THE LAND MANAGERS

Guide to Invasive Plant Management

DCR
Virginia Department of Conservation & Recreation

The Land Managers Guide to Invasive Plant Management

Prepared by Kevin Heffernan, Lindsay Caplan, and AG Sweany
Invasive Species Team
Virginia Natural Heritage Program
dcr.virginia.gov/natural-heritage
invasive.species@dcr.virginia.gov

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Figure 1 *Aquatic invasive species such as two-horned trapa (*Trapa bispinosa*) can clog waterways and outcompete native vegetation.*

What Are Invasive Plants?

Introduced species, also known as non-native species, have been intentionally or unintentionally introduced by human activity into a region where they did not evolve. Many introduced species are well-known and economically important in agriculture and horticulture, such as domestic cattle, wheat, or tulips. Introduced species can be any organism, from microbial organisms to plants or animals. Typically, introduced species will not become established outside of cultivation; if they do, they usually have few negative impacts.

However, some introduced species that escape cultivation can successfully reproduce and establish in the wild with severe negative impacts. At this point, when an introduced species begins to cause harm to the environment, the economy, or human health, we label them "invasive" (Exec. Order No. 13112, 1999). Across the country and around the world, invasive species have become one of the most serious threats to native species, natural communities, and ecosystem processes (Luken and Thieret, 1997). Invasive species can reduce native plant species, decrease biodiversity, prevent ecosystem regeneration, and increase fire risk (Miller et al., 2010). They reduce wildlife habitat, do not act as host plants for our native pollinators, and are often nutritionally deficient when compared to our native species (Smith et al., 2013). They also exact a costly toll on human economies that depend on resources and services provided by healthy ecosystems. Examples include significant loss of crop yields due to depredation from invasive animals, damage to infrastructure such as roads, bridges, and buildings, and contamination and clogging of important waterways (Poland et al., 2021).

Figure 2 *Invasive wavyleaf grass (*Oplismenus undulatifolius*) forms monocultures that prevent native plants from growing and decrease biodiversity.*

The economic cost of invasive species is complex and challenging to quantify. Recent research suggests that the annual global costs of invasive species exceed $423 billion, and studies place financial losses in the United States anywhere from a conservative $26.26 billion up to $120 billion per year (IPBES, 2023; Crystal-Ornelas et al., 2021; Pimental et al., 2005). These threats are expected to increase in the future.

The impacts occur across the board, whether the issue is an extensive autumn olive population covering hundreds of acres or a small patch of common ivy growing in an apartment garden bed. Of Virginia's 3,344 known plant species, 755 are introduced, and 103 are now considered invasive (Fleming et al., 2017; Heffernan and Sweany, 2024). A recent study found that 61% of the species identified as invasive plants were introduced for horticultural purposes (Beaury et al., 2021). Additional introductions occurred for erosion control and wildlife benefit or accidentally through packing materials, ship ballast, and other vectors.

Once considered a problem only on farms or in lawns, invasive plants are now recognized as a threat to natural areas, parks, forests, and other wildlands. Land managers, weed scientists, foresters, ecologists, and other conservationists are joining together to face this challenge in ways that help conserve native species and natural communities and protect environmental quality.

Since humans introduce invasive species, we must focus on preventing introductions, responsibly managing species already here, and making educated choices. To assist with those efforts, the Virginia Department of Conservation and Recreation's Natural Heritage Program assesses introduced plants for invasiveness and maintains a regularly updated list of invasive plants in Virginia (Heffernan and Sweany, 2024). This non-regulatory list exists for educational purposes only and is separate from the Virginia Department of Agriculture and Consumer Services (VDACS) Virginia Noxious Weed List. The Noxious Weed Law regulates the listing of a species as a noxious weed (Regulations for the Enforcement of the Noxious Weeds Law, 2024). Species designated as noxious are prohibited from sale.

VIRGINIA INVASIVE PLANT SPECIES LIST

EFFECTIVE DATE: SEPTEMBER 2024

The list is for educational purposes only and has no regulatory authority. Per Virginia Code §10.1-104.6:2, the Virginia Invasive Plant Species List is periodically reviewed and updated. List updates require adherence to a specific invasives species risk assessment protocol developed by DCR. DCR routinely conducts data analysis and assessments for existing species and reviews potential list additions.

Two-horned trapa

The Virginia Invasive Plant Species List comprises species that are established — or may become established — in Virginia, cause economic and ecological harm, and present ongoing management issues.

To be included on the list, there must be demonstrable evidence that a species poses a threat to Virginia's forests, native grasslands, wetlands or waterways. Under the DCR Invasive Species Assessment Protocol, approved by the Virginia Invasive Species Working Group, January 2024, species were ranked as exhibiting **high**, **medium** or **low** levels of invasiveness based on their threat to natural communities and native species.

Invasiveness rank is higher for species that:

- Alter ecosystem processes, such as succession, hydrology or fire regime.
- Are capable of invading undisturbed natural communities.
- Cause substantial impacts on rare or vulnerable species or natural communities or high-quality examples of more common communities.
- Are found widely distributed and generally abundant where present.
- Disperse readily to new areas.
- Are difficult to control.

Scientific Name	Common Name	Virginia Invasiveness Rank	REGION: Mountain	Piedmont	Coastal
Ailanthus altissima	tree-of-heaven	High	•	•	•
**Aldrovanda vesiculosa*	waterwheel	High			•
Alliaria petiolata	garlic mustard	High	•	•	•
Alternanthera philoxeroides	alligator-weed	High			•
Ampelopsis glandulosa	porcelain-berry	High		•	•
**Arum italicum*	Italian arum	High	•	•	•
Carex kobomugi	Japanese sand sedge	High			•
Celastrus orbiculatus	Oriental bittersweet	High	•	•	•
Centaurea stoebe ssp. *micranthos*	spotted knapweed	High	•	•	•
Cirsium arvense	Canada thistle	High	•	•	•
Citrus trifoliata	trifoliate orange	High	•	•	•
Dioscorea polystachya	cinnamon vine	High	•	•	•
Elaeagnus umbellata	autumn olive	High	•	•	•
Euonymus alatus	winged euonymus	High	•	•	
Ficaria verna	lesser celandine	High		•	•
Hydrilla verticillata	hydrilla	High	•	•	•
**Imperata cylindrica*	cogon grass	High			•
Iris pseudacorus	yellow flag	High	•	•	•
Lespedeza cuneata	sericea lespedeza	High	•	•	•
Ligustrum sinense	Chinese privet	High	•	•	•
Lonicera japonica	Japanese honeysuckle	High	•	•	•
Lonicera maackii	amur honeysuckle	High	•	•	•
Lonicera morrowii	Morrow's honeysuckle	High	•	•	
**Ludwigia hexapetala*	large-flowered primrose-willow	High	•	•	•
Ludwigia peploides var. glabrescens	floating primrose-willow	High	•	•	•
Lythrum salicaria	purple loosestrife	High	•	•	•
Microstegium vimineum	Japanese stiltgrass	High	•	•	•
Murdannia keisak	marsh dewflower	High	•	•	•
Myriophyllum aquaticum	parrot feather	High	•	•	•
Myriophyllum spicatum	Eurasian water-milfoil	High	•	•	•
Oplismenus undulatifolius	wavyleaf grass	High	•	•	
**Oshuna crassipes*	water hyacinth	High			•
Persicaria perfoliata	mile-a-minute	High	•	•	•
Phragmites australis ssp. *australis*	common reed	High	•	•	•
Pueraria montana var. lobata	kudzu	High	•	•	•
Reynoutria japonica	Japanese knotweed	High	•	•	•
Rosa multiflora	multiflora rose	High	•	•	•
Rubus phoenicolasius	wineberry	High	•	•	•
Sorghum halepense	Johnson grass	High	•	•	•
**Trapa bispinosa var. iinumai*	two-horned trapa	High	•	•	•
Triadica sebifera	Chinese tallow-tree	High		•	•
**Tripidium ravennae*	ravenna grass	High	•	•	•
Urtica dioica	European stinging nettle	High	•	•	•
Vitex rotundifolia	beach vitex	High			•
Acer platanoides	Norway maple	Medium	•	•	•
Acetosa acetosella	sheep sorrel	Medium	•	•	•
Agrostis capillaris	colonial bent-grass	Medium	•	•	•
Akebia quinata	five-leaf akebia	Medium		•	•
Albizia julibrissin	mimosa	Medium	•	•	•
Arthraxon hispidus var. hispidus	joint head grass	Medium	•	•	•
Berberis thunbergii	Japanese barberry	Medium	•	•	•
**Cenchrus purpurascens*	fountain grass	Medium	•	•	•
Cirsium vulgare	bull thistle	Medium	•	•	•

* Early detection species

Figure 3 *The Virginia Invasive Plant Species List is a comprehensive, science-backed list of invasive plants in Virginia available on the DCR website.*

In addition to the invasive plant list, DCR and the Virginia Native Plant Society (VNPS) have worked together to produce invasive plant fact sheets and brochures on using native plants for restoration and landscaping. Those projects were initially funded partly by the Virginia Department of Environmental Quality's Virginia Coastal Program. DCR also collaborates with other state agencies, including the VDACS, the Virginia Department of Forestry (DOF), and the Virginia Department of Wildlife Resources (DWR), to manage invasive species as outlined in the Virginia Invasive Species Management Plan (VISMP). The FY 2024-2026 Virginia Biennial Budget newly funded the implementation of the VISMP in state agencies. Though active management has been occurring for decades with limited resources, the new funding enables state agencies to expand their capacity to manage invasive species and create outreach products.

This publication is intended as an introduction and guide to invasive plant management for professional land managers. The agencies listed above all offer additional information and resources on invasive species in Virginia. See the Resources section at the end of this document.

Creating an Invasive Plant Management Plan

Before making decisions and taking action, land managers must first evaluate the problem. What are the conservation goals and value of the site and the species it supports? What are the threats to the site goals? Are invasive species present on the property or nearby? Does an invasive plant population threaten rare species and/or natural communities? Are critical ecosystem processes or cultural resources threatened? Are the invasives threatening or endangering humans? Land managers should address these and other considerations to define site goals and help determine appropriate management actions. Control of invasive plants is time and labor-intensive, and applying treatments and monitoring the area requires a commitment of several years. It can also be expensive. Since invasive plant problems are often numerous and significant, land managers must prioritize the biggest threats and learn to live with many less threatening invasive plant species. Even when the most serious problems have been identified, management may not be feasible for various reasons, such as a lack of resources, the distribution pattern of the invasive plant within the site, or an absence of practical and/or acceptable control measures.

> *Vision without action is a daydream. Action without vision is a nightmare.*
>
> **– Anonymous Proverb**

Land managers seeking to control invasive plants should work to develop an invasive species management plan. The U.S. Fish and Wildlife Service and the California Invasive Plant Council (2018) have collaborated on the *Land Manager's Guide to Developing an Invasive Plant Management Plan* document, providing excellent step-by-step guidance for those seeking to develop a plan. Find information on accessing that document in the Resources section.

Such a plan should include site goals or management objectives, a list of the invasive plant species identified in the area and observed or potential impacts, species life history information, a list of control options, a thorough long-term management plan, and a detailed budget of project costs. A written plan is a record of the information used to make management decisions and will guide the implementation of the control program..

Figure 4 *Whether in the field or the office, collaborating with various stakeholders can lead to more effective management.*

When building a plan, including various stakeholders in the process is essential. Stakeholders could include conservation partners, adjacent landowners, subject matter experts, and other interested parties. Considering different viewpoints and having many expert opinions will help make the final plan stronger and more effective. Invasive species also spread irrespective of property lines, so collaboration is critical for effective management. Including all stakeholders from the beginning of the process leads to more successful management efforts.

A key aspect of any successful control program is to follow up management actions with monitoring activities. Collecting information throughout the control process and for many years afterward will allow managers to assess successes and failures and determine the need for further management. Monitoring activities may include measuring changes in plant populations, community structure, or environmental factors such as light levels. The priority level assigned to a site will help determine how vigorously it needs to be monitored.

Think of your plan as a living document that should be regularly revised and adapted to maintain effectiveness and modify achievable goals. Frequently review management objectives, progress, and the lessons learned from actions taken to control invasive plants. Adjusting management strategies may be necessary according to this and any other new information that has become available since the plan was developed.

Assessing Threats from Invasive Plants

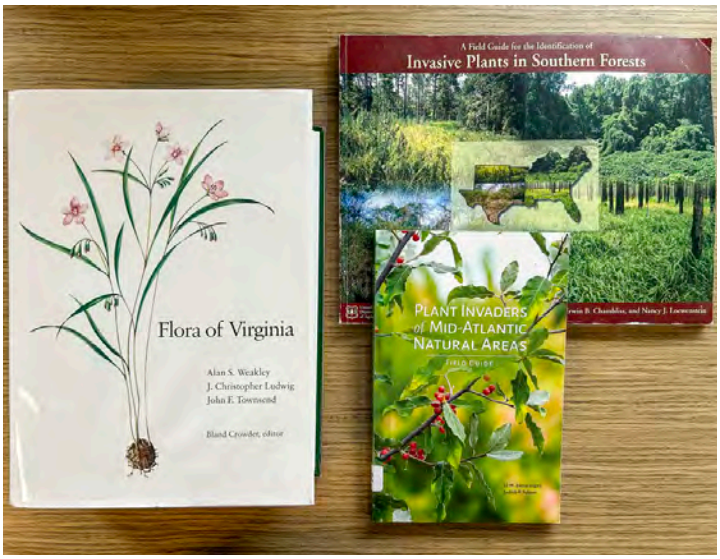

Figure 5 *Regional floras and field guides can provide information on life history characteristics and distribution of locally invasive plants.*

Threats posed by an invasive plant can change from site to site and through time. Land managers must gather information from scientific and management experts and literature sources regarding the species in question to assess the current threat level. This information should include the plant's life history, distribution and abundance, and influences on the natural communities and ecosystem processes. Site goals will determine the necessary monitoring level; high-priority sites usually justify intensive and quantitative measurements. Low-priority sites may only need qualitative monitoring.

Life history characteristics

Helpful information for understanding an invasive plant includes a taxonomic description of the species, its life history, and habitat requirements. The taxonomic description will help positively identify the species. A species' life history includes how it reproduces, when it germinates, flowers, and produces seeds. Such information can indicate whether or not a species competes with native species with similar life histories. Life history information may also reveal the most effective season for applying a control treatment. Understanding the species' habitat requirements can help determine the potential extent of an infestation.

Distribution and abundance

Land managers should address two primary questions to assess the invasiveness of an introduced plant species. First, how widespread is the plant in the region, and how abundant is it? Second, what is the historical trend of the plant species in the region? Natural areas, parks, and woodlands are not isolated from the surrounding landscape. The presence of a species in a region and its known propensity to become invasive will indicate the likelihood that a species will infest a given site. Such information can also suggest the potential for reinfestation after control efforts have been made.

Influences on natural communities and ecosystem processes

Knowledge of community ecology is essential in predicting the influences of an invasion on any given natural community. Information on community composition and structure, hydrology and soil water regimes, and disturbance history all play a role in understanding the changes an invasive species may cause. Much of this information is difficult to obtain. The higher a site's priority, the greater the importance of collecting as much information as possible. When results from scientific studies are unavailable, land managers may have to make decisions based on inferences from experiences at other sites.

The specific ways invasive plants influence natural communities often overlap and may interact. To clarify the scope of influence exerted by an invasive species, consider the following:

COMMUNITY COMPOSITION

Composition refers to the species present and their relative abundance at a site. Questions land managers should answer about an invasive species' influences on composition include: How does the invasive plant alter the composition of the community? Does it increase or decrease diversity? Does the invasive plant outcompete native species? Does its presence increase the likelihood of invasion by additional invasive species?

Figure 6 *Many invasive plants like kudzu (*Pueraria montana*) alter community composition by decreasing biodiversity, outcompeting native species, and physically altering community structure.*

COMMUNITY STRUCTURE

The physical arrangement of plants at a site is called community structure, and it most often refers to vertical vegetation strata, such as the height of the tree canopy, understory, shrub, and groundcover layers in a forest. Questions land managers should answer about an invasive species' influences on structure include:

Does the invasive species change the presence or density of existing vegetation layers?

Does it create a new layer?

Does it overtop the canopy and impact all layers below?

Figure 7 *Invasive grasses like silvergrass (*Miscanthus sinensis*), pictured here invading a forest clearing, increase fire activity and severity.*

ECOSYSTEM PROCESSES

The inputs, outputs, and cycling of nonliving elements, such as water, nutrients, and energy, as well as the interactions of living organisms, comprise ecosystem processes. Regarding an invasive species' influences on ecosystem processes, land managers should ask: Does the species alter the hydrologic regime, sedimentation rates, soil nutrient levels, or the fire regime?

Prioritizing Management Activities

Resources for the control of invasive plants are usually limited, so individual invasions must be ranked and prioritized. Land managers may choose to rank species in a spreadsheet, using online ranking tools such as the Invasive Plant Inventory and Early Detection Prioritization Tool (U.S. Fish and Wildlife Service, 2016), or follow a ranking method such as the one described in the National Park Services *Handbook for Ranking Exotic Plants for Management and Control* (Hiebert and Stubbendieck, 1993). Priorities may differ from site to site, depending on the projected impacts of an infestation and other site considerations.

The spreadsheet method starts with a list of all known species and/or areas of concern to be ranked. Ranking criteria may include but are not limited to invasiveness rank, ecological impacts, ease of control, or site accessibility. Ranking can be accomplished by assigning numerical values to each choice, such as 0 for not invasive, 1 for low, 2 for medium, and 3 for high invasiveness. After ranking, these numbers would be calculated to provide each species and/or area of concern with a final number to distinguish their priority

The Invasive Plant Inventory and Early Detection Prioritization Tool is an access database that works similarly. By assigning specific criteria to each area and species, the tool calculates what priorities land managers should focus on. The tool is easy to use and available freely online. See the References section of this document for a link to access it.

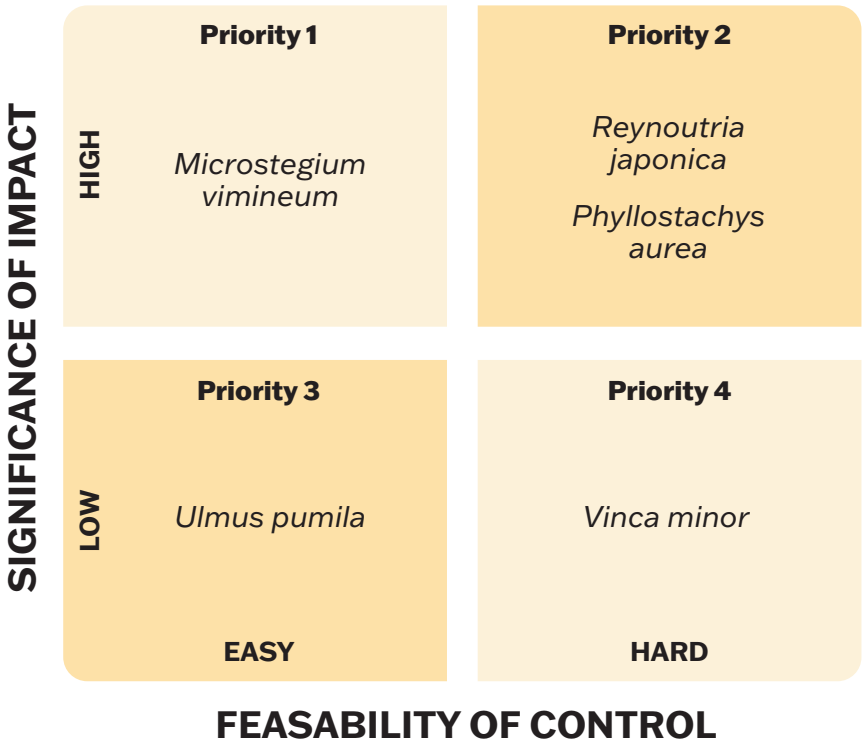

Figure 8 *The Hiebert and Stubbendieck method prioritizes species based on their feasibility of control and significance of impact. Different species can have varied impacts at different sites, so each site will need to be evaluated individually.*

The Hiebert and Stubbendieck (1993) model provides an alternative to the many methods that rank species and areas by separate individual factors. They suggest ranking by the significance of impact on a site and the feasibility of control. The ranking is visualized by plotting the significance of the impact on a graph over the feasibility of control. The graph is then divided into four quadrants, each representing a priority level for action. Priority 1 infestations are easy to control and have a high level of impact on a site. Priority 2 are those with a high impact but are difficult to control. Priority 3 areas exhibit a low impact and are easy to control, and Priority 4 items have a low impact and are hard to control. Including the feasibility of control in this ranking system allows land managers to make more efficient management choices for quicker progress.

Regardless of the chosen method, prioritizing management goals remains crucial and requires thorough consideration, discussion, and stakeholder involvement.

Management Strategies

Management strategies are designed to achieve the site goals or management objectives. Strategies for managing invasive species fall into three categories: prevention, control, and restoration. These categories may overlap to varying degrees and are most effective if combined.

Prevention

Preventing invasive species from establishing at a site should be a major component of any management plan. Early detection and control of an invasive species is a much more efficient and effective management strategy than waiting until an infestation becomes a crisis. It may be the only real opportunity for eradicating an invasive species from the site. Preventive efforts will save much time, trouble, and money. For this reason, it is wise to start a routine biological monitoring program and include monitoring for invasive species as part of that program.

Three key strategies for reducing the risk of infestation are:

1. Avoid planting known invasive species.
2. Reduce soil disturbance.
3. Exercise good sanitation efforts.

Figure 9 *Natural flooding disturbance cause by Hurricane Helene led to the introduction of mile-a-minute (*Persicaria perfoliata*) at new sites along the New River in Virginia.*

Many known invasive species are currently marketed for various uses, notably gardening and landscaping, wildlife habitat enhancement, and erosion control. Planting invasive species has long been acknowledged by multiple agencies and organizations as poor management, and this message continues to spread. Due diligence should be taken to ensure any species chosen for plantings are not listed on local or national invasive species or noxious weed lists. Screen new plant introductions for invasive characteristics and thoroughly assess how the species behaves in other similar environments. Introductions with negative consequences can be avoided by instead utilizing native species with the same desired characteristics.

Preventing infestation by invasive species can be pursued on several fronts. To the best possible extent, avoid or reduce soil disturbances. Soil and canopy disturbances associated with trail and road construction often create opportunities for the establishment of invasive species. When invasive species first appear in natural areas and parks, they are usually discovered around parking lots and trailheads. When undertaking activities that will cause disturbance, follow best management practices for protecting soil and water quality. For information on best management practices for protecting soil and water resources, contact DCR's Division of Soil and Water Conservation or reference the Virginia Agricultural Best Management Practices Cost-Share Program website. Following natural disturbances such as flooding or windthrow, watch for the appearance of invasive species and control them as swiftly as possible. Use native plant species for revegetation of disturbed areas.

Figure 10 *Informational boot brush stations encourage visitors to recreate responsibly.*

Another important method of prevention is sanitation. Land managers and contractors should be required to clean vehicles, equipment, clothing, and shoes before moving from one location to the next. Items like boot brush stations and educational signage can encourage visitors to recreate responsibly and clean their gear, clothes, and pets before and after their visit. The North American Invasive Species Management Association's PlayCleanGo campaign provides other education and actionable ideas to engage the public in invasive species prevention.

Educate neighbors, local policymakers, and others who make land use decisions about invasive species. See the Resources section for extensive educational materials about invasive species. Remember that the number of problematic species constantly increases and that education is one of our best tools against introducing new problems. Keep in touch with other regional land managers, agricultural extension offices, state and regional pest plant councils, and other groups and agencies that disseminate invasive plant information. Use unified signage and messaging to make it easier for the public to recognize specific campaigns.

Control

A variety of methods are used to control invasive vegetation. Effectiveness varies with the method used, skill of application, severity of invasion, and many other factors. The best way to control invasive species is not by focusing on one method but through an integrated pest management (IPM) approach, where a combination of complementary methods is used. This approach is generally more successful and can help prevent herbicide resistance (U.S. Fish and Wildlife Service and California Invasive Plant Council, 2018). This concept can be visualized as a pyramid. The pyramid's layers, from widest to narrowest, represent cultural, physical, biological, and chemical control methods. When choosing management strategies, start at the bottom of the pyramid and work up.

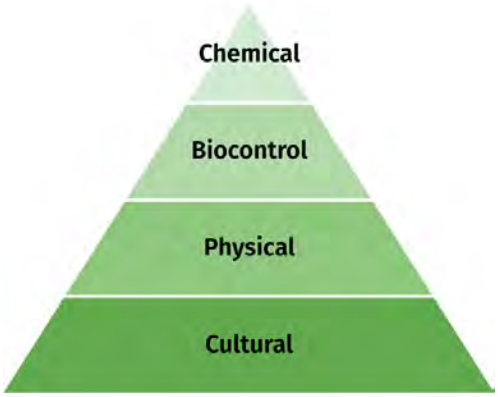

Figure 11 *The integrated pest management triangle is a helpful visual for understanding prioritization of invasive species control measures.*

Risk is inherent in any management method, whether pulling plants by hand or spraying herbicide. Always wear the appropriate personal protective equipment (PPE) for the task. For some methods, work gloves may be the only necessary PPE. Higher-risk methods might require hard hats, safety glasses, or protective clothing. Be sure to assess safety before beginning a task.

CULTURAL CONTROL METHODS

Cultural control refers to a broad range of management activities, with the standard approach of manipulating or mimicking one or more natural ecological processes to modify the habitat in a less hospitable way to the target species. Implementing cultural control practices can not only be beneficial in reducing invasive species cover, but it is also imperative in the long-term restoration of a site. Some of the most used cultural control methods are prescribed burning, grazing, and water level manipulation.

Figure 12 *Prescribed burns can be an effective control method for some species, particularly when combined with chemical control.*

Historically, fire regimes have long been a part of numerous ecological communities. Many managers are working to reinstate these regimes through prescribed burning to restore or maintain fire-adapted or dependent species and natural communities. Many invasive plants are not adapted to fire; thus, prescribed burning may be a useful tool for control of some species. Burning can also help clear thick vegetation and improve access to a site for future treatment. However, land managers must determine if fire is a natural component in the plant community in question and if prescribed fire can help meet site goals.

Conducting a prescribed burn to achieve specific conservation goals requires extensive training and experience. The intensity of the fire and the time of year it is applied are variables that will significantly affect the natural community's response. Many land managers may not have a well-trained burn crew and the equipment necessary for a safe and effective burn. Furthermore, fire stimulates the growth of some invasive plants, such as sericea lespedeza (*Lespedeza cuneata*) and silver grass (*Miscanthus sinensis*) (Miller et al., 2010).

Given these ecological and logistical challenges, prescribed burning may not be appropriate if considered only for controlling invasive species. It is best suited to a site where restoration and maintenance of fire-dependent or tolerant communities are part of the site conservation goals.

Historically, grasslands dominated a significantly large portion of our landscapes and were maintained as such due to large grazers like bison (Estes et al., 2016). While bison no longer roam free across the southeast, domestic animals such as goats, sheep, and cattle can be used to accomplish similar desired management outcomes. They are also being increasingly used for invasive species management. Many invasive species are palatable to livestock and can be particularly useful in clearing out vegetation in overgrown areas. Be careful to choose the appropriate animal and method of grazing for the management goals and type of vegetation present (Miller et al., 2010). Grazers can also spread seeds of invasive plants, so avoid using this method when invasive plants are in seed or be prepared to quarantine the animals afterward. The non-selective nature of grazers can also cause damage to desirable native species (Manning & Miller, 2011).

Figure 13 *Dense plantings of native plants, known as competitive planting, can act as a barrier to growth for invasive plant species due to the lack of space and light.*

Water levels can be manipulated to control invasive plants in some settings, such as impoundments. Species with less tolerance to flooding than native species can be flooded; water can be drawn down for aquatic invasive species that cannot survive in dry habitats. However, caution should be exercised to prevent the spread of problem species to other areas, as invasive plant seeds can be moved through water (Miller et al., 2010).

Figure 14 *A herd of goats takes a digestion break after many hours of consuming invasive plants.*

Prescribed burning, grazing, and water level manipulation may be some of the most commonly used forms of cultural control, but they are not the only options. Other methods include flaming, solarizing, mulching, and competitive planting. Invasive plant cover can often be reduced using these natural processes to change the community structure. However, most reductions will not be permanent unless they are used in combination with other methods, like chemical control.

PHYSICAL CONTROL METHODS

The physical control method consists of two categories: manual and mechanical control. Both categories involve physically removing invasive plants from the environment. Manual methods are completed by hand, either with or without tools. They can be especially labor-intensive and time-consuming. Mechanical methods complete many of the same tasks but with the benefit of using machinery and allow work to be completed more efficiently, often with less strain on the workers. Both can be helpful options but resprouts will occur unless the entire root system is successfully removed.

Hand pulling can control small annual and biennial species, as well as seedlings of woody species. Certain species benefit from use of digging tools such as a hori-hori or mattock. Another option is weed-pulling tools designed to pull up the entire plant,

Figure 15 *Manual control can be effective, but is time consuming and often physically taxing to the worker.*

Figure 16 *The addition of power equipment can make invasive plant removal more efficient.*

including the roots, by clamping onto the base of the plant and using a long handle to gain leverage. Other manual control options include cutting and girdling. Combining cutting with an herbicide application to the stump will significantly increase the control of woody invasive species.

Mechanical methods utilize power equipment such as chainsaws, mowers, tractors, mulchers, and skid steers to complete manual removal on a larger scale. Many of these machines can be particularly useful in areas of dense infestation where access on foot is difficult. However, these methods can cause much soil disturbance and potentially result in further invasion (Manning and Miller, 2011). Plan to treat and monitor the site for several years after initial treatment.

BIOLOGICAL CONTROL METHODS

Biological control or biocontrol methods use living organisms to target an invasive species. The most commonly used form of biocontrol is classical biocontrol, where predator organisms of the target invasive species are intentionally introduced into the areas they invade to enable them to establish in the area and negatively impact the invader. When introducing a new organism into an area, there is always a possibility it could have detrimental impacts on the native ecosystem; thus, classical biocontrol is heavily regulated to minimize this risk, and the timeline from the discovery of a predator species to approved release is often 10 or more years (Reardon, 2018). Despite these risks, biocontrol can be a very effective method of reducing invasive populations. In the United States, one particularly notable use of biocontrol for invasive plant management is the release of a mile-a-minute weevil (*Rhinoncomimus latipes*) to control the mile-a-minute vine (*Persicaria perfoliata*). After significant testing, the weevil was approved for release

into the United States in 2004 (Reardon, 2018). The weevil has been documented to reduce seed production and cause significant damage and even mortality in the plant (Goldstein et al., 2015). One may successfully eradicate mile-a-minute populations by conducting multiple weevil releases and combining these biocontrol efforts with cultural, physical, and chemical control methods.

Less commonly referenced forms of biocontrol include augmentative biocontrol and conservation biocontrol. Augmentative biocontrol is similar to classical biocontrol; the main difference is that the predator species is one native to the release area (Miller et al., 2010). Conservation biocontrol also focuses on native predator species. However, instead of releasing them into an area, the focus is creating a habitat that encourages them to reproduce or spread naturally.

Biocontrol continues to be a growing management tool, with new species continuously being researched and going through the regulatory approval process. Promising future control organisms include using the native fungus *Verticillium nonalfalfae* as a bioherbicide for the invasive tree of heaven (*Ailanthus altissima*) (Miles et al., 2025).

CHEMICAL CONTROL METHODS

Herbicides are arguably one of the most effective tools against invasive species. Chemical control must be completed responsibly by certified personnel. In Virginia, VDACS is the certifying agency for pesticide applicators. They offer certification for private and commercial applicators, as well as registered technicians who apply certain pesticides under the supervision of a certified commercial applicator. Training manuals are published by the Virginia Tech Pesticide Program, which also offers online training. Anyone in Virginia who applies pesticides on their employers' land as part of their job duties must be certified (Virginia Department of Agriculture and Consumer Services, 2025).

Remember that the herbicide label is a legally binding document that must be followed when using herbicides. You must read the most up-to-date label every time you use the chemical. Updated labels can be found online on the National Pesticide Information Center Product Research Online site (https://npic.orst.edu/NPRO/). Labels include information on acceptable habitats for treatment, maximum use rates, required PPE, emergency information, environmental conditions to avoid during treatment, mixing instructions, and more.

Figure 17 *Mile-a-minute weevil (*Rhinoncommimus latipes*) is seen predating on the invasive mile-a-minute (*Persicaria perfoliata*) vine.*

Figure 18 *Certain areas may need to be closed when applying herbicides, which would be specified on the label.*

Labels will also contain a signal word. This word indicates how toxic the herbicide is to mammals (Virginia Cooperative Extension, 2012). You'll commonly see three designations of signal word. In order from least to most hazardous, they are "caution," "warning," and "danger." Certain products with very low toxicity may not carry a signal word. How hazardous a particular chemical is depends on the toxicity level and the amount of exposure. For safety purposes, DCR recommends choosing products with the lowest signal word when possible. Following all label instructions is required by law and minimizes exposure.

Applicators are legally required to wear the PPE listed on the herbicide label. At a minimum, this will likely include a long-sleeve shirt, long pants, socks, and closed-toed shoes. Many herbicides also require the use of eye protection and chemical-resistant gloves. Applicators may always wear more than the required PPE, but never less. Ensure PPE is properly cleaned and maintained after every use. Clothing used for herbicide treatment should be laundered separately from other clothing.

Be prepared to act in emergencies. Ensure a copy of the herbicide label and material safety data sheet (MSDS) is always kept with the herbicide. Keep a list of emergency numbers at storage and field site locations. Purchase or build a spill kit and eye wash station, and ensure they are nearby during mixing, application, and storage. Always have a change of clothing available during mixing and application in case of a spill. Finally, ensure an adequate water source for handwashing in the field and wash your hands before eating, drinking, or touching your face as well as at the end of the day.

Many different herbicides are on the market, and application methods vary according to the herbicide, target species, and other factors.

Figure 19 *Adhering to the label requirements for PPE is not only a crucial safety measure, but is also legally required.*

Figure 20 *Low-cost field handwashing stations can be made with properly labeled water jugs and soap.*

The following section touches on the primary techniques and most commonly used herbicides for invasive plant management, but this is only a starting point. Always research the options carefully to find the appropriate product and method.

Using Herbicides

The most commonly used herbicides in invasive plant management are glyphosate and triclopyr. Glyphosate is a broad-spectrum, non-selective herbicide that can damage monocots and dicots. Triclopyr is a selective herbicide that primarily controls dicots. Both herbicides exhibit minimal to no soil activity and can be used for various applications.

While the safety of glyphosate has been a source of discussion in recent years, many studies have shown that the risk to humans from using glyphosate is low when used according to label directions (Buhl and Bubl, 2018).

Other commonly used herbicides for invasive plant management include imazapyr, clopyralid, aminopyralid, aminocyclopyrachlor, and metsulfuron. Some herbicides are better suited for specific situations. When choosing an herbicide, consider all factors including the signal word, acceptable use sites, maximum label rates, efficacy, selectivity, soil activity, and more. Local extension agents can be a great resource for assistance choosing an herbicide.

Figure 21 *Marking dye makes herbicide application clearly visible.*

Best practice dictates utilizing a marking dye when applying herbicides. These vibrantly colored dyes make the application more visible to the applicator, aid precise treatment, and help avoid worker exposure. Depending on the herbicide and application method chosen, you may also need to add an adjuvant, an additive that helps make the herbicide more effective. One of the more common adjuvants is a surfactant, which will improve herbicide penetration of the plant when applying foliar sprays.

Herbicides can be powerful tools against invasive plants when used alone. When used in combination with other techniques in the IPM triangle, they can be even more effective and facilitate significant change.

There are four primary methods of herbicide application: foliar spray, basal bark, injection, and cut stump applications. To view a demonstration of these methods, look for the “Methods for Treating Invasive Plants with Chemicals” video on the DOF YouTube channel, listed in the Resources section of this document.

Figure 22 *Low-volume foliar sprays allow the applicator to selectively choose intended targets.*

Figure 23 *Basal bark treatments can be completed with a backpack sprayer or a hand sprayer.*

Figure 24 *Downward angled hacks are spaced a few inches apart to allow the tree to continue transporting nutrients.*

Figure 25 *Herbicide daubers allow for targeted herbicide application without any spraying.*

FOLIAR SPRAY

A foliar spray involves applying a low concentration of herbicide directly to the leaves of an invasive plant. Sprays can be high volume, like those typically completed with a large truck-mounted spray tank, or low volume, like those delivered with backpack sprayers. High-volume applications can be effective on large infestations, but are not very selective and risk impacting non-target species. Low-volume applications can be applied more selectively to intended targets. Apply just enough spray to coat the leaves, but not so much as to create runoff. Avoid allowing excess spray to drift onto non-target plants.

BASAL BARK

For smaller woody species, basal bark might be a practical option. In this method, an oil-soluble herbicide mixed in a penetrating oil is applied directly to the bark of a tree or shrub in a complete band from the base up to an approximate height of 12-20 inches. Basal bark is most effective on smooth-barked species of 8 inches or less in diameter. When applying, remove soil and leaf litter from the base of the plant and apply herbicide to any exposed roots. For shrubs with multiple stems, ensure each stem is treated. This method is most effective in the fall but can be used most of the year except during spring leaf out or when the ground is frozen (Miller et al., 2010).

INJECTION

Injection is an effective method for larger woody species. Different injection application methods exist, but the hack and squirt method is the most commonly used. Downward-angled cuts are made into the bark of a tree or shrub, and a concentrated herbicide is immediately applied directly into the cuts. Cuts should be evenly spaced with a few inches between each. Do not girdle the tree. Be careful not to overapply the chemical; the herbicide should not run out of the cuts. This method is also most effective in the fall.

CUT STUMP

If the above-ground portion of a woody plant is to be removed, use the cut stump method. After cutting down the tree or shrub, apply a concentrated water-based herbicide to the stump's surface within 15 minutes of cutting. The herbicide should only be applied to the cambium layer along the edge of the stump. On smaller stumps, apply herbicide to the entire surface. Herbicide daubers are excellent tools for this method, but spray bottles or paintbrushes may also be used. While this method is relatively low risk to the chemical applicator since little to no spraying is involved, the addition of hand saws or chainsaws adds another risk that should be considered.

Restoration and Monitoring

Removal of invasives does not signal the end of the work, as invasive plants thrive in disturbed areas with open ground. Following removal efforts, planting and/or seeding native species can establish a desirable natural community and preempt the establishment of invasives. Whenever possible, native plant material should be from locally sourced seeds or cuttings. The DCR Native Plant Finder can help identify which native species would be most appropriate for your location. Other resources for native plant sourcing and information include the Virginia Native Plant Society and the Plant Virginia Natives campaign. Ensure new plant material can be established and be prepared to replace species that do not thrive.

Frequently monitor the area for several years after initial removal. Many invasive plants have a seed bank that lasts multiple years. Be prepared to spot-treat any unwanted species that germinate in the area, particularly in the first few years after restoration. Remember that even after restoration, reinvasion can happen at any time. Continued surveillance efforts ensure long-term success.

Figure 26 *DCR often utilizes drones for long term monitoring of invasive species control.*

Summary

Once established, invasive plants are difficult and costly to control. Effective management of plant invasions depends upon careful planning, research, and prioritization. Managers can make the most of their time, money, and staff by directing actions at populations with the most significant impact on a site and for which control is feasible. To do otherwise is not only wasting resources, but may also lead to a sense of futility regarding the challenge posed by invasive plants. In summary, the following three guidelines for invasive plant management should be followed:

1. Be informed about invasive plants on your property and in your region, their threats, and current invasive plant management practices.
2. Rank the natural resources and invasive plant populations at your site.
3. Carry out action where management priorities and feasibility of control meet.

Even the most challenging invasive plant populations can be reduced with time, effort, and dedication.

Resources

A Field Guide for the Identification of Invasive Plants in Southern Forests: https://www.srs.fs.usda.gov/pubs/gtr/gtr_srs119.pdf

A Management Guide for Invasive Plants in Southern Forests: https://www.srs.fs.usda.gov/pubs/gtr/gtr_srs131.pdf

Best Management Practices for Non-Chemical Weed Control: https://www.cal-ipc.org/resources/library/publications/non-chem/

Blue Ridge PRISM: https://blueridgeprism.org/

Digital Atlas of the Virginia Flora: https://www.vaplantatlas.org/

Flora of Virginia Project: https://floraofvirginia.org/

Invasive Plant Inventory and Early Detection Prioritization Tool: https://catalog.data.gov/dataset/invasive-plant-inventory-and-early-detection-prioritization-tool-for-eastern-shore-of-virg/resource/9f99a9a3-4a55-4407-8914-92a350970163

Land Manager's Guide to Developing an Invasive Plant Management Plan: https://www.cal-ipc.org/resources/library/publications/developingplan/

Natural Heritage Program Native Plants Page, including Native Plants for Conservation, Restoration and Landscaping brochures: https://www.dcr.virginia.gov/natural-heritage/nativeplants

Plant Invaders of Mid-Atlantic Natural Areas: https://dnr.maryland.gov/wildlife/Documents/midatlantic.pdf

Plant Virginia Natives: https://www.plantvirginianatives.org/

PlayCleanGo: https://playcleango.org/

Virginia Agricultural Best Management Practices Cost-Share Program: https://www.dcr.virginia.gov/soil-and-water/costshar2

Virginia Department of Agriculture and Consumer Services: https://www.vdacs.virginia.gov/

Virginia Department of Conservation and Recreation: https://www.dcr.virginia.gov/

Virginia Department of Conservation and Recreation Natural Heritage Program: https://www.dcr.virginia.gov/natural-heritage/

Virginia Department of Conservation and Recreation Natural Heritage Program Invasive Plant Page: https://www.dcr.virginia.gov/natural-heritage/invspinfo

Virginia Department of Forestry: https://dof.virginia.gov/

Virginia Department of Forestry Invasive Plants Page, including a link to the Invasive Plant Herbicide Chart: https://dof.virginia.gov/forest-management-health/forest-health/invasive-plants-in-virginia/

Virginia Department of Forestry YouTube Channel: https://www.youtube.com/@ForestryTV

Virginia Department of Wildlife Resources: https://dwr.virginia.gov/

Virginia Native Plant Finder: https://www.dcr.virginia.gov/natural-heritage/native-plants-finder

Virginia Native Plant Society: https://vnps.org/

Virginia Native Plant Society Native Plant Guides: https://vnps.org/virginia-native-plant-guides/

Virginia Pesticide Safety: https://www.vapesticidesafety.com/

Virginia Tech Pesticide Programs: https://vtpp.ento.vt.edu/

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Appendices

A. Invasive Plant List

B. DOF Herbicide Cheat Sheet

C. Figures

D. Tables

VIRGINIA INVASIVE PLANT SPECIES LIST

EFFECTIVE DATE: SEPTEMBER 2024

The list is for educational purposes only and has no regulatory authority. Per Virginia Code §10.1-104.6:2, the Virginia Invasive Plant Species List is periodically reviewed and updated. List updates require adherence to a specific invasives species risk assessment protocol developed by DCR. DCR routinely conducts data analysis and assessments for existing species and reviews potential list additions.

Two-horned trapa

The Virginia Invasive Plant Species List comprises species that are established — or may become established — in Virginia, cause economic and ecological harm, and present ongoing management issues.

To be included on the list, there must be demonstrable evidence that a species poses a threat to Virginia's forests, native grasslands, wetlands or waterways. Under the DCR Invasive Species Assessment Protocol, approved by the Virginia Invasive Species Working Group, January 2024, species were ranked as exhibiting **high**, **medium** or **low** levels of invasiveness based on their threat to natural communities and native species.

Invasiveness rank is higher for species that:

- Alter ecosystem processes, such as succession, hydrology or fire regime.
- Are capable of invading undisturbed natural communities.
- Cause substantial impacts on rare or vulnerable species or natural communities or high-quality examples of more common communities.
- Are found widely distributed and generally abundant where present.
- Disperse readily to new areas.
- Are difficult to control.

Scientific Name	Common Name	Virginia Invasiveness Rank	REGION		
			Mountain	Piedmont	Coastal
Ailanthus altissima	**tree-of-heaven**	High	•	•	•
**Aldrovanda vesiculosa*	**waterwheel**	High			•
Alliaria petiolata	**garlic mustard**	High	•	•	•
Alternanthera philoxeroides	**alligator-weed**	High			•
Ampelopsis glandulosa	**porcelain-berry**	High		•	•
**Arum italicum*	**Italian arum**	High	•	•	•
Carex kobomugi	**Japanese sand sedge**	High			•
Celastrus orbiculatus	**Oriental bittersweet**	High	•	•	•
Centaurea stoebe ssp. micranthos	**spotted knapweed**	High	•	•	•
Cirsium arvense	**Canada thistle**	High	•	•	•
Citrus trifoliata	**trifoliate orange**	High	•	•	•
Dioscorea polystachya	**cinnamon vine**	High	•	•	•
Elaeagnus umbellata	**autumn olive**	High	•	•	•
Euonymus alatus	**winged euonymus**	High	•	•	
Ficaria verna	**lesser celandine**	High		•	•
Hydrilla verticillata	**hydrilla**	High	•	•	•
**Imperata cylindrica*	**cogon grass**	High			•
Iris pseudacorus	**yellow flag**	High	•	•	•
Lespedeza cuneata	**sericea lespedeza**	High	•	•	•
Ligustrum sinense	**Chinese privet**	High	•	•	•
Lonicera japonica	**Japanese honeysuckle**	High	•	•	•
Lonicera maackii	**amur honeysuckle**	High	•	•	•
Lonicera morrowii	**Morrow's honeysuckle**	High	•	•	
**Ludwigia hexapetala*	**large-flowered primrose-willow**	High	•	•	•
Ludwigia peploides var. glabrescens	**floating primrose-willow**	High	•	•	•
Lythrum salicaria	**purple loosestrife**	High	•	•	•
Microstegium vimineum	**Japanese stiltgrass**	High	•	•	•
Murdannia keisak	**marsh dewflower**	High	•	•	•
Myriophyllum aquaticum	**parrot feather**	High	•	•	•
Myriophyllum spicatum	**Eurasian water-milfoil**	High	•	•	•
Oplismenus undulatifolius	**wavyleaf grass**	High	•	•	
**Oshuna crassipes*	**water hyacinth**	High			•
Persicaria perfoliata	**mile-a-minute**	High	•	•	•
Phragmites australis ssp. australis	**common reed**	High	•	•	•
Pueraria montana var. lobata	**kudzu**	High	•	•	•
Reynoutria japonica	**Japanese knotweed**	High	•	•	•
Rosa multiflora	**multiflora rose**	High	•	•	•
Rubus phoenicolasius	**wineberry**	High	•	•	•
Sorghum halepense	**Johnson grass**	High	•	•	•
**Trapa bispinosa var. iinumai*	**two-horned trapa**	High	•	•	•
Triadica sebifera	**Chinese tallow-tree**	High		•	•
**Tripidium ravennae*	**ravenna grass**	High	•	•	•
Urtica dioica	**European stinging nettle**	High	•	•	•
Vitex rotundifolia	**beach vitex**	High			•
Acer platanoides	**Norway maple**	Medium	•	•	•
Acetosa acetosella	**sheep sorrel**	Medium	•	•	•
Agrostis capillaris	**colonial bent-grass**	Medium	•	•	•
Akebia quinata	**five-leaf akebia**	Medium		•	•
Albizia julibrissin	**mimosa**	Medium	•	•	•
Arthraxon hispidus var. hispidus	**joint head grass**	Medium	•	•	•
Berberis thunbergii	**Japanese barberry**	Medium	•	•	•
**Cenchrus purpurascens*	**fountain grass**	Medium	•	•	•
Cirsium vulgare	**bull thistle**	Medium	•	•	•

* Early detection species

Incised fumewort

Wavyleaf Grass

EARLY DETECTION SPECIES The list includes a subcategory of invasive plants that are considered early detection species. These are species not yet established or, if established, are not yet widespread in Virginia but known to be highly invasive in habitats similar to those found here. If discovered in Virginia, these species need to be quickly mapped, photographed and reported to DCR. The management goal for early detection species is eradication, as preventing the establishment and spread of newly arrived species will save valuable natural and economic resources.

INFORMATION For more information, or to report early detection species, contact DCR Stewardship Biologist Kevin Heffernan at kevin.heffernan@dcr.virginia.gov.

PHOTO CREDITS

Two-horned trapa, Kevin Heffernan, DCR.

Incised fumewort, Gary P. Fleming, DCR.

Wavyleaf grass, Kerrie L. Kyde, Maryland Department of Natural Resources, Bugwood.org.

Scientific Name	Common Name	Virginia Invasiveness Rank	REGION		
			Mountain	Piedmont	Coastal
Clematis terniflora	**sweet autumn clematis**	Medium	•	•	•
**Corydalis incisa*	**incised fumewort**	Medium	•	•	•
Dipsacus fullonum	**wild teasel**	Medium	•	•	•
Egeria densa	**Brazilian waterweed**	Medium	•	•	•
Euonymus fortunei	**winter creeper**	Medium	•	•	•
Glechoma hederacea	**gill-over-the-ground**	Medium	•	•	•
Hedera helix	**English ivy**	Medium		•	•
**Heracleum mantegazzianum*	**giant hogweed**	Medium	•	•	
Holcus lanatus	**common velvet grass**	Medium	•	•	•
Humulus japonicus	**Japanese hops**	Medium	•	•	•
**Ipomoea aquatica*	**water spinach**	Medium	•	•	•
Ligustrum obtusifolium var. obtusifolium	**border privet**	Medium	•	•	•
Lonicera tatarica	**tartarian honeysuckle**	Medium	•	•	
Lysimachia nummularia	**moneywort**	Medium	•	•	•
**Mahonia bealei*	**leatherleaf mahonia**	Medium	•	•	•
Miscanthus sinensis	**Chinese silvergrass**	Medium	•	•	•
Najas minor	**brittle naiad**	Medium	•	•	•
Paulownia tomentosa	**royal paulowina**	Medium	•	•	•
Persicaria longiseta	**long-bristled smartweed**	Medium	•	•	•
Phyllostachys aurea	**golden bamboo**	Medium	•	•	•
Poa compressa	**flat-stemmed bluegrass**	Medium	•	•	•
Poa trivialis ssp. trivialis	**rough bluegrass**	Medium	•	•	•
Potamogeton crispus	**curled pondweed**	Medium	•	•	•
Pyrus calleryana	**callery pear**	Medium	•	•	•
Rhodotypos scandens	**jetbead**	Medium	•	•	•
**Salvinia molesta*	**giant salvinia**	Medium	•	•	•
**Solanum viarum*	**tropical soda apple**	Medium		•	•
Spiraea japonica	**Japanese spiraea**	Medium	•	•	
Stellaria media	**common chickweed**	Medium	•	•	•
Veronica hederifolia	**ivy-leaved speedwell**	Medium	•	•	•
Viburnum dilatatum	**linden arrow-wood**	Medium		•	
Wisteria sinensis	**Chinese wisteria**	Medium	•	•	•
**Buddleja davidii*	**orange-eye butterfly-bush**	Low	•	•	•
Commelina communis	**Asiatic dayflower**	Low	•	•	•
Elaeagnus pungens	**thorny olive**	Low	•	•	•
Lespedeza bicolor	**shrubby bushclover**	Low	•	•	•
Lonicera fragrantissima	**winter honeysuckle**	Low	•	•	•
Melia azedarach	**chinaberry**	Low		•	•
Morus alba	**white mulberry**	Low	•	•	•
Nandina domestica	**nandina**	Low	•	•	•
Perilla frutescens	**beefsteak plant**	Low	•	•	•
Phleum pratense	**timothy**	Low	•	•	•
Populus alba	**silver poplar**	Low	•	•	•
Rumex crispus ssp. crispus	**curly dock**	Low	•	•	•
Securigera varia	**crown-vetch**	Low	•	•	•
Trapa natans	**European water chestnut**	Low			•
Ulmus pumila	**Siberian elm**	Low	•	•	
Vinca major	**greater periwinkle**	Low	•	•	•
Vinca minor	**periwinkle**	Low	•	•	•
Wisteria floribunda	**Japanese wisteria**	Low		•	•

* Early detection species

DCR Virginia Department of Conservation & Recreation

Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, Va.

Non-Native Invasive Plant Species Control Treatments

Timing, Methods and Herbicide Rates

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This is a list of management tactics for major invasive plants, not a comprehensive control plan. For recommendations specific to your property, consult a professional forester or land resource manager. Follow all label prohibitions, precautions and safety requirements during herbicide transport, storage, mixing and application.

	INVASIVE PLANT	CONTROL TIMING	CONTROL METHOD	HERBICIDE RATES *	NOTES
GRASSES	Japanese Stiltgrass	Prior to seed maturity	Manual – hand pull		Remove all roots
		Prior to seed maturity	Mechanical – mow/cut repeatedly		To reduce seed formation
		Late spring – late summer	Foliar spray	Sethoxydim 1.5% or Glyphosate 0.5%-2%	Several years needed to control seed bank
	Wavyleaf Grass	Prior to seed maturity	Manual – pull small areas		Follow-up treatment required
		Late May – early June, again in late June – early July	Foliar spray	Glyphosate 2%, Clethodim 1%	Several years (as needed); avoid plants that have set seed
HERBS/FORBS	Garlic Mustard	Late spring – early summer, prior to any seedpods maturing to brown	Manual – hand pull and remove taproot		Do not leave flowering plants on ground, seeds will form; bag/ remove flowering plants
		March – June, before seedpods	Mechanical – mow or cut		To reduce seed formation
		Late fall – winter is best, but susceptible any time	Foliar spray on evergreen leaves	Glyphosate or Triclopyr 2%	Dormant season timing protects many other species
VINES	Gen. Recommendations for All Vines	All year when soil is moist	Manual – hand pull small vines		Remove as many roots as possible to prevent resprouts
		Any	Manual or mechanical – cut to "treatable" height		Follow-up with foliar herbicide applied to resprouts
		June – October, through winter for evergreen species	Foliar spray	Glyphosate 2%-3% or Triclopyr 2%-5%	Several years (as needed)
		June – February	Basal spray	Triclopyr ester 20%-25%	Follow-up usually required
		June – August	Foliar spray	Metsulfuron 2-4 oz./acre	Several years (as needed)
		June – February, late summer – fall ideal	Cut stump	Glyphosate or Triclopyr ester 20%-25%	Follow-up usually required; highly selective and uses minimal herbicide
	Japanese Honeysuckle	Before seed formation	Foliar spray	Glyphosate 2%-3% or Triclopyr 2%-5%	Treat evergreen leaves on warm days in winter

* Rates are listed as common herbicide formulations. Application rates may vary with specific products so always follow label instructions.

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	INVASIVE PLANT	CONTROL TIMING	CONTROL METHOD	HERBICIDE RATES *	NOTES
VINES, continued	Porcelain-berry	June to October, late summer – early fall ideal	Foliar spray	Triclopyr 2%-3%	Manual ineffective due to extensive root system
	Oriental Bittersweet	All year, late summer – fall ideal	Injection or hack-n-squirt	Triclopyr amine or Glyphosate undiluted	Vines more than 1 inch in diameter
	Mile-a-Minute	May – October	Manual/mechanical – hand pull, mow or cut repeatedly		Protect skin from thorns
		May – July	Foliar spray	Glyphosate 1% or Triclopyr 1%-2%	Likely to injure other plants
	Kudzu	All year	Manually remove all root crowns		
		All year	Mechanical – mow and cover with plastic sheeting		Leave sheeting in place two years
		July – September	Mechanical – cut or mow to ground		Many, many years needed
		June – October	Foliar spray	Picloram 3%	*Restricted use pesticide
		July – September	Foliar spray	Metsulfuron 3-4 oz./acre, Triclopyr 4%, Clopyralid 1.3 pt./acre, Aminopyralid 7 oz./acre	Repeat in successive years
		June – February	Basal spray	Triclopyr ester 20%	Woody stems
		June – February	Injection or hack-n-squirt	Imazapyr, Triclopyr amine or Glyphosate undiluted	Vines more than 1 inch in diameter
SHRUBS	Gen. Recommendations for All Shrubs	When soil is moist	Manual – hand pull small plants		Roots left in ground resprout
		When fruit is not present	Mechanical – cut or mow		Follow-up treatment required
		June – February	Foliar spray	Imazapyr 1% or Triclopyr 2%	Several years (as needed)
		June – February	Cut stump	Imazapyr 5%-10% or Glyphosate 20%	Selective, minimal herbicide
		June – February	Basal spray	Triclopyr ester 20%	
	Multiflora Rose	See General Recommendations for all shrubs			
		June – October	Foliar spray	Glyphosate 2%-4% or Triclopyr 1%	
	Autumn Olive	See General Recommendations for All Shrubs			
	Chinese Privet	See General Recommendations for All Shrubs			
TREES	Gen. Recommendations for All Trees	June-February	Injection or hack-n-squirt	Triclopyr or Imazapyr undiluted	Small to large trees
		July – February	Basal spray	Triclopyr ester 20%-25%	Saplings
	Tree-of-Heaven	See General Recommendations for All Trees			Follow-up usually required
		Summer – fall	Foliar spray	Triclopyr 2%	Seedlings, saplings, resprouts

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Virginia Department of Forestry
900 Natural Resources Drive, Suite 800
Charlottesville, Virginia 22903
Phone: (434) 977-6555
www.dof.virginia.gov

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