Using Hack-and-Squirt Herbicide Applications to Control Unwanted Trees

Dense understories of shade-tolerant tree species naturally develop in hardwood forests. Partial cutting practices—for example, select cuts, thinnings, or preparatory harvests for some regeneration practices—can lead to the development of shade-tolerant understory species, including red maple (Acer rubrum), American beech (Fagus grandifolia), blackgum (Nyssa sylvatica), and black birch (Betula lenta). In addition, preferential browsing by white-tailed deer favors less-desirable shade-tolerant tree species such as striped maple (Acer pensylvanicum), American beech, and eastern hop hornbeam (Ostrya virginiana). These species are increasing in abundance throughout Pennsylvania’s forests.

Dense understories of undesirable shade-tolerant trees interfere with the establishment and development of desirable regeneration such as northern red oak (Quercus rubra), white oak (Quercus alba), black cherry (Prunus serotina), and yellow poplar (Liriodendron tulipfera). Researchers have concluded that species diversity declines as shade-tolerant reproduction continues to expand. Recognizing and treating less-desirable trees prior to a planned harvest increases the proportion of desirable species in the future stand.

Removing or deadening undesirable trees is a forest management tool owners can employ to achieve their objectives. It allows the owner to favor species better suited to the site that meet future desired conditions and their objectives. The most effective method for deadening undesirable standing trees involves using an herbicide.

Hack-and-squirt, also known as frill and spray, herbicide applications offer one of the most target-specific, efficient, and economical means for controlling unwanted trees. Applications made to undesirable trees facilitate the regeneration or growth of desirable trees in mixed-species stands—for example, oak/hickory or cherry/maple. Hack-and-squirt applications are effective on various size stems and can be used on steep topography and on small ownerships. Hack-and-squirt applications are applicable in hardwood stands where mechanical broadcast spray treatments are not feasible or desirable.

What Are Hack-and-Squirt Herbicide Applications?

Hack-and-squirt herbicide applications are one of the least expensive manual herbicide application methods. This method introduces the herbicide into the stem using spaced cuts made at a convenient height, below the last live branch, around the trunk. Using a hatchet or similar device, frill cuts, or downward-angled incisions, are made evenly spaced around the stem, one per inch of diameter (two cuts minimum).

Frill cuts are approximately 2 inches long and spaced 1 to 2 inches apart. The cuts must penetrate through the bark into the living tissue or sapwood (the outer area of lighter-colored wood.
in the stem cross-section) and produce a cupping effect to hold the herbicide. Each cut is filled with herbicide using a spray bottle or gunjet herbicide gun attached to a backpack sprayer. Do not overfill. Herbicide that runs out is wasted and might impact nontarget plants. The herbicide solution is often mixed with colorants or dyes, thus allowing the applicator to see treated stems from a distance.

**When Are Hack-and-Squirt Herbicide Applications Most Effective?**

Hack-and-squirt herbicide applications are effective at any time of the year, except during heavy spring sap flow or severe drought. Research has shown that hack-and-squirt applications made during periods of heavy sap flow are largely ineffective. Do not treat when trees are solidly frozen. When hard freezes are forecasted to occur at night following application, add RV antifreeze (propylene glycol) to the spray solution according to label directions.

Note that black birch may have heavy fall sap flow, which will render autumn hack-and-squirt treatments ineffective on this species (see Figure 6). Applications to control root-suckering species such as American beech, black gum, and tree-of-heaven (*Ailanthus altissima*) are most effective from July to the onset of fall coloration.

**What Are Hack-and-Squirt Herbicide Applications Used For?**

Hack-and-squirt applications are target-specific treatments generally used to control trees that are 1 inch in diameter and greater. Stems less than 1 inch in diameter are too small to treat properly. When encountered, cut or break small stems and spray the stub with herbicide solution.

Hack-and-squirt treatments are most commonly used in hardwood forest timber stand improvement projects to deaden undesirable “cull” trees and invasive tree species, such as tree-of-heaven. These applications are often used to help establish desirable regeneration by removing low shade cast by dense understories of undesirable saplings and poles. Hack-and-squirt treatments control competition without impacting existing regeneration or desirable residual trees. It is effective for releasing crop trees in hardwood poletimber stands. In addition, hack-and-squirt can be used to create standing dead trees, called snags, to provide desirable wildlife habitat.

**Herbicides Labeled for Hack-and-Squirt Applications**

Herbicides used for hack-and-squirt applications are water-soluble systemic materials, meaning they move vertically and horizontally within the tree. Numerous products have labels for hack-and-squirt applications (Table 1).
<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Herbicide Trade Names</th>
<th>Application Equipment</th>
<th>Application Method</th>
<th>Mixture (Rate)</th>
<th>Time of Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td>2,4-D Amine, 2,4-D Amine 4, DMA 4 IVM, Frelexx, Weedeestroy AM-40</td>
<td>Tree injection or axe frill girdle and spray</td>
<td>Injector: apply 1 to 2 ml per injection spaced 1 to 2 inches at root collar; frill girdle: continuous frill at base, fill cuts with solution</td>
<td>Injector: undiluted; frill girdle: 2.5 oz per gal of water</td>
<td>Any time of year; best between May 15 and October 15</td>
</tr>
<tr>
<td>Aminopyralid</td>
<td>Milestone</td>
<td>Tree injector or axe frill girdle and spray</td>
<td>Injector: apply 1 ml per injection spaced 3 to 4 inches between wound centers; frill girdle: make continuous frill at convenient height, apply 1 ml into cuts</td>
<td>10% solution in water</td>
<td>Any season, except for periods of heavy sap flow in spring</td>
</tr>
<tr>
<td>Clopyralid</td>
<td>Clean Slate, Transline</td>
<td>Tree injection or axe frill girdle and spray</td>
<td>Apply 0.5 ml undiluted or 1 ml diluted per injection spaced 3 to 4 inches between wound centers, at convenient height; controls legumes only</td>
<td>Undiluted or diluted 1:1 with water</td>
<td>Periods of active growth</td>
</tr>
<tr>
<td>Dicamba</td>
<td>Vanquish</td>
<td>Axe frill girdle and spray or brush</td>
<td>Make continuous frill; spray or paint cut surface</td>
<td>25 to 50% solution in water</td>
<td>Any season, except during heavy sap flow in spring</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Accord XRT II, AquaNeat, Glyphosate 5.4, Razor, Razor Pro, Refuge, Rodeo, Roundup Pro</td>
<td>Injection or axe frill and spray</td>
<td>Apply 1 ml per 2 to 3 inches of trunk diameter to evenly spaced cuts or continuous frill below all live branches</td>
<td>25 to 100% (undiluted) solution in water</td>
<td>During active growth after full leaf expansion; avoid peak sap flow in spring</td>
</tr>
<tr>
<td>Hexazinone</td>
<td>Velossa, Velpar L</td>
<td>Injector or Hypo-Hatchet</td>
<td>Inject 0.8 to 1 ml at 4-inch intervals around circumference</td>
<td>Undiluted</td>
<td>Best results with summer treatments</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>Arsenal AC, Imazapyr 4 SL, Polaris AC Complete</td>
<td>Injection or axe frill and spray or brush</td>
<td>Injection: Apply 1 ml per cut, 1-inch intervals between cuts; frill: 2-inch interval between cuts, thoroughly wet cuts</td>
<td>4 to 6 oz per gal water</td>
<td>Any time of year, except during heavy sap flow in spring</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>Arsenal, Chopper Gen 2, Polaris, Polaris SP, Rotary 2 SL, Stalker</td>
<td>Injection or axe frill and spray or brush</td>
<td>Injector: Apply 1 ml per cut, 2 to 3 inches between edges of wounds; frill: 2-inch interval between cuts, spray or brush into each cut</td>
<td>8 to 12 oz per gal water</td>
<td>Any time of year, except during heavy sap flow in spring</td>
</tr>
<tr>
<td>Picloram and 2,4-D</td>
<td>Pathway (ready to use)</td>
<td>Injector or axe frill and spray or paint</td>
<td>Injector: Apply 1 ml in each cut at 2- to 3-inch intervals between wound edges; frill: overlapping single girdle around tree, wet treated areas</td>
<td>Undiluted (ready to use)</td>
<td>Any season, except during spring sap flow</td>
</tr>
<tr>
<td>Picloram and 2,4-D</td>
<td>Picloram + D, Tordon 101M, Trooper P+D (all restricted use)</td>
<td>Injection or axe frill and spray</td>
<td>Injector: Apply 0.5 ml or 1 ml diluted in each cut, 3 inches between edges; frill: single girdle completely around tree, wet surface with dilute solution</td>
<td>Undiluted or diluted 1:1 with water</td>
<td>Any season, except during heavy sap flow in spring or during periods of drought</td>
</tr>
<tr>
<td>Triclopyr (amine)</td>
<td>Garlon 3A, Tahoe 3A, Triclopyr 3, Triclopyr 3A, Vastlan</td>
<td>Injection or axe frill and spray</td>
<td>Apply 0.5 ml or 1 ml diluted at 3- to 4-inch intervals between wound centers at convenient height completely around tree</td>
<td>Undiluted or diluted 1:1 in water</td>
<td>Any season, except during periods of heavy sap flow</td>
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</tbody>
</table>
Applied Research
This section shares information from studies conducted by Penn State and the U.S. Forest Service. These studies involve hack-and-squirt herbicide treatments on four problematic species: striped maple, red maple, black birch, and American beech. The objective of these studies was to develop recommendations for time of year, rates, and active ingredients effective at controlling these species.

Methods: Controlling Striped Maple, Red Maple, and Black Birch Using Hack-and-Squirt Herbicide Applications
These four studies examined the effectiveness of glyphosate as Accord Concentrate (53.8 percent), Accord XRT II (50.2 percent), and Glypro Plus (41 percent); imazapyr as Polaris AC (53.1 percent) and Arsenal (28.7 percent); and triclopyr as Garlon 3A (44.4 percent) at controlling striped maple, red maple, and black birch using hack-and-squirt applications.

For back birch and red maple, hack-and-squirt herbicide applications were made in February, April, June, August, October, and December. For striped maple, hack-and-squirt applications were made only in June and September. Treatments were randomly distributed over the various months. One incision per inch of diameter was made using a hatchet with a bit ground to a 1.75-inch width (see bottom photo on page 2). A plastic spray bottle was used to dispense the herbicide solution. Herbicide solution was applied to each frill incision until full.

Each study site was evaluated one year following treatment. A numerical rating system based on the percentage of the crown controlled—complete control (100 percent) to no control (0 percent)—was used to evaluate treatment effectiveness.

Caution
Herbicides can potentially kill or injure nearby trees through root grafts. Restricting treatments to tree species different from desirable crop trees will minimize this concern. Herbicides containing glyphosate (e.g., Rodeo) and imazapyr (e.g., Arsenal AC) are more prone to movement through functional root grafts than herbicides containing triclopyr (e.g., Garlon 3A and Vastlan). Triclopyr does not translocate well in plants and will not impact nearby trees of the same species. When using herbicides containing the active ingredients imazapyr or glyphosate, recommendations are to leave a 10-foot buffer between crop trees and treated trees of the same species.
**Striped Maple Control Using Hack-and-Squirt Treatments**  
*J. Kochenderfer, U.S. Forest Service*

This study evaluated the effectiveness of Glypro Plus (41 percent glyphosate) and Arsenal (28.7 percent imazapyr) applied using manual hack-and-squirt applications two times of year, June and September, for controlling (top kill and basal sprouting) striped maple. Herbicide applications were made to frill cuts based on one incision per inch (minimum of two incisions) of diameter measured at breast height (DBH).

**Location:** Central West Virginia  
**Average diameter:** 1.8 inches DBH  
**Four herbicide solutions:**  
- 50 percent Glypro Plus (glyphosate)  
- 100 percent Glypro Plus (glyphosate)  
- 6 percent Arsenal (imazapyr)  
- 9 percent Arsenal (imazapyr)  
**Time of year:** Two applications—September 2004 and June 2005  
**Results collected:** September 2005 and June 2006

**Results and discussion:** When applied in June or September the hack-and-squirt treatments controlled 100 percent of the striped maple stems (Figure 1). No basal sprouting was observed on stems treated with Arsenal (imazapyr) (Figure 2). Some basal sprouting occurred on stems treated with Glypro Plus (glyphosate). Basal sprouting was highest on stems treated in June using the lowest concentrations of Glypro Plus. Striped maple treated with glyphosate herbicides is prone to resprouting.

These results are consistent with studies on the efficacy of foliar glyphosate applications on striped maple, which found control is lower in June than in late summer. They also observed that lower application rates were more sensitive to application timing. To control striped maple, the 6 percent Arsenal (imazapyr) treatment is recommend—the lower rate reduces application cost and the amount of herbicide used.

**Red Maple Control Using Hack-and-Squirt Treatments (Treating Stems Only)**  
*D. Jackson, Penn State*

This study evaluated the effectiveness of Accord Concentrate (53.8 percent glyphosate), Garlon 3A (44.4 percent triclopyr), and Polaris AC (53.1 percent imazapyr) applied using manual hack-and-squirt for controlling (top kill and basal sprouting) red maple saplings and poles with both dormant and growing-season applications. Herbicide applications were made to frill cuts at the rate of one incision per inch (minimum of two incisions) of diameter measured at DBH.

**Location:** Central Pennsylvania  
**Range of red maple sizes:** 1.7 to 6 inches DBH  
**Four herbicide solutions:**  
- 50 percent Accord Concentrate (glyphosate)  
- 50 percent Garlon 3A (triclopyr)
For difficult-to-control species, like red maple, black gum, and hickory (*Carya* spp.), the U.S. Forest Service recommends treating additional incisions at the base near the root collar. This will increase herbicide efficacy. The next study, highlighted below, examined the effectiveness of treating additional incisions on red maple root flares to control basal sprouting.

- 5 percent Polaris AC (imazapyr)
- 50 percent Accord Concentrate and 5 percent Polaris AC

**Time of year:** Six applications—June, August, October, and December 2015; February and April 2016

**Results collected:** June 2018

**Results and discussion:** All hack-and-squirt treatments outside the spring sap-flow window, February to April, resulted in 100 percent top kill of red maple saplings and poles (Figure 3). With the exception of Polaris AC and Polaris AC/Accord Concentrate solutions applied in June (Figure 4), basal sprouting was observed at some level for all other herbicide active ingredients and treatment months. Basal sprouting was highest for applications made during spring sap flow. Basal sprouting remained consistent throughout the remainder of the year for all herbicides studied, ranging from 10 to 50 percent.

If basal sprouting is unacceptable, only a very small window is available for treatment. In areas with high deer browse impact this may not be a concern as sprouts will likely experience heavy browsing. If red maple basal sprouting is undesirable, follow-up foliar treatments are likely necessary to achieve full control.
Red Maple Control Using Hack-and-Squirt Treatments (Treating Stems and Root Flares)

This study evaluated the effectiveness of Accord XRT II (50.2 percent glyphosate) and Polaris AC (53.1 percent imazapyr) applied using manual hack-and-squirt applications to stems and root flares for controlling red maple basal sprouting. Herbicide applications were made to frill cuts at the rate of one incision per inch (minimum of two incisions) of diameter measured at DBH as well as to an equal number of frill cuts made to root flares.

Location: Central Pennsylvania
Range of red maple sizes: 0.7 to 5.8 inches DBH
Three herbicide solutions:
• 50 percent Accord XRT II (glyphosate)
• 5 percent Polaris AC (imazapyr)
• 50 percent Accord XRT II and 5 percent Polaris AC
Time of year: Five applications—July, August, September, October, and November 2017
Results collected: September 2018
Results and discussion: The results showed that once again 100 percent top kill is achieved on red maple using hack-and-squirt treatments applied July through November (results not shown). No basal sprouting was observed on stems treated with Accord XRT II (glyphosate), Polaris AC (imazapyr), or a combination of both Accord XRT II and Polaris AC when applied July through October (Figure 5). In addition, no basal sprouting occurred with November hack-and-squirt treatments made with Polaris AC.

These results are consistent with U.S. Forest Service recommendations for adding a few additional incisions and treating root flares to control difficult species, like red maple. Hack-and-squirting root flares, in addition to the stems, during periods of active growth is effective with both glyphosate and imazapyr herbicides at preventing basal sprouting.

Black Birch Control Using Hack-and-Squirt Treatments

D. Jackson, Penn State

This study evaluated the effectiveness of Accord Conc. (53.8 percent glyphosate), Garlon 3A (44.4 percent triclopyr), and Polaris AC (53.1 percent imazapyr) applied using manual hack-and-squirt applications for controlling black birch with both dormant and growing-season applications. Herbicide applications were made to frill cuts at the rate of one incision per inch (minimum of two incisions) of diameter measured at DBH.

Location: Central Pennsylvania
Range of black birch sizes: 2 to 14 inches DBH
Three herbicide solutions:
• 50 percent Accord Concentrate (glyphosate)
• 50 percent Garlon 3A (triclopyr)
• 5 percent Polaris AC (imazapyr)
Time of year: Six applications—October and December 2012; February, April, June, and August 2013
Results collected: August 2014

![Figure 5. Red maple basal sprouting percent.](image)
Results and discussion: With the exception of two sap-flow periods, April and October, all other times and active ingredients studied provided significant control of black birch saplings and poles (Figure 6). Spring and fall sap flows are especially prevalent in black birch. Hack-and-squirt applications during periods of sap flow are ineffective. The 50 percent Accord Concentrate (glyphosate) solution provided 100 percent control during February, June, August, and December. Limiting application time to periods outside sap-flow windows is extremely effective at controlling black birch. No basal sprouting was observed with any treatments.

Methods: Controlling American Beech Using Hack-and-Squirt Herbicide Applications

D. Jackson, Penn State

The objective was to determine the effectiveness of glyphosate as Rodeo (53.8 percent) and imazapyr as Polaris AC (53.1 percent) using manual hack-and-squirt applications for controlling American beech root suckers.

All treatments were made on ¼-acre plots where numerous beech stems of various sizes occurred, from 1 foot tall to large sawtimber. Two herbicides and two diameter treatment limits were evaluated: all trees above 4 inches and all trees above 10 inches in diameter were treated on separate plots using the hack-and-squirt method. Each treatment was replicated four times. A hatchet with a ground-down bit 1.75 inches wide was used to make one incision per inch of DBH. A plastic spray bottle was used to dispense the herbicide solution. Material was sprayed into each frill cut until full.

A nested ¼-acre plot was located at plot center. Within this plot all live beech stems 1 foot tall and less than the treated diameter, 4 inches or 10 inches, were tallied prior to treatment. To summarize results, stem counts were recorded for all beech as follows: over 1 foot to 3 feet, over 3 feet to 6 feet, over 6 feet to 1 inch DBH, and over 1 inch DBH. All plots were evaluated 12 months after treatment.

Location: Northcentral Pennsylvania

Two size classes treated:
• All beech stems over 4 inches DBH
• All beech stems over 10 inches DBH

Two herbicide solutions:
• 50 percent Rodeo (glyphosate)
• 5 percent Polaris AC (imazapyr)

Time of year: Mid-September 2013

Results collected: September 2014

Results and discussion: Both herbicide active ingredients, glyphosate and imazapyr, were effective at controlling treated overstory trees (Table 2). A 50 percent solution of Rodeo (53.8...
percent glyphosate) applied by hack-and-squirt at the rate of one incision per inch of diameter provided 100 percent control of all treated overstory trees. The 5 percent solution of Polaris AC (53.1 percent imazapyr) provided sufficient control (83 to 93 percent) (Table 2). Herbicide response with imazapyr is slower; complete effectiveness often does not show until the second growing season following treatment.

The number of root sprouts controlled by hack-and-squirt ing parent beech trees with herbicides containing the active ingredients glyphosate and imazapyr is significant. This study showed that nearly 60 percent of all beech root sprouts up to 6 feet tall are controlled by treating all parent trees 4 inches in diameter and larger with Rodeo (Table 3). Polaris AC was not as effective as Rodeo, achieving 55 percent control on suckers less than 6 feet tall when treating all parent trees 4 inches in diameter and larger.

A large drop in the number of root suckers controlled was observed in the larger size classes (Table 3). Two treatments, Rodeo 4” and Polaris AC 10”, controlled no stems greater than 1 inch in diameter. Even the best treatment, Rodeo 10”, only achieved 20 percent control of stems greater than 1 inch in diameter. The large dropoff observed is likely explained by the large amount of herbicide required to control the parent tree. Said another way, little herbicide is left to translocate through the root system to control sprouts, especially larger sprouts.

These results are comparable to a U.S. Forest Service study conducted by Kochenderfer et al. (2004) where about half of
cide applications provide seasonal flexibility, with effective year-round treatments, except for periods of heavy spring sap flow (and fall for black birch). Treatments are most effective June 1 to November 1 and when stems are not frozen. The herbicides reviewed in this publication are nonrestricted in Pennsylvania, meaning forest landowners can purchase these products and apply them to their own properties without certification.

Hack-and-squirt treatments effectively control a wide range of species, including striped maple, red maple, black birch, and American beech. Concentrated glyphosate herbicides diluted 50 percent with water are particularly effective at controlling black birch and American beech. Some species, particularly maples, are prone to basal sprouting following hack-and-squirt treatments with glyphosate herbicides. Additional incisions made to root flares are effective at preventing basal sprouting in difficult-to-control species, like red maple. Herbicides containing the active ingredient imazapyr (e.g., Arsenal AC and Polaris AC) are effective at controlling striped maple.

Traditional understory treatments of beech and striped maple have used mechanized (skidder-mounted) mist blowers or a combination of mist blowers and basal bark applications. Mist-blower applications are nonselective and treat all understory vegetation. This may be appropriate in some instances where desirable vegetation is absent. For a more selective

Conclusions and Management Implications

Hack-and-squirt herbicide applications allow for targeted, selective vegetation control with little danger of off-site and nontarget species damage. They are effective at controlling trees 1 inch in diameter and greater. Hack-and-squirt herbicide applications provide seasonal flexibility, with effective year-round treatments, except for periods of heavy spring sap flow (and fall for black birch). Treatments are most effective June 1 to November 1 and when stems are not frozen. The herbicides reviewed in this publication are nonrestricted in Pennsylvania, meaning forest landowners can purchase these products and apply them to their own properties without certification.

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application, consider hack-and-squirt treatments. Applications made to parent beech trees 6 inches and larger will effectively control about half the existing beech stems less than 1 inch in diameter.

Hack-and-squirt herbicide applications offer one of the safest, most efficient, target-specific, and least expensive means of eliminating unwanted tree species. The herbicides used are nonrestricted and control a wide range of common species. The method is applicable for use on steep topography and small ownerships. It provides a flexible tool landowners and managers can use to accomplish a variety of vegetation management objectives over a wide range of forest types.