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Manual Herbicide Application Methods for Managing Vegetation in Appalachian Hardwood Forests

**Jeffrey D. Kochenderfer
James N. Kochenderfer
Gary W. Miller**





Stem injection



Foliar spray



Basal spray



Cut-stump treatment

SECTION I: STEM INJECTION SUMMARY

- Use 38-percent solution of Accord® Concentrate in a water carrier.
- Use 50-percent solution of Garlon® 3A, Roundup Pro®, Glyphomate®, or Razor® Pro in a water carrier.
- Use 6-percent solution of Arsenal® or 3-percent solution of Arsenal® AC in a water carrier.
- Arsenal® herbicide is very effective on maple (*Acer* spp.).
- Make one incision per inch of diameter at breast height (d.b.h.) spaced evenly around the stems.
- Apply 1.5 milliliters (ml) (0.05 oz.) of solution per incision.
- Treatment is applicable to stems ≥ 1.0 inch d.b.h.
- The “cut stub” treatment (Figure 14) is very effective on stems smaller than 1.0 inch d.b.h.
- Treatment is best applied from June 1 to November 1.
- Do not apply during periods of heavy sap flow (February through May).
- Treatment costs \$50-\$75 per acre (chemical and labor).

Table 1.—How to prepare various herbicide solutions for stem injection vegetation control treatments

Desired herbicide solution concentration	Chemical name (percent active ingredient)	Herbicide component	Carrier component	All Components ^a	Reference
38-percent Accord® Concentrate	Glyphosate (53.8-percent a.i.)	1,438 ml (49 oz.) chemical	2,347 ml (79 oz.) water	3,785 ml or 1 gallon	Figure 7
50-percent Roundup Pro®	Glyphosate (41.0-percent a.i.)	1,893 ml (64 oz.) chemical	1,892 ml (64 oz.) water	3,785 ml or 1 gallon	Figure 6
50-percent Glyphomate®	Glyphosate (41.0-percent a.i.)	1,893 ml (64 oz.) chemical	1,892 ml (64 oz.) water	3,785 ml or 1 gallon	Figure 5
50-percent Razor® Pro	Glyphosate (41.0-percent a.i.)	1,893 ml (64 oz.) chemical	1,892 ml (64 oz.) water	3,785 ml or 1 gallon	Figures 4, 9, 12
50-percent Garlon® 3A	Triclopyr (44.4-percent a.i.)	1,893 ml (64 oz.) chemical	1,892 ml (64 oz.) water	3,785 ml or 1 gallon	Figure 8
6-percent Arsenal®	Imazapyr (28.7-percent a.i.)	227 ml (8 oz.) chemical	3,558 ml (120 oz.) water	3,785 ml or 1 gallon	Figures 10, 11
3-percent Arsenal® AC	Imazapyr (53.1-percent a.i.)	114 ml (4 oz.) chemical	3,671 ml (124 oz.) water	3,785 ml or 1 gallon	Figures 10, 11, 13

^a Agitate well.



Figure 3.—Applying herbicide to incision. To make a good incision, chop through the bark into the wood at an angle to make a cuplike incision; then bend the hatchet head down by twisting your arm to open the incision. Leaving the hatchet blade in the incision, squirt herbicide directly into the incision. Do not overfill incisions because any herbicide that runs out is wasted and might impact nontarget plants. When defective incisions will not hold herbicide, make additional incisions next to them. In difficult-to-control species like black gum (*Nyssa sylvatica* Marsh), hickory (*Carya* spp.), red maple (*Acer rubrum* L.), and large cull trees, space incisions closer or add a few incisions at the base of the tree where large roots are attached to the trunk to increase efficacy.



James N. Kochenderfer, U.S. Forest Service (ret.)

Figure 4.—An applicator injecting a cull tree using a hatchet with a ground-down bit and a spray bottle with a 50-percent solution of Razor® Pro herbicide in a water carrier. This tree injection method is called hack-and-squirt. It is usually considered one of the cheapest manual application methods. Use 1.5 milliliters (ml) of solution per inch of tree d.b.h. in incisions spaced evenly around the tree. Spray bottles do not all spray the same amount per pull, but they can be readily calibrated. Fill the spray bottle with water and use a complete pull to squirt 10 times into a graduated cylinder and then determine the average volume dispensed with each complete pull. The spray bottle shown here dispenses 2.8 ml per complete pull, so it requires about one-half pull per incision.



Figure 8.—Tree injection in a yellow-poplar (*Liriodendron tulipifera* L.) stand using a 50-percent solution of Garlon® 3A in a water carrier to release a yellow-poplar crop tree from other competing yellow-poplar trees. Since functional root grafts are often formed between roots of the same species, Garlon® 3A was used because triclopyr, the active ingredient, is not translocated well in plants and will not impact nearby yellow-poplar trees. However, injecting competing trees attached to the same stump as crop trees is not recommended. A 5-foot buffer between crop trees and treated trees of the same species is recommended with use of glyphosate herbicides, the most commonly used herbicides in crop tree release operations. Arsenal® AC is not recommended for crop tree release operations because damage can occur to nontarget plants. Imazapyr, the active ingredient, exhibits soil activity and can be absorbed by the roots of nontarget plants. However, reduced concentrations of Arsenal® (Figure 10) can be used to inject scattered cull trees and small understory trees of species different from nearby desirable trees.



Figure 9.—Basal sprouts on a top-killed striped maple (*Acer pensylvanicum* L.) that had been injected with a 50-percent solution of Razor[®] Pro. Some trees, especially maples, are prone to resprouting after being injected with glyphosate herbicides.

SECTION II: BASAL SPRAY SUMMARY

- Use 10- to 20-percent mixture of Garlon[®] 4 in an oil carrier (10-percent mixture on thin-bark species).
- See herbicide label for recommended oil carriers.
- Spray completely around stems 12-15 inches above groundline to point of runoff.
- Treatment is applicable to stems <6.0 inches d.b.h. and treatments involving <1,000 stems per acre.
- Apply any time of the year stems are dry.
- Treatment costs \$80-\$125 per acre depending on the number of stems treated (chemical and labor).

Table 2.—How to prepare various herbicide solutions for basal spray vegetation control treatments

Desired herbicide solution concentration	Chemical name (percent active ingredient)	Herbicide component	Carrier component	All components	Reference
10-percent Garlon® 4 Ultra	Triclopyr (60.5-percent a.i.)	379 ml (13 oz.) chemical	3,406 ml (115 oz.) oil	3,785 ml or 1 gallon	Figures 15, 16, 17, 18
20-percent Garlon® 4 Ultra	Triclopyr (60.5-percent a.i.)	757 ml (26 oz.) chemical	3,028 ml (102 oz.) oil	3,785 ml or 1 gallon	



Figure 15.—Basal bark spraying small beech stems 12-15 inches above the groundline using a backpack sprayer with a 10-percent mixture of Garlon® 4 and oil. Target stems must be dry, free of snow to the groundline, and completely wetted on all sides with the spray mixture. Basal spraying is a very effective treatment on small stems <6 inches d.b.h., but it can require carrying large volumes of solution on steep topography and it normally costs more than tree injection treatments. Basal spraying is especially adapted for treating relatively low numbers of small, thin-bark species like beech and striped maple because they require less spray, and lower concentrations of spray (10-percent Garlon® 4) are effective.

SECTION III: CUT-STUMP TREATMENT SUMMARY

- Use 50- to 100-percent glyphosate herbicide product in a water carrier.
- Use 3-percent Arsenal® AC or 6-percent Arsenal® in a water carrier.
- Treat stumps as soon as possible after cutting, although treatment can be effective on beech in the central Appalachians up to 4 days after cutting.
- Spray outer 2 inches of stump surface.
- Treatment is effective on all sizes of stumps.
- Root sprout mortality is greater around larger stumps.
- Do not use this treatment when stumps and nearby desirable trees are the same species.
- Treatment is best applied from June 1 to November 1.
- Do not apply during heavy sap flow (February through May).
- Treatment costs \$40-\$60 per acre (chemical and labor).

Table 3.—How to prepare various herbicide solutions for cut-stump vegetation control treatments

Desired herbicide solution concentration	Chemical name (percent active ingredient)	Herbicide component	Carrier component	All components	Reference
50-percent Roundup Pro®	Glyphosate (41.0-percent a.i.)	1,893 ml (64 oz.) chemical	1,892 ml (64 oz.) water	3,785 ml or 1 gallon	Figures 26, 28, 30
50-percent Glyphomate® 41	Glyphosate (41.0-percent a.i.)	1,893 ml (64 oz.) chemical	1,892 ml (64 oz.) water	3,785 ml or 1 gallon	Figures 27, 28, 30
50-percent Razor® Pro	Glyphosate (41.0-percent a.i.)	1,893 ml (64 oz.) chemical	1,892 ml (64 oz.) water	3,785 ml or 1 gallon	Figures 21, 22, 28, 30
6-percent Arsenal®	Imazapyr (28.7-percent a.i.)	227 ml (8 oz.) chemical	3,558 ml (120 oz.) water	3,785 ml or 1 gallon	Figure 30
3-percent Arsenal® AC	Imazapyr (53.1-percent a.i.)	114 ml (4 oz.) chemical	3,671 ml (124 oz.) water	3,785 ml or 1 gallon	Figure 30
10-percent Garlon® 4 Ultra	Triclopyr (60.5-percent a.i.)	379 ml (13 oz.) chemical	3,406 ml (115 oz.) oil	3,785 ml or 1 gallon	Figure 29



Figure 21.—Applying the cut-stump treatment to a freshly cut beech stump using a 50-percent solution of Razor® Pro in a water carrier. Brush the sawdust from the stumps before treatment. Using a glyphosate herbicide that contains a surfactant or adding a nonionic surfactant is often recommended to increase penetration. It is necessary to wet only the outer 2 inches around larger stump surfaces; the entire surface of small stumps is treated.



Figure 22.—Applying the cut-stump treatment using a spray bottle to dispense herbicide on a freshly cut beech stump. Although it is usually recommended that this treatment be applied to stump surfaces as quickly as possible after cutting, recent research indicates that waiting up to 4 days after partial cutting before treating beech stumps with a 50-percent solution of Razor[®] Pro in a water carrier did not significantly reduce root sprout or stump sprout efficacy in a partially cut Appalachian stand.



James N. Kochenderfer, U.S. Forest Service (ret.)

Figure 23.—Stumps after treatment with a glyphosate herbicide. They turn yellow within 1 hour after treatment.



James N. Kochenderfer, U.S. Forest Service (ret.)

Figure 24.—Beech stumps treated with a glyphosate herbicide containing dye. Using a dye recommended for use with glyphosate to enhance the coloration, makes it easier to keep track of treated stumps. It is necessary to wet only a 2-inch band encompassing the cambium layer on larger stumps while the entire surface of smaller stumps is sprayed.



Figure 27.—Northern red oak seedlings being planted in the spring among beech stumps that were treated the previous fall with a cut-stump treatment using a 50-percent solution of Glyphomate® herbicide in a water carrier.

SECTION IV: FOLIAR SPRAY SUMMARY

- Use 1-percent or 2-percent solution of a glyphosate product that contains a surfactant, or add a surfactant.
- Use 1-percent or 2-percent solution of Arsenal® AC and add a surfactant.
- Use 2-percent solution of Arsenal® and add a surfactant.
- See herbicide label for recommended surfactants.
- Use minimum sprayer pressure to control drift.
- Mix with clean water.
- Treatment is applicable to target stems less than 6 feet tall.
- Completely wet foliage.
- Apply during rain-free periods.
- Best results are obtained in late summer while foliage is still green.
- Add Oust® (sulfometuron-methyl) for better control of herbaceous weeds and grass.
- Treatment costs \$150-\$200 per acre (chemical and labor).

Table 4.—How to prepare various herbicide solutions for foliar spray vegetation control treatments

Desired herbicide solution concentration	Chemical name (percent active ingredient)	Herbicide component	Carrier component	Other component	All components	Reference
2-percent Glyphomate® 41 (weeds, brush, fern and grass)	Glyphosate (41.0-percent a.i.)	76 ml (3 oz.) chemical	3,709 ml (125 oz.) water	0.08 oz. Oust® XP ^a	3,785 ml or 1 gallon	Figure 31
2-percent Razor® Pro (weeds, brush, fern and grass)	Glyphosate (41.0-percent a.i.)	76 ml (3 oz.) chemical	3,709 ml (125 oz.) water	0.08 oz. Oust® XP ^a	3,785 ml or 1 gallon	Figure 33
2-percent Accord® Concentrate (weeds, brush, fern and grass)	Glyphosate (53.8-percent a.i.)	76 ml (3 oz.) chemical	3,709 ml (125 oz.) water	19 ml (0.6 oz.) surfactant	3,785 ml or 1 gallon	Figure 32
2-percent Glyphomate® 41 (weeds, brush, fern and grass)	Glyphosate (41.0-percent a.i.)	76 ml (3 oz.) chemical	3,709 ml (125 oz.) water		3,785 ml or 1 gallon	
2-percent Arsenal® AC (weeds, brush)	Imazapyr (53.1-percent a.i.)	76 ml (3 oz.) chemical	3,709 ml (125 oz.) water	19 ml (0.6 oz.) surfactant	3,785 ml or 1 gallon	Figure 35
3-percent Garlon® 4 Ultra (<i>Rhododendron</i> and <i>Kalmia</i> species)	Triclopyr (60.5-percent a.i.)	114 ml (4 oz.) chemical	3,671 ml (124 oz.) water	19 ml (0.6 oz.) Cide-Kick® II ^b	3,785 ml or 1 gallon	Figure 34
5-percent Garlon® 4 Ultra (Dense <i>Rhododendron</i> and <i>Kalmia</i> species)	Triclopyr (60.5-percent a.i.)	189 ml (7 oz.) chemical	3,596 ml (121 oz.) water	19 ml (0.6 oz.) Cide-Kick® II ^b	3,785 ml or 1 gallon	Figure 34

^aOust® XP as sulfometuron-methyl (75-percent a.i.)

^bSpray adjuvant



Figure 31.—Tubed northern red oak seedlings planted on the edge of a skidroad with a heavy grass cover. A backpack sprayer was used to spray a 3-foot radius circle around the seedlings. A spray mixture containing a 2-percent solution of Glyphosate®, which contained a surfactant and the equivalent of 2 ounces of Oust® XP (sulfometuron-methyl) per acre (approximately 0.25 oz. per 3 gallons of solution), in a water carrier was used. Including Oust® XP in the spray mixture adds longevity to the treatment because Oust® XP has preemergent activity that helps prevent grass and herbaceous seeds from germinating.



James N. Kochenderfer, U.S. Forest Service (ret.)

Figure 32.—Using a backpack sprayer and minimum pressure with a 2-percent solution of Accord® Concentrate and 0.5-percent nonionic surfactant in a water carrier to spray around a seedling protected with a section of 10-inch stovepipe, equipped with a cover and handle. Foliar sprays with glyphosate herbicides are more effective later in the growing season. This same solution can also be used to prepare planting sites by spraying small circular spots of groundcover in August or September to control competition prior to spring planting.



Figure 35.—Direct spraying a clump of autumn olive using a backpack sprayer to thoroughly wet leaves to the point of runoff (but not causing runoff) with a 2-percent solution of Arsenal® AC plus 0.5 percent by volume nonionic surfactant in a water carrier. Nonnative invasive plants are especially difficult to control; thus follow-up treatments will probably be necessary. Since Arsenal® AC has soil activity, avoid treating areas where the roots from desirable plants are present. It is difficult to foliar spray vegetation taller than 6 feet with a backpack sprayer. Foliar spraying tall vegetation increases the possibility of drift, which can damage nontarget vegetation.

APPENDIX

Herbicide Solution Concentration Comparisons

Herbicide products are sold in a variety of concentrations of active ingredients (a.i.). For example, undiluted Glyphomate® is sold as 41.0-percent a.i. (glyphosate), while undiluted Accord® Concentrate is sold as 53.8-percent a.i (glyphosate). Use the following procedure to determine the equivalent herbicide solution mixture when changing from a familiar herbicide product and a standard solution mixture to a different herbicide product with a different concentration of active ingredient. In this example, assume you have been using a 50-percent standard mixture of Glyphomate® and you wish to change to an equivalent mixture of Accord® Concentrate.

Step 1: Assemble information about the familiar herbicide product, the desired standard solution mixture, and the mixing instructions.

Familiar herbicide product: Glyphomate® 41.0 percent-a.i. (glyphosate)

Standard solution mixture: 50 percent

Per-gallon (128 ounces) mixing instructions: Add 64 ounces (50 percent of 1 gallon) of

Glyphomate® to 64 ounces of water for a total of 128 ounces or 1 gallon.

Step 2: Compute the equivalent concentration of the new or unfamiliar herbicide product and the new mixing instructions.

$$\frac{\text{Familiar herbicide} \times \text{Standard solution mixture}}{\text{New herbicide}} = \text{Equivalent concentration}$$

$$\frac{\text{Glyphomate}^{\circledR} \text{ 41.0-percent a.i. (glyphosate)}}{\text{Accord}^{\circledR} \text{ Concentrate 53.8-percent a.i. (glyphosate)}} \times 50 \text{ percent} = 38.1 \text{ percent}$$

A 38.1 percent solution of Accord[®] Concentrate is equivalent to a 50-percent solution of Glyphomate[®].

Per-gallon (128 ounces) mixing instructions: Add 49 ounces (38.1 percent of 1 gallon) of Accord[®] Concentrate to 79 ounces of water for a total of 128 ounces or 1 gallon.

Herbicide Solution Cost Comparisons

Often there are large differences in cost for undiluted forms of herbicides. The important point to consider is the cost of the herbicide solution that will be applied for a given treatment. The following example is a comparison of stem injection solution costs (\$ per gallon) for a 3-percent solution of Arsenal® AC and a 50-percent solution of Glyphomate®.

To calculate the cost per gallon for a 3-percent solution of Arsenal® AC:

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Assume Arsenal® AC costs \$150 per gallon.

1 gallon = 3,785 milliliters (ml)

$$\frac{\$150}{1 \text{ gal}} \times \frac{1 \text{ gal}}{3,785 \text{ ml}} = \$0.0396 \text{ per ml}$$

1 gallon of a 3-percent solution of Arsenal® AC contains 114 ml (0.03 x 1 gal x

$$\frac{3,785 \text{ ml}}{1 \text{ gal}}) \text{ of the herbicide.}$$

$$\text{Cost per gallon for a 3-percent solution of Arsenal® AC} = \frac{\$0.0396}{1 \text{ ml}} \times 114 \text{ ml} = \$4.51 \text{ per gallon}$$

To calculate the cost per gallon for a 50-percent solution of Glyphomate®:

Assume Glyphomate® costs \$26 per gallon.

$$1 \text{ gallon} = 3,785 \text{ ml}$$

$$\frac{\$26}{1 \text{ gal}} \times \frac{1 \text{ gal}}{3,785 \text{ ml}} = \$0.0069 \text{ per ml}$$

1 gallon of a 50-percent solution of Glyphomate® contains 1,893 ml (0.50 x 1 gal x $\frac{3,785 \text{ ml}}{1 \text{ gal}}$) of the herbicide.

$$\text{Cost per gallon for a 50-percent solution of Glyphomate®} = \frac{\$0.0069}{1 \text{ ml}} \times 1,893 \text{ ml} = \$13.06 \text{ per gallon}$$

Table 6.—Summary of herbicide information

Herbicide	EPA Reg. No.	Active ingredient (%)	Herbicide cost ^c (\$)	Treatment	Soil activity	Carrier	Solution conc. (%)
Accord [®] Concentrate (glyphosate) ^a	62719-324	53.8	\$23/gal.	Foliar ^d spray, stem injection, cut-stump	No	Water	2-100
Razor [®] Pro ^b (glyphosate)	228-366	41.0	\$17/gal.	Foliar spray, stem injection, cut-stump	No	Water	2-100
Roundup Pro ^{®b} (glyphosate)	524-475	41.0	\$50/gal.	Foliar spray, stem injection, cut-stump	No	Water	2-100
Glyphomate [®] 41 ^b (glyphosate)	2217-847	41.0	\$26/gal.	Foliar spray, stem injection, cut-stump	No	Water	2-100
Garlon [®] 3A (triclopyr)	62719-37	44.4	\$72/gal.	Stem injection, cut-stump	No	Water	50-100
Garlon [®] 4 Ultra (triclopyr)	62719-527	60.5	\$91/gal.	Foliar and basal spray	No	Water-Oil	3-20
Arsenal [®] (imazapyr)	241-346	28.7	\$119/gal.	Foliar ^d spray, stem injection, cut-stump	Yes	Water	2-6
Arsenal [®] AC (imazapyr)	241-299	53.1	\$150/gal.	Foliar ^d spray, stem injection, cut-stump	Yes	Water	1-3
Oust [®] XP (Sulfometuron-methyl)	352-601	75.0	\$83/lb.	Foliar	Yes	Water	2-5 oz./ac.

^aTrade name and (common active-ingredient name)

^bContains surfactant

^cAverage costs obtained from herbicide distributors in 2010

^dRequires nonionic surfactant

Labels can be downloaded at <http://www.cdms.net>
PLEASE READ AND FOLLOW THE LABEL.