foot wide fence perimeter will be maintained and herbicides applied as needed to prevent vegetation regrowth so that the fence can be used again the following season, if needed.

Cost

The total cost of renting the goats, and purchasing fencing, battery, charger, fence tester, water trough and shipping charges was \$968.79.

Aquatic Plant Control

Freshwater aquatic plants are plants (not algae) that can only grow in freshwater or permanently saturated soils. Typical freshwater habitats where aquatic plants are found include lakes, ponds, marshes, bogs, wetlands, rivers, streams and ephemeral pools, which exist seasonally. There are three forms of aquatic plants: emergent plants, submersed plants and floating-leaf plants. Emergent plants are rooted underwater and have stems that grow above the waterline. A well-known example is the cattail. Floating-leaf plants have roots and stems underwater, but produce leaves and flowers on or slightly raised above the waterline. Water-lilies are a classic example. Submersed plants live entirely beneath the waterline and are the only one of the three forms of aquatic plants that can be considered truly aquatic.

Pennsylvania is home to many native aquatic plants but this section is dedicated to those non-native invasive plants that are causing economic and ecologic harm to the state's freshwater areas.

Why Control Aquatic Plants?

Aquatic invasive plants can negatively affect recreational activities, businesses that rely on boats, the dissolved oxygen content needed for aquatic life, and human health via disease vectors like mosquitoes. When aquatic invasive plants infest waters that are used commercially or recreationally by boaters, they get entangled in propeller blades and stress the engine, leading to costly repairs. Thick aquatic invasive plant infestations in recreational swimming areas can make the area look unsightly and potentially dangerous for swimming. They can change completely the character of the habitat, making it unsuitable for native wildlife and vegetation.

Manual Control

Mechanical control of aquatic invasive plants typically involved large power-driven equipment, although it can also include hand-pulling or using a rake to dredge up rooted, submerged vegetation and drawing down the water to expose submerged vegetation. The type of equipment and method you use will depend on the type of invasive plant to be controlled and the habitat in which it can be found. Mechanical harvesters include cutter boats, shredding boats, rotovators, dredgers and harvesters (the most commonly used aquatic plant control machine).

Emergent plants like *Phragmites* and purple loosestrife can be mowed during dry seasons, although significant environmental damage and harm to non-target species could result. Pulling these species by hand is not recommended, however, as their root structure is difficult to remove fully and the population size of these species is usually so large as to make hand-pulling too onerous.

Most mechanical control for aquatic invasive plants occurs in water greater than two feet deep. Floating plants tend to have a very large biomass, which can make gathering and disposing of all the plant material time consuming and difficult. Submersed plants like *Hydrilla* tend to have a much smaller biomass and can therefore be harvested more easily.

Water drawdowns require a combined permit from the Department of Environmental Protection and the Fish and Boat Commission. If your project involves dredging and any other control effort that may impact wetlands or streams, be sure



Aquatic plants attached to a boat.

to contact the nearest DEP regional office to ensure that you are meeting all regulations. A list of DEP regional office contacts can be found at <http://www.dep.pa.gov/About/Regional/Pages/Office-Locations.aspx>.

Biological Control

Biological control, also known as biocontrol, involves the intentional use of an organism, like an insect or fungus, to suppress the growth of another organism, such as an invasive plant. Like all control methods, biological approaches to aquatic invasive plant control can have positive and negative effects on aquatic ecosystems. Biocontrols are typically brought over from the invasive plant's country of origin, then rigorously tested in laboratory and field settings to ensure that they will not cause damage to native plant species. Only if successful and not harmful to non-target species, can biocontrols be released into the wild. The USDA Animal and Plant Health Inspection Service (APHIS) is responsible for approving all biocontrol agent releases in the U.S. Biocontrol agents for *Hydrilla*, purple loosestrife, mile-a-minute and Eurasian watermilfoil are now available.

Chemical Control

Hundreds of herbicides are registered in the U.S. but only a dozen or so are registered for use in aquatic habitats. Anyone wishing to apply an herbicide in an aquatic setting is required to obtain a permit from the Pennsylvania Fish and Boat Commission, who will then obtain approval from the Department of Environmental Protection's Bureau of Water Supply Management. This process ensures that the proper chemical is selected and applied in the correct manner, to minimize impacts to non-target species. The permit form can be downloaded [here](#).

Herbicides for aquatic invasive plant control will either be applied to emergent or floating foliage through a spray or wipe method or to submerged vegetation using concentrated liquids, granules or pellets. Two types of herbicides can be used: contact and systemic. Contact herbicides are those that do not travel through the plant's tissues; they injure the plant tissue with which the herbicide comes in contact. These include Copper, Endothall, Diquat, and Carfentrazone. Systemic herbicides, on the other hand, move through the plant's tissues, affecting roots, stems and leaves. Aquatic-approved systemic herbicides include 2,4-D, Triclopyr, Glyphosate, Imazapyr, and Fluridone (for in-water use only).

No matter which chemical control you decide to use, be sure to follow all instructions on the label and abide by all state and federal herbicide regulations.

And for more detailed information about the biology, impacts and control of aquatic invasive plants, download a copy of the "Best Management Practices Handbook" from the *Aquatic Ecosystem Restoration Foundation* [here](#). Most of the information included above came from that comprehensive document.



Management Planning

Land managers who have been successful at tackling invasive plants typically take the time to develop an invasive species management plan. To be successful, plans should be well thought out and designed to meet the goals of the project. In cases time, money and staff resources are limited, management planning will help land managers best use these resources. The management plan is the guiding document for any invasive plant management program and should be designed for long-term goals for treating and monitoring invasive plants.

The management of natural, biological systems is inherently difficult because predicting the way an ecosystem will behave is highly unpredictable. The outcome of invasive species management and control is based on a relatively short history and understanding of invasive plant management. Taking an adaptive approach to invasive plant management will provide the most successful results.

The Adaptive Management Approach

Many approaches can be taken to address invasive plant problems. The obvious considerations include money, time and available resources (tools, staff, etc.). Most often, all are limited. Fortunately, a great many land managers who have faced these challenges over the years and have developed guidelines, plans and approaches that can assist you.

Overview of the Adaptive Management Approach (AMA)

Adaptive management differs from traditional management approaches because it allows management activities to proceed despite uncertainty regarding how best to achieve desired outcomes, and adjust practices when inevitable changes or surprises arise. In fact, it specifically targets such uncertainty: it compels ecosystem managers to be open and explicit regarding what is not known about how best to achieve conservation and management objectives.

Steps in the AMA

- (1) Establish conservation goals and objectives for the site. These may be identified in a broader management plan for the site or may need to be identified for purposes of the invasive plant management plan for the site.
- (2) Conduct an assessment to determine if invasive plants exist that could impede achieving desired management goals and objectives. If invasive plants are found to be an issue, mapping and ranking these plants becomes important. If no invasive plants are found during the assessment, then regular follow-up assessments should be performed to detect early introductions.
- (3) Determine which methods are available to control the invasive plants.
- (4) Develop and implement a management plan designed to move conditions toward management goals and objectives. Evaluate which control methods will work best given your site conditions and resource constraints.
- (5) Monitor and evaluate the effectiveness of management actions in moving conditions toward these goals and objectives. If the evaluation reveals that management goals and objectives have not been met, then begin the cycle

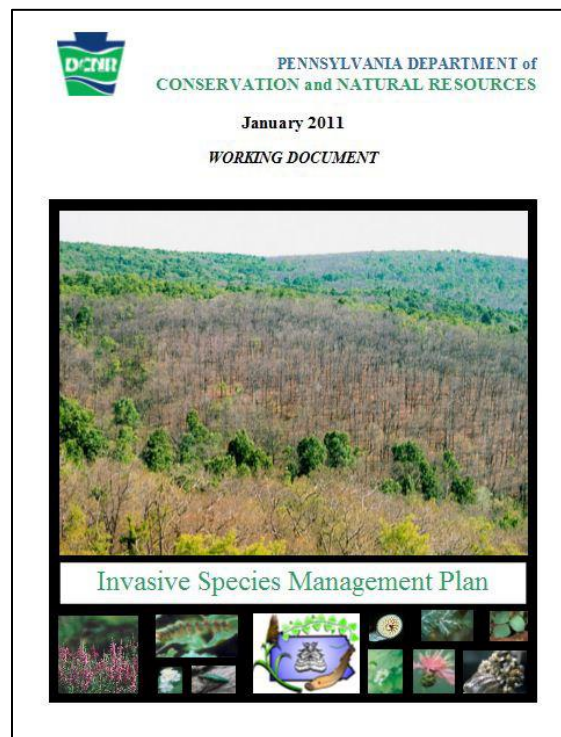
again and determine whether or not you need to modify your goals and objectives. If you reach success, then it is important to use preventative measures for reintroduction and regularly monitor and evaluate the site.

Control activities are not started until the first three steps have been taken. Invasive plant control programs should be part of an overall restoration program, so focus on what species or conditions are desired to replace the invasive plant, rather than simply eliminating the plant. When selecting control methods, keep in mind that the ultimate purpose of the work is to preserve native species, communities or functioning ecosystems.

Invasive Species Management Plans

The most effective invasive species management programs have taken the time to develop management plans that were well thought out and designed to meet the goals of the project. In cases where resources (time, money and staff) are limited, management planning will ensure that those resources are used wisely. The management plan is the guiding document for any invasive plant management program and should be designed for the long-term.

Before developing a management plan under the Adaptive Management Approach, several steps need to occur first. Those include goal setting, assessment and prioritization and evaluating what methods or tools will be used to control the invasive plants that you have targeted.



Management Plan Templates

1. *Invaders in the Commonwealth, PA Invasive Species Management Plan* is a framework for response that will aid in minimizing the harmful ecological, economic and human health impacts of nonnative invasive species through the prevention and management of their introduction, expansion and dispersal into, within and from Pennsylvania. Developed by the Pennsylvania Invasive Species Council, this document outlines risk assessment, prevention, early detection, control and restoration. http://www.invasivespeciescouncil.com/Documents/FINAL%20Plan_low_res.pdf
2. The Nature Conservancy's Invasive Species Initiative has developed a Weed Management Plan Template that is widely used. The strength of this template is that it is self-explanatory. Measures have been taken to thoroughly explain what the user should be considering in addressing each component of the plan. http://www.invasivespeciescouncil.com/Documents/FINAL%20Plan_low_res.pdf
3. The National Invasive Species Council's 2016 to 2018 Management Plan directs federal efforts to prevent, control and minimize invasive species and their impacts. The Plan is focused upon five "Strategic Goals": Prevention; Early Detection and Rapid Response; Control and Management; Restoration; and Organizational Collaboration. <https://www.doi.gov/sites/doi.gov/files/uploads/2016-2018-nisc-management-plan.pdf>

4. A Cooperative Weed Management Area (CWMA) is a distinguishable zone based on similar geography, weed problems, climate or human-use patterns. These management areas cross jurisdictional boundaries between agencies and municipalities and are recognized by a natural boundary as opposed to a legal boundary. The concept is popular in the western U.S. The Center for Invasive Species Management hosts an information webpage about CWMA's <http://weedcenter.org/cwma/index.html>
5. An Annual Operating Plan (AOP) addresses how, on an annual basis, the objectives of the over-all Management Plan are implemented. Due to manpower, funding or other limitations, it may not be possible for the AOP to address all the objectives of the Management Plan in a given year. The Management Plan must address long term objectives and priorities. The Annual Operating Plan guides implementation of the Management Plan in yearly increments. Budgets and circumstances may change from year to year and these changes are best addressed in making new Annual Operating Plans rather than rewriting the Management Plan annually.
6. For species-specific or state/region-specific management plans, visit the National Invasive Species Information Center and search for "management plan". <https://www.invasivespeciesinfo.gov/index.shtml>

Inventory and Mapping

Identification and prioritization of species or infestations that threaten conservation targets or goals is the second step in the Adaptive Management Approach. To be cost-effective and efficient in using resources, it is critical to know which plants exist and the extent of their occurrences. For the majority of public lands in Pennsylvania this information is limited. Therefore, it will be necessary to take this step for the site under consideration. Not only will this information benefit management planning efforts for this site, but it will assist in filling in information gaps for the state's biodiversity.

Inventory can be described as a point-in-time measurement of the resource to determine location or condition. Without location and distribution information, park resource managers lack the critical tools required to develop a focused strategy for addressing invasive plant management issues.



Field identification and note keeping

What can Invasive Plant Inventory and Mapping Information do?

- Increase the ability of resource managers to analyze and prioritize invasive plant management needs and to appropriately direct work efforts and resources, enhancing the time and cost-effectiveness of invasive plant management actions.

- Serve as a baseline for long-term monitoring, and assist with the evaluation of changes in invasive plant populations over time or the detection of new exotic plant infestations.
- Combine with other layers of information (e.g. soil types, depth to water table, elevations) that can assist in identifying appropriate treatment or control options as well as adding to the knowledge of ecological relationships associated with alien plant invasions (predictive modeling).
- Serve as a critical tool for increasing public and political awareness and education on invasive plant issues.

Inventory and mapping of invasive plants should be integrated with general vegetation surveys and surveys being conducted by other agencies and organizations. Data organized into maps and databases provide valuable information towards the development of a network-monitoring scheme. Ancillary uses of maps and data are for public education, development of predictive models and estimations of risk from various plant species. Goals and objectives for inventory and mapping should ensure products can serve the above purposes

Mapping

Mapping is an important way to communicate inventory information. This tool provides a visual picture of how abundant a species is and how it is distributed across the landscape. When overlaid on a map of priority habitats or natural communities, one may be able to quickly evaluate the species that are priorities for control or eradication. Mapping can take many forms, everything from recording written information on a paper map to using GPS (global positioning system) and recording in a mapping program such as GIS (global information system).

Pennsylvania iMapInvasives (<https://www.paimapinvasives.org/>) is an online resource useful for mapping invasive species. This program supports the work of natural resource professionals. It provides an online platform where sightings and management efforts can be recorded. The iMapInvasives program also offers tools for private citizens and land owners wishing to contribute invasive species findings.

The Early Detection and Distribution Mapping System (EDDMapS; <http://www.eddmaps.org/>) is another resource for mapping new invasive species sightings. The EDDMapS database shows species occurrences at a national, state and county level. Species are listed by plant type and are connected to the Bugwood Network, which includes many photos and species descriptions that are useful for identification purposes. You can even download a free smart phone app for iPhone or Android that will help you keep track of invasive sightings in the field.

Prioritization

Managing and controlling invasive plants is difficult, expensive and requires a long-term commitment. Land managers have limited resources and so prioritizing efforts is critical. High priority should be given to those species that have substantial impacts on natural resources or on attainment of management goals and are believed to be easy to manage. High priority should also be given to those species that are not yet established or causing major impacts, but have the potential to do so. Low priority should be given to species that cause little impact, are virtually impossible to control, or both.

Monitoring and Evaluation

Monitoring refers to repeated observations and evaluation as well as relating that information to the objectives of a management plan (changes in condition and progress towards meeting management objectives). Monitoring and evaluation provide the documentation of site conditions for managed areas and provide a means for reporting changes in vegetation trends. Through the process of monitoring and evaluation, we can also measure progress towards or success at meeting a management objective. This is the fifth step in the Adaptive Management Approach. If an objective is met, the management activities have been effective. If not, monitoring provides the needed evidence for changes to the management plan.

Monitoring

Monitoring begins with pooling all available information to establish baseline data. The purpose of a Monitoring System is as follows:

- Collect baseline field data on existing infestations and control practices.
- Compile data on which to base invasive control decisions.

- Evaluate the effectiveness of treatments, including modifications to the design or maintenance of the system and the education and training program.
- Prevent re-invasion by returning to eradicated stands to determine if new plants have established.

Monitoring Resources

The National Park Service hosts a website for Guidance for Designing an Integrated Monitoring Program, which provides a good overview of the steps it takes to design such a program. <https://science.nature.nps.gov/im/monitor/guidance.cfm>

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The Early Detection and Distribution Mapping System (EDDMapS; <http://www.eddmaps.org/>) is another useful resource for reporting new invasive species sighting, as well as tracking and monitoring invasive species control programs. The site is free to use and endorsed by a variety of well-known organizations.

Evaluation

Evaluation is relating information obtained from monitoring to the objective of the management plan.

Use evaluation to determine:

- If the weed management program accomplishes the objectives of the management plan.
- If the management plan is still desirable and realistic. Evaluation requires analyzing information gained through monitoring, including benefits versus costs, comparing it with the cost/benefit of other alternatives, comparison with untreated areas, and projected costs of no action.

Evaluation should answer the following questions:

- Was the weed population adequately suppressed?
- Was the planned procedure used? If not, what was different and was it documented?
- Was the cost of weed suppression equal to or less than the potential loss?
- What was the effect on target organisms?
- Were natural enemies affected by the treatment?
- Were there any other side effects from the treatment?
- Were the side effects included in the cost-benefit analysis?
- Should the treatment be repeated or modified?
- Should another kind of treatment be considered?
- Was funding and manpower available at the appropriate time?
- Was training adequate?
- Were changes in the weed regime due to external factors?
- Make changes to the management based on your evaluation.



Restoration

Ecological restoration is an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability. Frequently, the ecosystem that requires restoration has been degraded, damaged, transformed or destroyed as the direct or indirect result of human activities, such as the intentional or unintentional introduction of invasive species. In some cases, impacts to ecosystems have been caused or aggravated by natural agents such as wildfire, floods or storms, to the point at which the ecosystem cannot recover to its pre-disturbance state.

Restoration consists of removing or modifying a specific disturbance, thereby allowing ecological processes to recover. Restoration also may require the deliberate reintroduction of native species that have been lost, along with the elimination or control of harmful, invasive species.

When the desired outcome is realized, the ecosystem under manipulation may no longer require external assistance to ensure its future health and integrity, in which case restoration can be considered complete. Nevertheless, the restored ecosystem often requires continuing management to counteract the invasion of opportunist species and the impacts of various human activities, climate change and other unforeseeable events. In this respect, a restored ecosystem is no different from an undamaged ecosystem of the same kind, and both are likely to require some level of ecosystem management.



Butterfly weed, a native species that tolerates dry, poor soil.

Native Plant and Seed Sources

Depending on the site conditions, goals for restoration and resources available, native plant material in the form of a seed mix or nursery stock can be used to restore a site once the invasive plants have been removed.

It is an ideal situation if the expertise, equipment and staff are available to produce propagated native plant material or native seed on site for the restoration project. However, this is usually not feasible. Native plant material is available from retail or wholesale nurseries or specialized growers. Native seed is available from commercial seed suppliers. Choosing a supplier who specializes in native plants and seeds is desirable, but is not always an option.

Select nurseries or plant growers that have experience working in your ecoregion and carry plant materials or can collect plant materials from the area in which you are doing the project (within the same ecoregion). The supplier should have staff knowledgeable about local native flora. If specific plants are to be grown for the restoration project, interview the grower about their knowledge of propagating all planned species.

Find out where and how the plants they are selling have been grown. Plants may have been grown in a very different part of the country and would thus not be well-suited for the restoration site. Make sure plant material has never been dug in the wild and removed from its natural habitat. Nursery owners and growers should assure the customer that all plants have been "nursery propagated." This means that staff have collected only seeds or cuttings from the wild, and have not removed whole plants from the wild. You should also ask the supplier for information about the original location of the parent plant material so you can determine how locally adapted the plants might be. Good native plant nurseries will have this type of information on record. If plants have been salvaged, ask the staff person where and how they were salvaged. Ethical salvage occurs when plants are removed before some type of construction or destruction takes place and always with the landowners' permission.

To learn more about native plants resources, visit DCNR's native plant website (<http://www.dcnr.state.pa.us/forestry/plants/nativeplants/index.htm>).