# Guidelines-Best Practices
## Invasive Plant Management- Ecology


## Summary

Non-native invasive species are the single greatest threat to biodiversity on lands owned by The Trustees of Reservations. This document summarizes the problems caused by invasive plant species in natural and minimally managed communities as well as our more managed cultural and agricultural landscapes. It also provides guidelines for land managers and volunteers seeking to address these problems. Because complete eradication is unrealistic in most cases, these guidelines also provide a method for prioritizing invasive control efforts, thus ensuring that finite dollars and human resources are used in the most effective way possible.


In the Northeast, invasive species have invaded a variety of habitats from grasslands to intact forests. Invasive species threaten our native biodiversity by directly competing with native species, altering ecosystem processes, changing hydrological characteristics, and degrading gene pools through hybridization with native species. Furthermore, invasive species can degrade the productivity of agricultural lands and compromise significant cultural landscapes (e.g., historic gardens). Due to the characteristics of invasives (e.g., high seed production, rapid growth), they may be better adapted to colonizing disturbed landscapes and respond more quickly than native species to changes that result from global warming.

**General Principles in Invasive Plant Management**

- Prevention
- Early Detection and Rapid Response
- Control and Management
- Education and Public Awareness

**Prioritization of Invasive Plant Management**

Prioritization of our control efforts is essential to maximizing our ability to protect biodiversity with the limited financial, staff and volunteer resources available. Control efforts will focus on those species that are threatening rare species or priority community types, or are known to compromise the ecological integrity of habitats beyond competition with native species (e.g., a species that changes soil chemistry or alters community structure). Control efforts on agricultural lands and designed landscapes will take into account any potential economic and cultural impacts resulting from invasives.


**Responsible Department:** Operations & Programs
**Staff Lead:** Russ Hopping
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**Guideline for Prioritization:**

- Identify significant and important resources to protect.
- Inventory properties to identify invasive species population sizes and locations.
- Prioritize populations for management based on the significance of the resource, the existence of effective control methods, the invasiveness of the species, and the potential for long-term control.
- Implement control and document our successes/failures.
- Reevaluate priorities based on our experiences with control and as we learn about new information and control methods.

# Guideline-Best Practice

## I. Introduction

The Trustees of Reservations protects and manages more than 25,000 acres of natural areas and managed landscapes throughout Massachusetts. All of this acreage has been influenced by humans to various extents during the past 200 years, including the introduction of non-native species. All of The Trustees' reservations include plant species that are not native to Massachusetts. According to Sorrie and Somers (1999) nearly one-third of the current Massachusetts flora is not native to the Commonwealth. Of these, less than 10% are considered invasive and are having detrimental impacts on the ecological and, in some cases, agricultural, scenic, and recreational resources on our reservations.

As invasive species are the single greatest threat to biodiversity on The Trustees' properties, this document summarizes the problems caused by invasive plant species in natural and minimally managed communities, and provides guidelines for land managers and volunteers seeking to address these problems. Because complete eradication is unrealistic in most cases, these guidelines also provide a method for prioritizing invasive control efforts, thus ensuring that finite dollars and human resources are used in the most effective way possible.

## II. Invasive Plants and their Impacts

Invasive plants are common throughout the Northeast and are spreading from disturbed areas into native vegetation (Randall & Marinelli 1996, Hunter & Mattice 2002). These invasives include herbs, shrubs, trees, and vines that grow rapidly, form dense thickets, and negatively impact native species and natural communities. Non-native invasives, such as Asian honeysuckles (*Lonicera* spp.), Japanese barberry (*Berberis thunbergii*), autumn olive (*Elaeagnus umbellata*), burning bush (*Euonymus alata*), multiflora rose (*Rosa multiflora*), garlic mustard (*Alliaria petiolata*), and European and glossy buckthorn (*Rhamnus cathartica* & *Frangula alnus*), are considered by the Invasive Plant Council of New York State, Massachusetts Invasive Plant Working Group, New England Wildflower

Society, U.S. Forest Service and others as some of the worst invaders in the region. Land managers are interested in removing or substantially reducing the density of these species to mitigate their negative impacts.

In the Northeast, invasive species have invaded a variety of habitats from grasslands (both native and those managed for agriculture and grazing) to "disturbed" wooded tracts (woodlands impacted by natural disturbances such as fire, wind, ice storms, and insect and disease outbreaks or anthropogenic disturbances such as timber harvesting and road building) to intact forests. Invasive species compete with other species directly, alter ecosystem processes, change hydrological characteristics where they invade, and may hybridize with native species and thereby degrade gene pools (Randall 1996). Examples of invaders and their impacts include: oriental bittersweet (*Celastrus orbiculatus*), a vine that climbs up trees and competes with them for light, water, and nutrients and, as a result of their weight, make the trees prone to structural damage. (Weatherbee 1994, Randall & Marinelli 1996); Japanese barberry, which can adversely affect soil pH (Kourtev *et al.* 1998); glossy buckthorn, which invades rapidly and out- competes native species (Randall & Marinelli 1996); and Amur honeysuckle (*Lonicera maackii*), which negatively affects fecundity, fitness and survival of native annuals (Gould & Gorchov 2000). In some areas woody invasives, such as multiflora rose and autumn olive, have converted open grasslands into shrub thickets, thereby threatening or eliminating grassland obligate species (Dunwiddie *et al.* 1997, Mitchell 2000). In other cases, woody invasive species have spread into naturally wooded tracts, resulting in decreased regeneration of native species (Clark & Mattrick 1998, Clark *et al.* 1998).

Invasive species can affect natural communities by decreasing species richness and altering ecosystem processes. Woody species, including trees and shrubs, can alter understory richness and seedling establishment by decreasing the amount of light available in the understory, reducing water and/or nutrients available in surface soils, and in some cases producing allelopathic1 compounds (Woods 1993, Myers & Bazely 2003). Ecosystem processes (e.g., nutrient cycling) and the frequency and intensity of natural disturbances can also be impacted by invasive species (Kourtev et al. 1998, Rice et al. 2004).

The most aggressive invasive species have a suite of characteristics that allow them to rapidly invade and dominate suitable habitats. These traits include prolific seed production and seedling survival, rapid growth rate, ability to spread asexually, and ability to survive in a wide range of habitats (Myers & Bazely 2003). Many non-native invasive species were introduced to North America because they had one or more of these characteristics. Multiflora rose, autumn olive, Asian shrub honeysuckles, and other shrubs planted as hedgerows for erosion control or as "wildlife plantings" have invaded grasslands, abandoned fields, and nearby forests and wetlands (Dirr 1990, Randall & Marinelli 1996, Clark *et al.* 1998, Epstein & Hill 1999). In addition, many invasive plants can survive and even proliferate in habitats impacted by disturbance (natural or

anthropogenic). Recent data are indicating that climate change may increase the proliferation of invasive plant species due to changes in the length of growing seasons, water availability, and other factors that directly or indirectly impact native ecosystems (Dukes & Mooney 1999, Vila *et al*. 2007). Due to the characteristics of invasives, they may be better adapted to colonizing disturbed landscapes and respond more quickly than native species to changes that result from global warming.

In addition to the many ecological issues associated with invasive species, these plants can also degrade other important features of our protected landscapes. They can degrade the scenic qualities of our natural landscapes (e.g., bittersweet choking a hedgerow of native trees), alter an otherwise intact cultural feature (e.g., goutweed taking over a formal garden), and impair agricultural activities (e.g., multiflora rose dominating a pasture, buckthorn spreading in a hayfield).

Why manage invasive plants?

- *Preservation of biodiversity*. The loss of biodiversity is an issue of global concern. Management that protects and encourages native species, communities, and ecological processes at the property level as well as at the landscape level will help maintain the biodiversity of Massachusetts. Non-native invasive plants may reduce native species diversity through direct competition or other means as described above. Similarly, invasive species may alter habitats and thereby impact native wildlife species. Invasives are currently the greatest threat to biodiversity on The Trustees' properties.
- *Promotion of good land stewardship to facilitate private and public interest in land preservation*. As a leader in the field of land conservation and management, The Trustees sets an example for public and private landowners. The practice of ecologically based land management and its interpretation on The Trustees' properties will encourage private and public landowners to similarly preserve and/or manage their own lands. By controlling invasive species on our properties, we not only provide a good example of land stewardship, we also eliminate potential invasive species source populations for our neighbors.
- *Preservation of cultural resources, including designed gardens and landscapes, and agricultural productivity.* Designed landscapes require continual maintenance, often including the removal of non-native invasive "weeds." In other cases, these same gardens may include within their original design, species now classified as prohibited invasive species. These landscapes require careful evaluation as The Trustees work to control or eliminate these species, while maintaining a garden's historical values.

Invasive species are also impacting the success of agricultural programs by degrading the quality of the product (e.g., hay), reducing the productivity of an area, and draining

resources away from production. Examples include multiflora rose invading pastures and thereby reducing the forage available; buckthorn, bittersweet, and other woody species invading hayfields; and knotweed establishing in compost piles, thereby threatening to spread elsewhere as the compost is applied.

## I. General Principles in Invasive Plant Management

While Section II describes why The Trustees manage invasive plants, the following principles and their associated strategies will serve as management and prioritization guidelines. However, due to the infinite variability of our reservations and their values, specific management recommendations for individual reservations are beyond the scope of this document. The Trustees' ecologists are available to help managers identify and prioritize invasive plant management strategies, assess the ecological impact of invasives, and identify any possible regulatory requirements that may apply to control methods.

**Prevention**: The first line of defense for invasive species is prevention. The most cost-effective and complete approach to combating invasive species is to keep them from becoming established in the first place. Prior to any active management that could lead to the introduction of invasive species, Trustees' staff will evaluate the real and potential. Impact of these species on the resource (natural, cultural, or agricultural) and the reservation in general. At a minimum, staff should take the following steps to prevent unwanted or accidental introductions.

- Use only clean fill for all projects including trail and parking area construction.
- Clean equipment before transporting it between properties or habitats, especially when used in areas with known invasive species.
- Do not plant or propagate known or potential* invasive species. Review the MA Department of Agricultural Resources' prohibited species list, Invasive Plant Atlas of New England (IPANE), and Nature Serve's invasive species ranks prior to any planting. [See Table 2 for URLs.]
- Remove invasive species from designed landscapes before they spread into minimally managed habitats and natural areas.
- Monitor new plantings, whether within designed landscapes, farms, or elsewhere, for invasives that may have been present in soils.
- Work with neighbors to encourage these practices on abutting or neighboring parcels (see Education and Public Awareness below).

**Early Detection and Rapid Response:** When prevention fails, invasive species must be detected and dealt with before they become established and spread.

- Monitor all properties regularly for potential introductions, especially near trails, roads, property boundaries (especially at points where there is abutting development), and disturbed areas.

    - Train all field and farm staff on invasive species identification.
    - Engage volunteers to serve as "Weed Watchers."
- Remove, using best management practices, any new invasive species detected.
    - Use least-disruptive techniques to remove and appropriately dispose of any debris.
    - Monitor location to ensure completeness of removal.

**Control and Management:** Reducing established invasive species populations and limiting their spread can dramatically decrease their ecological and economic impacts.

- Conduct invasive species inventories at all properties, including agricultural and garden properties, to determine which species are present and the size and locations of their populations.
- Identify sensitive species (state-listed and at-risk) and priority habitats. These resources are often identified as part of the management planning and acquisition process.
- Prioritize control (see strategy below).
- Monitor control projects to ensure success of treatments.
- Review recent research and the organization's own control projects to develop best management practices.
- Restore native plant communities (and their ecological functions) in areas heavily degraded by invasives to provide habitat for native species and to reduce the risk of future invasions.

**Education and Public Awareness:** Although public awareness of the negative impacts of invasive species is increasing, education is crucial to the long-term success of efforts at prevention and management. Strategies to reduce the impacts of invasive species must communicate humans' role in facilitating their establishment and spread, their detrimental impacts on our native biota, and their effect on our enjoyment of the environment. One of the most effective ways to address invasive species issues is to inform people of how to avoid contributing to the problem and how they can reduce the threats posed by these species. Gardens and designed landscapes are particularly well suited to educating visitors and the public about the threat from invasive plants.

- Provide information to the public on our invasive species control efforts (i.e., why we are doing what we are doing).
- Engage volunteers to assist with hands-on control efforts.

## III. Prioritization of Invasive Plant Management

Non-native plant species are encountered on every property that The Trustees owns, although not all non-native species are invasive. Some species may be naturalized as small populations that are not spreading or negatively impacting native species or habitats;

others may have become dominant across vast areas at the expense of native species.

**Principles:**

- Control of all non-native species is impractical and not necessary.
- Control of non-native species needs to be prioritized, at the property and regional levels.
- Control efforts should focus on important values and features (i.e., rare species habitat, priority communities, and those invasive species that compromise a reservation's ecological integrity). In some cases, designed landscapes or agricultural lands may be important features to protect from invasive species.
- Management will use resources (financial, staff and volunteers) wisely.

Generally, control efforts will focus on those species that are threatening rare species, priority community types, or are known to compromise the ecological integrity of habitats beyond competition with native species (e.g., a species that changes soil chemistry or alters community structure). Control efforts on agricultural lands will also take into account any potential economic impacts resulting from invasives. Similarly, some invasives may compromise the integrity of gardens and other designed landscapes and will need to be prioritized separately on this basis. On some of our reservations, there may be populations of invasive species that, although they are not threatening any ecologically, agriculturally, or historically important feature, may provide an opportunity to educate volunteers and others about the problem of invasives and ways to control them. For example, getting volunteers excited about protecting a city park from invasives will spread the knowledge of the problems of invasive plants well beyond the reaches of the park. However, due to the ubiquitous nature of many invasive species on our landscape, prioritization of populations solely based on their educational value should not be done lightly, but only in situations where the educational value is very high.

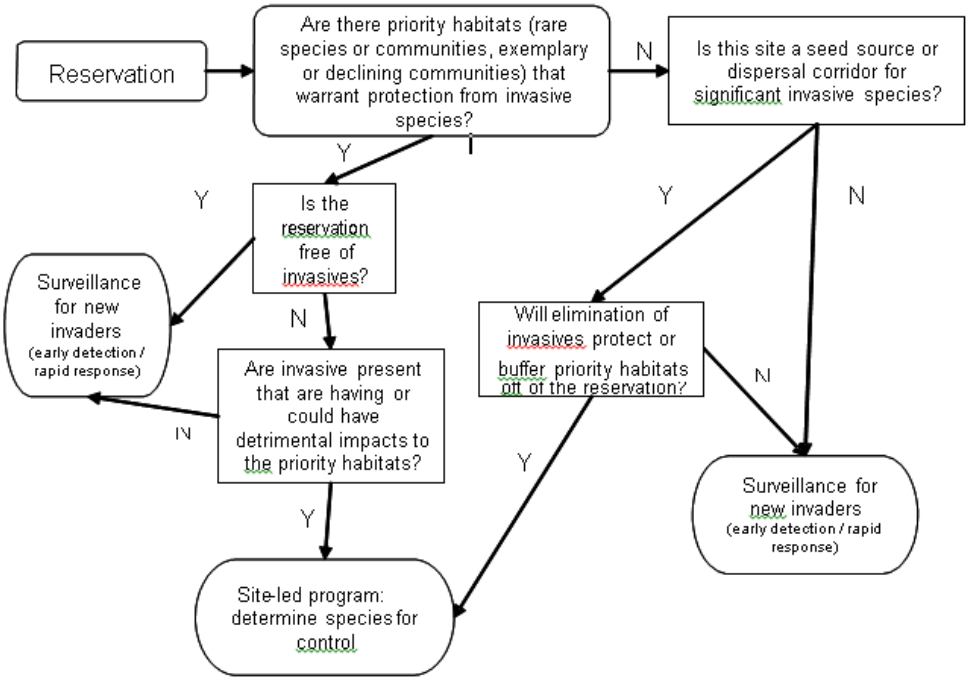
**Strategy:**

- Step 1. Identify significant and important resources to protect (e.g., rare species, priority communities).
- Step 2. Inventory properties to identify invasive species, their locations, and population sizes. Map these resources as needed using GPS/GIS technology to facilitate descriptions and track control measures.
- Step 3. Determine management pathways (i.e., weed-led or site-led, as defined below).
- Step 4. Prioritize populations for management.

The initial step in prioritizing our control strategy is to identify the problem invasive species on our reservations. Reservations need to first be inventoried to identify and describe species and community types, wetland resources, wildlife habitat, boundaries, surrounding land use (potential for invasive source populations), and land use history. This process should identify priority species (listed by the Massachusetts Natural Heritage and

Endangered Species Program or others), priority plant communities (e.g., rich mesic forest), uncommon habitats that warrant protection (e.g., early successional habitat), and community types that could benefit from active management (e.g., grasslands). The extent of invasions should be evaluated and mapped. Work could (and often will) be initiated before we have complete knowledge of all of the above but, at a minimum, we should know which significant features need protection on the reservation and which invasive species are present. A schematic to help determine the extent of invasive species management necessary at a reservation is depicted in Figure 1. The flow chart highlights some of the key questions to be addressed at the reservation level.

**Figure 1. Determining extent of invasive species management within minimally managed habitats at a reservation.**




Following a model described by the New Zealand Department of Conservation (Timmins & Owen, 2001), our invasive plant control will follow one of two pathways: weed-led or site-led. Although the NZ DOC (and other agencies and organizations) uses a numerical score approach to prioritization, this level of detail is not necessary (and likely not practical) for our invasive species prioritization. However, we can utilize the thoughts behind these numerical systems to devise a prioritization system that is simple and easy to use.

Weed-led control (see Table 1) is suitable for new invasions and small populations of species that have proven successful control methods. In these instances, we should implement control efforts not only on our reservations but also con++sider assisting our neighbors with control efforts if there is a source population in close proximity but outside of our boundaries. We may want to control plants falling into this category no matter where they occur on our properties (i.e., non-priority habitats) and even if they are not

yet considered invasive in Massachusetts. Examples of the latter include species such as Japanese stiltgrass (*Microstegium vimineum*) and kudzu (*Pueraria montana*), which are currently found in only a few locations in Massachusetts. The Trustees should immediately control any populations of these species found on or near our reservations.

Weed-led control relies heavily on the detection of new invasions before they become established in a region/state, and may be particularly useful in designed landscapes to prevent new species transported in horticultural material from establishing on Trustees properties.

Site-led control (see Table 1) focuses on controlling populations in specific areas where we have a feature that we want to protect (e.g. rare species, priority community). A site-led approach could involve controlling an invasive plant across an entire reservation or management unit, or just within the priority community type within a reservation. Most of our invasive plant control efforts will fall into this category. At Dinosaur Footprints, for example, we have initiated a site-led program to control invasive species near the state-listed false pennyroyal population. By removing invasive shrubs (honeysuckle and privet) and controlling the pale swallowwort population, the pennyroyal population has greatly increased.

**Table 1.** Comparison of weed-led and site-led control.

| | **Weed-led** | **Site-led** |
|---|---|---|
| *Purpose* | Prevent new weed species from becoming entrenched in natural | Protect threatened species and valuable |
| *Scale* | Greater than one reservation. Look at | A defined area within a reservation or |
| *Species focus* | Species that are newly naturalized in or newly invading the region/state; | Those necessary to protect the place. Often widespread weeds. |
| *Sites* | All infestations within a region, on sites | Infestations within the place; plus buffers |
| *Success when…..* | The species is eradicated or contained within the region. | The native species or natural community responds in a desired way (e.g., |
| *Other activities* | Public awareness<br>Control on sale/spread<br>Surveillance | Public awareness<br>Integrate control with other threat management<br>Survey places with high biodiversity value |

Modified from NZ DOC

## I. Developing a Site-led Plan

*Step – Determine Species Invasiveness*

After determining that a site-led program is required, the populations of invasive species need to be prioritized for control efforts. Figures 2 and 3 are flow charts designed to assist managers in determining the priorities within a reservation or management unit. When prioritizing control efforts, several factors need to be considered, including the biology of the species, the size of the infestation, and whether suitable control methods exist. NatureServe assigns each invasive species a U.S. Invasive Species Impact Rank (I- rank) based on the species' biological and ecological characteristics, ecological impact, current distribution/abundance, trend in distribution/abundance, and management difficulty.[2] Species are ranked high, medium, low, and insignificant. Many of the invasive species in Massachusetts have been evaluated with the I-rank protocol (see Tables 2 and 4 for selected species in Massachusetts). Although the I-rank is based on national trends with the species, it can provide a useful starting point for prioritization of species within The Trustees' reservations. In addition, a species not ranked high by NatureServe may be of local concern. For example, narrowleaf bittercress (*Cardamine impatiens*) occurs at Bartholomew's Cobble, where it has expanded within a few years from a few individuals to covering several acres. NatureServe's I-rank is low for this species, partially because there is little data on how this species impacts native species and habitats and because of the general ease of control by hand-pulling. Although the rank may be considered low from a nationwide perspective, it is clearly of great concern at Bartholomew's Cobble. Therefore, the I-rank should just be a first step and species should also be evaluated using statewide, regional, or local knowledge such as that provided by the Massachusetts Invasive Plant Advisory Group ratings, the MA Prohibited Plant list, the Invasive Plant Atlas of New England, and other documented sources.

*Step 2 – Evaluate the Habitat*

The second step is to evaluate the habitat(s) where the invasive is occurring.

- Is the habitat primarily a disturbed cultural area?
- Is the habitat a priority natural community?
- Has the habitat been recently disturbed, or has there been little previous disturbance?
- What matrix is the target habitat within? (Cultural, agricultural, second growth, etc.)
- Are the surrounding habitats dominated by invasives?
- Are the surrounding habitats relatively free from invasive species?

Key features of the habitat to assess are whether it is classified as a priority natural community or is close to a priority natural community, the likelihood that the site would be reinvaded from a nearby population, and whether human disturbance influences the condition of the habitat. In managed or designed landscapes, important features to consider may include the historical importance of a garden, any economic impacts to agriculture, or other values.

**Table 2.** Selected invasive plant species in Massachusetts, including ranks by Nature Serve, MA Invasive Plant Advisory Group, MA Department of Agricultural Resources, and the Invasive Plant Atlas of New England.*

| Species | Nature Serve I-Rank* | MIPAG Category | MADA Prohibited Plant List | IPANE Early Detection for MA |
|---|---|---|---|---|
| *Acer platanoides* Norway maple | High | Invasive | Prohibited | |
| *Acer pseudoplatanus* Sycamore maple | Medium | Invasive | Prohibited | |
| *Aegopodium podagraria* Bishop's | Low | Invasive | Prohibited | |
| *Ailanthus altissima* Tree-of-heaven | Medium | Invasive | Prohibited | |
| *Alliaria petiolata* Garlic mustard | High | Invasive | Prohibited | |
| *Ampelopsis brevipedunculata* Porcelainberry | Medium | Likely Invasive | Prohibited | |
| *Berberis thunbergii* Japanese barberry | High | Invasive | Prohibited | |
| *Cardamine impatiens* Narrowleaf bittercress | Low | Likely Invasive | Prohibited | Yes (1 known pop) |
| *Celastrus orbiculatus* Asiatic bittersweet | High | Invasive | Prohibited | |
| *Centaurea maculosa* Spotted knapweed | High | Likely Invasive | Prohibited | |
| *Cirsium arvense* Canada thistle | High | | | |
| *Cynanchum louiseae* Black swallowwort | High | Invasive | Prohibited | |
| *Cynanchum rossicum* Pale swallowwort | High | Likely Invasive | Prohibited | Yes (>3 known pops) |
| *Elaeagnus umbellata* Autumn olive | High | Invasive | Prohibited | |
| *Euonymus alatus* Winged euonymus | Medium | Invasive | Prohibited | |
| *Euphorbia esula* Leafy spurge | High | Invasive | Prohibited | |
| *Frangula alnus* Glossy buckthorn | High | Invasive | Prohibited | |
| *Glaucium flavum Sea poppy* | Medium | Invasive | Prohibited | Yes (>3 known pops) |
| *Hesperis matronalis* Dame's rocket | Medium | Invasive | Prohibited | |
| *Iris pseudacorus* Yellow iris | High | Invasive | Prohibited | |
| *Lepidium latifolium* Broad-leaved pepperweed | High | Invasive | Prohibited | Yes (>3 known pops) |
| *Ligustrum obtusifolium/ vulgare* Border privet | High | Likely Invasive | Prohibited | |
| *Lonicera japonica* Japanese honeysuckle | High | Invasive | Prohibited | Yes (>3 known pops) |
| *Lonicera morrowii* & others Asian bush | High | Invasive | Prohibited | |
| *Lysimachia nummularia* Moneywort | Medium | Invasive | Prohibited | |
| *Lythrum salicaria* Purple loosestrife | High | Invasive | Prohibited | |
| *Microstegium vimineum* Japanese stiltgrass | High | Likely Invasive | Prohibited | Yes (3 known pops) |
| *Phalaris arundinacea* Reed canary-grass | High | Invasive | Prohibited | |
| *Phellodendron amurense* Amur corktree | Medium | Likely Invasive | Prohibited | |
| *Phragmites australis* Common reed | High | Invasive | Prohibited | |
| *Polygonum cuspidatum* Japanese knotweed | High | Invasive | Prohibited | |
| *Polygonum perfoiatum* Mile-a-minute weed | Medium | Potentially | Prohibited | Yes (0 known pops) |
| *Ranunculus ficaria* Lesser celandine | Medium | Invasive | Prohibited | Yes (>3 known pops) |
| *Rhamnus cathartica* Common buckthorn | High | Invasive | Prohibited | |
| *Robinia pseudoacacia* Black locust | High | Invasive | Prohibited | |
| *Rosa multiflora* Multiflora rose | Medium | Invasive | Prohibited | |

*Nature Serve www.natureserve.org, U.S. Invasive Species Impact Rank (I-rank)

Massachusetts Invasive Plant Advisory Group http://www.massnrc.org/mipag/index.htm,
MA Department of Agricultural Resources http://www.mass.gov/agr/farmproducts/proposed_prohibited_plant_list_v12-12-05.htm,
Invasive Plant Atlas of New England http://nbii-nin.ciesin.columbia.edu/ipane/

*Step 3 – Determine if an Effective Control Method Exists*

The third step is to determine whether a control method exists that can eliminate or successfully reduce the presence of the species; whether there is a control method that is suitable for the site; and if the proposed method is feasible (do we have the necessary resources to control the invasives at this site?). Although the I-rank includes some of this information in the management difficulty category, the effectiveness of potential methods may be different when considering limited populations on The Trustees' properties.

Best management practices together with integrated pest management (IPM) procedures should constitute any approach for controlling invasive species. IPM is a control strategy that uses a variety of methods beginning with, as outlined earlier, prevention. Once a pest or invasive species is established, IPM follows with targeting the most effective, economical, and environmentally sensitive method for controlling the pest for the specific situation or area where it occurs. Although there is no one-size-fits-all IPM formulation, control of invasive plants will often consider hand-pulling, mechanical treatment, and herbicide application depending on the species involved, the size of the infestation, the necessity for control, and the resources available. Information on how to control invasive species continues to be updated as researchers and land managers learn more about the species and test control methods. The Trustees' ecology team will work to maintain up-to-date information about invasives species control, but managers may also wish to consult some of these resources to learn about control methods:

- Journals: Natural Areas Journal, Ecological Restoration.
- Web sites: The Nature Conservancy Global Invasive Species Initiative (http://tncinvasives.ucdavis.edu), Massachusetts Association of Conservation Commissions (http://maccweb.org/resources_invasive.html), New England Wildflower Society (www.newfs.org/protect/invasive-plants), National Park Service (www.nps.gov/plants/alien/).
- Personal information: talk to other land managers to find out which methods they have tried and where, and whether or not their efforts were successful. Be sure to find out what doesn't work as well as what does.

Several control methods may be available to control a species, with different impacts and costs associated with each. The method that is chosen will depend on its effectiveness, its cost, and the non-target impacts (Step 4).

*Step 4 – Consider Non-target Impacts*

The fourth step is to evaluate the impacts of the control on non-target species. Are the impacts minimal and/or acceptable? In some cases, although native species may also be eliminated by the control method, the habitat may have been so degraded that replacing native species following removal of the invasives is the best course of action. In other instances, it may be unacceptable to impact native species (e.g., rare species) with the most practicable control method and, therefore, alternative less practicable methods may need to be chosen instead.

*Step 5 – Determine the Potential for Long-Term Control*

The fifth step is to determine the potential long-term success of the control method. Is the area defensible from reinvasion? Can the area be monitored closely to control any residuals that remain following a large-scale control effort?

*Step 6 – Prioritize Multiple Invasive Species Populations for Management*

The final step incorporates all of the previous information and ranks populations of invasive species as high, medium, and low priority for control or determines that no action is needed. By using the two flow charts in Figures 2 and 3, managers can determine which species and populations are most important to control. Although the flow charts focus on species within natural or minimally managed habitats, the thinking behind them can similarly be used for designed landscapes and agricultural land. The key is identifying the important resources needing protection (e.g., rare species, historic garden, prime agricultural field), and then determining the impact of the invasive, the likelihood of successful control, and whether there are unacceptable non-target impacts (e.g., using herbicide in an area certified as organic, thereby losing the organic certification for a period of time). By evaluating all of the invasive species present at a reservation or management unit and assigning them prioritization ranks, an invasive species management plan can be created for the area (see Table 3). In many cases control of multiple species, regardless of rank, will occur simultaneously due to the species occupying the same area and the efficacy of controlling at the same time all of the species in priority areas.

**Table 3**. Reservation-specific invasive species plan.

| Species | Prioritization Rank | Habitat/Location Size of population | Prioritization comments: feasibility, alteration to rank from flow chart, conservation target(s) | Suggested Control Method | Control comments: costs, expected non- target impacts, potential for long- term control |
|---|---|---|---|---|---|
| Species, population X | | | | | |
| Species, population Y | | | | | |
| Species, population Z | | | | | |

## I. Adaptive Management for Invasive Species

It is important to reevaluate our invasive species priorities as new control methods arise and more is understood about the species' biology. As we establish control programs, we will be able to determine which methods are successful; their impacts, if any, on non-target species; and opportunities to improve. In addition to our programs, other agencies may also be controlling species using alternative methods. We need to share our knowledge with others and hope to learn from our colleagues as well. We should strive to dialogue not only with other land managers, but also with researchers working with invasive species and experimental controls.

In addition, as we begin to have success with our control efforts, our priorities for control might change (e.g., a formerly low-ranked population may rise in importance due to a new control method). Therefore, we will periodically review and update our invasive species plans.

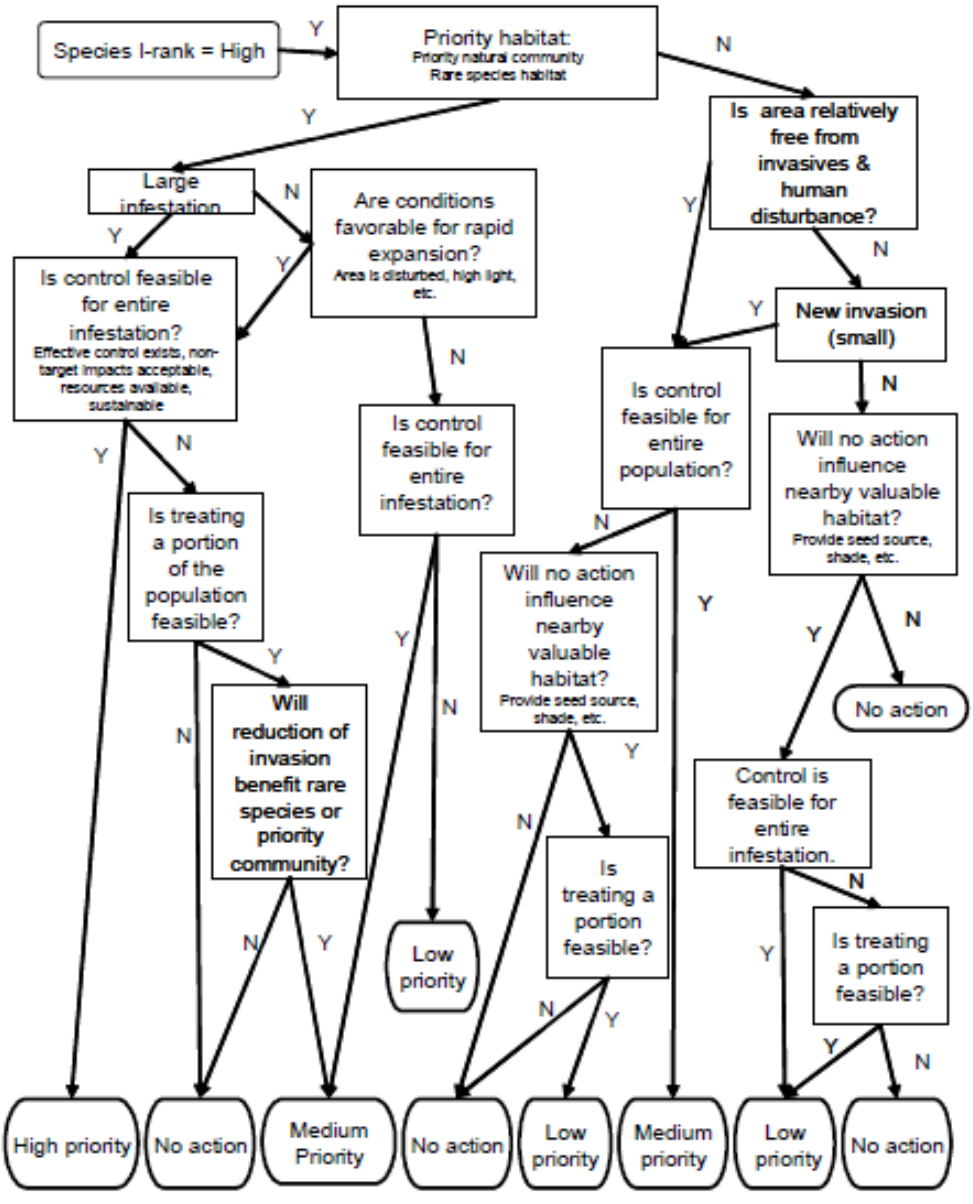
## II. Implementing Invasive Species Control

Within The Trustees, ecologists will work with superintendents and property managers to develop reservation-specific control plans (see Table 3). Initial plans will identify priorities for control and recommended control methods. Those plans will evolve as more is learned about the reservation and its existing invasive species populations, and as new invasive species colonize. Generally, control plans will be created as part of a property management plan. In cases where a management plan already exists, a separate invasive species control plan will be completed. Superintendents, property managers and their staff and, in some cases, regional ecologists will implement the plan

on the ground with the help of volunteers and possibly contractors. Plans should be reviewed periodically to update information, including new invasive plant infestations or new populations, what has or hasn't worked, and changes in the prioritization.

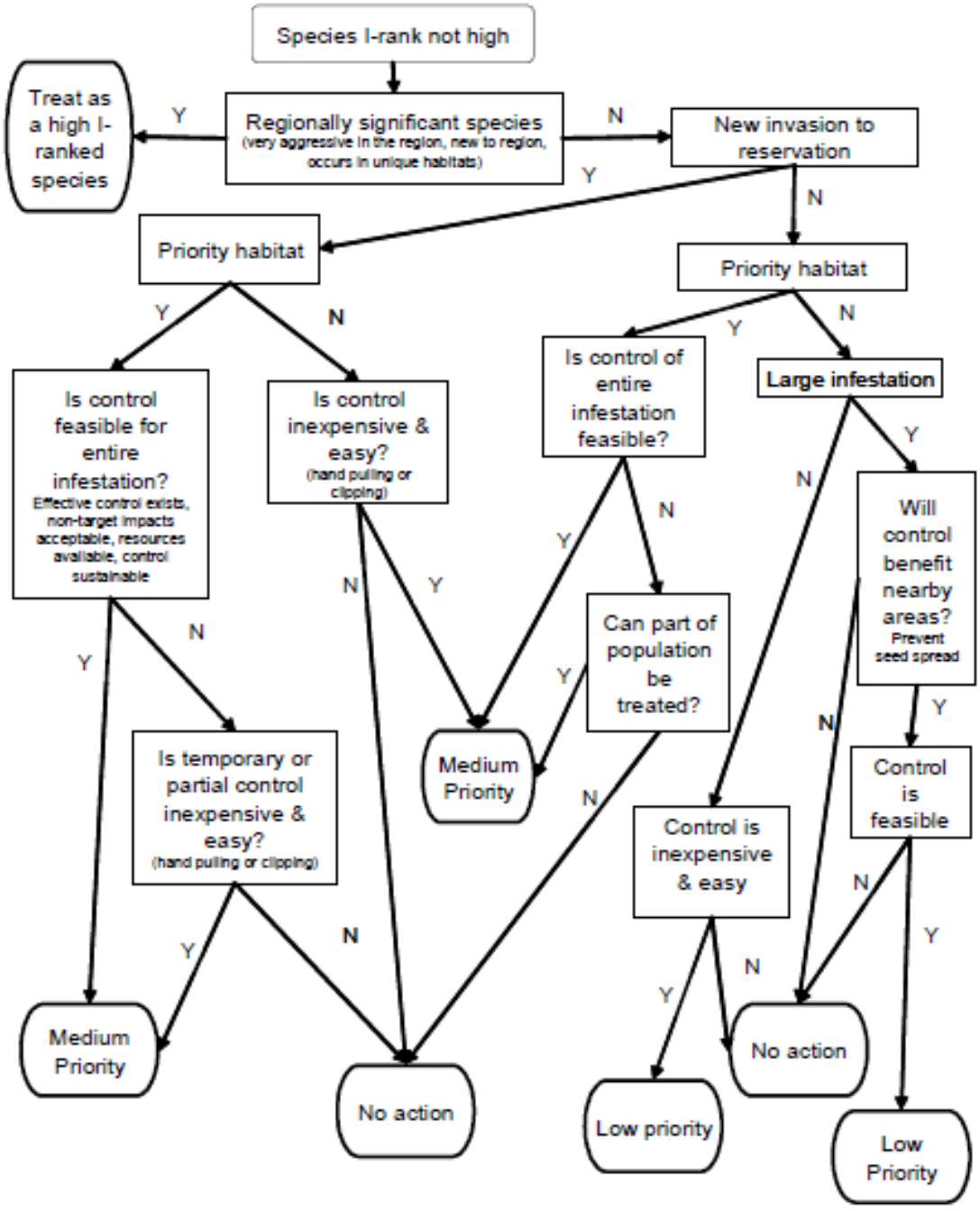
For questions regarding the prioritization or how to create or implement a plan, contact The Trustees' ecologist for the region in question.

**Figure 2.** Prioritization of control for a species with a high NatureServe I-rank.




**No action = monitor, prevent further spread, and reevaluate**

**Figure 3.** Prioritization of control for a species without a high NatureServe I-rank.




**No action = monitor, prevent further spread, and reevaluate**

**Table 4.** NatureServe Invasiveness rank and supporting ranks for selected species in Massachusetts. Check NatureServe Web site* for updated information.

| Species | I-Rank | Ecological Impact | Current Distribution/ Adundance | Trend in Distribution/ Adundance | Management Difficulty |
|---|---|---|---|---|---|
| *Acer platanoides* Norway maple | High | Medium | High/medium | High/medium | Medium/low |
| *Alliaria petiolata* Garlic mustard | High | Medium/low | High | High/medium | Medium |
| *Berberis thunbergii* Japanese barberry | High | High/medium | High | Medium/low | Insignificant |
| *Celastrus orbiculatus* Asiatic bittersweet | High | Medium/low | High | High/low | Medium |
| *Centaurea maculosa* Spotted knapweed | High | Medium | High | High/medium | High/low |
| *Cirsium arvense* Canada thistle | High | Medium/low | High | Medium/low | High/medium |
| *Cynanchum louiseae* Black swallowwort | High | High/medium | High | Medium | High |
| *Elaeagnus umbellata* Autumn olive | High | High | High | High/medium | Low |
| *Frangula alnus* Glossy buckthorn | High | High/low | High | Medium | Medium |
| *Iris pseudacorus* Yellow iris | High | Medium/low | High | Medium | High/medium |
| *Ligustrum obtusifolium/ vulgare* Border privet | High | High/low | High/medium | High/medium | High/medium |
| *Lonicera morrowii* & others Asian bush honeysuckle | High | Medium/low | High | High/medium | Medium |
| *Lythrum salicaria* Purple loosestrife | High | High | High | High | High |
| *Microstegium vimineum* Japanese stiltgrass | High | Medium | High/medium | Medium/low | High/medium |
| *Polygonum cuspidatum* Japanese knotweed | High | High/medium | High | High/low | Medium |
| *Rhamnus cathartica* Common buckthorn | High | Medium | High | High/low | Medium |

* www.natureserve.org/explorer/. To access I-rank information, search on species name, select species from list, expand U.S. Invasive Species Impact Rank from comprehensive report summary.

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**Responsible Department:** **Last Updated:**
**Staff Lead:** **Date of Next Review:** (Within two years of last update)