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Wildland Weed Management
College of Agricultural Sciences
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Natural Resource Management Factsheet

Herbicide Selection and Use 3

Why Use Herbicides?

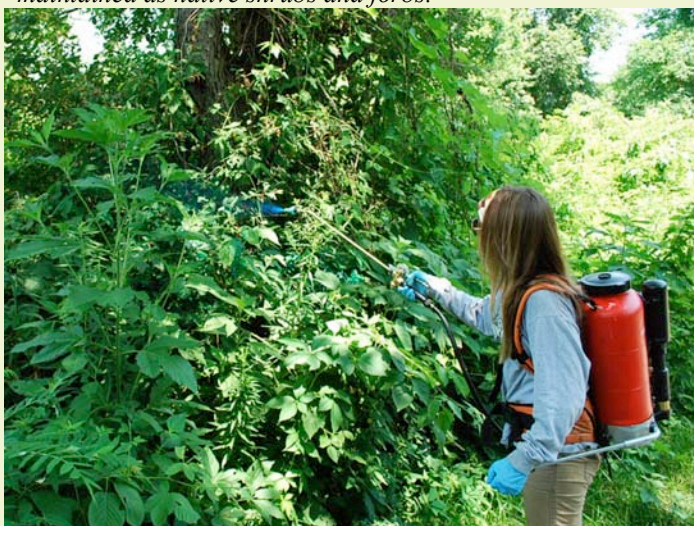
Herbicides are one of many tools available to manage vegetation. When looking at the resources to complete an operation, your considerations will include labor availability, equipment, time, and associated risk. Herbicides replace a lot of labor, equipment, and time, and when used properly they present an acceptable risk.

In addition to labor and time savings, herbicides provide a means to suppress or kill the persistent, underground parts of problem plants that cannot be practically treated by other means. Herbicides can be used to remove undesirable plants in a highly selective manner, and preserve desirable plants and the other non-target organisms that are present.

Herbicide Considerations

Choosing an herbicide is not simply a matter of picking a product that will control the weed species you are targeting. Consider the desired end result. What is the vegetation you want? You are not just controlling weeds; you are manipulating the vegetation to achieve a more desirable plant community.

Figure 1. A common herbicide application technique is a low-volume, spot foliar treatment using a backpack sprayer. In this instance, the exotic shrub multiflora rose (Rosa multiflora) is being selectively targeted in a habitat area maintained as native shrubs and forbs.



Selectivity

Selectivity is achieved both through the nature of the herbicide, and by how you apply it. *How* you apply can refer to targeting, application rate, or timing of the application.

All herbicides have some plant species they do not affect as much, but some herbicides only work on certain species or types of plants. Herbicides with this type of limited spectrum are known as *selective*. The most common selective herbicide used in natural resource settings is *triclopyr* (e.g. 'Vastlan'), which is a 'broadleaf' herbicide – it does not injure grasses. A broadleaf herbicide can be used to remove weeds such as thistles or clovers from grasses. Another selective herbicide example is *quizalofop* (e.g. 'Assure II'), which only injures grasses, and can be used to treat Japanese stiltgrass (*Microstegium vimineum)* that is growing among broadleaf plants (forbs).

You can also achieve selectivity through how you apply the treatment. When the target weed makes up just a part of the plant community, you can often spot treat and preserve the remaining desired plant species (Figure 1).

Quizalofop also provides an example of how application rate affects what species are controlled. You can apply a low dosage to control Japanese stiltgrass, but leave more-tolerant, desirable grasses such as deertongue (*Dicanthelium clandestinum*) relatively uninjured.

Application timing is another way to achieve selectivity. You can treat early-growing, cool-season grasses such as tall fescue (*Schedonorus arundinaceus)* or reed canarygrass (*Phalaris arundinacea)* in a native warm-season grass planting in the spring before the warm-season grasses begin to grow. In a reforestation planting, you can treat those same weedy agronomic grasses in the early spring, or fall, before the desired woody plants break bud or after they drop their leaves.

Herbicide Activity

Two factors that influence how herbicides work against target plants is how they enter the plant, and how they move in the plant after uptake. Herbicides can enter the plant through foliage and stems, or the roots. Some herbicides enter only through foliage and stems (*glyphosate*, e.g. 'Rodeo'*)*, some only through the roots (*prodiamine*, e.g. 'ProClipse'), and some can enter

Figure 2. A high-volume foliar application is useful for tall or dense targets such as this Japanese knotweed (Fallopia japonica). This application allows more productive coverage because the spray pattern can be thrown farther than with a low-volume backpack application.

through either route (*imazapyr*, 'Polaris').

Herbicides also differ in how they move in the plant, or *translocate*, after entry. This is determined by how quickly they affect the plant, and how they are transported in the plant's conductive tissues. A very fast-acting herbicide injures the plant tissue before it can be transported. This type of herbicide is often called a 'contact' herbicide – it only injures the parts of the plant it contacts. *Glufosinate* ('Finale') and *diquat* are examples of fast-acting herbicides. An herbicide that takes longer to impact the plant has a greater opportunity to translocate. Herbicides that move throughout the plant are called 'systemic'. *Glyphosate* is the classic example of a systemic herbicide, as it usually takes several days before you can observe any injury symptoms.

Behavior in the Environment

All herbicides break down into simpler molecules when they enter the environment. What varies between herbicides is how long the degradation takes (half-life), and the degree to which they can move through the soil profile. The two most practical reasons to understand how an herbicide behaves in the soil is to know what the potential is for non-target plants to be injured through root absorption of herbicide, and the possibility for an herbicide to move from the treatment site into groundwater or surface waters.

Three common herbicides demonstrate the variability of how herbicides behave in the soil and potentially impact non-target plants and water resources.

Glyphosate binds strongly to soil particles, so despite being moderately persistent and highly water-soluble, it is not available for absorption by plant roots or likely to move towards ground- or surface waters.

Triclopyr is highly water soluble and mobile in soil, as well as moderately persistent. Potential root absorption is minimized by relatively low use rates that reduce concentrations in the soil.

Prodiamine is highly persistent in the soil, but quite insoluble in water. Movement towards groundwater or surface water is unlikely, and the effects of root absorption are limited to germinating seedlings – established plants are not affected.

Application Techniques

Herbicides are most commonly applied to plant foliage as a spray, to the soil as a spray or granular application, or sprayed on woody plant stems.

Foliar

Application to target foliage is the most common treatment method. The leaves make a ready target and provide the most surface area for treatment. Effective foliar treatments are timed for when the herbicide will move through the plant and kill the growing points to prevent regrowth. For perennial plants, a foliar application should be later in the season so that the herbicide moves into the underground portions of the plant and kills the growing points. When perennial plants are treated too early, the injury is limited to the top growth and the plant resprouts from roots or rhizomes.

Foliar applications are often described as 'high volume' or 'low volume'. High volume treatments are applied as 'spray-to-wet' – completely wetting the foliage up to the point where the spray begins to drip. High volume treatments are usually applied using a motorized sprayer and a handgun to treat large or dense targets (Figure 2). Low volume treatments use as little solution as practical – the spray is visible on the foliage as discrete droplets rather than completely wetting the surface. Low volume applications are great for spot treatments using a backpack sprayer (see Figure 1).

A common foliar treatment would be a mixture of *glyphosate* plus *triclopyr*, which can be used to spot treat almost any target weed. This combination is non-selective, so the application must be directed to target weeds only to prevent injury to desirable plants.

Preemergence

Preemergence (PRE) treatments are applied to prevent the emergence of target weed seedlings. This approach is used to suppress annual weeds arising from

seed each year, such as mile-a-minute (*Persicaria perfoliata*) or Japanese stiltgrass, and is typically applied early in the season (Figure 3). A PRE application will include an herbicide that persists in the soil so that germinating seedlings are suppressed for an extended period. Additionally, the treatment may include an herbicide that will eliminate seedlings that have already emerged.

An example of a PRE treatment used in park settings is a combination of *prodiamine* plus a low rate of *imazapic* (e.g. 'Plateau'). The low rate of *imazapic* suppresses the emerged seedlings with minimal injury to existing vegetation, and *prodiamine* prevents subsequent germination.

Woody Stem Treatment

In addition to foliar application, undesirable woody plants can be suppressed by applying herbicide to their stems. Herbicides can be applied to intact stems or to cuts that expose the conductive tissue under the outer bark.

Basal Bark

Basal bark treatments are mixed in an oil-based carrier and applied to the lower (basal) portion of the stem, from the soil line up 8 to 18 inches, depending on stem diameter (Figure 4). Apply a taller band to larger stems. This treatment is an efficient way to treat stems up to 6-inches in diameter. The oil carrier helps the herbicide diffuse through the bark and enter the conductive tissue. If the treatment is applied during active growth, the herbicide will translocate through the plant. If applied during the dormant season, the injury is largely limited to the site of application, and serves to chemically girdle the stem. On many species, including most exotic shrubs, this treatment can be applied any time of year. An exception is suckering species, such as tree-of-heaven (*Ailanthus altissima*), which sprouts from its root system. This species must be treated during late-season active growth to allow the herbicide to translocate to the root system. If suckering species are treated outside of this window, only the stems are killed and the roots sprout vigorously.

Triclopyr is the most commonly used herbicide for basal bark applications. It is available as a ready-to-use product (e.g. 'Pathfinder II'), or a concentrate (e.g. 'Garlon 4 Ultra') to dilute in an oil carrier.

Cut-surface

A second way to treat woody stems is to apply herbicides to cut surfaces that expose the meristematic (*cambium*) and conductive tissue under the bark. The two basic approaches are to leave the stem standing and treat the cuts, or to cut off the stem and treat the remaining stump.

Stem treatment is distinguished between spaced cuts (hack-and-squirt, Figure 5), and a continuous cut around the trunk (frill girdle).

Hack-and-squirt: Use spaced cuts when you need the herbicide to translocate to the root system, to control suckering species such as tree-of-heaven or black locust (*Robinia pseudoacacia*). You would make this application later in the growing season. The intact conductive tissue between the cuts allows downward translocation of the herbicide.

Frill Girdle: When treating species that do not root sucker, a girdling treatment ensures that the conductive tissue at the cut is killed. During active growth, the herbicide will translocate up to the foliage as well. In the dormant season, the injury is limited to the cut site.

It is not uncommon for larger stems treated in the dormant season to persist for at least a growing season. Even though the top and the roots of the plant are separated, the roots have enough stored energy to continue to take up water and minerals, which allows the top to function normally until the roots starve and die.

Stump treatment will vary based on whether you are using water-based or oil-based treatments. When using water-soluble herbicides such as 'Rodeo' (*glyphosate)* or 'Vastlan' (*triclopyr),* you should treat as you are cutting. If you wait too long, the cut desiccates; and if done during the growing season, the plant begins to 'seal' the injury to prevent spread of decay. Both of these processes reduce the effectiveness of a water-based spray.

Figure 3. A preemergence treatment is being applied in early spring to prevent establishment of the annual weed mile-a-minute (Persicaria perfoliata). The handgun is equipped with a 'turf' nozzle that produces a showerhead-type spray.

An oil-soluble treatment, such as 'Pathfinder II' (*triclopyr*) gives you the latitude to treat anytime after cutting. If applying some time after you've cut, treat the bark of the stump to the soil line – just like a basal bark treatment. The oil mixture will diffuse through the bark and kill the cambium tissue. However, it is better to treat as you cut because it can be hard to locate previously cut stumps among the slash.

Herbicides

You can accomplish most of the vegetation management work in the park with just a few herbicides. As you expand your efforts, there are additional herbicides that provide a better solution to specific weed problems. The herbicides described here are also summarized in Table 1.

Preferred characteristics of herbicides for natural resource management include aquatic labeling, minimal soil activity, and reduced toxicity.

Primary Herbicides

The herbicides *glyphosate, triclopyr,* and *prodiamine* give you the tools to use all the application methods described so far and treat most of the vegetation issues you will encounter in a park setting.

Glyphosate

Properties: Systemic, non-selective, enters through foliage or cut-stem, no soil activity.

Uses: There are a number of nearly identical products available, but the current item on the state contract is 'Rodeo'. Use for foliar applications in terrestrial and aquatic settings, and woody stem cut surface treatments. Effect will vary with dose and timing and species, but *glyphosate* injures all plants. When mixed with *triclopyr*, the combination provides a foliar treatment that will control practically all target species with minimal risk of non-target root uptake.

Triclopyr

Properties: Systemic, selective, enters through foliage, stems, and roots, moderate soil activity.

Uses: Available in three common forms. The water-soluble concentrate (e.g. 'Vastlan') is used for foliar and woody cut-stem treatments in terrestrial and aquatic settings. It injures broadleaf plants and can be used to preserve grasses and grass-like plants. If mixed with *glyphosate* for foliar application, it is part of a broad-spectrum treatment that will control most target species. The oil-based, ready-to-use 'Pathfinder II' is applied to woody stems as a basal bark or stump treatment. The oil-soluble concentrate, (e.g. 'Garlon 4 Ultra)' can also be mixed in water for foliar applications. Mixed in an oil carrier, this product can be applied to woody stems as basal bark or stump treatment. This product does not have aquatic labeling

Figure 4. A basal bark treatment is applied to the complete circumference of the lower 8 to 18 inches of the target stem.

Prodiamine

Properties: Does not translocate, controls only germinating seedlings, enters through emerging root tip, persistent in soil.

Uses: 'ProClipse' is one of several available products. *Prodiamine* is labeled for use in turf and landscape settings, as well as selective, preemergent control of problem annual species such as mile-a-minute and Japanese stiltgrass in habitat settings. *Prodiamine* must be present in the soil when the root tip emerges from the germinating seed, or it is completely ineffective. If used alone, it needs to be applied in advance of germination. *Pendimethalin* ('Pendulum Aquacap') has historically been used in parks to control invasive annuals and was previously available on the state contract. It is nearly identical to *prodiamine* in its activity and use requirements, and is a viable equivalent.

Specialty Herbicides'

There are a number of situations where an alternate herbicide will provide an advantage over the basic herbicides described above. The following herbicides can provide significant utility in specific weed management situations.

Imazapic

The most familiar product is 'Plateau'. Used at a low rate in combination with *prodiamine, imazapic* allows

you to apply the treatment after problem annuals have emerged. *Imazapic* controls the emerged seedlings, allowing the insoluble *prodiamine* time to move into the soil and suppress subsequent germination. A second use is for weed control in native warm-season grass seedings and established plantings including big bluestem (*Andropogon gerardii)*, little bluestem *(Schizachyrium scoparia)*, and Indiangrass (*Sorghastrum nutans.)* *Imazapic* is injurious to switchgrass (*Pancium virgatum)*.

Imazapyr

The most common use of *imazapyr* ('Polaris') is against the emergent aquatic weeds phragmites (*Phragmites australis)* and narrowleaf cattail (*Typha angustifolia)*. It can be used alone or combined with *glyphosate*. At high rates it is non-selective, and has significant soil activity so it cannot be used around desirable trees and shrubs.

Sulfometuron

'Oust XP' is useful for suppressing weeds in woody species plantings, such as riparian forest buffers and habitat improvements, and it is very effective against reed canarygrass (*Phalaris arundinacea)*. *Sulfometuron* can be used at low rates around woody plants when they are dormant, or when they are protected in tree tubes, but may cause significant injury of some species if it contacts the foliage.

Quizalofop

Quizalofop is an example of a foliar-applied herbicide that only injures grasses. At low rates, it is useful for selective control of Japanese stiltgrass – broadleaf plants are not injured, and even desirable perennial grasses are relatively unscathed.

Figure 5. A late-season hack-and-squirt treatment (spaced cuts) provides control of root suckering species such as tree-of-heaven (Ailanthus altissima).

Aminopyralid and Aminocyclopyrachlor

Two additional herbicides undergoing evaluation for use in natural resource areas are *aminopyralid* and *aminocyclopyrachlor*. They are both potent broadleaf herbicides, with significant activity against problem species such as Canada thistle (*Cirsium arvense)* and crownvetch (*Securigera varia)*. Neither has aquatic labeling, but both can be used to water's edge. They both have significant soil activity and must be used with caution around desirable woody species.

Aminopyralid is available alone ('Milestone') or in a pre-mix with *triclopyr* ('Capstone'), or *metsulfuron* ('OpenSight'); while *aminocyclopyrachlor* is available as 'Method 240 SL' , and in several pre-mixes, including 'Streamline', which is also a mixture with *metsulfuron*.

An unusual and beneficial feature of both these broadleaf herbicides is that they injure Japanese stiltgrass – but typically not other grasses.

Adjuvants

Adjuvants are products added to a spray mixture that are not pesticides. The two most commonly used are surfactants and colorants. Surfactants reduce the surface tension of the spray mixture so that the droplets do not bead as much, and therefore wet more leaf area for a given droplet size. Surfactants also improve adherence to the foliage, movement into the waxy cuticle, and slow drying time. These effects are subtle, but have been clearly demonstrated over decades of use. Common types include non-ionic; methylated seed oils (MSO); and crop oil concentrates. There are many surfactant products available with aquatic labeling.

A second type of adjuvant is a colorant. Colorants make the deposition of the spray material more apparent on the target vegetation. This helps you apply the desired dose of material, as well as prevent skips and oversprays. Colorants are available for either water-based or oil-based sprays. Be certain to match the colorant to the type of mixture, or you may experience chemical incompatibility and have an unfavorable reaction between the colorant and the spray carrier.

Summary

With just a few products and the application techniques at your disposal, you can use herbicides to treat problem vegetation any time of year. Even inexperienced staff can accomplish a lot, as just a few herbicides provide you the latitude to control almost any plant species.

Table 1. Herbicides useful for natural resource management are listed by common name, product examples, and a brief summary of properties and uses. Unless indicated, herbicides used for foliar application should be mixed with a surfactant. Products available on the PA State Herbicide Contract (2017) are indicated with ''.*

Herbicide	Product Examples	Characteristics and Use
glyphosate	Rodeo* Glyphomate 41	Aquatic label, non-selective, no soil activity. Use for foliar applications, and cut woody stem treatments. Mix with *triclopyr* for a broad-spectrum foliar treatment to control perennial weeds and woody species. 'Glyphomate 41' is pre-mixed with surfactant'.
triclopyr	Vastlan* (4 lb/gallon) Garlon 3A* (3 lb/gallon)	Aquatic label, controls broadleaf weeds. Use for foliar applications and cut woody stem treatments. Mix with *glyphosate* for broad-spectrum foliar treatment to control perennial weeds and woody species.
triclopyr	Pathfinder II	Terrestrial only, ready-to-use, oil-based. Basal bark and stump treatment.
prodiamine	ProClipse, Barricade	Terrestrial only, significant soil activity. Preemergent control of annual weeds, does not injure established vegetation.
imazapic	Plateau*	Terrestrial only, some selectivity, soil activity. Use in combination with *prodiamine*, or for weed control in certain native warm-season grasses.
imazapyr	Habitat*, Polaris	Aquatic label, non-selective, soil activity. Mix with *glyphosate* for foliar treatment of perennial weeds such as phragmites and narrowleaf cattail.
quizalofop	Assure II	Terrestrial only, controls grasses. Use low rates for foliar treatment of Japanese stiltgrass to preserve forbs and desirable perennial grasses.
aminopyralid	Milestone Capstone OpenSight	Terrestrial only, control broadleaf weeds, soil activity. Foliar treatment of certain perennial weeds such as Canada thistle and crownvetch. Tank mix to expand control spectrum. Also suppresses Japanese stiltgrass.
aminocyclopyrachlor	Method 240SL*, Streamline	Terrestrial only, control broadleaf weeds, soil activity. Foliar treatment of certain perennial weeds such as Canada thistle and crownvetch. Tank mix to expand control spectrum. Also controls Japanese stiltgrass.

Prepared by:
Art Gover, Penn State University
Rachel Reese, PA DCNR, Bureau of State Parks

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DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
www.dcnr.state.pa.us