JAMES MADISON UNIVERSITY

Stream Buffer Maintenance Guidebook

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CONTENTS

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PURPOSE OF THIS GUIDEBOOK

This guidebook will provide the information needed to care for the stream buffers that exist on campus and assist in creating a sustainable stream buffer maintenance program to further enhance the benefits that these buffers provide to our campus, students and local community. The best buffer is a well-maintained buffer!

What is a stream buffer? Buffers simply act as filters. They can come in many shapes and sizes and can contain a diverse plant population. The filtering performance of a buffer is influenced by many factors, including its width, vegetative composition, age, bank stability and depth to water table (1). Stream buffers provide wildlife habitat, sequester carbon, reduce greenhouse gas emissions, create recreation opportunities and reduce flood impacts. The benefits of buffers are maximized the healthier the buffer is. This guidebook will assist James Madison University (JMU) staff in creating a sustainable stream buffer maintenance program by sharing treatment options for invasive plants, methods of stabilizing eroding stream banks, funding sources to get the work done year after year, processes for establishing native plants after invasive plant removal, collaborating with students, faculty and the community and engaging in outdoor learning experiences.

Figure 1. Native willow tree "live" stakes being planted along the banks of Sibert Creek on campus by JMU staff (Photo: Dale Chestnut).

OUR CAMPUS STREAMS AND THEIR BUFFERS

JMU has approximately three miles of streams that run through campus. The streams and their adjacent buffers are an important asset to not only the university and its students, but also the surrounding community. Two streams run through campus, Sibert Creek and Blacks Run. Both streams run underground at several points on campus to account for buildings, roadways, pedestrian walkways, athletic fields or parking lots and re-appear above ground through culverts or other outlets. This underground hydrology is typical for urban streams where development has occurred around or on top of them; or in our campus's case where karst topography is also present.

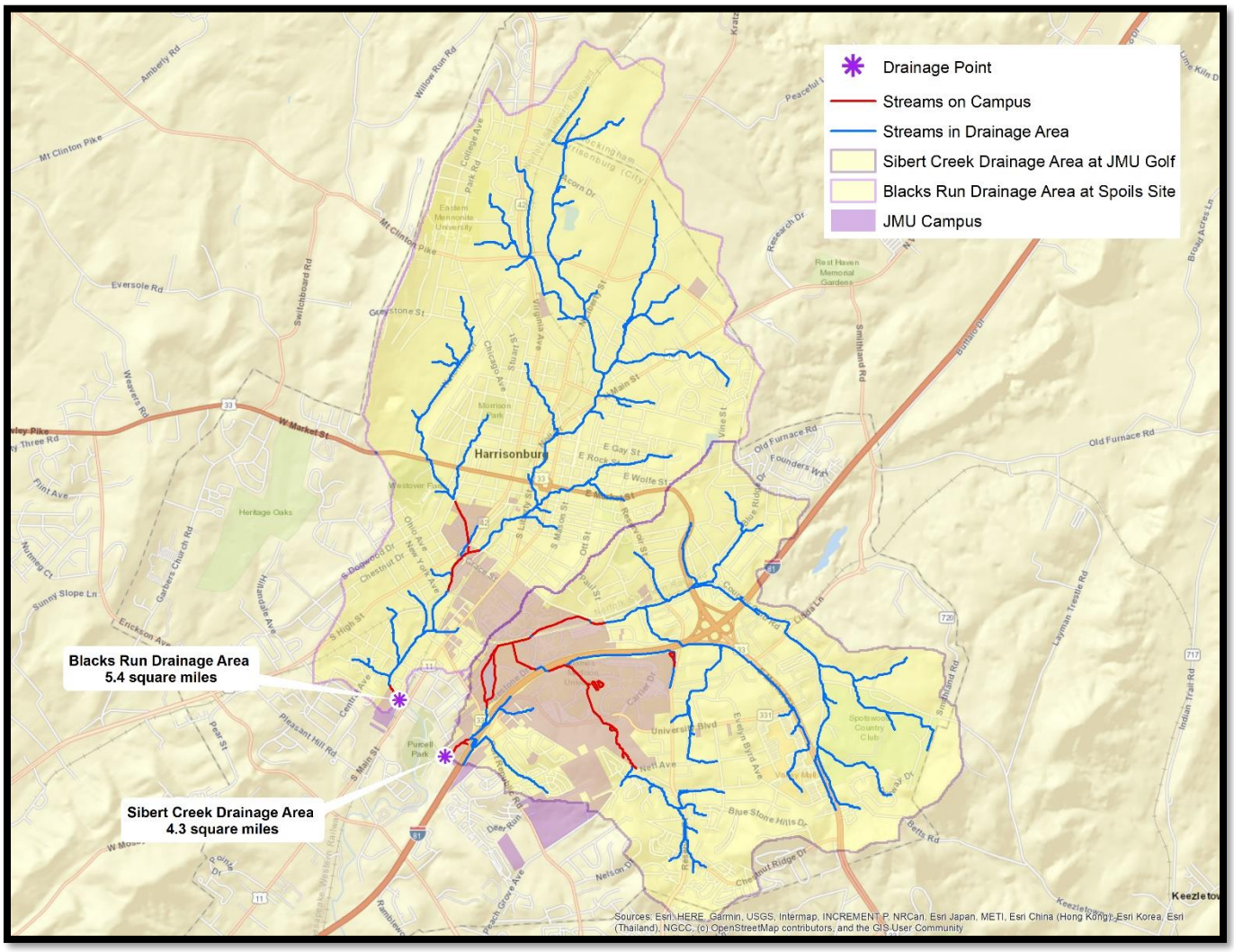


Figure 2. Drainage areas of Blacks Run and Sibert Creek watersheds as the streams leave campus.

The map above (Figure 2) displays streams that run through campus and their associated watersheds from the point the streams leave campus. The highlighted red lines are stretches of stream that are located on campus property. These red-lined streams and their adjacent buffers have varying width, plant composition, age, bank stability and depth to water table.

Blacks Run is an impaired waterway. This status was given to it and it's watershed by the Virginia Department of Environmental Quality (DEQ) because of high levels of E.coli and low numbers of benthic macroinvertebrates (2). Higher

numbers of macroinvertebrates equal a healthier stream and vice versa. A plan is in place to improve the water quality of Blacks Run. Partnerships between the City of Harrisonburg, DEQ, James Madison University and other key local businesses, non-profits and landowners within the Blacks Run watershed are working together to meet the pollution reduction goals targeted in the plan. Sibert Creek, the other watershed mapped on Figure 2, flows into Blacks Run, contributing to its impairment. Riparian buffer establishment is listed as one tool that will be used in the implementation plan for improving the water quality of Blacks Run. JMU has committed to complete the installation of riparian buffers and naturalized areas along all streams on campus by 2023 in our Facilities Management Sustainability Plan (3). This guidebook will support Facilities Management in that effort.

There are four different categories of buffers along our campus streams: naturalized, designed, hardscaped/landscaped and forested. Each type will have different maintenance needs. Descriptions and photos of each campus buffer type are below:

A. Naturalized Buffers: These stream buffers have been left to grow naturally and are not mowed by campus staff. They have varying widths from 10 feet to over 35 feet, as well as, varying plant composition.
B. Designed Buffers: These have been professionally designed and planted using a certified landscape architect planting plan as part of a stream restoration project.
C. Hardscaped/Landscaped Buffers: Include buffers that are adjacent to parking lots or buildings and to protect sediment from entering stormwater have been hardscaped or armored and any vegetation is mowed regularly.
D. Forested Buffers: These are areas on campus where streams flow through forested areas. Examples include the stream buffers in the Edith J. Carrier Arboretum on campus.

Figure 3. The four different types of buffers on campus - starting at the top left and moving clockwise: Naturalized, Designed, Hardscaped/Landscaped and Forested (Photos: Dale Chestnut)

CONSIDERATIONS FOR URBAN/CAMPUS STREAMS AND BUFFER

Streams that flow through urban areas have unique characteristics (4). These characteristics must be considered in the development of a maintenance plan. When it rains our campus streams look very different depending on the storm intensity and the groundwater level. Our campus streams' hydrology and health are directly related to the land uses immediately adjacent to them. The same is true for our campus buffers. Our campus stream buffers tend to have the following characteristics:

A. **Increased invasive species**
B. **Unstable banks**
C. **Low biodiversity**
D. **Limited space**
E. **Increased recreation**
F. **Wildlife corridors**

Figure 4. A campus naturalized stream buffer that has become dominated by invasive species and has restrictions to buffer width because of tennis courts located directly adjacent to the stream on one side.

The buffers on campus have an increased presence of invasive species due to a variety of reasons: wildlife spreading seeds from an off-campus source, people spreading seeds, lack of resources to monitor and remove invasive species in buffers, increased stormwater carries seeds and deposits them in the buffer and bare soil from eroding banks gives invasive plants a foothold to establish. As mentioned, most of the stream buffers on campus have a strong flow during and immediately after storm events, which causes the banks to be unstable and potentially erode. The hardscaped/landscaped and naturalized buffers on campus have low biodiversity. The landscaped buffers are primarily turf, typically a monoculture of cool season grasses, and are mowed frequently. The naturalized buffers are becoming dominated by invasive plant species which provide little to no benefits to stormwater, downstream properties, native wildlife and campus recreation.

In 2018 the City of Harrisonburg, US Forest Service (USFS), Virginia Department of Forestry (VDOF) and the Green Infrastructure Center (GIC) performed a pilot study to evaluate new approaches in estimating the role of trees in stormwater uptake (5). This resulted in baseline data on urban trees, urban canopy coverage and urban forests within the City of Harrisonburg. Since James Madison University sits within the City, this study collected data about our campus as well. One of the outcomes was determining existing land cover. GIC determined that the JMU campus has 25% tree canopy cover, 28% pervious cover, 46% impervious cover (5). As illustrated in Figure 4, once a watershed moves into the 30-50% impervious cover category – runoff increases and evapotranspiration and infiltration decrease. This is when stormwater BMPs, like riparian buffers become important players in the health and natural function of our campus streams.

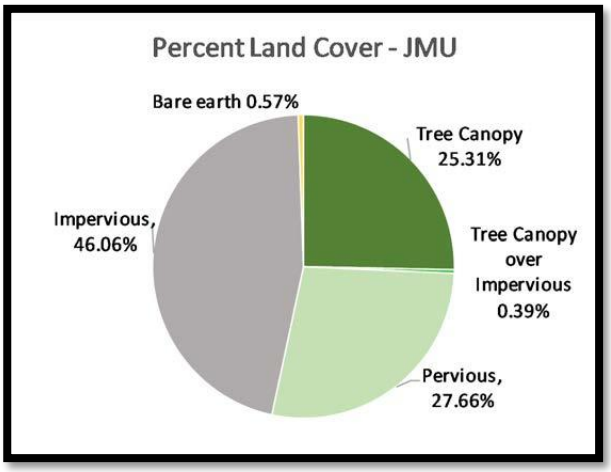


Figure 5. Land cover type percentages on JMU campus (Green Infrastructure Center).

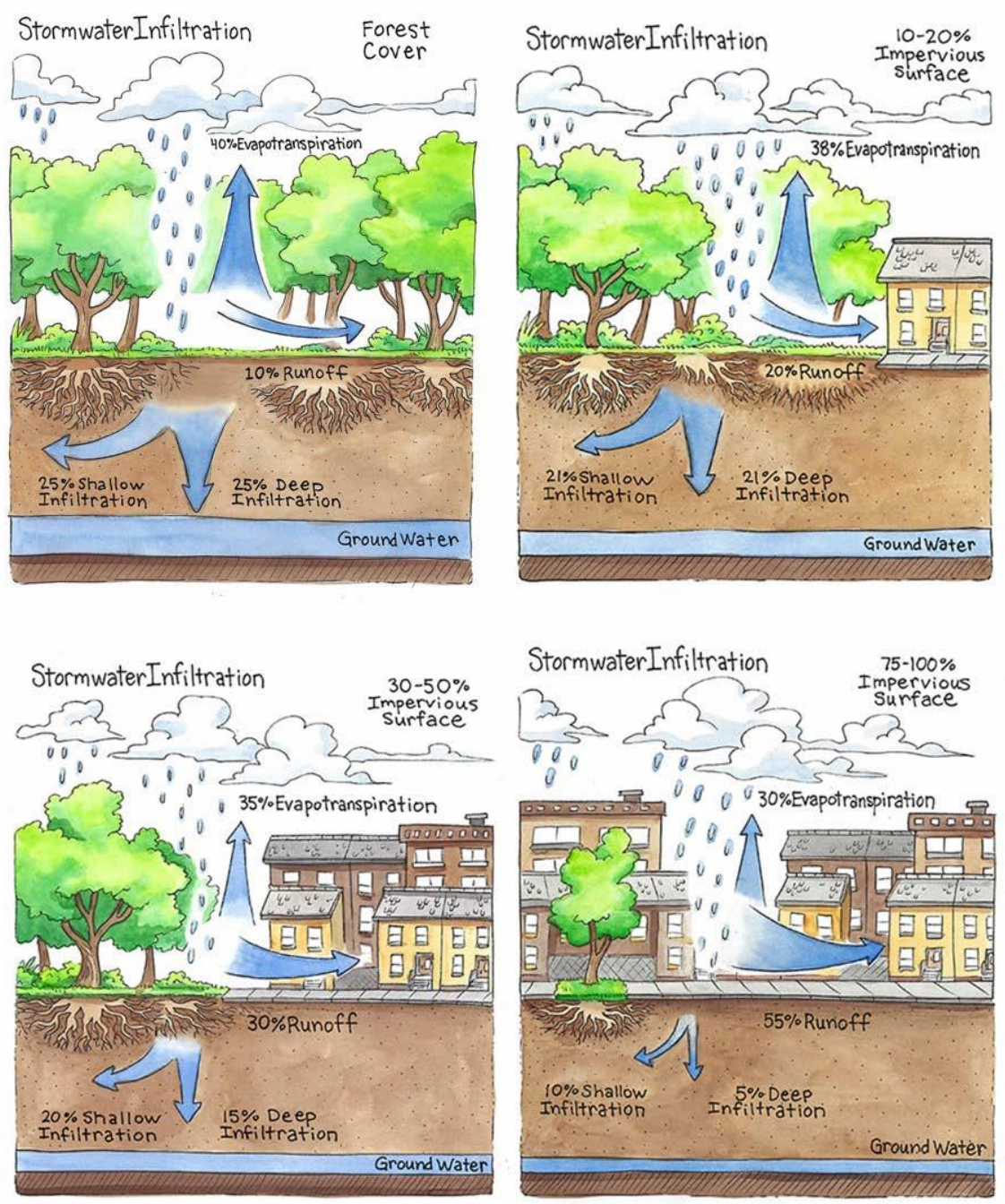


Figure 6. Graphic illustrating how developed land effects groundwater, runoff and evapotranspiration. Original artwork by the Green Infrastructure Center (5).

Campus and urban stream buffers composition and health are directly related to the land uses adjacent to them. A greater amount of impervious surface area (parking lots, roofs, roads) in a stream's watershed increases the speed and volume of stormwater runoff leading to flooding, eroding stream banks, polluted runoff and reduced groundwater infiltration (Figure 4). Often though our campus stream buffers do not get a chance to do their jobs as filters because the runoff moves too fast, there is too much of it, there is not enough buffer, it completely bypasses the buffer and empties directly into the stream via a traditional gray stormwater infrastructure (like a concrete outfall draining a parking lot) or another one of the factors listed in Figure 8 below. This can lead to further increases of sediment and nutrient runoff in the streams and a greater volume of stormwater, all of which have an effect on the stream's existing buffer, overall watershed's health, flooding frequency and water quality.

Factors that Enhance Buffer Performance	Factors that Reduce Buffer Performance
Slopes less than 5%	Slopes greater than 5%
Contributing flow lengths < 150 ft	Overland flow paths over 300 ft
Water table close to surface	Groundwater far below surface
Check dams/level spreaders	Contact time < 5 minutes, concentrated flow
Permeable, but not sandy soils	Compacted soils
Growing season	Non-growing season
Long buffer width	Buffer width less than 10 ft
Organic matter, hummus, or mulch layer	Snowmelt conditions, ice cover
Small runoff events	Runoff events > 2 year event
Runoff velocity less than 1.5 ft/sec	Runoff velocity more than 5 ft/sec
Poorly drained soils, deep roots	Shallow vegetative roots
Dense grass cover, six inches tall	Sparse vegetative cover

Figure 7. A listing of factors that affect the pollutant removal performance of buffers (1). Highlighted factors are ones observed to be present in our campus buffers/streams that reduce performance or are factors that could be addressed to enhance the performance of campus buffers. (Table: StormwaterCenter).

INVENTORY AND ASSESSMENT OF CAMPUS STREAM BUFFERS

A great deal of work has been done to assess the quality of water in the streams on campus and throughout the surrounding City of Harrisonburg. Students, faculty, staff, local partners and state agencies have worked together on multiple research projects to assess water quality of streams flowing through campus. There has not yet been an effort to inventory and assess the buffers associated with the streams on campus. Starting in 2022, Facilities Management Engineering and Sustainability staff, will initiate an inventory of the stream buffers on campus. Buffer type, vegetative composition or hardscape type, invasive plants present, stream bank erodibility, stormwater infrastructure, % areas of bare soil, evidence of recreative use and buffer width will be documented. JMU staff will be joined by student volunteers. A JMU student will assist FM staff in determining the bank erodibility hazard index (BEHI) of all the streambanks on campus as part of a yearlong capstone research project beginning in the fall of 2022 (6). A Stream Bank Field Assessment form (Appendix D) will be used and is located at the end of this guidebook as a reference. At the end of this capstone project the university will receive geospatial data that will be used to create maps for stream stretches showcasing the BEHI values as seen in Figure 8. This data will give JMU baseline information to use to help determine where best to spend additional time and resources for the improvement of stream buffers in order to maximize the benefits of the buffer and increase stream health and local water quality. The inventory and assessments will assist JMU staff in prioritizing treatment of invasive plant infestations, locate any damaged or vulnerable infrastructure and prioritize areas where buffer restoration and native plantings will make the greatest impact for the watershed and for our campus community.

Figure 8. An example of an end product the university will have once campus streams have been assessed using a modified Bank Erodibility Hazard Index (BEHI). The modified BEHI protocol was initially developed by Cleveland MetroParks.

COMMON ISSUES FOR CAMPUS STREAM BUFFERS

The most common issues observed in urban and campus stream buffers are: erosion, bare soil, compacted soil, invasive plants, lack of signage or defined boundaries, damaged or vulnerable infrastructure and flood debris and deposition.

Erosion is a common issue in our campus streams due to the high volume of runoff after storm events that flows off impervious surfaces into conveyance structures like downspouts and stormwater culverts or as sheet flow that concentrates into rills and gullies across the university's landscape and then ends up in the streams on campus. As mentioned in the last section, the potential erodibility of banks in our campus buffers will be assessed and proactive treatment will be prioritized. Typical treatment of stream banks with a high erodibility index will involve planting more native plants where invasive plants or turf grass are currently present.

Figure 9. Typical erosion observed on urban stream banks. (Alabama Cooperative Extension) (7)

Along with erosion, comes another issue common in campus stream buffers, bare and compacted soil. Bare soil could be from a recent storm event that killed vegetation or pulled out vegetation. Bare and compacted soil could be from a footpath that is frequented in the buffer to access the stream. Compacted soil is common in our landscaped buffers were turf grasses are mowed on a regular basis and foot traffic is greater. Soil found in urban stream buffers are typically low in organic matter and dominated by clay and silt, which can change the structure of the soil, making it more easily compacted.

Flood waters that can cause erosion in campus streams are also a source of invasive plants. Seeds are carried from an upstream population of invasive plants downstream and are deposited in our campus buffers. If bare soil is available, then those plants take root and begin to become established. Invasive plants will easily outcompete any native plants by smothering, shading, strangling or emitting toxins. Buffers dominated by invasive plants severely decrease the benefits they can provide to the local watershed. By adequately maintaining a stream buffer, invasive plants will not have a chance to gain a foothold and can be caught before they get established and become costlier to control and before they cause issues downstream. This guidebook will be focusing on invasive plants in buffers and how to control and treat them and restore the buffers on campus with native plants. Invasive plants have been identified as the biggest issue in our campus streams as of this writing.

Another issue that is common to urban buffers is a lack of defined boundaries. Urban buffers are mostly invisible to the average person. Unless a buffer's boundary has been designated with signage, fencing or distinct landscaping feature, it's invisible and its protection may become compromised. Human disturbance, vehicle traffic, and overall unawareness can create impacts to a buffer (1). For example, a buffer with newly planted native trees and shrubs without a defined boundary or signage could accidentally get mowed causing harm to the plants growing and the

Figure 10. Example of educational signage that helps to make a buffer visible to the general public (Lexington Herald-Leader).

investment. Signage along our campus buffers will make them visible to local government, university faculty, staff and students, the community and contractors. Educational signs will improve not only the visibility of the buffer, but awareness of why the buffers on campus are important and the benefits they bring to the campus and community.

In urban streams very often underground infrastructure is located in close proximity and will cross under streams. Protecting stream buffers and supporting the widening of buffers will guard against potential damage to many of these underground assets (8). Some of these utilities, like sanitary sewer lines, could cause harmful pollution to local waterways and cost tens of thousands of dollars in repairs if the lines fail. Figure 10 illustrates how close sanitary sewer lines can be to streams in urban environments. The map in Figure 11 shows various utility infrastructure on campus and their proximity to Sibert Creek. This section of Sibert Creek has a 10-foot buffer, if the buffer were to be widen the infrastructure running underground along the stream would be further protected from bank erosion, future construction projects and other disturbing or harmful activities.

Figure 11. Sewer manhole next to stormwater outfall on hardened stream bank on campus. (Photo: Dale Chestnut)

SECTION 1: GENERAL ANNUAL MAINTENANCE

The routine maintenance of campus stream buffers is extremely important in order to make sure that the buffer is successful in achieving its intended long-term benefits and usefulness. Our campus buffers are a key partner in protecting water quality, but they can't be planted, ignored or left alone. More time, attention and effort are needed in the first few years following a stream buffer establishment or planting to ensure long term success. JMU's campus has the four previously described buffer types: Naturalized, Designed, Hardscaped/Landscaped and Forested – maintenance tasks will differ based on the type of buffer. An annual stream buffer inspection report (Appendix A) will be completed by Facilities Management staff. This inspection report is located in the Appendix. A stream buffer maintenance checklist (Appendix B) which includes the items listed below is at the end of this guidebook as a one-page reference sheet. The checklist will be used by Facilities Management staff in the field.

The following general maintenance items should be completed on all buffer types on campus each year:

- Visually inspect buffers annually and after major storm events. Look for damage to the buffer or any other issues.
- Replant or reseed any areas where plants have died or been washed away.
- Inspect for areas of bare soil, broken infrastructure or active erosion and consult with FM Engineering and Sustainability for an appropriate fix with stabilization or with native plantings or erosion matting.
- Look for invasive plants and remove as soon as possible. For large infestations, work with FM Sustainability to determine the best treatment plan. Refer to Section 2 for help in identifying invasive plants and Section 3 of this guide for information on removing invasive plants.

For forested, naturalized and designed buffer types, in addition to the above items, the following may also apply:

- As newly planted trees and shrubs grow, prune and thin to ensure adequate growing space is available.
- Where tree tubes are used, inspect yearly and remove if too tight, remove any small animal or insect nests present in the tube.
- If erosion blankets are installed, inspect for damage after major storm events and repair as needed.
- Inspect new plantings and replace dead plants to ensure at least a 75% survival rate. Fall dormant plantings will ensure the best root growth before spring leaf out.
- Water new plants, if possible and in any long dry periods during its first year of summer growth.
- If the buffer is meadow-style, mow once a year to 6-12 inches to prevent tree and shrub growth.

The maintenance of our campus buffers will be a phased approach. The first couple years will involve documenting the baseline or current conditions of each buffer on campus. Once Facilities Management staff has a complete inventory of stream bank and buffer conditions, the data will be analyzed and priority areas will begin the process of treating invasive plants and restoration via native plantings. Any treated and restored stream buffers on campus will need to follow the maintenance checklist (Appendix B) and complete a stream buffer inspection report (Appendix A) annually.

SECTION 2: COMMON INVASIVE PLANTS IN OUR CAMPUS BUFFERS

Invasive plants are spread easily and often along riparian buffer corridors. Seeds are spread via wind, animals and water from upstream or upland areas that may be infested. Flood waters during major storm events can deposit seeds within the buffers on our campus streams. The best prevention and most cost-efficient control is monitoring and addressing invasive plant populations before they have time to establish themselves and harm the structure and composition of a buffer. If you find invasive plants have become established in a stream buffer, a detailed plan to control and replace them with natives should be carefully prescribed. There are many state and federal agencies that have specialists that will provide free technical assistance to universities attempting to manage their campus streams and buffers and control invasive plants. As a university, knowledgeable faculty in the fields of environmental science and natural resources can be an invaluable source in the planning and management of your stream buffers.

The Virginia Department of Conservation and Recreation (DCR) ranks non-native invasive plant species in order of their invasiveness in the state. The Virginia Invasive Plant Species List can be found here. High, medium and low rankings were determined through DCR's Invasive Species Assessment Protocol, approved by the VA Invasive Species Working Group in May of 2015. Invasive species that rank higher have the following characteristics:

- Alter ecosystem processes, such as succession, hydrology or fire regimes.
- Are capable of invading undisturbed natural communities.
- Cause impacts on rare or vulnerable species or natural communities.
- Are found widely distributed and generally abundant where present.
- Disperse readily to new areas.
- Are difficult to control. (9)

In addition to being invasive, some non-native and even native plants are poisonous and can pose a threat to the campus and local community if populations are left unchecked. A common toxic plant found in the City of Harrisonburg and in campus buffers is Poison hemlock. More information about the toxicity of this and other native and non-native plants in Virginia can be found in "The Socrates Project – Poisonous Plants in Virginia", a publication that was developed by volunteers of the Old Rag Chapter of the Virginia Master Naturalist Program and peer review was conducted by professionals from the University of Virginia School of Medicine, Virginia Department of Wildlife Resources, Virginia Tech Department of Plant Pathology and the Virginia Tech Department of Forest Resources and Environmental Conservation (10). The publication is linked here.

The Virginia Department of Agriculture and Consumer Services regulates the movement of noxious weeds. They define noxious weeds as "any living plant, or part thereof, declared by the Board through regulations under this chapter to be detrimental to crops, surface waters, including lakes, or other desirable plants, livestock, land or other property, or to be injurious to public health, the environment, or the ecomony,…" (11). The Noxious Weed Law provides authority to the Board of Agriculture and Consumer Services (BACS) to add or delete weeds from Virginia's list. The movement of a listed noxious weed requires a permit application. Tier 1 noxious weeds are not known to be present in Virginia, but pose a significant threat if they become introduced. Tier 2 noxious weeds are present in Virginia and complete eradication is considered feasible. If you observe a Tier 1 or Tier 2 noxious weed, they are to be reported to VDACS. A full list of those species can be found on VDACS website here. Tier 3 noxious weeds are present in Virginia and their spread could be slowed by restrictions on movement, but are considered unfeasible to fully eradicate from Virginia.

The following table lists invasive and/or poisonous plants observed in our campus stream buffers and their invasiveness rank, noxious weed status and any additional designations. This list will be updated as Facilities Management staff completes the inventory and assessment of the buffers on campus throughout 2022-2023. Updates will occur as invasive species are detected in buffers by students, faculty, staff or citizen scientists. Information on how to identify the species listed on the following table are detailed in the next section.

Common Name	Invasiveness Rank (DCR)	Virginia Noxious Weed (VDACS)	Additional Designations
Poison hemlock*			HIGHLY TOXIC
Tree of heaven	High	Tier 3	Spotted Lanternfly preferred host
Mile-a-Minute	High	Tier 3	FEDERAL NOXIOUS WEED (USDA)
Oriental bittersweet	High	Tier 3	
Porcelain berry	High	Tier 3	
Japanese honeysuckle	High		
Garlic mustard	High		
Canada thistle	High		
Multiflora rose	High		
Johnson grass	High		
English ivy	Medium		
Norway maple	Medium		
Siberian elm	Low		
White mulberry	Low		
Crown-vetch	Low		
Beefsteak plant	Low		

Table 1. Invasive species observed in campus stream buffers, ranked by invasiveness and toxicity. The highlighted species have fact sheets and removal plans detailed in Section 3.

*DCR did not rank poison hemlock, but the biologist who created the list states that hemlock can become highly invasive in disturbed soils.

One cannot monitor effectively without knowing how to identify invasive plants from natives or from noninvasive non-native plants. In the following section, there are one-page sheets that can be printed off and taken out in the field when monitoring that include descriptions of commonly found invasive plants in our campus buffers. In addition to these documents, there are also smartphone apps, like PlantNet or LeafSnap that have free versions available for both Android and Apple phones. These apps have you take a photo of the leaf of an unknown plant and then it attempts to identify it. These apps are a great start in the identification of a plant, but do require additional verification to make sure the ID is indeed accurate. Another great resource to use while identifying plants within stream buffers is the following document, "Mistaken Identity? Invasive Plants and their Native Look-alikes: an Identification Guide for the Mid-Atlantic" (12). This resource compares native and invasive plants side by side that are often confused with each other. It is an excellent resource if you find yourself needing additional confirmation of a plant's specific species.

SECTION 3: REMOVING INVASIVE PLANTS

Why should invasive plants be removed from our campus buffers? Invasive plants can wreak havoc on the structure and composition of stream buffers because they outcompete native plants and create dense ground cover or canopy layers of only one to two species. These dense layers are damaging to not only wildlife and aquatic habitat, but also create visual and physical barriers. Native trees and shrubs that are strangled, smothered or outcompeted by invasive plants can become hazards to the community and to adjacent structures and limit safe recreational use.

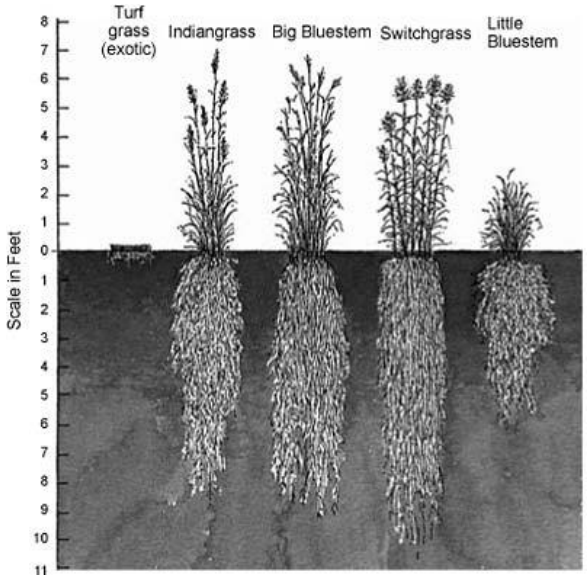


Figure 12. Diagram comparing the root systems of turf grass and native warm season grasses. (National Bobwhite Conservation Initiative).

Non-native turf grasses which are very common in campus landscapes and are often adjacent or a part of our campus stream buffers, have very short root systems. In comparison, native warm season grasses, like Little bluestem, Indiangrass and Switchgrass, have root systems that grow over 10 times as deep into the soil profile then the nonnative turfgrass. (Figure 12). These deeper root systems have greater stormwater benefits, by way of increased infiltration, and can aid in stabilizing previously eroding banks. Compared to turf grass management, native warm season grasses, once established, do not require fertilizers or pesticides and only need one annual mowing.

In this section, common treatment methods for the removal of invasive plants observed in our campus buffers will be described. Detailed treatment schedules for each specific invasive plant has been created. This will assist campus staff in determining the times when control methods will be the most effective.

There are four different types of control methods for invasive plants: mechanical, chemical, biological and cultural.

- **Mechanical Control:**
  - Hand-pulling, digging, mowing, or cutting of smaller infestations or individual plants observed or solarization for larger areas of infestations
  - More labor intensive – need appropriate resources and tools, repeated treatments are needed until seed bank is depleted or entire root system is removed
  - Disturbs soil – seed bank from invasive plants love soil disturbance and will re-

Figure 13. Top photo - Hand pulling, Bottom photo - Foliar spray application (Woody Invasives of the Great Lakes Collaborative).

sprout vigorously. Any disturbed soil must be planted immediately with desired native plants.

- **Chemical Control:**
  - Foliar spray – applying a lower concentration of herbicide to young invasive plant leaf growth, higher potential of damage to surrounding desired native plants
  - Cut-stem or cut-stump or hack-squirt – applying a higher concentration of herbicide to a recently cut stump, stem or vine of an invasive plant, minimal or low damage to any surrounding desired native plants
  - Basal bark – applies a higher concentration of herbicide, carried in oil, around the base of a woody invasive plant, generally only effective on plants with a diameter at breast height (DBH) of 6" or less
  - Always read the entire pesticide label and follow the instructions for mixing and application
  - Wear the appropriate personal protective equipment, as indicated on the pesticide label
- **Biological Control:**
  - Uses plant diseases or insect predators
  - Only certain plants have biological controls available
  - Other controls are often needed in addition to this
- **Cultural Control:**
  - Changing human behaviors to address the spread, i.e.
  - Education is key to this control's effectiveness
  - An integrated approach utilizing other controls is necessary

Figure 14. Top photo: cut-stump application, Bottom photo: basal bark application (Woody Invasives of the Great Lakes Collaborative)

The Virginia Department of Forestry (DOF), the United States Forestry Service (USFS) and the Virginia Cooperative Extension (VCE) have created extensive guidance documents on how best to control the invasive plants that are present in our campus buffers. Utilizing the best available technical guidance and with consultation from local experts, the following pages will provide removal strategies for invasive plants observed in our campus buffers and listed on the table (Table 1) as either High Invasiveness or a threat to community health (plants with high toxicity).

All herbicide application on campus requires those applying the chemical to be trained under a state certified pesticide applicator. JMU Facilities Management (FM) has several certified pesticide applicators on staff.

USE PESTICIDES WISELY: Always read the entire pesticide label carefully, follow all mixing and application instructions and wear all recommended personal protective gear and clothing. Contact your state department of agriculture for any additional pesticide use requirements, restrictions or recommendations.
NOTICE: Any mention of pesticide products in this guidebook does not constitute endorsement of any material.

Herbicides are to be used sparingly and as a last resort to treat difficult infestations and as recommended by Department of Forestry and/or Virginia Cooperative Extension professionals. For a more extensive guide on herbicide use and weed control, please refer to the Global Invasive Species Team's "Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas" created in partnership with the University of Georgia's Center for Invasive Species and Ecosystem Health and The Nature Conservancy (15). An electronic version is located here.

POISON HEMLOCK, *CONIUM MACULATUM*

IDENTIFY: Stems have reddish or purple spots and streaks, non-hairy and are hollow. Leaves are bright green, fern-like, toothed on edges and have a strong musty odor when crushed. Flowers are small, white and arranged in umbrella-like clusters on the end of the branched stems. It is biennial and germinates throughout the year. First year plants stay low on the ground and may over-winter in mild climates. Young plants have smooth, purple-reddish blotched stems. Second year plants reach up to 6-10 ft tall by the spring and produce white small 5-petaled flowers in clusters like umbrellas. Flowering hemlock may become confused with wild carrot or Queen Anne's Lace. Queen Anne's Lace flowers later in the summer, only reaches to about 3 feet tall, has one purple spot in the center of its flower clusters and has a hairy stem.

TOXICITY: Poison hemlock is very poisonous to people and animals. If ingested, symptoms occur within 20 minutes to three hours. All parts of the plant are toxic and contain a neurotoxin. The dead canes remain toxic for up to 3 years. Ingesting the plant is the most dangerous threat, but it is also toxic to the skin and respiratory system. Gloves and other protective equipment are recommending when handling any part of the plant.

REMOVAL: A combination of mechanical and chemical methods are the most effective in eradicating poison hemlock. Young plants and small infestations can be hand pulled. Dead canes and older plants can be cut and residues bagged and removed. Herbicide treatments are most effective in larger infestations. Those treatments on larger infestations should only be applied on seedlings or small rosettes and should not be used on mature plants. Herbicide treatments will need to be repeated until the seedbank is depleted. Typically, this takes 3-5 years.

Figure 15. Poison hemlock flowers, stem and first year plant (Photo credit: Virginia Tech).

TREATMENT SCHEDULE:

March: Apply non-selective herbicide to areas with large infestations, before surrounding native plants begin to leaf out.
April/May: Remove dead plants and residue as much as possible. Broadcast desired grass seed over area – see Section 4 for complete native plant establishment and erosion control recommendations
May/June: Once leaves of desired grasses have fully emerged, spray the area again with a broadleaf selective herbicide.
July-Dec: Monitor treated area(s) and spot spray poison hemlock seedlings with broadleaf selective herbicide.
Following years: Spot spray hemlock seedlings with a broadleaf selective herbicide. Alternatively, mow spring growth of weeds/cold season grasses once at a height no less than 8 inches. No mowing should occur after August.

TREE OF HEAVEN, *AILANTHUS ALTISSIMA*

IDENTIFY: A weedy, fast-growing tree that often grows in clumps. Leaves are compound and arranged alternately on stem. Leaves emit a distinct, unpleasant aroma when crushed. Leaves are hairless with entire margins. Its bark is smooth, brownish-green when young and turns light brown to gray as it matures. At the base of each leaflet are one to two protruding bumps, called glandular teeth. The twigs have large V- or heart-shaped leaf scars. It can be easily confused with some native trees that have compound leaves and numerous leaflets, like staghorn sumac, black walnut and hickory. The leaflet edges of these native trees all have teeth (serrations), while tree of heaven's is smooth.

SPOTTED LANTERNFLY: Tree of heaven is another invasive species, Spotted Lanternfly's, preferred host. This new to Virginia pest utilizes tree of heaven as a food source for all life stages. It is a significant pest to the surrounding agricultural community, threatening the surrounding Shenandoah Valley orchards and vineyards. Originally spotted in North America in Pennsylvania in 2014, it was observed in 2018 in Winchester City and Frederick County. To identify adult insects, egg masses or nymphs and/or to report any sightings of this insect on campus, please visit the Virginia Cooperative Extension's spotted lanternfly website.

Figure 16. Tree of Heaven growth, leaflet, leaf scar and glandular teeth (Photo credit: Virginia Tech (top), VDOF (middle and bottom)).

REMOVAL: Chemical herbicides are the most effective tool for controlling tree of heaven, according to the Virginia Department of Forestry. The quickest method to kill the root system and prevent re-sprouting of cut trees. Basal bark application is considered by DOF to be the easiest and most effective method of control. It does not require any cutting and works best between late winter and early spring. Applicators will use a backpack sprayer or handheld sprayer and apply the herbicide mixture in a continuous 12-inch-wide band all the way around the tree. It's used most effectively on trees less than 6 inches in diameter, but larger stems up to 16 inches may be treated by thoroughly covering the bark.

TREATMENT SCHEDULE:

Feb-April: Basal bark applications for trees between 1-16 inches in diameter are most effective as leaf out begins in early spring when the trees are absorbing the most nutrients. Cut down trees once they die and remove from site. For younger plants, less than 1 inch in diameter and with a height shorter than 4 feet, do a foliar spray application.
May-August: Monitor root shoots and stump sprouts for regrowth and foliar spray once those sprouts leaf out.
Following years: Continue to monitor for new plants in buffers and keep a lookout for spotted lanternfly eggs and adult insects on any remaining tree of heaven trees. When large infestations are removed, replace with native trees or shrubs.

MILE-A-MINUTE, *POLYGONUM PERFOLIATUM*

IDENTIFY: Triangular green leaves that alternate on the stem. Young stems are green and may turn reddish as they mature. Backs of leaves and stems are lined with tiny, recurved barbs. Clusters of tiny, white flowers bloom from June. Plant can grow up to 6 inches a day right up until first frost. Fruits ripen to bright blue. A unique identifier is the small, saucer-shaped leaflike structure that encircles the stems beneath the flower and fruit clusters.

NOXIOUS: Mile-a-minute is a considered highly invasive by the Department of Conservation and Recreation (DCR) and it is a state and federally listed noxious weed. It's ability to grow 6 inches in a day, if ideal conditions exist, allow this annual plant to rapidly overtake areas it settles in. It is a prolific seeder, as are most annual plants. Its seeds are viable in the soil for 6-7 years.

REMOVAL: Mile-a-minute is easy to kill, but it is difficult to completely eradicate. Small areas of infestation or individual plant populations can be manually removed. Hand-pulling is easy to do with the right protective gloves. As an annual plant, its roots are shallow and fibrous. Chemical control can also be used for small and medium sized infestations. A foliar spray application will kill the plant, but other surrounding plants and the plant mile-a-minute is growing on top of will be negatively impacted. A pre-emergent herbicide can be used for large infestations, it will target germinating seedlings of ALL plants, but does not harm existing perennial or woody plants. Preemergent herbicide CANNOT be used near wetlands or streams as it harms aquatic life. There is an approved biological control – the mile-a-minute weevil. The weevil was approved as a biological control by the USDA in 2004. It has been released in several locations throughout Virginia. The weevil will set back, but not completely kill mile-a-minute – helping to slow its spread. For larger, established infestations, a combination of manual, chemical and biological controls should be utilized.

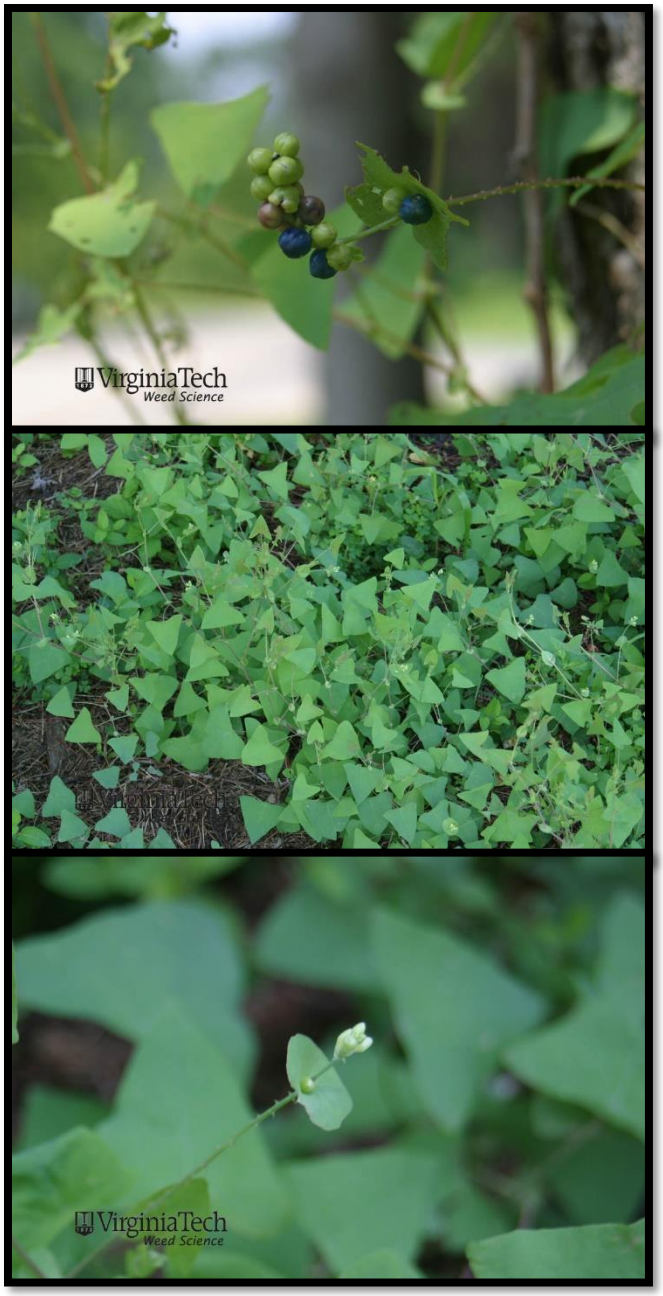


Figure 17. Mile-a-minute berries, leaves and encircled stem (Photo credit: Virginia Tech).

TREATMENT SCHEDULE:

April-May: Hand pull emerging seedlings (use protective gloves) and foliar spray mature plants once they leaf out.
June-October: Foliar spray mature plants and new seedlings. Do not manually remove (hand-pull or cut) once fruits are present, to prevent further spreading of seeds.
Nov.-Dec: Remove any dead plant debris, be careful not to harm desirable native species. Plant desired native trees and shrubs in this dormant season where mile-a-minute has left bare areas.

ORIENTAL BITTERSWEET, *CELASTRUS ORBICULATUS*

IDENTIFY: Bark of larger vines have a distinctive netting pattern and are light to medium tan or gray. Roots are brightly orange. Leaves are 2-5 inches long, with a glossy green and are alternate spaced on stems. In late summer, the leaves turn yellow. Round to elliptical shaped leaves are toothed and may or may not have an elongated tip. New vine growth spirals upward in a distinct corkscrew pattern. (Reference). Only female vines produce fruit. The fruits in summer are clusters of green, round, ½ inch berries that ripen to a golden-yellow. The golden covering splits open in the fall to reveal several red, seed-containing arils/fruit. The native American bittersweet will only have fruit and flower clusters at the tips of branches. Oriental bittersweet, on the other hand, will typically produce fruit and flowers up and down the stems.

NOXIOUS: Fast climbing vine that overtops trees, strangling trunks and stems and smothering understory shrubs, saplings and mature trees. It poses a hazard to foresters as vine-laden trees become unpredictable when falling when they are cut down. If left untreated, it can strangle and kill large trees. Birds love its berries and are the main sources of spread. It can also send up sprouts from its root system.

Figure 18. Oriental bittersweet berries, leaves and vine (Photo credit: Virginia Tech (top two), Bugwood Apps (bottom).

REMOVAL: On well-developed vines, most of the leaves are up in the canopy of the host tree, out of reach of herbicides. (PennState Extension). The most feasible approach to treating mature vines is to cut the existing stem(s), immediately spray the cut stem with herbicide and then foliar spray the new shoots that sprout up from the roots (approximately 8 weeks after cutting). The "window-cut" method is advised – cut the vine at ground level and then at eye level. This ensures all vines are cut and clears the area for the follow-up herbicide application of new growth. Cut-stump or hack-squirt for vines, will be the most effective form of herbicide treatment and will cause the least amount of damage to surrounding native plants. All herbicide treatments should occur late in the growing season, no earlier than July 1, to increase its uptake and damage to the root system. Manual control via cutting will only be effective if re-sprouts are repeatedly cut until the root system is exhausted.

TREATMENT SCHEDULE:

April-June: Monitor areas with known infestations and hand pull first year seedlings.
July-October: Foliar spray application to isolated low-growing vines or regrowth eight weeks after cutting larger vines to ensure enough foliage is present to translocate herbicide to the root system. Hack-squirt method can be used during this time for vines where leaf growth is too high for an effective foliar spray application.
ANY TIME: Basal bark applications can be done year-round, as weather permits, for larger vines.

PORCELAIN-BERRY, *AMPELOPSIS BREVIPEDUNCULATA*

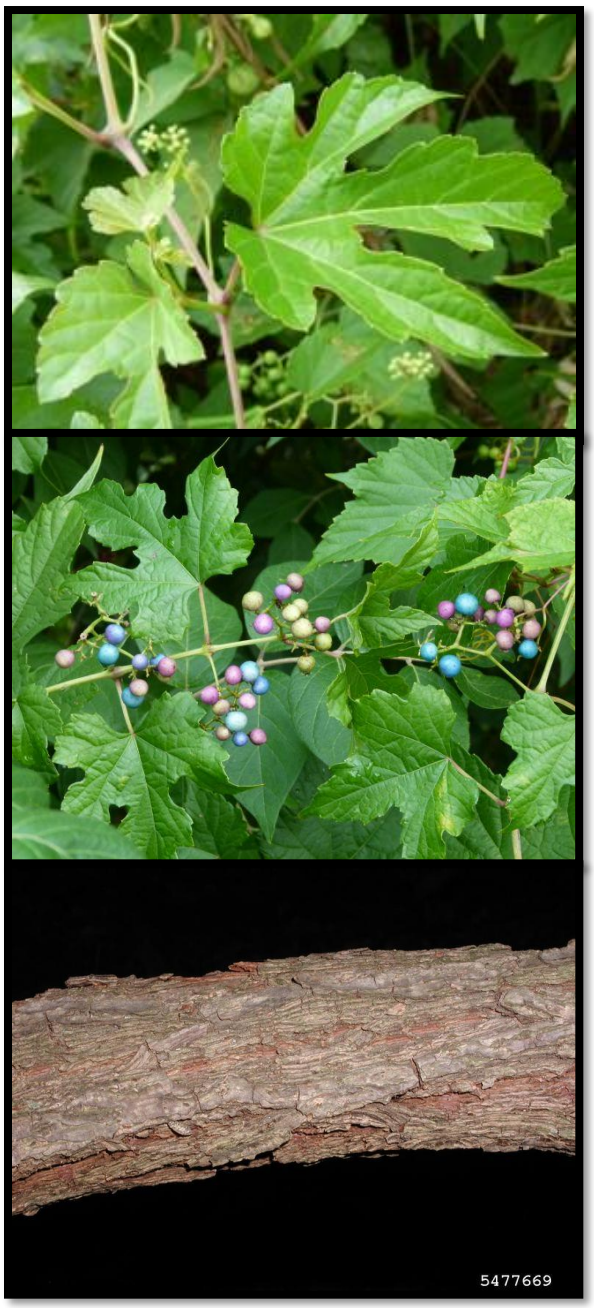


Figure 19. Leaves, berries and bark of porcelain-berry (Photo credit: Bugwood Apps).

IDENTIFY: A woody vine in the grape family. Has shiny, dark green leaves alternately arranged. Leaves are coarsely-toothed edges and undersides are hairy to the touch. Leaves vary from heart-shaped to 3- to 5-lobed or deeply dissected. (Blue Ridge PRISM). Berries are shiny, speckled and look like porcelain. The berries vary in color from creamy-white or green or yellow or purple. The berries will ripen to a bright turquoise blue in September and October. As the vine matures, the bark acquires rough patches, but does not shred – unlike the native grape vine. Unlike native grape vines, porcelain-berry fruit clusters will grow upwards. Native grape vine fruits grow downward. Porcelain-berry's flowers also grow in flat clusters; native grape vines typically have elongated flowering clusters.

NOXIOUS: Porcelain-berry will invade open and wooded habitats where it will spread and grow quickly. Its spread will shade out native plants as it climbs over shrubs and trees. This vine can grow up to 15 feet in a single growing season, especially in moist soils. The seeds are spread by birds and other animals and can be viable in the soil for several years.

REMOVAL: Effective control will require a combination of manual and chemical control methods. Smaller plants can be hand pulled in the fall or spring to prevent flower buds from forming. Avoid pulling plants that have already fruited. For vines that are too large to pull, use the cut-stump method. Cut-stump should be done in the summer to maximize plant uptake of the herbicide during the peak of the growing season. Allow any re-sprouts to grow for 4-8 weeks and then use a foliar application on regrowth. You can hand pull the regrowth only if the entire root system can be removed and you have desirable native plants or seeds ready to install into the disturbed soil.

TREATMENT SCHEDULE:

March-June: Monitor areas with known populations for new growth. Hand pull young plants and remove the complete root system for the most effective control. Hand pulling or cutting should only be done before the vine fruits to prevent seed dispersal.

July-October: From late summer to early fall is the time when herbicide applications are the most effective. Cut-stump plants that cannot be hand pulled and foliar spray any regrowth from earlier hand pulling or cutting.

November-February: Basal bark application can be done over the winter months as access to larger vines in the interior of larger infestations is easier.

JAPANESE HONEYSUCKLE, *LONICERA JAPONICA*

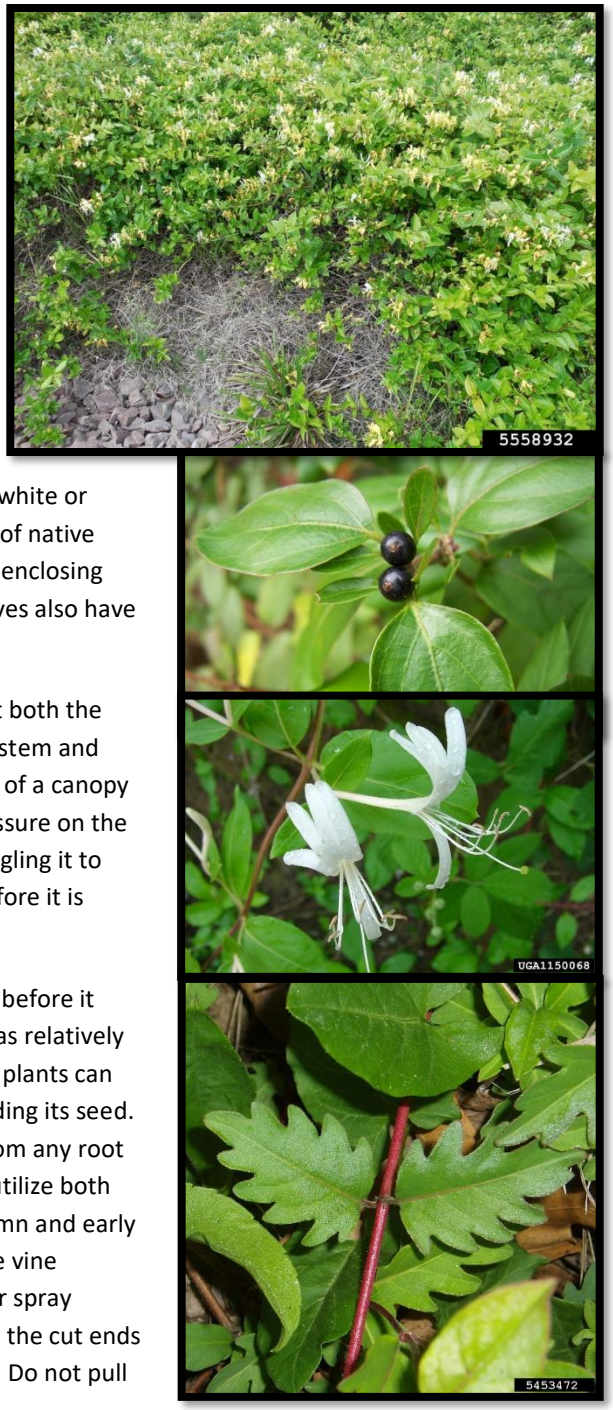


Figure 20. Photos of Japanese honeysuckle (Photo credit: Bugwood Apps).

IDENTIFY: A perennial woody vine with glossy, dark green leaves. The leaves are oval in shape, occasionally lobed like an oak leaf and have smooth edges. Leaves are oppositely arranged on the stem. This vine is easy to identify in the winter, as it is an evergreen; foliage remains on the plants well into and through winter. Young vine stems are reddish-brown to light brown and slightly hairy. Older stems have bark that peels in long strips (Blue Ridge PRISM Fact Sheet). Flowers bloom in pairs starting in late spring and persist into the fall. Flowers are white or pinkish and then mature to light yellow and are very fragrant. The leaves of native honeysuckle do not have stems (petioles) and leaf pairs join together and enclosing the stem. Japanese honeysuckle leaves have short stems (petioles). Natives also have red or orange flowers, not white and red berries, not black.

INVASIVENESS: This vine will completely crowd out native vegetation at both the ground and canopy level. It will send shoots up from its spreading root system and branches. The vine will climb anything as a ladder to get to the sunny top of a canopy opening – twisting up the trunks of trees. As the vine grows, it exerts pressure on the tree trunk cutting off the flow of water and nutrients and eventually strangling it to death. A mature vine's dense growth can topple a tree with its weight before it is strangled or smothered, which makes it a hazard during/after a storm.

REMOVAL: The best control is preventative - early detection of this vine before it becomes established is the best form of control. Japanese honeysuckle has relatively slow growth and seed formation in its initial developmental years. Young plants can be hand pulled from moist soil, before the vine has fruited to avoid spreading its seed. The entire root must be removed when pulling as it can and will sprout from any root material left in the soil. Mature plants or heavy infestations will need to utilize both chemical and manual controls. Foliar spray low growing vines in the autumn and early winter to avoid damaging native plants that may be underneath the dense vine growth. Do not spray overhead vines, cut them near the ground and foliar spray regrowth. If there are thick vines present cut them and immediately treat the cut ends with a concentrated herbicide – best timing is the fall through the winter. Do not pull heavy vines from the trees.

TREATMENT SCHEDULE:

January-March: Monitor buffers for new plants and hand pull young vines before they begin flowering or fruiting.
April-August: No treatment should be done while plant is flowering or fruiting to avoid spreading seeds and to avoid collateral damage to adjacent native plants.
Sept.-Dec.: Best time to foliar spray ground level vines and to cut-stump and treat larger vines for maximum effectiveness and least damage to desired native plants.

GARLIC MUSTARD, *ALLIARIA PETIOLATA*

IDENTIFY: A biennial plant in the mustard family. Its seeds can germinate any time between the spring and fall. First year plants are heart-shaped rosettes with evergreen leaves that will overwinter. Rosettes have scalloped edges and veins create a quilted texture. Second year plants will send up flower stalks in early spring and then form seeds in early summer. Leaves on the stalk are triangular with toothed edges. All parts of the plant emit a strong garlic odor, if in doubt, crush a leaf and smell it. Typically, it's the tallest plant on a forest floor in May due to its early spring growth. Flowers are tiny and white, arranged in a cross pattern on the top of the stalk.

INVASIVENESS: A single plant is known to produce anywhere from 400-7,000 seeds before it dies. Garlic mustard will discourage other plants from growing by shading them out due to its early spring growth (March and April) and by releasing cyanide-containing toxins into the soil. The toxins kill beneficial soil fungi necessary for forest tree growth and regeneration and inhibit native wildflowers (Blue Ridge PRISM). It has no known insects or animals that eat it.

REMOVAL: First year rosettes can be removed at any time of year, but be careful to get the tap root and not to disturb the soil too much. Too much soil disturbance will activate germination of dormant mustard seeds. Second year stalks may be pulled, but they must be bagged and properly disposed off site to prevent spreading any seeds from plants that have flowered. Hand pulling may not be feasible depending on how large the infestation is. Foliar spraying larger infestations can be done any time the ground is not frozen. Preferably, any foliar herbicide application should be done once native plants have gone dormant or lost their leaves.

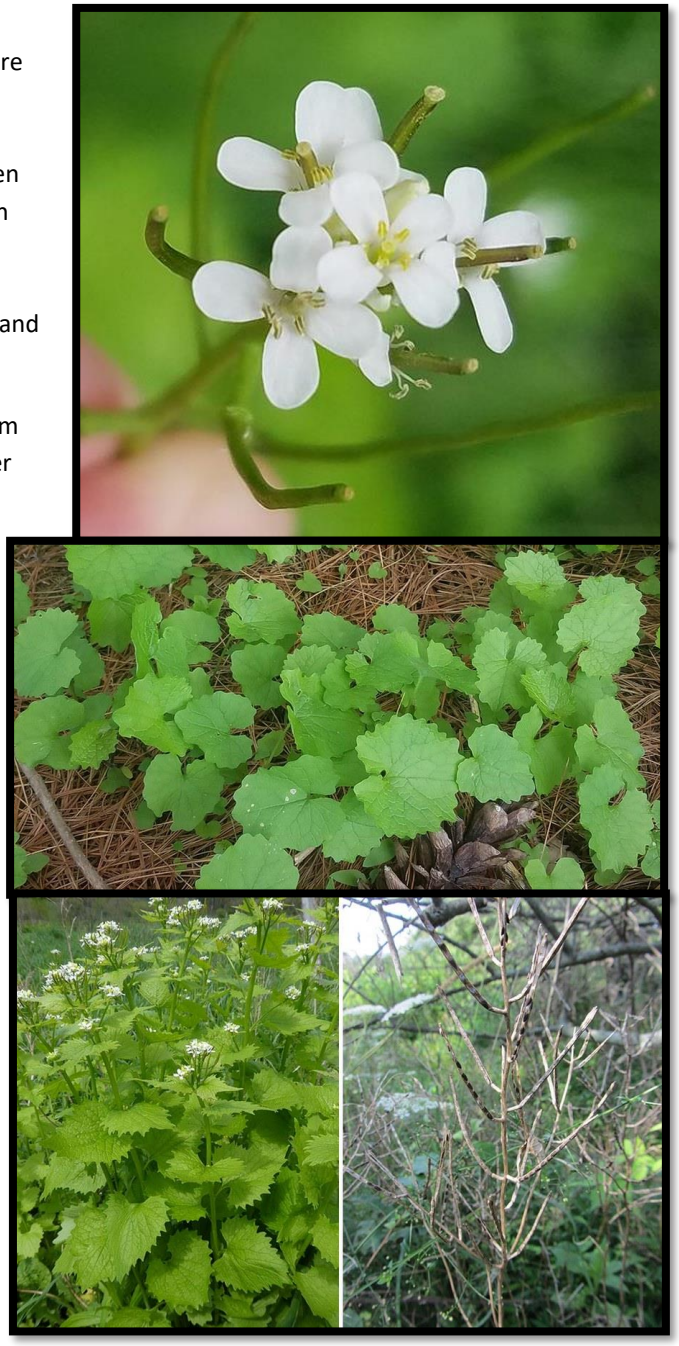


Figure 21. Photos of garlic mustard in various growth stages. (Photo credit: top photo – Virginia Tech, bottom two photos – Bugwood App).

TREATMENT SCHEDULE:

Jan-June: Manual removal recommended before second year plants flower and go to seed. Bag and dispose of second year stalks too prevent the spread of seeds. First year rosettes may be hand pulled as well, but may become too tedious in larger populations. Re-plant or re-seed desirable native plants in any areas with disturbed soil.

July-October: Monitor new plants and re-growth in hand-pulled areas, spot spray new plants where damage to natives will be minimal. Do not disturb any second year plants that have seeded – if they must be disturbed, bag and remove offsite.

October-Dec.: Foliar spray first year rosettes any time the ground is not frozen. Winter is the best time to target first year plants while also minimizing damage to native wildflowers and other desirable plants.

CANADA THISTLE, *CIRSIUM ARVENSE*

IDENTIFY: This is a biennial herb. In the first year of growth it is a rosette of spiny leaves close to the ground. Second year plants produce flowers from June until August. New shoots usually begin to form in January. Leaves are dark green and smooth on top, light green and hairy on the lower sides. Edges of oblong-shaped leaves are lobed and spiny. Second year plants will grow to between 1-4 feet tall. Mature plants will have alternate leaves and the base of each leave surrounds the stem. Its purple to pink (rarely white) flowers are ½ to 1 inch long (DCR Natural Heritage). Flowers will bloom from June through September. It closely resembles native thistles, but its aggressive spread will give it up. Native thistles tend to have spineless stems and almost white leaf undersides.

INVASIVENESS: Canada thistle spreads by root and by seed. A single flower head can produce up to 1,500 seed in a year. Its roots can grow up to 18 feet in a year, producing shoots every 3-6 inches (DCR-Natural Heritage). Seeds can remain viable in the soil for up to 20 years.

REMOVAL: This plant's ability to sprout from the root system means that any treatment not targeting the roots will be largely ineffective (Cornell University). Any plants mowed or pulled while flowering have enough reserves in their stalk to go to seed, so care should be taken to cut plants in spring or early summer before they flower or bag and dispose of flowering plants. Cutting plants will cause the plant to sprout from its roots creating a greater population the following year. Follow up with a foliar application of herbicide in spring and summer on new growth. In some situations, it might be possible to shade out first year plants with annual cover crops that grow vigorously in the spring, but those applications are usually limited to agricultural row crop fields; not as applicable to our campus environment.

Figure 22. Photos of Canada thistle in various growth stages. (Photo credit: Virginia Tech).

TREATMENT SCHEDULE:

April-June: Mow or cut down plants before they flower.
July-September: Second year plants will likely be flowering during this time. Care should be taken to spray only as needed and to avoid spraying the flower heads as they attract many native pollinators. Foliar spray the stems/stalks of second year plants. First year rosettes should be the main targets when foliar spraying during this time.

ENGLISH IVY, *HEDIRA HELIX*

IDENTIFY: This is a perennial trailing or climbing vine. There are many cultivated forms of English ivy. It was brought over from England and has been used as ground and wall cover in landscapes, as houseplants and as greenery in floral arrangements. The wild form has two leaf types: juvenile leaves, which typically are trailing along the ground, and adult leaves, which are typically flowering and climbing up and hanging from trees. Juvenile leaves are 1.5-4 inches long with 3-5 lobes, dark green above. Often with whitish veins and lighter below. Adult leaves are egg-shaped to triangular and rounded to wedge-shaped at the base. Flowers appear on adult vines from June to October. The fruit is a black, fleshy berry and matures from April to May.

Figure 23. Top two photos – leaves of juvenile ivy and below it leaves of an adult ivy flowering. Bottom photo – English ivy cut method when climbing up a tree. (Photo credit: Mississippi State University and NC State Extension).

INVASIVENESS: English ivy spreads fast by root and by seed. It is unique in that it grows aerial root-like structures on the stems to enable it to cling to and climb trees and buildings (Mississippi State University Extension). An individual plant can produce tens of thousands of fruit each year. Fruits are consumed and dispersed primarily by birds. It's mat-forming growth habit allows it to smother out perennials and smaller shrubs. It will also climb trees quickly and cover the tree's foliage, slowly killing it.

REMOVAL: This vine is drought and shade tolerant and grows fast. Juvenile plants along the ground, can be pulled up. Stem fragments of juvenile and adult plants left in contact with moist soil can regenerate into a new plant (DiTomaso, J.M., G.B. Kyser et al. 2013). Mowing can be used as another non-chemical control, but it must be as frequent as mowing a lawn and the entire infestation must be mowed in order to "starve out" the plants. Most effective control has been chemical treatment with glyphosate in the spring when the vine has 2-4 new leaves. New growth does not yet have the waxy cuticle covering present on the older leaves, which allows for better penetration of herbicides. Follow up with a foliar application of herbicide 6 weeks after treatment **IF** new growth is present. English ivy becomes less and less susceptible to glyphosate as the season progresses (NC State Extension). English ivy in trees can be killed by cutting the stems at the ground and removing the vines from the tree as high as you can easily reach. The remaining vines in the tree will die and eventually fall off.

TREATMENT SCHEDULE:

March-May: Chemical treatment of new growth of ivy via foliar spraying of appropriate herbicide – before waxy cuticle covers the more mature leaves.
June-October: New growth should be the main targets when foliar spraying during this time. Mechanical treatment may occur during this time, but be sure to not leave any stem fragments behind. Cutting vines climbing trees can occur during this time.

PURPLE CROWN-VETCH, *SECURIGERA VARIA*

IDENTIFY: Crown vetch, a member of the pea family, is a perennial herb with creeping stems that may reach two to six feet in length. The compound leaves bear fifteen to twenty-five leaflets. The pea-like, pink to white flowers occur in clusters at the end of extended stalks. The narrow, leathery seed pods may be two to three inches long (VA DCR). It is often mistaken for other legumes. A few differing features include: compound leaves with an odd number of leaflets, leaves and flower stalks that come off the main stem and flowers that are present in a radiating cluster or umbell.

INVASIVENESS: Crown-vetch was introduced into the US for use in erosion control along highways embankments and as a green fertilizer crop. It has been recommended over the years as the plant to use in erosion and sediment control applications, thus it is widespread in Virginia. It spreads rapidly by its creeping root system and its seeds. Native plant species can get easily overcome by this aggressive plant's dense growth. A single plant may fully cover 70 to 100 square feet within a four-year period (US Forest Service).

REMOVAL: On younger or smaller populations, manual control can be effective. This can include pulling entire plants (making sure to include as much of the rhizomatous roots as possible). Mowing is another potential method of controlling crown vetch. The mowing should occur in late spring and then multiple times through the growing season, for several consecutive years (PA Department of Conservation and Natural Resources). For areas where crown vetch has established large, dense populations, chemical controls can be used. Herbicides can be applied at any time during the growing season when crown-vetch is green. A combination of spring mowing and a follow up foliar spray application of herbicide has been proven to be most effective.

TREATMENT SCHEDULE:

April-June: Hand-pull small areas of infestations and be sure to get the entire root and rhizome system removed. Mow or weedwhack large infestations in the spring repeatedly.
June-Sept: Repeat mowing and combine with herbicide application immediately following a mow to increase effectiveness of treatment in areas with dense growth. Monitor new plants and re-growth in hand-pulled and mowed areas, spot spray new plants where damage to natives will be minimal.

Figure 24. Photos of various stages of crownvetch growth. (Photo credit: Jerry Oldenettel, Sue Gier and Karen Milne).

MULTIFLORA ROSE, *ROSA MULTIFLORA*

IDENTIFY: This rose is a multi-stemmed, spreading shrub that sometimes climbs trees. Its stems or canes branch and arch. Young stems have green bark and flexible with sharp thorns. Mature canes have rough, stout brown bark and large thorns. The thorns are the distinctly curved with a wide base, resembling cat's claws and usually the thorns occur in pairs. They have pinnately compound leaves with 5-9 leaflets and have a uniquely fringed base or stipule, where it connects to the stem. White flowers with 5 petals and bright yellow pollen show between May and June. Rose hips, fruit, replace flowers mid-summer and persist through the winter. Rose hips are small, shiny and start out a bright red and then darken over time.

INVASIVENESS: Multiflora rose forms dense thickets by three methods: rooting at the tips of its long, arching canes, forming new crowns and canes from its spreading root system, and producing abundant fruits. A large multiflora produces thousands of seeds each year and they can be viable for 10 to 20 years (Blue Ridge PRISM). Migrating and wintering birds eat the fruit and are the main dispersers of the seed.

REMOVAL: The longer an infestation has been present, the more difficult it will be to control. Combining several control methods and repeating them for two to three or more years works best. Mowing multiflora rose 3-6 times a year when present in areas that allow it, may kill or greatly reduce plant numbers. Herbicide treatment via foliar spray is most effective, and least damaging to adjacent native plants, when rose plants are young and less than hip height. For any roses that have climbed trees, it is best to use the cut stump method. Cut stems near the ground and immediately paint or spray a recommended concentrated herbicide on the cut stump. Leave the rose to die on the tree, pulling it down will likely create more damage to the host tree. (Blue Ridge PRISM Fact Sheet).

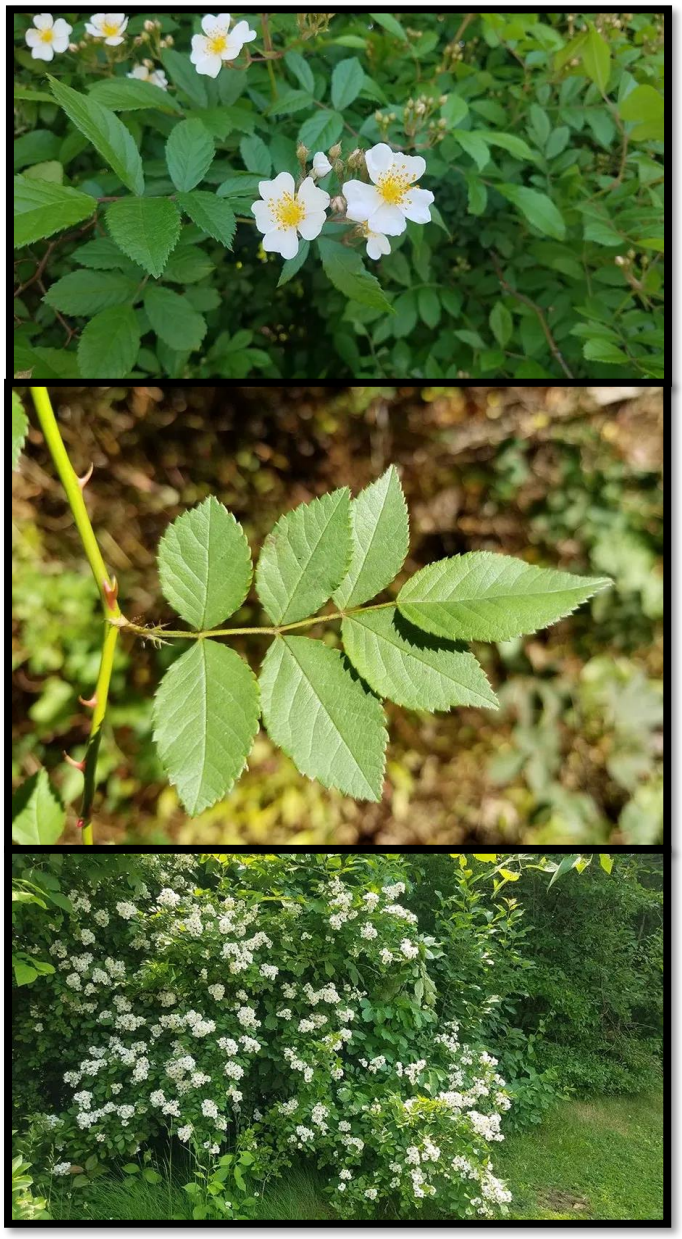


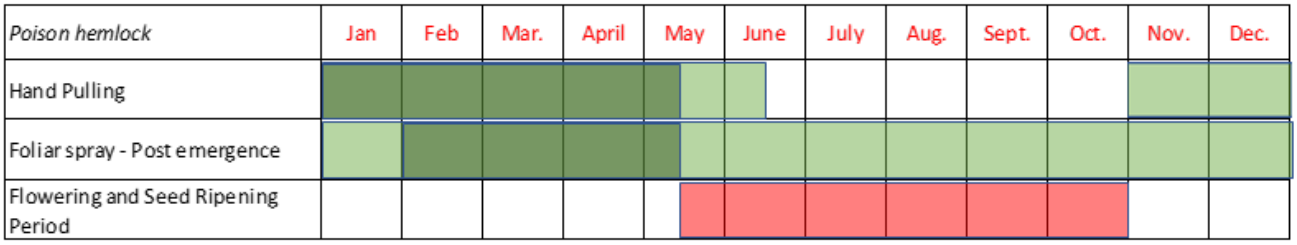
Figure 22. Photos of Multiflora rose in various growth stages. (Photo credit: Penn State Extension).

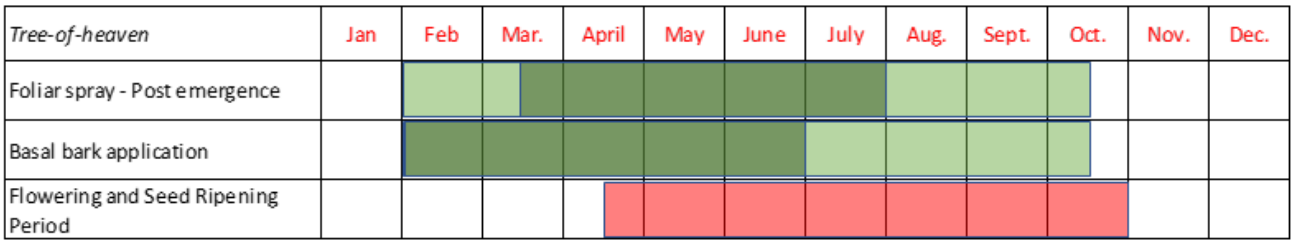
TREATMENT SCHEDULE:

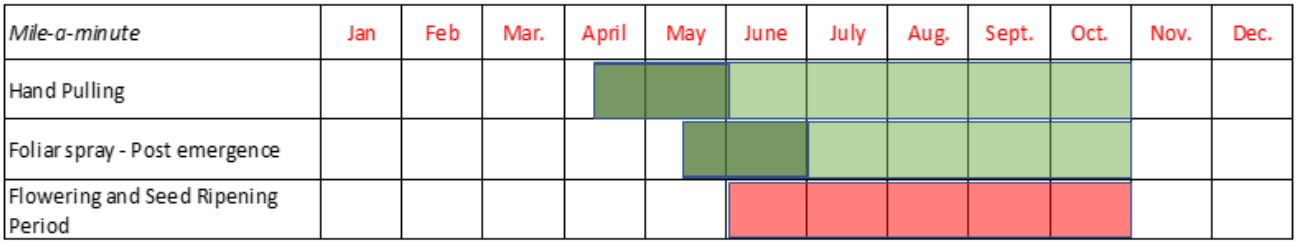
April-June: Begin to cut down or mow young plants
July-September: Continue mowing areas of infestation or foliar spray young, shorter plants as long as leaves are still green. Cut-stump older, larger plants or climbing roses at any time of year, but this method is most effective while leaves are green.

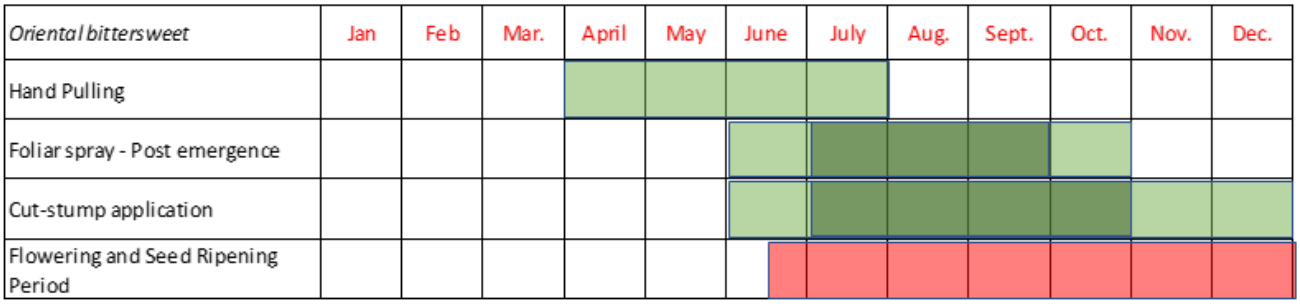
SECTION 4: INVASIVE PLANT MANAGEMENT CALENDAR BY SPECIES

The proceeding graphics display a quick snapshot of the best treatment at the most effective time of year and provide insight into each invasive plant species flower bloom and seeding period. The darker green bars are the most recommended times for treatments where the method will be either be the most effective, the least detrimental to the surrounding native plant communities or will help to prevent further spread of the plant. The red bar represents the period in which each plant is flowering and when the seeds or fruit ripen. When treatment occurs within the red bar for a plant, staff must be careful not to spread seeds or leave seeds or flowers on site. Please refer to each plant species fact sheet for further details on the best type of removal method. Removal methods may differ based on the life stage of the specific plant.









Porcelain-berry	Jan	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hand Pulling												
Foliar spray - Post emergence												
Cut-stump application												
Flowering and Seed Ripening Period												

Japanese honeysuckle	Jan	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hand Pulling												
Foliar spray - Post emergence												
Flowering and Seed Ripening Period												

Garlic mustard	Jan	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hand Pulling												
Foliar spray - Post emergence												
Flowering and Seed Ripening Period												

Canada thistle	Jan	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hand Pulling												
Foliar spray - Post emergence												
Flowering and Seed Ripening Period												

English ivy	Jan	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hand Pulling												
Foliar spray - Post emergence												
Flowering and Seed Ripening Period												

Canada thistle	Jan	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hand Pulling												
Foliar spray - Post emergence												
Flowering and Seed Ripening Period												

Crown-vetch	Jan	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hand Pulling												
Foliar spray - Post emergence												
Flowering and Seed Ripening Period												

Multiflora rose	Jan	Feb	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hand Pulling												
Foliar spray - Post emergence												
Cut-stump application												
Flowering and Seed Ripening Period												

SECTION 5: RE-ESTABLISHING NATIVE PLANTS

When invasive plants are removed, something will replace it. Bare and/or disturbed soil is prime real estate for invasive plant species. Campus staff will need to be proactive and have a plan in place and natives selected before any invasive plants are removed. Successful invasive plant management and eradication is only possible when invasive plant populations are replaced with the right native plants. In some cases, non-native plants are appropriate, given they do not display any invasive characteristics.

Why native plants?

- **Need less care** – When a native plant is planted in the right place, they will need less care and less water over the long term because they are already adapted to local conditions.
- **Support native wildlife** – Many native butterflies, birds and pollinators require native plants for food, habitat, and/or a phase of their life cycle.
- **Decreased stormwater runoff** – Native species, when compared to turf grasses, have much deeper root systems. These root systems increase infiltration and help to absorb runoff.
- **Cost less** – Native plants do not require fertilizers or pesticides that turf grasses and some non-native plants need to survive. No fertilizer applications also mean less contributions to pollutants in streams.
- **Increased biodiversity** – Native plants, typically (there are exceptions to every rule), will not become invasive and co-exist well with other non-invasive plants. Greater number of the types of plants, equals a greater benefit to wildlife and greater resiliency for the habitat area.

Figure 21. Black-eyed susan flower and native pollinator on campus meadow area. (Photo credit - Dale Chestnut)

Figure 22. A riparian buffer planted with Switchgrass, a native warm season grass. (Ernst Seeds, Inc.)

A native planting plan will be created for each specific site where large areas of invasive plants have been removed. Please consult with Facilities Management – Stormwater and Sustainability staff for a planting plan, specific timing, planting density and native species recommendations prior to invasive plant removal. In some cases grant funding is available to pay for larger quantities of plant material and supplies, but advanced (3-6 months) notice of the need for grant funding is required.

A great place to start when selecting a native plant is the Department of Conservation and Recreation (DCR)'s Native Plants for Conservation, Restoration & Landscaping guide (Appendix E) or available here. Species are listed by preferred region, our campus is located in the Mountain and Valley region. It also lists the wet and shade tolerance for each native plant.

SECTION 6: COLLABORATING WITH FACULTY, STUDENTS AND THE COMMUNITY

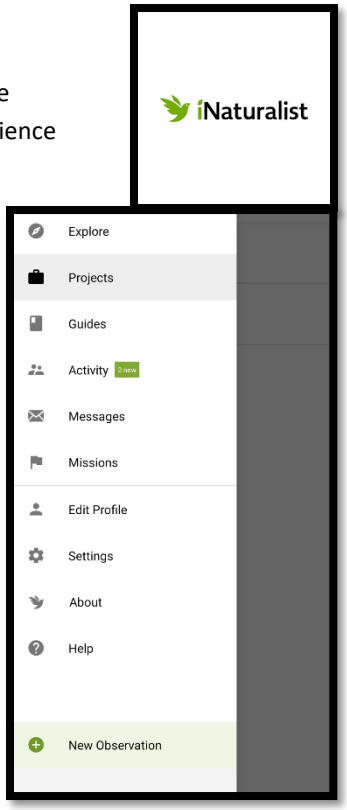
The nature of a university means that we have at our finger tips the ability to: harness a wide array of professional expertise, promote innovative ideas, create outdoor learning experiences and engage with a multitude of different disciplines to tackle any need within campus, the community and the broader world. In order to improve the quality of the campus stream buffers and implement a campus stream buffer maintenance program a team of staff, faculty, students and community members will have to join together. There are several opportunities available for engagement and learning each year and the hope is that this guidebook will become a dynamic and ever-changing document that provides connections and promotes collaboration between staff, faculty, students and the community.

Figure 23. Faculty, staff and student collaboration that planted an urban food forest on campus. (Photo credit – Dale Chestnut)

Opportunities for community, faculty and student collaboration as it relates to the campus stream buffer maintenance program include the following (list updated annually):

Monitor campus buffers for invasive plants and collect geospatial data on any sightings.

a. Timing: Year-round
b. Supplies: Good walking shoes, insect repellant, sunscreen, water, smartphone
c. Applicable majors: Biology, Earth Science, Geography, Geology, Integrated Science and Technology, and any plant enthusiast
d. Method: Walk along buffer areas looking for invasive plants.
e. Identify: Use a plant identification smartphone app, like Seek, LeafSnap or PlantNet (free versions available) and confirm your plant identification.
f. Report Sighting: Download iNaturalist app on your smartphone. Find the project titled, JMU Stream Buffers. To report an observation, click new observation , take photos of the plant (close up of leaves, whole plant, any flowers, bark or other unique characteristics). Confirm the location is correct, if you can identify the species please do so and then add any additional information in the notes section and then hit the green checkmark at the bottom to save. Repeat Step F as needed to document more observations.
g. Any training or assistance needed, please contact Ali Sloop, at witmanad@jmu.edu or 540-568-3174



2. **Assist with removal of invasive plants.**
   a. Timing: 2-4 times a year
   b. Supplies: Depends on the invasive plant targeting, but could include gloves, safety glasses, trash bags, pruning shears, insect repellant, etc.

c. Related Majors: Biology, Geography, Geology, Integrated Science and Technology or anyone not afraid to get their hands dirty!
d. Method: Hand-pulling or cutting with hand shears and bagging up plant material for disposal
e. Contact: Email Ali Sloop at witmanad@jmu.edu for buffer locations in need of invasive plant removal and for more details.

3. **Create native planting plans for specific campus buffer areas**.
    a. Timing: Any time
    b. Supplies: graphic or landscape design software or a pencil and paper, computer
    c. Related majors: Architectural Design, Studio Art, Biology, Computer Science, Earth Science, Geology, Geography, Graphic Design, Integrated Science and Technology, Media Arts and Design
    d. Method: Research and develop a native planting plan for specific buffer areas on campus. Deliverables include: Conceptual drawings of planted buffers, landscape plan with planting densities, etc.
    e. For more information, contact Ali Sloop at witmanad@jmu.edu

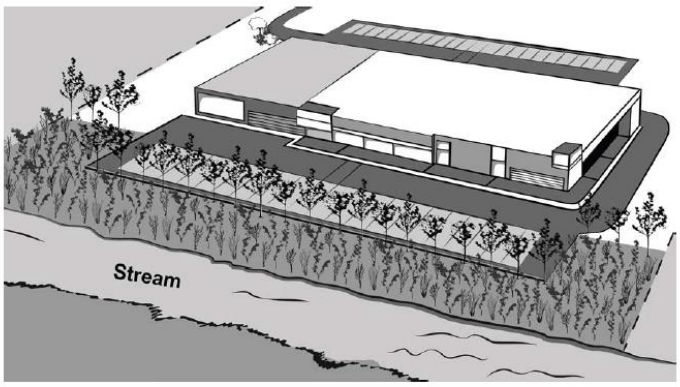


Figure 17b. One-acre commercial lot: Buffer with bare root seedlings and visual screen of container/B&B stock just after planting

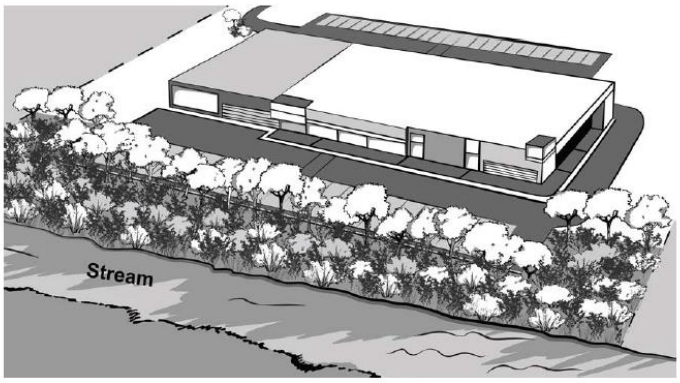


Figure 17c. One-acre commercial lot: Buffer with bare root seedlings and visual screen of container/B&B stock showing five years of growth

4. **Educational material or program development related to riparian buffers – signage, virtual media, etc.**
    a. Timing: Year-round
    b. Supplies: none
    c. Related majors: Biology, Communication Studies, Early Childhood Education, Earth Science, Education, Elementary Education, Graphic Design, Industrial Design, Integrated Sciences and Technology, Marketing, Media Arts and Design, Middle Grades Education, Secondary Education, Special Education or any local teachers (includes retired professionals) or faculty.
    d. Method: Develop and create educational signage for placement along campus stream buffers. Educational signs are important to the campus and community to promote the importance of riparian buffers, ensure future protection and highlight a stream buffer's many benefits. Other projects could include creating educational programs about riparian buffers, developing outdoor learning experiences utilizing campus stream buffers or about stream buffers, creating training material for campus staff related to invasive plant treatment, native plantings and maintenance of campus stream buffers, etc.
    e. For more information, please contact Katie Rankin at rankinkt@jmu.edu or Ali Sloop at witmanad@jmu.edu.

5. **Trash removal in campus stream buffers.**
    a. Timing: 2-4 events a year
    b. Supplies: Gloves, appropriate footwear or boots and trash bags
    c. Related majors: ALL

d. Method: Organize trash removal large group events or grab your own shopping bag and take a walk along a campus buffer, picking up trash as you go. This is important to keep our campus looking great, to protect wildlife and their habitats and to decrease the amount of pollutants in our local water.
e. For a list and map route of campus buffers in need of trash removal, please contact Ali Sloop at witmanad@jmu.edu.

6. **Send us your ideas for future collaborations! Contact Facilities Management – Stormwater staff at witmanad@jmu.edu or chestndl@jmu.edu for more information or with any questions.**

SECTION 7: CREATING A SUSTAINABLE CAMPUS STREAM BUFFER MAINTENANCE PROGRAM

The Facilities Management staff at JMU are on a mission to operate in such a way as to maintain an exemplary and sustainable environment that is conducive to academic pursuits and in support the university's mission. Which is to be a community committed to preparing students to be educated and enlightened citizens who lead productive and meaningful lives (JMU Plans: Mission, Vision and Values - https://www.jmu.edu/jmuplans/mission-vision-values.shtml).

Vision: To be the national model for the engaged university: engaged with ideas and the world.
Our central pursuit as we seek to fulfill our mission will be to become the national model for what it means to be engaged. And, for JMU, engagement means:

- ***Engaged Learning:*** *Developing deep, purposeful and reflective learning, through classroom, campus, and community experiences in the pursuit, creation, application and dissemination of knowledge.*
- ***Civic Engagement:*** *Advancing the legacy of James Madison, the Father of the Constitution, by preparing individuals to be active and responsible participants in a representative democracy dedicated to the common good.*
- ***Community Engagement:*** *Fostering mutually beneficial and reciprocal partnerships, ranging from local to global, that connect learning to practice, address critical societal problems and improve quality of life.*

The stream buffer maintenance program is one tool in our toolbox that will aid Facilities in supporting JMU's mission to engage, educate and prepare students to lead impactful lives within campus, their own communities and the world. This section will explore how we will begin the process of creating a sustainable stream buffer maintenance program that aligns with our university's mission and vision. A successful, productive program will need to establish short- and long-term goals, be able to utilize a variety of partners, become self-sustaining and garner institutional and community support. In this section we will share goals, tools utilized and potential partnerships that will contribute to the maintenance program's sustainability.

Short Term Goals (1-3 years):

- Engaged Learning:
  - Locate populations of invasive plants in campus stream buffers – report sightings in iNaturalist.
  - Collaborate with faculty and students on assessment of stream bank erodibility hazard.
  - Create maps and unique identifiers for each campus buffer location.
- Community Engagement:
  - Begin control of Poison Hemlock infestation.
  - Organize a volunteer event to collect trash along campus buffers.
  - Plant more native plants in campus stream buffers.

Long Term Goals (5-10 years):

- Engaged Learning:
  - Engage students annually with established outdoor learning programs, research projects and volunteer events.
- Community Engagement:
  - Secure grant and/or institutional funding for native plant restoration and maintenance of campus buffers.
  - Develop community programs that educate the public on the importance of restoring and maintaining stream buffers.
- Civic Engagement:
  - Student-led environmental campaigns to create awareness and action related to pollution reduction, native plants and stream buffers.
  - Participate with and promote the campus stream buffer maintenance program to local environmental groups, municipalities, neighboring campuses and natural resource agencies.

Partnerships are vital to any program or project's success. Our campus stream buffer maintenance program will begin the process of reaching out to campus partners and community partners that do similar work and where our goals may align. Potential partner categories are listed below:

1. **Local municipalities –** These entities typically have stormwater management plans or regulations that protect riparian buffers and have staff designated to work on improving local water quality through the installation of best management practices, like riparian buffer plantings, environmental education, and the implementation of stormwater pollution prevention plans and ensure construction sites install measures and plans to protect sediment and other pollutants from entering local streams. Co-hosting workshops and trainings for the community and municipality and campus staff on the importance of stream buffers and how to properly maintain them.
2. **Neighboring K-12 schools –** Opportunities to collaborate on outdoor learning experiences on campus with faculty, staff and students. Environmental education and service-learning are shared goals. Could provide an opportunity for education majors to gain real-life experience by teaching environmental education programs in K-12 classrooms or in an outdoor learning experience on campus incorporating a stream buffer.
3. **Non-profit organizations –** Find a group of passionate environmentalists that engage within the local community to assist them with highlighting volunteer events or programs that students can become involved with. In addition to these organizations providing community engagement opportunities, these organizations could provide volunteers back to the campus to assist with a multitude of different stream buffer maintenance program needs.

CITY OF HARRISONBURG PUBLIC WORKS

4. **State agencies** – These agencies core is to provide a service to Virginia residents. Typically, natural resource related agencies will provide free technical assistance, sharing their professional expertise to improve the conservation of the state's natural resources. Many provide opportunities for grant funding. In exchange, the campus provides these agencies with an opportunity to identify, nurture and recruit high quality talent early.
5. **Federal agencies –** Agencies at the federal level can provide technical and financial assistance in support of a campus buffer maintenance program's goals. Grants are available from federal agencies related to riparian buffers: flood control, climate change, native plantings, pollution prevention, green infrastructure and water quality improvement.
6. **Local businesses –** Students that develop educational or campaign related materials will look to utilize local businesses in the printing or manufacturing of those items – providing support to that business. Businesses love giving back to their communities as well, and they could be another source of volunteers or funding to support the goals of the stream buffer maintenance program.

SECTION 7: REFERENCES

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SECTION 8: APPENDIX

The following pages are the documents referenced in this guidebook that will be used by JMU staff, students, faculty and local community to implement the Campus Stream Buffer Maintenance Program.

Appendix A: Annual Stream Buffer Inspection Report – In development
Appendix B: Stream Buffer Maintenance Checklist – In development
Appendix C: Map of Stream Buffers with Invasive Plant Locations – In development
Appendix D: Stream Bank Field Assessment Form – In development
Appendix E: DCR Native Plants for Conservation, Restoration and Landscaping