# COMMONWEALTH OF PENNSYLVANIA
## DEPARTMENT OF TRANSPORTATION

**PENNDOT RESEARCH**

PENNDOT

# ROADSIDE VEGETATION MANAGEMENT RESEARCH REPORT 2008 REPORT

## FINAL REPORT


**Intergovernmental Agreement**
**Research Agreement No. 510602, PSU005**

**April 7, 2008**



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PENNSTATE

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**Technical Report Documentation Page**

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|---|---|---|
| **1. Report No.**<br>PA-2008-003-PSU 005 | **2. Government Accession No.** | **3. Recipient's Catalog No.** |
| **4. Title and Subtitle**<br>Roadside Vegetation Management Research – 2008 Report | | **5. Report Date**<br>April 7, 2008<br>**6. Performing Organization Code** |
| **7. Author(s)**<br>Art Gover, Jon Johnson, Kirsten Lloyd and Jim Sellmer | | **8. Performing Organization Report No.**<br>PA-4620-08-01 / LTI 2008-09 |
| **9. Performing Organization Name and Address**<br>The Pennsylvania State University, College of Agricultural Sciences<br>via The Thomas D. Larson Pennsylvania Transportation Institute<br>201 Transportation Research Building<br>University Park, PA 16802-4710 | | **10. Work Unit No. (TRAIS)**<br>**11. Contract or Grant No.**<br>510602, PSU 005 |
| **12. Sponsoring Agency Name and Address**<br>The Pennsylvania Department of Transportation<br>Bureau of Planning and Research<br>Commonwealth Keystone Building<br>400 North Street, 6th Floor<br>Harrisburg, PA 17120-0064 | | **13. Type of Report and Period Covered**<br>Final Report: May 14, 2007 – May 13, 2008<br>**14. Sponsoring Agency Code** |
| **15. Supplementary Notes**<br>Research Project – 4620<br>Project Management – Joe Demko – Bureau of Maintenance and Operations, Office of Roadside Development | | |

**16. Abstract**

This report details a cooperative research project performed for the Pennsylvania Department of Transportation's Bureau of Maintenance and Operations by Penn State. The report includes the following: Basal Timing Study on Mixed Tree Species; Grass-Safe Herbicide Mixes for Woody Vegetation Control; Update on Removal of Well-Established Ailanthus from a Limited Access Corridor: A Pilot Project; Herbaceous Weed Control Research; Comparing Grass-Safe Herbicides for Converting Canada Thistle Infested Crownvetch to Formula L; Grass-Safe Herbicides; Implementing Japanese Knotweed Removal and Conversion to Grasses; Alternatives to Diuron for Kochia Control; Payload Herbicide Efficacy If Applied 96 Hours after Mixing; Seed Mix Establishment Implementation Work Plan; Broadleaf Herbicide Comparison; Late Season Bareground Demonstration; Off-site Herbicide Movement Demonstration; and Roadside Planting Restoration of the Capital Beltway Beautification Project.

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|---|---|---|---|
| **17. Key Words**<br>Roadside vegetation management, invasive plants, herbicides, brush control, herbaceous weed control, ground cover, basal application, ailanthus, kochia, diuron, payload | | **18. Distribution Statement**<br>No restrictions. This document is available from the National Technical Information Service, Springfield, VA 22161 | |
| **19. Security Classif. (of this report)**<br>Unclassified | **20. Security Classif. (of this page)**<br>Unclassified | **21. No. of Pages**<br>49 | **22. Price** |

**Form DOT F 1700.7** **(8-72)** **Reproduction of completed page authorized**

## ACKNOWLEDGMENTS

This research was funded by the Pennsylvania Department of Transportation, Bureau of Maintenance and Operations, and conducted by researchers in the Department of Horticulture, of the College of Agricultural Sciences, by contract through The Thomas D. Larson Pennsylvania Transportation Institute at Penn State. Personnel contributing to the production of this report include Arthur E. Gover, research support associate; Jon M. Johnson, research support associate; Kirsten L. Lloyd, research support associate; and James C. Sellmer, associate professor of ornamental horticulture at Penn State.

The authors would like to begin by thanking the PENNDOT District Roadside Specialists who have been instrumental in locating the field sites needed for this research. Our sincere appreciation goes to Joe Demko for his support of this research project. We are also indebted to student employee Mike Jankowski for his invaluable assistance throughout the season.

Each year, much of our effort centers around the Roadside Vegetation Management Conference and its field day. We are grateful to Bill Tyson and Jim Cessna from District 8-0 for helping pull the summer meeting together. We would also like to extend our appreciation to Jim Weikel and DBI Services, Inc. for their support during the field day.

We are grateful for the assistance of the representatives of the various manufacturers providing products for the vegetation management industry, who have lent their time, expertise, and material support on many occasions. The following manufacturers assisted this research project during the 2007 season: Arborchem Products, Inc.; BASF Specialty Products; DowAgroSciences LLC; E.I. DuPont de Nemours & Co.; Nufarm Turf & Specialty; PBI/Gordon Corporation; Syngenta Professional Products; Valent Professional Products.

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## INTRODUCTION

In October 1985, personnel at Penn State began a cooperative research project with the Pennsylvania Department of Transportation to investigate several aspects of roadside vegetation management. An annual report has been submitted each year which describes the research activities and presents the data. The previous reports are listed below:

Report # PA86-018 + 85-08 - Roadside Vegetation Management Research Report

Report # PA87-021 + 85-08 - Roadside Vegetation Management Research Report
- Second Year Report

Report # PA89-005 + 85-08 - Roadside Vegetation Management Research Report
- Third Year Report

Report # PA90-4620 + 85-08 - Roadside Vegetation Management Research Report
- Fourth Year Report

Report # PA91-4620 + 85-08 - Roadside Vegetation Management Research Report
- Fifth Year Report

Report # PA92-4620 + 85-08 - Roadside Vegetation Management Research Report
- Sixth Year Report

Report # PA93-4620 + 85-08 - Roadside Vegetation Management Research Report
- Seventh Year Report

Report # PA94-4620 + 85-08 - Roadside Vegetation Management Research Report
- Eighth Year Report

Report # PA95-4620 + 85-08 - Roadside Vegetation Management Research Report
- Ninth Year Report

Report # PA96-4620 + 85-08 - Roadside Vegetation Management Research Report
- Tenth Year Report

Report # PA97-4620 + 85-08 - Roadside Vegetation Management Research Report
- Eleventh Year Report

Report # PA98-4620 + 85-08 - Roadside Vegetation Management Research Report
- Twelfth Year Report

Report # PA99-4620 + 85-08 - Roadside Vegetation Management Research Report
- Thirteenth Year Report

Report # PA00-4620 + 85-08 - Roadside Vegetation Management Research Report
- Fourteenth Year Report

Report # PA01-4620 + 85-08 - Roadside Vegetation Management Research Report
- Fifteenth Year Report

Report # PA02-4620 + 85-08 - Roadside Vegetation Management Research Report
- Sixteenth Year Report

Report # PA03-4620 + 85-08 - Roadside Vegetation Management Research Report
- Seventeenth Year Report

Report # PA04-4620 + 85-08 - Roadside Vegetation Management Research Report - Eighteenth Year Report

Report # PA05-4620 + 85-08 - Roadside Vegetation Management Research Report - Nineteenth Year Report

These reports are available by request from the authors, and are available online in portable document format (PDF) at http://rvm.cas.psu.edu.

**Use of Statistics in This Report**

Many of the individual reports in this document make use of statistics, particularly techniques involved in the analysis of variance. The use of these techniques allows for the establishment of criteria for significance, or, when the differences between numbers are most likely due to the different treatments, rather than due to chance. The authors have relied almost exclusively on the commonly used probability level of 0.05. When a treatment effect is significant at the 0.05 level, this indicates that there is only a five percent chance that the differences are due to chance alone. At the bottom of the results tables, where analysis of variance has been employed, there is a value for least significant difference (LSD). When analysis of variance indicates that the probability that the variation in the data is due to chance is equal to or less than 0.05, Fisher's LSD means separation test is used. When the difference between two treatment means is equal to or greater than the LSD value, these two values are significantly different. When the probability that the variation in the data is due to chance is greater than 0.05, the LSD value is reported as "n.s.," indicating non-significant.

This report includes information from studies relating to roadside brush control, herbaceous weed control, total vegetation control, native species establishment and roadside vegetation management demonstrations. Herbicides are referred to as product names for ease of reading. The herbicides used are listed on the following page by product name, active ingredients, formulation, and manufacturer.

**Product Information Referenced in This Report**

The following details product names, active ingredients, formulation, and manufacturer information for products referred to in this report. DF=dry flowable, DG=dispersible granules, E=emulsion, EC=emulsifiable concentrate, ME=microencapsulated, S=water soluble, WDG or WG=water dispersible granules.

| Trade Name | Active Ingredients | Formulation | Manufacturer |
|---|---|---|---|
| Arborchem Basal Oil | diluent | - - - | Arborchem Products, Inc. |
| Aquaneat | glyphosate | 5.4 S[1] | Nufarm Turf & Specialty |
| Arsenal | imazapyr | 2 S | BASF Specialty Products |
| Endurance | prodiamine | 65 WG | Syngenta Crop Protection, Inc. |
| Escort | metsulfuron methyl | 60 DF | E.I. DuPont de Nemours & Co. |
| Garlon 3A | triclopyr amine | 3 S | DowAgroSciences LLC |
| Garlon 4 | triclopyr ester | 4 EC | DowAgroSciences LLC |
| Glyphosate | glyphosate | 4 S[1] | E.I. DuPont de Nemours & Co. |
| GlyPro Plus | glyphosate | 4 S[1] | DowAgroSciences LLC |
| Goal | oxyfluorfen | 1.6 E | DowAgroSciences LLC |
| Journey | glyphosate + imazapic | 0.75+1.5 S | BASF Specialty Products |
| Karmex XP | diuron | 80 DF | E.I. DuPont de Nemours & Co. |
| Landmark XP | sulfometuron + chlorsulfuron | 50+25 DG | E.I. DuPont de Nemours & Co. |
| Milestone VM | aminopyralid | 2 S | DowAgroSciences LLC |
| Milestone VM Plus | aminopyralid + triclopyr | 0.1+1 S | DowAgroSciences LLC |
| Oust Extra | sulfometuron + metsulfuron | 71.25 DG | E.I DuPont de Nemours & Co. |
| Oust XP | sulfometuron | 75 DG | E.I. DuPont de Nemours & Co. |
| Overdrive | dicamba + diflufenzopyr | 70 DG | BASF Specialty Products |
| Payload | flumioxazin | 51 WDG | Valent Professional Products |
| Pendulum AQ | pendimethalin | 3.8 ME | BASF Specialty Products |
| Plateau | imazapic | 2 S | BASF Specialty Products |
| RoundUp PRO | glyphosate | 4 S[1] | Monsanto |
| Sahara | imazapyr + diuron | 7.8+62 DG | BASF Specialty Products |
| Snapshot | trifluralin + isoxaben | 2+0.5 DG | DowAgroSciences LLC |
| Spike 80W | tebuthiuron | 80 W | DowAgroSciences LLC |
| Stalker | imazapyr | 2 EC | BASF Specialty Products |
| Telar XP | chlorsulfuron | 75 DF | E.I. DuPont de Nemours & Co. |
| Throttle XP | chlorsulfuron, sulfometuron, + sulfentrazone | 9+18+48 DG | E.I. DuPont de Nemours & Co. |
| Tordon 101M | picloram + 2,4-D | 0.5+2 S | DowAgroSciences LLC |
| Tordon K | picloram | 2 S | DowAgroSciences LLC |
| Transline | clopyralid | 3 S | DowAgroSciences LLC |
| Triplet | 2,4-D + MCPP + dicamba | 3.2 S | Nufarm Turf & Specialty |
| Vanquish | dicamba-glycolamine | 4 S | Syngenta Professional Products |
| Weedestroy | 2,4-D | 3.8 S | Nufarm Turf & Specialty |

[1]Glyphosate formulations given in lbs per gal isopropylamine salt.

## BASAL TIMING STUDY ON MIXED TREE SPECIES

Herbicide trade and common chemical names: Garlon 4 (triclopyr, ester formulation).
Plant common and scientific names: black birch (*Betula lenta*), blueberry (*Vaccinium* spp.), pin cherry (*Prunus pensylvanica*.), gray birch (*Betula populifolia*), hemlock (*Tsuga canadensis*), hickory (*Carya spp.*), green ash (*Fraxinus pennsylvanica*), quaking aspen (*Populus tremuloides*), red oak (*Quercus rubra*), red maple (*Acer rubrum*), sassafras (*Sassafras albidum*), staghorn sumac (*Rhus typhina*), sugar maple (*Acer saccharum*), white oak (*Quercus alba*).


### ABSTRACT

The seasonal effective timing of Garlon 4 basal bark applications was examined. Timing of Garlon 4 basal bark application was tested and will continue to be tested at two sites with applications administered in August 2007, November 2007, and March 2008 (planned). The results of this study are intended to further define the effectiveness of fall (November) treatments on mixed brush species compared to previously recommended treatment periods.


### INTRODUCTION

Basal bark treatments are performed by some contract applicators at the onset of significant fall color and early dormancy (November). Current operational recommendations by the Penn State Vegetation Management Team employ basal bark applications from January to fall color. If fall applications are effective, this would be an ideal time to retain contractors and accomplish low-profile brush clearance.

The objective of this trial was to compare basal bark applications at three different times in order to further define effective application windows on mixed-species brush. Garlon 4 is a common herbicide for control of mixed tree species using the basal bark treatment method. Three basal application dates using Garlon 4 were compared at two locations in Pennsylvania.

### MATERIALS AND METHODS

Experimental sites were established along a cut slope on the ramp shoulder of I-81 N, Exit 155 near Dorrance, PA (Luzerne Co.) and in the median of I-80 E, Seg. 1264 near Woodland, PA (Clearfield Co.). Treatments included an untreated check and three basal bark application timings. Applications were made in August and November 2007 (third application planned for March 2008). The solution used was 25% v/v Garlon 4 (triclopyr, ester formulation) and 75% v/v Arborchem Basal Oil with colorant added. This solution was applied using standard backpack sprayers or a $CO_2$-powered backpack sprayer operating between 20 and 40 psi. All were equipped with an ultra low volume wand, adjustable conejet nozzle, and Y-2 tip. Applications targeted the lower 6 to 12 inches of stems, which ranged in size from 0.5 to 6 inches diameter at the base.

At the Luzerne site, twelve 75-by-50-ft plots were located beyond the edge of the mowline on the cut slope. Three replications per application date were made on August 11 and November 8, 2007, with a third application planned for March 2008. Target species included ash, birch, blueberry, hickory, pin cherry, quaking aspen, red maple, red oak, sassafras, staghorn sumac, and white oak.

At the Woodland site, twelve 75-by-30-ft plots were located in the median. Applications were made on August 10 and November 14, 2007 (with a third planned for March 2008), with three replications per date. Target species included black and gray birch, cherry, green ash, hemlock, quaking aspen, red oak, sugar maple, and white oak.

## RESULTS AND DISCUSSION

Complete evaluations of the efficacy of application timings at both sites are planned for the summer of 2008. Percent canopy reduction for abundant species will be rated at both locations. Results from the completed experiment should provide a measure of the success of the fall (November) timing relative to the recommended timings in August and March.

## CONCLUSIONS

This research will be finalized after the completion of the third treatment applications in March 2008 and subsequent evaluation during the summer of 2008. No data have been collected to date pending completion of all treatment timings. Results from this experiment will be detailed as part of a future contract.

## GRASS-SAFE HERBICIDE MIXES FOR WOODY VEGETATION CONTROL

Herbicide trade and common chemical names: Escort XP (*metsulfuron methyl*), Garlon 3A (*triclopyr amine*), Milestone VM (*aminopyralid*), Overdrive (*dicamba + diflufenzopyr*), Tordon 101M (*picloram + 2,4-D)*, Vanquish (*dicamba-glycolamine*).
Plant common and scientific names: buckthorn (*Rhamnus* spp.), fine fescue (*Festuca* spp.), jewelweed (*Impatiens capensis*), Japanese honeysuckle (*Lonicera japonica*), Kentucky bluegrass (*Poa pratensis*), Morrow's honeysuckle (*Lonicera morrowii*, LONMO), multiflora rose (*Rosa multiflora*, ROSMU), privet (*Ligustrum* spp., LIGXX), tall fescue (*Festuca arundinacea*), Tartarian honeysuckle (*Lonicera tatarica*, LONTA).


### ABSTRACT

PennDOT's weed and brush program comprises a significant percentage of the roadside vegetation management program and, if improperly implemented, can adversely affect the survival of underlying grass ground covers along the roadside. In order to advance the weed and brush program, eight herbicide mixtures were tested for woody vegetation control and compatibility with grass survival. Injury to exotic bush honeysuckle, multiflora rose, and privet was visually evaluated approximately 4 weeks after treatment (WAT). Initial injury ratings suggested that Garlon 3A plus Tordon 101M caused severe injury to all targeted species. Mixes containing *dicamba* appeared to cause greater injury to Morrow's honeysuckle at carrier rates of 100 gal/ac compared to other treatments. Lower carrier volumes (35 gal/ac) provided unacceptable injury ratings for Tartarian honeysuckle and privet, except for privet injury by Garlon 3A plus Escort XP. All of the mixes used in this study significantly injured multiflora rose. The late-season application and evaluation of injury to turf from these treatments gave little indication of any detrimental effects to existing turf stands. This is an ongoing study in which injury evaluation has provided some insight into target species response to herbicide treatments. In reality, the most important implication of this research is data on the long-term, species-specific control provided by each herbicide mixture. This information will be collected during the 2008 season and will be reported in the next report.


### INTRODUCTION

The weed and brush program is a significant portion of PennDOT's roadside vegetation management effort. The success of this program depends on the identification of selective herbicides that will preserve desirable grasses. The combination of Garlon 3A plus Escort XP is a standard mix often used for weed and brush management. This study investigated several other herbicide combinations on a variety of brush species. Each mix was developed based on its anticipated effectiveness on brush and probable safety to grasses.

### MATERIALS AND METHODS

*Brush Treatments*

Trial sites were located at Toftrees in State College, PA and along SR 422 E at the SR 286 off-ramp near Indiana, PA (Indiana Co.). Nine treatments were arranged in a randomized complete block design (RCBD) with three replications. Treatments were applied to 45-by-8-ft plots at the Toftrees site using a $CO_2$-powered backpack sprayer equipped with an XP20L nozzle delivering 30 gal/ac at 40 psi. At the Indiana site, individual shrubs within plots approximately 25 by 30 ft in size were selectively treated using $CO_2$-powered backpack sprayers and ULV wands equipped with X-12 tips delivering 100 gal/ac at 30 psi. Treatments were completed on September 13 and 17, 2007, at the State College and Indiana sites, respectively. The treatments included an untreated check; 64 oz/ac Garlon 3A alone or combined with 1 oz/ac Escort XP, 32 oz/ac Vanquish, 7 oz/ac Milestone VM, 8 oz/ac Overdrive, or 64 oz/ac Tordon 101M; 32 oz/ac Garlon 3A plus 7 oz/ac Milestone VM and either 32 oz/ac Vanquish or 8 oz/ac Overdrive. Activator 90, surfactant, at 0.25% v/v was added to all treatments.

Percent injury to Tartarian honeysuckle (LONTA), multiflora rose (ROSMU), and privet (LIGXX) was evaluated on October 10, 2007, 27 days after treatment (DAT) at State College. Other common species present, but not evaluated, included buckthorn, jewelweed, and Japanese honeysuckle. Percent injury to Morrow's honeysuckle was rated on October 15, 2007, 28 DAT at the Indiana site.

*Turf Treatments*

Trial sites were located at the Oak Hall interchange of SR 322 and the SR 22/I-99 interchange near Duncansville, PA. The same brush treatments, including surfactant, were applied to existing turf stands. Both sites were arranged in a RCBD with three replications. Treatments were applied to plots 6 by 15 ft using a $CO_2$-powered backpack sprayer equipped with a 6-ft boom and 8006VS tips delivering 100 gal/ac at 35 psi. Treatments were completed on October 22 and 30, 2007, at the Oak Hall and Duncansville sites, respectively. The turf canopy height at the time of treatment averaged 4 inches, with some plants reaching 8 inches. The turf species at both sites included tall fescue and Kentucky bluegrass, while fine fescue was an additional component at the Oak Hall site.

Percent total vegetative cover and cover by turf were evaluated on October 25, 2007 (3 DAT) at Oak Hall and on October 30, 2007 (0 DAT) at Duncansville. Injury to the turf was evaluated on December 11, 2007, 50 and 42 DAT for the Oak Hall and Duncansville sites, respectively. Injury ratings were assigned values on a scale of 0 to 10, where 0 = no injury; 5 = moderate injury, some chlorosis; and 10 = dead.

## RESULTS AND DISCUSSION

*Brush Treatments*

The exotic bush honeysuckles LONMO and LONTA varied in response to the treatments. Both species showed a similar range of response with injury values from 45 to 98 percent for LONMO and 45 to 95 percent for LONTA. Only Garlon 3A plus Tordon 101M produced satisfactory injury on LONTA at 95 percent. All remaining treatments were rated between 45 and 63 percent injury. Treatments containing *dicamba*, in the form of Vanquish or Overdrive, were among the most effective on LONMO. Garlon 3A plus Vanquish alone or with Milestone VM and Garlon 3A plus Overdrive provided 91 to 96 percent injury and were similar to the best performing treatment, Garlon 3A plus Tordon 101M at 98 percent injury.

ROSMU injury averaged 98 percent except for Garlon 3A plus Milestone VM at 95 percent. LIGXX was most affected by Garlon 3A plus Tordon 101M, which caused 98 percent injury. Garlon 3A plus Escort XP produced significantly lower injury at 83 percent. Treatments containing *dicamba* ranged from 57 to 63 percent injury, while Garlon 3A alone or combined with Milestone VM produced injury ratings of 50 percent.

*Turf Treatments*

At the initiation of the study the turf cover averaged from 69 to 83 percent at the Oak Hall site and 92 to 96 percent at the Duncansville location (data not presented). Injury ratings were "0" for all turf plots except two, as evaluated at 50 and 42 DAT at Oak Hall and Duncansville, respectively. The Garlon 3A and Garlon 3A plus Vanquish treatments each had one plot that was given a "3" rating, meaning that the treatment plot was slightly off color compared to the untreated plot. Subsequent evaluations of potential turf injury were made late in December, and by this time, natural discoloration had occurred. The initial indications of limited turf injury should not prohibit the use of Garlon 3A and Garlon 3A plus Vanquish in industrial turf settings.

## CONCLUSIONS

Garlon 3A plus Tordon 101M produced extremely high injury to all targeted species at all carrier volumes. This combination is a proven brush control mix, but Tordon 101M is a 'restricted use' product and requires public notification prior to use. Mixes containing *dicamba* appear to increase injury to LONMO at carrier rates of 100 gal/ac compared to other treatments. Lower carrier volumes (35 gal/ac) provided unacceptable injury ratings for LONTA and LIGXX with the exception of LIGXX injured using Garlon 3A plus Escort XP.

In other earlier research, lower carrier volumes applied to exotic bush honeysuckle have yielded poor results using the same herbicide mix. This may explain the difference in level of control observed between the LONMA and LONTA at the two sites. Higher carrier volumes may be required to control some of these troublesome brush species. Any of the mixes used in this study will significantly injure ROSMU.

The two mixes that produced turf injury are among the least likely candidates to cause such injury. Even though these late-season treatments showed no sign of excessive turf injury, another trial conducted earlier in the season would be prudent. Products like Milestone VM are not suggested for industrial turf applications, and Escort XP is only safe at lower rates. However, the herbicide mixes used in this study should provide some level of safety to a grass understory when targeting brush.

This is an ongoing study. Proof of herbicide efficacy on targeted brush species depends on long-term control of the targets in addition to initial injury. Final control information will be collected and analyzed in 2008 and reported in a future project report.

## MANAGEMENT IMPLICATIONS

The early results are encouraging. Garlon 3A plus Escort XP is a proven brush control mix, and the initial findings support its efficacy on several target species. The addition of *dicamba* and increased carrier volumes may be necessary to control exotic bush honeysuckle species.

Table 1: Summary of percent injury, by species, for brush treated September 13 or 17, 2007, and evaluated October 10 or 15, 2007, 27 or 28 days after treatment (DAT), respectively. Species evaluated included Morrow's honeysuckle (LONMO), Tartartian honeysuckle (LONTA), multiflora rose (ROSMU), and privet (LIGXX). Two plots containing the LONTA, ROSMU, and LIGXX were eliminated from the statistics due to anomalies found during the rating. ROSMU was not present in all plots. Otherwise, the injury values are the mean of three replications.

| Product[1/] | Rate | LONMO[2/] Injury | LONTA Injury | ROSMU Injury | LIGXX Injury |
|---|---|---|---|---|---|
| | (oz/ac) | (---------------------------- | % | ----------------------------- | ) |
| Untreated | --- | --- | 0 c | 0 c | 0 e |
| Garlon 3A | 64 | 45 | 50 b | 98 a | 50 d |
| Garlon 3A<br>Escort XP | 64<br>1 | 73 | 45 b | 98 a | 83 b |
| Garlon 3A<br>Vanquish | 64<br>32 | 95 | 50 b | 98 a | 57 cd |
| Garlon 3A<br>Milestone VM | 64<br>7 | 78 | 63 b | 95 b | 50 d |
| Garlon 3A<br>Vanquish<br>Milestone VM | 32<br>32<br>7 | 96 | 63 b | 98 a | 60 c |
| Garlon 3A<br>Overdrive | 64<br>8 | 91 | 50 b | 98 a | 57 cd |
| Garlon 3A<br>Overdrive<br>Milestone VM | 32<br>8<br>7 | 82 | 60 b | 98 a | 63 c |
| Garlon 3A<br>Tordon 101M | 64<br>64 | 98 | 95 a | 98 a | 98 a |
| Protected LSD (p=0.05) | | 13 | --- | --- | --- |

[1/] A single LSD value could not be calculated for tartarian honeysuckle (LONTA), multiflora rose (ROSMU), and privet (LIGXX) injury because of missing data. Values followed by the same letter are not significantly different according to Fisher's LSD at p=0.05 significance level.
[2/] LONMO was treated using a carrier volume of 100 gal/ac. All other species were treated with a targeted carrier volume of 35 gal/ac.

**UPDATE: REMOVAL OF WELL-ESTABLISHED AILANTHUS FROM A LIMITED ACCESS CORRIDOR: A PILOT PROJECT**

Herbicide trade and common chemical names: Arsenal (*imazapyr*), Escort (*metsulfuron*), *glyphosate*, Garlon 4 (*triclopyr ester*), Stalker (*imazapyr*), Tordon K (*picloram*)
Plant common and scientific names: ailanthus (*Ailanthus altissima*)


ABSTRACT

Activities related to an operational scale pilot project initiated in 2001 were continued to clear remaining ailanthus and maintain a 14-mile stretch of SR 22 in Perry County. The control phase, consisting of a high-volume foliar (HVF) and a basal bark (BB) application, was completed on SR 22 W in August 2003. An introduction and description of the project prior to 2003 are available in the Roadside Vegetation Management Eighteenth Year Report. In 2004, the entire length of SR 22 W was scouted for the treatment of misses and some previously untreated patches. SR 22 E was treated with basal bark from the Juniata County line to SEG 120. From 2004 to 2007, the project used 2,423 gallons of HVF mixture applied in 76 man-hours and 196 gallons of BB mixture applied in 308 man-hours. Two scenarios for ailanthus management are presented.


INTRODUCTION

Ailanthus, or tree-of-heaven, is a fast-growing, weak-wooded tree species native to East Asia. It was introduced to the United States in the late 18th century for use as a pollution-tolerant urban tree. Ailanthus tolerates infertile, droughty sites, and reproduces by abundant, wind-borne seeds and by producing rapid-growing suckers from its root system. This plant is ideally suited to grow in disturbed highway corridors. Ailanthus warrants specific roadside management effort for three main reasons: (1) acute effects on highway safety, (2) negative impacts on adjacent properties, and (3) the ability to spread under current vegetation management practices. Failure to remove ailanthus as soon as possible increases both maintenance efforts and liability, and hinders the Department's efforts to act as a good neighbor to the rest of the Commonwealth.

The current SR 22 (US Route 22) in Perry County was completed in 1965. Tree ring counts have indicated that ailanthus began to establish in disturbed soils along this corridor no later than 1972, and by the early 1990s, the entire 14-mile passage through Perry County was infested, requiring an ailanthus-specific management strategy. Penn State began research and management activities in the corridor in April 1994 and has continued efforts to date. Research activities, documented in annual reports from 1995 through 2000 demonstrated that well-established ailanthus infestations require intensive initial effort and sustained maintenance.

In the fall of 2000, an operational-scale clearance of the entire 14-mile SR 22 corridor in Perry County was initiated. The setting provided the challenge of worst-case scenario (i.e., a well-established infestation, challenging terrain, and a wide ROW) as well as a means to evaluate a corridor-wide clearance project, producing baseline time and materials data. The project was conceived as having two major phases - control and maintenance. The objective of the control phase was to clear the existing stems on the ROW. The maintenance phase consisted of periodic operations to treat the inevitable resprouts and seedlings. The initial clearance method was a high-volume foliar treatment (HVF), applied with a handgun attached to several hundred feet of hose providing a means to reach the target trees. The objective of this treatment was to reduce the number of ailanthus stems and reduce the canopy. HVF is a productive treatment in terms of acres per hour, but it is not particularly selective and can cause non-target injury. The HVF treatment produced a severe aesthetic impact. Basal bark (BB) applications were used for follow-up and maintenance after the majority of the small stems had been eliminated by foliar treatment. BB applications are more labor intensive but are highly selective, thus reducing collateral damage on non-target plants. With proper treatment, dead ailanthus decayed quickly, and formerly infested areas on suitable terrain could be converted to mowable herbaceous vegetation. Conversely, steep terrain often limited access and treatment of ailanthus. During the operational period, small-scale studies were also conducted to evaluate basal bark diluents, basal bark herbicide mixtures, and dormant stem application techniques.

Year 2003 basal bark applications completed the control phase on the westbound shoulder of SR 22. Goals for the period beginning in 2004 included removal of large ailanthus stems, foliar treatment of regrowth along the westbound shoulder of SR22, and continuation of primary treatment along SR 22 east.

## MATERIALS AND METHODS

For HVF treatments, a mixture of either glyphosate alone at 4 qt per 100 gal or combined with either Arsenal at 4 oz per 100 gal or Escort at 0.5 oz per 100 gal was applied on a spray-to-wet basis with a handgun. The specific equipment used to apply the HVF was a 150-gallon sprayer with a Bean R10 (10 gal/min) piston pump, 150 ft of 0.5-in-diameter hose, and a Spraying Systems GunJet AA2AL with a AY-SS 90 spray tip.

Basal bark treatments consisted of Garlon 4 plus at 15% v/v plus either Stalker at 3% or Tordon K at 5% v/v in Arborchem Basal Oil and were applied with a backpack sprayer equipped with a low-volume nozzle to limit solution applied. The lower 12 to 18 inches of each target stem were treated to completely encircle the stem. The solution was applied to the point of wetting the stem, avoiding any run-off or puddling.

## RESULTS AND DISCUSSION

Activities related to an operational-scale pilot project initiated in 2001 were continued to clear remaining ailanthus and maintain a 14-mile stretch of SR 22 in Perry County. Table 1 lists publications from project-related research and demonstrations to date. Following completion of the control phase on SR 22 W in August 2003, SR 22 W was scouted the entire length for misses, and some previously untreated patches were treated in 2004. SR 22 E was treated with basal bark from the Juniata County line to SEG 120. As shown in Table 2, from 2004 to 2007, the project used 2,423 gallons of HVF mixture applied in 76 man-hours and 196 gallons of BB mixture applied in 308 man-hours.

## CONCLUSIONS

Observations made during the operational period have provided extensive insight into managing ailanthus infestations in challenging roadside environments. Because ailanthus is a suckering species (i.e., a species that produces new stems from its root system) the key to managing this plant is controlling the root system. For herbicides to enter the root system, they must be applied at a time of year when the canopy is exporting carbohydrates produced through photosynthesis. This requires a late-season timing. The window to treat ailanthus to best effect is late June up to the beginning of fall coloration. Treatments made outside this window may only control the treated stem and leave the roots intact, resulting in vigorous resprouting. Ailanthus needs to be removed entirely from the Department's ROW, but where infestations are old and well-established, *mileage* cleared should be maximized by clearing to 50 feet from road edge in the first phase. Subsequent phases can remove missed stems and expand the control program deeper into the ROW. Where ailanthus has expanded beyond the ROW onto adjacent properties, basal bark application allows for ailanthus management at ROW/property line interface due to its highly selective nature. Using a backpack-based treatment, such as basal bark, also provides the access flexibility to treat all but the most inhospitable areas of the ROW. When ailanthus stems are large enough that they present a hazard if left dead and standing, they should be treated during the late growing season prior to removal.

## MANAGEMENT IMPLICATIONS

Ailanthus management involves two scenarios - maintenance and reclamation. In ailanthus-prone corridors, all possible terrain should be mowed, even if only once every one or two years. Routine mowing will prevent establishment of ailanthus colonies. The two management scenarios are outline below.

1. Maintenance

   A. Rely heavily on capabilities of current spray vehicles. Spray vehicles specified by most Districts can treat a 34-ft horizontal swath. Using this capability during the 7713 program and on an annual or biennial basis will prevent establishment of large ailanthus and other brush close to the roadway. Regular implementation and progressive expansion will effect a transition from a crownvetch/brush groundcover toward a grass groundcover.

   B. Implement a program to treat vegetation outside of the 34-ft pattern on a regular interval of approximately every five years. This application can be accomplished with backpack-equipped crews or a truck with a handgun and a hose reel. Once this program is implemented and repeated, it will require less time than the initial cycle. The timing of this program should be later in the growing season, between July 1 and the onset of fall color.

2. Reclamation

   A. Selective removal. Where ailanthus is too large and too close to the roadway to treat and leave standing, remove the larger stems. Due to the extreme cost of brushing, limit removals to the large stems that have a potential to create hazardous situations.

   B. A foliar application using a handgun will provide elimination of smaller targets and significantly reduce stem number in large, tall colonies. To maximize mileage covered, this program should be implemented over several seasons, with each season increasing the extent of the program and the distance cleared from the road edge.

C. During the same season as the foliar application, a basal bark application should be made to eliminate the stems that were too tall to reach with the foliar application described in Section B above. The basal treatment provides a means to very selectively remove the remaining stems and preserve groundcover. By using a two-phase treatment, the applicator has the latitude to skip some targets with the foliar application that are better treated with basal bark. Foliar is more productive, but treating isolated stems with a handgun will result in unnecessary non-target injury that can be avoided by waiting to treat the target with the follow-up basal bark treatment.

D. Maintenance. Once steps 2 (A-C) have been implemented, you have transitioned into maintenance mode and can utilize the program described in Section 1 above.

Table 1: Publications summarizing research and demonstration related to the ailanthus management project along SR 22 in Perry County, Pennsylvania. All reports are available at http://vm.cas.psu.edu/report.html.

| |
|---|
| Control of tree-of-heaven and conversion to fine fescue. Thirteenth Year Report (1999). |
| Ongoing ailanthus management demonstration project – District 8-0. Thirteenth Year Report (1999). |
| Ongoing ailanthus management demonstration project – District 8-0. Fourteenth Year Report (2000). |
| Preliminary results: Effect of basal bark applications of Garlon 4 plus Stalker on suckering of ailanthus. Fourteenth Year Report (2000). |
| Influence of basal bark applications of Garlon 4 and Stalker on tree-of-heaven resprouting. Fifteenth Year Report (2001). |
| Control of tree-of-heaven and conversion to fine fescue update. Fifteenth Year Report (2001). |
| Control of tree-of-heaven provided by foliar herbicide applications. Sixteenth Year Report (2002). |
| Effect of basal bark application timing on suppression of ailanthus resprouts. Seventeenth Year Report (2003). |
| Effect of cut surface application timing on suppression of ailanthus resprouts. Seventeenth Year Report (2003). |
| Evaluation of herbicides for control of ailanthus using cut surface applications. Seventeenth Year Report (2003). |
| Removal of well-established ailanthus from a limited access corridor: a pilot project. Eighteenth Year Report (2004). |
| Update: control of tree-of-heaven to fineleaf fescue groundcover. Eighteenth Year Report (2004). |
| Update: control of tree-of-heaven to fineleaf fescue groundcover. Nineteenth Year Report (2006). |

Table 2: Summary of time and materials for ailanthus management activities along the SR 22 corridor in Perry County from 9/16/04 to 10/30/07.

| Date | Treatment | Mix | Gallons | Crew Hours | Total Hours |
|---|---|---|---|---|---|
| 9/16/04 | High Volume Foliar (HVF) | Glyphosate 4 qt/100 gal<br>Arsenal 4 oz/100 gal | 600 | 8 | 16 |
| 7/15/04 | Basal Bark (BB) | Garlon 4 15% v/v<br>Stalker 3%v/v<br>Basal oil 82% v/v<br>(G4/Stalker/Oil) | 7 | 6.5 | 26 |
| 7/16/04 | | | 8 | 5.5 | 16.5 |
| 7/19/04 | | | 10 | 6.5 | 26 |
| 8/30/04 | | | 11 | 5.7 | 22.8 |
| 8/31/04 | | | 12 | 6.2 | 18.5 |
| 9/1/04 | BB | Garlon 4 15% v/v<br>Tordon K 5% v/v<br>Basal oil 80% v/v<br>(G4/K/oil) | 12.9 | 5.1 | 20.4 |
| 9/8/04 | | | 4.2 | 2.8 | 5.6 |
| 9/10/04 | | | 13.2 | 5.9 | 17.7 |
| 9/22/04 | | | 13.2 | 6.5 | 19.5 |
| 7/15/05 | HVF | Glyphosate 4 qt/100 gal<br>Escort 0.5 oz/100 gal<br>(Gly/Escort) | 600 | 4 | 12 |
| 7/26/05 | BB | G4/Stalker/oil | 4.8 | 5 | 10 |
| 8/8/05 | | | 6.6 | 5 | 10 |
| 8/9/05 | | | 5.8 | 5.5 | 11 |
| 8/11/05 | | | 5.3 | 4 | 8 |
| 9/8/05 | | | 12 | 5 | 15 |
| 9/13/05 | | | 21.2 | 5.5 | 16.5 |
| 9/22/05 | | | 4.5 | 3 | 9 |
| 9/22/05 | | | 11.1 | 4.8 | 9.5 |
| 9/7/06 | HVF | Glyphosate 4 qt/100 gal<br>(Gly) | 22.5 | 5.3 | 10.5 |
| 9/8/06 | | | 300 | 5.3 | 10.7 |
| 9/11/06 | HVF | Gly/Escort | 300 | 3.5 | 7 |
| 9/15/06 | | | 150 | 1.6 | 3.2 |
| 9/21/06 | | | 300 | 3.5 | 7 |
| 9/28/06 | HVF | Gly | 150 | 4.8 | 9.5 |
| 9/21/06 | BB | G4/K/oil | 5.3 | 5 | 5 |
| 9/24/07 | BB | G4/Stalker/oil | 11 | 5 | 20 |
| 9/28/07 | | | 10 | 6 | 12 |
| 10/30/07 | | | 5.3 | 4.3 | 8.7 |
| **Total** | **HVF** | **All mixes** | **2423** | **35.9** | **75.9** |
| **Total** | **BB** | **All mixes** | **196** | **108.8** | **307.7** |

# COMPARING GRASS-SAFE HERBICIDES FOR CONVERTING CANADA THISTLE INFESTED CROWNVETCH TO FORMULA L

Herbicide trade and common chemical names: Milestone VM (*aminopyralid*), Overdrive (*dicamba + diflufenzopyr*), RoundUp Pro Concentrate (*glyphosate*), Tordon K (*picloram*), Transline (*clopyralid*), Vanquish (*dicamba-glycolamine*).

Plant common and scientific names: canada thistle (*Cirsium arvense,* CIRAR), creeping red fescue (*Festuca rubra*), crownvetch (*Coronilla varia,* CZRVA), hard fescue (*Festuca brevipila*), perennial ryegrass (*Lolium perenne*).


## ABSTRACT

Field observations along Pennsylvania roadsides have suggested that a companion relationship between Canada thistle (CIRAR) and crownvetch (CZRVA) may exist where the CZRVA supports the growth and development of CIRAR colonies. One solution to prevent this relationship and reduce long-term control requirements would be to renovate CZRVA areas into perennial competitive grass zones through selective removal of CIRAR and CZRVA followed by overseeding and promotion of a grass groundcover. This study tested seven grass-safe herbicides and herbicide combinations for control of CIRAR and CZRVA accompanied by seeding with a grass mixture at two sites. Treatments were applied October 5 near State College, PA and October 11, 2007 near St. Clairsville, PA. Degree of injury to the target species was evaluated 31 and 34 days following treatment at the respective sites. Severe injury was observed to both CIRAR and CZRVA with all treatments. Hard fescue and perennial ryegrass seeded four days after treatment (State College) and immediately following treatment (St. Clairsville) germinated within the study areas by four weeks after treatment. The true success of CIRAR and CZRVA control plus potential impacts of the treatments to turfgrass establishment will be evaluated in early 2008.


## INTRODUCTION

Crownvetch (CZRVA) has been widely used by PennDOT as a conservation planting to provide groundcover and soil stabilization. Unfortunately, Canada thistle (CIRAR), a Pennsylvania noxious weed, has demonstrated an affinity for co-existing with CZRVA. Selectively removing CIRAR from a CZRVA stand has proven ineffective to date. Previous trials have shown that removing both species with herbicides and replacing the stand with grasses is effective[1/]. Once grasses replace the weed-infested site, routine mowing or broadleaf herbicide treatments must be used to combat further CIRAR and CZRVA invasion.

Glyphosate and a limited selection of broadleaf-specific chemicals have provided satisfactory results in eliminating both CIRAR and CZRVA and allowed for seeding immediately after application. This study was conducted to evaluate the efficacy of alternative broadleaf herbicides and herbicide combinations in order to expand and optimize applicator options for control of CIRAR and CZRVA while providing a safe environment for grass establishment.

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[1/] Comparing Sequences To Convert Canada Thistle-Infested Crownvetch To A Cool-Season Grass Mixture. 2000. Roadside Vegetation Management Research Report – Fifteenth Year Report. http://vm.cas.psu.edu/2000/final2000.pdf

## MATERIALS AND METHODS

Trials were established along Park Avenue at University Park, PA and in the median of SR 99 N to the south of Exit 10 St. near St. Clairsville, PA (Bedford Co.). Experimental treatments consisted of RoundUp Pro Concentrate at 96 oz/ac; Milestone VM at 7 oz/ac or Transline at 8 oz/ac alone or combined with Overdrive at 8 oz/ac; Tordon K at 24 oz/ac; Vanquish at 32 oz/ac plus Overdrive at 8 oz/ac; and an untreated check. Activator 90, surfactant was added at 0.25% v/v to all treatments except RoundUp Pro Concentrate.

At both sites, treatments were applied to 9-by-20-ft plots, arranged in a randomized complete block design with three replications, using a $CO_2$-powered backpack sprayer with 9 ft boom and equipped with 8002VS tips delivering 20 gal/ac. Herbicides were applied on October 5 and 11, 2007 at the University Park and St. Clairsville sites, respectively. Both sites were broadcast seeded with a grass seed mix containing 52% hard fescue, 35% creeping red fescue, and 10% perennial ryegrass. The St. Clairsville site was seeded immediately after application, while seeding occurred five days after application at the University Park site.

A representative 1-by-1-m subplot was placed within each plot. The number of CIRAR stems in each subplot was counted at the time of treatment. The response of CIRAR and CRZVA was rated according to foliar injury on a 0 to 10 scale, where 0 = no injury, 5 = moderate defoliation, epinasty, chlorosis, and 10 = complete necrosis or dead, on November 5 and 14, 2007, 31 and 34 days after treatment (DAT) for the University Park and St. Clairsville sites. All data were subjected to analysis of variance, and means were compared using Fisher's protected LSD (p=0.05).

## RESULTS AND DISCUSSION

Dramatic injury symptoms were observed for all herbicide treatments at both sites. Injury to CZRVA and CIRAR for all treatments ranged from 8 to 10 and was significantly greater than the untreated check. The long-term control of the treatments on CZRVA and CIRAR will be evaluated during the 2008 growing season. The change in number of CIRAR plants within and among the established subplots will help characterize the impact of the herbicides on sprouting from the root system. The level of establishment of the grass seed mix and elimination of CZRVA will also be assessed.

## CONCLUSIONS

Early results show that all herbicide treatments caused significant injury to the CZRVA and CIRAR present at the site. It is too early to determine the long-term effectiveness of the broadleaf treatments on these species and margin of safety to newly seeded areas. It is anticipated that the 2008 growing season observation will yield long-term efficacy information for each herbicide and herbicide combination treatments.

Table 1. Herbicide treatments were applied to a Canada thistle (CIRAR) infested crownvetch (CZRVA) stand near State College, PA on October 5, 2007 and near St. Clairsville, PA on October 11, 2007. Visual ratings of CZRVA and CIRAR injury were taken November 5, 2007 (State College) and November 14, 2007 (St. Clairsville), 31 and 34 days after treatment. Injury was rated on a 0 to 10 scale, where '0' = no injury, '5' = moderate defoliation, epinasty, chlorosis, and '10' = completely necrotic, dead. Each value is the mean of three replications.

| | Product | State College, PA | | St. Clairsville, PA | |
|---|---|---|---|---|---|
| Product | Rate | CZRVA | CIRAR | CZRVA | CIRAR |
| | oz/ac | ---------------------Injury (0-10 scale)--------------------- | | | |
| Untreated | --- | 0 | 0 | 0 | 0 |
| RoundUp Pro Conc. | 96 | 8 | 10 | 9 | 10 |
| Milestone VM | 7 | 10 | 9 | 9 | 9 |
| Transline | 8 | 9 | 8 | 9 | 8 |
| Tordon K | 24 | 10 | 9 | 9 | 9 |
| Vanquish<br>Overdrive | 32<br>8 | 10 | 9 | 9 | 9 |
| Milestone VM<br>Overdrive | 7<br>8 | 10 | 9 | 10 | 10 |
| Transline<br>Overdrive | 8<br>8 | 10 | 9 | 9 | 9 |
| Fisher's protected LSD (p=0.05) | | 1 | 1 | 1 | 1 |

## EFFECT ON GRASS SEED ESTABLISHMENT AND WEED CONTROL WITH SEVERAL BROADLEAF HERBICIDES

Herbicide trade and common chemical names: Garlon 3A (*triclopyr amine*), Accord Concentrate (*glyphosate*), Milestone VM (*aminopyralid*), Tordon K (*picloram*), Transline (*clopyralid*), Vanquish (*dicamba-glycolamine*), Weedestroy (*2,4-D*)

Plant common and scientific names: bedstraw (*Galium* spp.), Canada thistle (*Cirsium arvense*), chicory (*Chicorium intybus*), crown vetch (*Coronilla varia*), dandelion (*Taraxacum officinale*), downy brome (*Bromus tectorum*), goldenrod (*Solidago* spp.), lambsquarters (*Chenopodium album*), multiflora rose (*Rosa multiflora*), quackgrass (*Agropyron repens*), prickly sida (*Sida spinosa*), purslane (*Portulaca* spp.), redroot pigweed (*Amaranthus retroflexus*), speedwell (*Veronica* spp.), wild carrot (*Daucus carota*), yellow foxtail (*Setaria glauca*)


### ABSTRACT

Perennial broadleaf weeds, such as Canada thistle, often plague crownvetch stands and are difficult to selectively remove. A solution used in previous trials and demonstrations has been to apply glyphosate to the entire area and replace the crownvetch stand with desirable turfgrass. Glyphosate is safe to establishing turf when applied pre-germination. Once the turf has established, mowing and selective herbicides can be used to discourage further weed problems. However, broadleaf herbicides may provide better weed control than glyphosate on some weed species. This test investigated the use of broadleaf herbicides for control of weeds and safety to grass seed and early emerging turf. In order to assess broadleaf control, determine inhibition to turf establishment, and evaluate application timing intervals at two sites, six herbicides were applied at five times, ranging from 30 days pre-seeding to 30 days postemergence of grass seedlings. Results showed that applying broadleaf herbicides on the day of seeding caused significant turf reduction at one location. Tordon K and Milestone VM were among the best broadleaf weed control materials at both sites while 2,4-D and Garlon 3A were equally effective at one site. Broadleaf weed control was best at 15 DAE. Vanquish, and in some cases, Garlon 3A, may damage turf when applied near the time of seeding.


### INTRODUCTION

Crownvetch stands are often infested with perennial broadleaf weeds. Unfortunately, selective removal is nearly impossible once the weeds have become established. One approach to the problem is to remove both the weeds and remnant crownvetch with herbicides and replace the site with grasses. Conversion to grass provides the advantage of a competitive groundcover and easier management of broadleaf weed encroachment. Broadleaf weed management options after conversion include the use of selective herbicides for removal of broadleaf weeds from the turf and mowing in areas where the terrain allows.

Glyphosate is frequently used to clear existing weeds and crownvetch prior to establishing grass. Although glyphosate will damage emerged turf, glyphosate does not have soil activity and thus will not harm seed planted after application. It is unknown whether some herbicides may provide better broadleaf control and produce less damage to establishing turf than others. Furthermore, the most effective time to apply broadleaf herbicides during the process of turf seeding and establishment is also unclear. In order to assess broadleaf control, determine inhibition to turf establishment, and evaluate application timing intervals at two sites, six herbicides were applied at five times, ranging from 30 days pre-seeding to 30 days postemergence of grass seedlings.

## MATERIALS AND METHODS

The study sites were located at the Landscape Management Research Center (LMRC) in State College, PA and the Southeastern Ag Research and Extension Center (SEARC) near Manheim, PA. Accord Concentrate, at 3 qt/ac plus 0.25% v/v Activator 90, surfactant was applied to kill existing weeds using a $CO_2$-powered backpack sprayer with 9-ft boom equipped with six 8002VS tips on July 18 and 19, 2007 at the LMRC and SEARC, respectively. Plots sizes were 3 by 12 ft at LMRC and 4 by 11 ft at SEARC. Seven treatments included Garlon 3A at 64 oz/ac, Vanquish at 64 oz/ac, Transline at 8 oz/ac, Milestone VM at 7 oz/ac, Tordon K at 32 oz/ac, 2,4-D (Weedestroy) at 64 oz/ac, and an untreated check. Activator 90, surfactant, was added at 0.25% v/v to all herbicide treatments. Herbicide treatments were applied using a $CO_2$-powered backpack sprayer with ULV basal wand and single 9506EVS tip. Treatments were applied at five different times as shown in Table 1 and according to the following schedule: 30, 15, or 0 days before seeding (DBS) and 15 or 30 days after emergence (DAE). The experiment followed a randomized complete block design with four replications of each herbicide for each time of application.

Accord Concentrate was applied a second time at the same rate (3 qt/ac plus 0.25% v/v Activator 90, surfactant) to the entire study area immediately before seeding on September 7 and 12, 2007 at LMRC and SEARC, respectively. After the glyphosate application, Formula L mix at 120 lb/ac was applied with a dropseeder and then the area was sliced. Data consisting of percents total cover, broadleaf cover, and turf cover were collected approximately 80 days following seeding on November 27 and 29, 2007 at the LMRC and SEARC, respectively. At LMRC, quackgrass cover was also recorded since this species is not desired and quickly infested the establishing turf. Data were analyzed for the effects of herbicide product, timing, and herbicide x timing interaction on total, turf, and broadleaf cover.

## RESULTS AND DISCUSSION

Results from SEARC and LMRC are reported in Tables 2 and 3, respectively. Data from two time intervals, 0 DBS and 15 DAE are shown in detail for the SEARC site, and the intervals 15 and 30 DAE are detailed for the LMRC site; at the time of data collection, these timings showed the most apparent treatment effects. Approximately 80 days after seeding, total cover was similar among sites and ranged from 35 to 91 percent. Results for total cover are reported but will not be discussed since total cover is confounded by the relative success of grass establishment and weed mortality. Broadleaf and grass cover ranged from 0 to 23 percent and 31 to 84 percent, respectively, among sites. Significant interactions of herbicide x time were found at both sites.

At SEARC, there were significant differences among herbicide treatments in broadleaf and grass cover when averaged across all time intervals (Table 2). Average turf cover on Vanquish-treated plots, 63 percent, was significantly lower than all other treatments. Garlon 3A, with 70 percent turf cover, also significantly depressed turf establishment relative to the remaining treatments, which were not significantly different than the untreated check at 77 percent. The Tordon K and Milestone VM treatments, with 3 and 5 percent broadleaf cover, respectively, appeared most effective against broadleaf weeds when averaged across application timings; however, only Tordon K significantly reduced broadleaf coverage relative to the untreated check at 8 percent broadleaf cover. Considering each time interval, individual herbicide treatments had a significant impact on broadleaf cover only when applied at 15 DAE. Overall, the herbicides were most effective when applied at 15 DAE, reducing broadleaf cover significantly more than any other timing. Reductions in turf cover were most apparent when treatments were applied at time of seeding, 0 DBS (67 percent), and least apparent when applied 30 DAE (79 percent). Percent turf cover among all other application timings was statistically similar.

At LMRC, results showed few significant differences, although trends in the data were largely similar to results from SEARC. Among herbicides, average turf cover ranged from 54 to 65 percent, and Tordon K and Garlon 3A treatments allowed the highest average turf coverage. Tordon K, Milestone VM, 2,4-D, and Garlon 3A demonstrated the greatest control on broadleaf weeds at LMRC, and herbicides were most effective when applied at 15 and 30 DAE. There were no statistically significant differences in turf cover among application dates. 2,4-D treatment tended to reduce total, broadleaf, and grass cover much more at 15 DAE than at any other timing. Unfortunately, results from several of the plots at LRMC, including at least one of the afore-mentioned plots, could have been confounded by leftover grass clippings or uneven terrain that may have impeded turf establishment.

## CONCLUSIONS

Vanquish and Garlon 3A depressed grass establishment at SEARC. Tordon K and Milestone VM were among the best broadleaf weed control materials at both sites while 2,4-D and Garlon 3A were equally effective at the LMRC. Treating areas the day of seeding caused the most significant injury to the turf, and broadleaf weed control had greatest effect at 15 DAE.

Several plots at the LMRC had grass clippings or uneven terrain that may have impeded turf establishment. Leftover grass residue could have prevented seed from reaching the ground and germinating or smothered germinating grasses, thus reducing percent grass cover on these and potentially other plots. Although not deleted from the statistical analysis, at least two plots were clearly outliers that should have been removed from the ANOVA. Results from the LMRC may also have been confounded by the quackgrass invasion. Competition from the quackgrass could have reduced grass establishment.

## MANAGEMENT IMPLICATIONS

The herbicides tested in this study could be used to target broadleaf weeds at least 15 days prior to or following turf seedling emergence. It is advisable not to use broadleaf chemistry the day of seeding in order to avoid damage to establishing turf. Vanquish should not be used within 30 days prior to seeding or after emergence. Garlon 3A should not be used on germinating desirable grasses prior to 30 days after emergence. Always follow seeding restrictions and intervals that are found on the label of the product.

Table 1. Summary of treatment schedule for herbicide applications and turf seeding at the Landscape Management Research Center (LMRC) in State College, PA and the Southeastern Ag Research Center near Manheim, PA. DBS = days before seeding, DAE = days after emergence.

| LMRC | SEARC | Time | Action |
|---|---|---|---|
| 7/18/07 | 7/19/07 | ----- | Glyphosate applied to entire study area |
| 8/9/07 | 8/13/07 | 30 DBS | Herbicide treatments applied – First timing |
| 8/24/07 | 8/28/07 | 15 DBS | Herbicide treatments applied – Second timing |
| 9/7/07 | 9/12/07 | 0 DBS | Herbicide treatments applied – Third timing;<br>Glyphosate applied to entire study area prior to seeding with Formula L mix |
| 10/2/07 | 10/8/07 | 15 DAE | Herbicide treatments applied – Fourth timing |
| 10/17/07 | 10/24/07 | 30 DAE | Herbicide treatments applied – Fifth timing |

Table 2: Summary of percent total vegetative cover, cover by broadleaf, and cover by desirable grasses (turf). Study area at SEARC was seeded to Formula L grass mix on September 12, 2007. Broadleaf herbicides were applied August 13, August 28, September 12, October 8, and October 24, 2007, 30, 15, 0 days before seeding (DBS) and 15 and 30 days after emergence (DAE). An ANOVA using a factorial treatment arrangement was conducted on the data collected November 29, 2007. Only 0 DBS and 15 DAE are reported. A '---' indicates that a significance level was not determined because the interaction was not significant. Each value is the mean of four replications.

| Application Timing | | Total Cover | Broadleaf Cover | Turf Cover |
|---|---|---|---|---|
| | | (%) | (%) | (%) |
| 0 DBS | | | | |
| Untreated | (n=4) | 88 | 8 | 80 |
| 2,4-D | (n=4) | 80 | 8 | 72 |
| Garlon 3A | (n=4) | 74 | 8 | 66 |
| Tordon K | (n=4) | 78 | 3 | 74 |
| Milestone VM | (n=4) | 75 | 5 | 70 |
| Transline | (n=4) | 80 | 8 | 72 |
| Vanquish | (n=4) | 40 | 6 | 34 |
| Significance level (p) | | 0.0001 | --- | 0.0001 |
| LSD (p=0.05) | | 7 | | 7 |
| 15 DAE | | | | |
| Untreated | (n=4) | 88 | 9 | 79 |
| 2,4-D | (n=4) | 75 | 1 | 74 |
| Garlon 3A | (n=4) | 61 | 0 | 61 |
| Tordon K | (n=4) | 85 | 1 | 84 |
| Milestone VM | (n=4) | 76 | 2 | 74 |
| Transline | (n=4) | 84 | 5 | 79 |
| Vanquish | (n=4) | 68 | 0 | 67 |
| Significance level (p) | | 0.0001 | --- | 0.0004 |
| LSD (p=0.05) | | 9 | | 8 |
| **Interaction (Herbicide x Time)** | | | | |
| Significance Level (p) | | 0.0001 | n.s. | 0.0001 |
| Untreated | (n=20) | 85 | 8 | 77 |
| 2,4-D | (n=20) | 84 | 8 | 76 |
| Garlon 3A | (n=20) | 77 | 7 | 70 |
| Tordon K | (n=20) | 84 | 3 | 80 |
| Milestone VM | (n=20) | 82 | 5 | 76 |
| Transline | (n=20) | 85 | 8 | 77 |
| Vanquish | (n=20) | 71 | 7 | 63 |
| **Herbicide** | | | | |
| Significance Level (p) | | 0.0001 | 0.0014 | 0.0001 |
| LSD (p=0.05) | | 4 | 3 | 4 |
| 30 DBS | (n=28) | 88 | 11 | 77 |
| 15 DBS | (n=28) | 82 | 7 | 75 |
| 0 DBS | (n=28) | 73 | 6 | 67 |
| 15 DAE | (n=28) | 77 | 3 | 74 |
| 30 DAE | (n=28) | 85 | 6 | 79 |
| **Time** | | | | |
| Significance Level (p) | | 0.0001 | 0.0001 | 0.0001 |
| LSD (p=0.05) | | 3 | 2 | 4 |

Table 3: Summary of percent total vegetative cover, cover by broadleaf, and cover by desirable grasses (turf). Study area at LMRC was seeded to Formula L grass mix on September 7, 2007. Broadleaf herbicides were applied August 9, August 24, September 7, October 2, and October 17, 2007, 30, 15, 0 days before seeding (DBS) and 15 and 30 days after emergence (DAE). An ANOVA using a factorial treatment arrangement was conducted on the data collected November 27, 2007. Only 15 and 30 DAE are reported. A '---' indicates that a significance level was not determined because the interaction was not significant. Each value is the mean of four replications.

| Application Timing | | Total Cover | Broadleaf Cover | Quackgrass Cover | Turf Cover |
|---|---|---|---|---|---|
| | | (%) | (%) | (%) | (%) |
| 15 DAE | | | | | |
| Untreated | (n=4) | 78 | 19 | 4 | 54 |
| 2,4-D | (n=4) | 35 | 1 | 3 | 31 |
| Garlon 3A | (n=4) | 71 | 0 | 2 | 69 |
| Tordon K | (n=4) | 83 | 1 | 1 | 82 |
| Milestone VM | (n=4) | 62 | 3 | 3 | 56 |
| Transline | (n=4) | 78 | 11 | 11 | 55 |
| Vanquish | (n=4) | 54 | 7 | 1 | 45 |
| Significance level (p) | | 0.0434 | --- | --- | --- |
| LSD (p=0.05) | | 30 | | | |
| 30 DAE | | | | | |
| Untreated | (n=4) | 80 | 18 | 2 | 60 |
| 2,4-D | (n=4) | 79 | 8 | 4 | 66 |
| Garlon 3A | (n=4) | 73 | 1 | 2 | 69 |
| Tordon K | (n=4) | 81 | 2 | 14 | 66 |
| Milestone VM | (n=4) | 69 | 2 | 4 | 63 |
| Transline | (n=4) | 74 | 16 | 3 | 55 |
| Vanquish | (n=4) | 71 | 6 | 5 | 59 |
| LSD (p=0.05) | | n.s. | --- | --- | --- |
| **Interaction (Herbicide x Time)** | | | | | |
| Significance Level (p) | | 0.0113 | n.s. | n.s. | n.s. |
| Untreated | (n=20) | 75 | 16 | 6 | 54 |
| 2,4-D | (n=20) | 72 | 9 | 6 | 57 |
| Garlon 3A | (n=20) | 74 | 9 | 4 | 61 |
| Tordon K | (n=20) | 76 | 5 | 6 | 65 |
| Milestone VM | (n=20) | 73 | 7 | 9 | 58 |
| Transline | (n=20) | 79 | 17 | 5 | 57 |
| Vanquish | (n=20) | 71 | 12 | 5 | 54 |
| **Herbicide** | | | | | |
| Significance Level (p) | | n.s. | 0.0001 | n.s. | n.s. |
| LSD (p=0.05) | | | 5 | | |
| 30 DBS | (n=28) | 80 | 15 | 8 | 58 |
| 15 DBS | (n=28) | 76 | 11 | 8 | 57 |
| 0 DBS | (n=28) | 74 | 13 | 5 | 56 |
| 15 DAE | (n=28) | 66 | 6 | 3 | 56 |
| 30 DAE | (n=28) | 75 | 8 | 5 | 63 |
| **Time** | | | | | |
| Significance Level (p) | | 0.0061 | 0.0002 | n.s. | n.s. |
| LSD (p=0.05) | | 8 | 4 | | |

## IMPLEMENTING JAPANESE KNOTWEED REMOVAL AND CONVERSION TO GRASSES

Herbicide trade and common chemical names: Accord Concentrate (*glyphosate*), Credit Extra (*glyphosate*), Vanquish (*dicamba-glycolamine*), Edict IVM (*pyraflufen*)
Plant common and scientific names: Canada thistle (*Cirsium arvense*), common teasel (*Dipsacus fullonum*), Japanese knotweed (*Polygonum cuspidatum,* POLCU).


ABSTRACT

Two sites infested with Japanese knotweed (POLCU) were treated with herbicides in 2007. The first site, located near Watsontown, PA was initially treated on June 21, with a broadleaf herbicide mix (Vanquish at 64 oz/ac plus Edict at 2.7 oz/ac) to reduce the stand and re-establish site distance. On August 30 a glyphosate treatment was applied to address any remaining foliage. A similar sequence of treatments was conducted at a site near Summerhill, PA. The initial broadleaf herbicide mix was applied on June 25, and a follow-up glyphosate treatment was applied on September 15, 2007. This dual sequence of treatments resulted in 98 percent or greater reduction of POLCU. Follow-up herbicide treatments to address any resprouts and broadcast seeding of grasses are planned for 2008.


### INTRODUCTION

Japanese knotweed (*Polygonum cuspidatum* Sieb & Zucc., POLCU) is a rhizomatous, herbaceous perennial native to East Asia. The plant forms dense monotypic stands reaching 6 to 10 feet in height. The plant can develop from seed, but the movement of root fragments is the primary means of migration. Events such as flooding, construction, and maintenance activities contribute to the spread of POLCU by moving rhizome segments to new areas.

Past efforts to control POLCU have demonstrated that a long-term, programmed approach is required to manage existing stands. Glyphosate-based mixtures applied later in the growing season have shown success, substantially decreasing the stand. Once the stand has been suppressed, then follow-up treatments and reseeding of the area to a competitive groundcover (e.g., grasses) may be possible, if the terrain allows.

This demonstration investigated a multiple-step approach to replacing a Japanese knotweed, POLCU, stand with desirable grass groundcover. The first herbicide treatment included a broadleaf herbicide mixture that provided a more rapid response to reducing foliage and regaining sight distance. This can be a concern where the plant grows adjacent to the roadway. A glyphosate product was applied to the remaining foliage late-season. The effectiveness of late-season glyphosate treatments has been documented[1/]. A follow-up herbicide treatment and seeding of a warm-season grass mixture is planned for spring 2008. A reference for managing this species can be found online at http://rvm.cas.psu.edu/Publications/FS_5a_POLCU.pdf.

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[1/] Johnson JM, AE Gover, and LJ Kuhns. 2007. Evaluation of Herbicides for Control of Japanese Knotweed. Proceedings of the Northeastern Weed Science Society 61:74-75.

## MATERIALS AND METHODS

Implementation sites were located along SR 405 S near Watsontown, PA and at the SR 219 S/SR 53 interchange near Summerhill, PA. At the time of application, POLCU at both sites was vegetative and ranged from 5 to 10 feet tall. On June 21 and 25, 2007, the Watsontown and Summerhill sites, respectively, received a targeted application of Vanquish at 64 oz/ac plus Edict at 2.7 oz/ac with Activator 90, surfactant, at 0.25% v/v. Treatments were applied using a John Bean truck-mounted hydraulic sprayer equipped with a No. 46 Spraying Systems GunJet and AYHSS120 tip. After the initial application, the sites were treated with glyphosate on August 30 and September 15, 2007, respectively. Credit Extra 1% v/v plus defoamer was applied at the Watsontown site, while 0.75% v/v Accord Concentrate plus 0.25% v/v Activator 90, surfactant, was applied at the Summerhill location. POLCU was sprayed to wet.

Percent control of POLCU was determined at the Watsontown site on October 6, 2007, 37 days after the second treatment. The Summerhill site was evaluated during the September 15, 2007 application.

## RESULTS AND DISCUSSION

Two plots were created at the Watsontown site following the initial spraying. These plots were distinguished by the two different applicators making the initial treatment on June 21. There was noticeable difference in control between these areas following the first treatment. Although the POLCU was heavily impacted in both plots, considerable foliage and resprouts were still present throughout the treatment area during the return visit on August 30. The differences between the two plots were largely eliminated following the second treatment. By October 6, 2007, prior to the onset of any frost, the percent control of POLCU varied from 97+ to 99+ among these two plots.

The POLCU stand at the Summerhill site was nearly eliminated by the initial, June 25 application. Few targets, other than Canada thistle and teasel, were present for the follow-up treatment on September 15. A later evaluation was not necessary given the success of the initial treatment with only isolated POLCU stems remaining.

## CONCLUSIONS

Sequential treatment applications during the first season are a viable approach to managing a Japanese knotweed stand. This study confirms that an early season herbicide treatment followed by a late-season glyphosate treatment can greatly reduce the knotweed stand. In the case of the Summerhill site, the stand was almost eliminated by the initial herbicide application. An additional treatment to address resprouts and broadcast grass seed is planned for both sites in 2008. The seed mix planned for application in 2008 is a mixture that includes warm season grasses. Further work and investigation on these two sites will determine if that seed mix offers a viable alternative to the cool season grass mix, Formula L. The quality of many sites is too poor to sustain a Formula L. Once established, the warm-season grasses will tolerate these poorer-quality sites.

## MANAGEMENT IMPLICATIONS

Japanese knotweed stands on the roadside are manageable. Targeting this species with a June herbicide treatment or cutting followed by a late-season glyphosate treatment is necessary the first year to re-establish sight distance and weaken the POLCU stand. Second year follow-up with additional glyphosate treatments and fall grass seeding will promote a competitive grass groundcover. In order to maintain the grass groundcover, annual visits are necessary to apply selective herbicide treatments targeting knotweed sprouts. These annual visits will require minimal time and chemical compared to the initial treatments. Broadleaf herbicides can be applied to remove isolated knotweed stems that develop without harming the grasses.

## ARE THERE ALTERNATIVES TO DIURON FOR KOCHIA CONTROL?

Herbicide trade and common chemical names: Endurance (*prodiamine*), GlyPro Plus (*glyphosate*), Karmex XP (*diuron*), Landmark XP (*sulfometuron plus chlorsulfuron*), Payload (*flumioxazin*), Pendulum AquaCap (*pendimethalin*), Throttle XP (*sulfometuron, chlorsulfuron, and sulfentrazone*).
Plant common and scientific names: kochia (*Kochia scoparia*), marestail (*Conyza canadensis*)


### ABSTRACT

Diuron-resistant kochia poses a management threat to the PennDOT bareground guiderail program. Several diuron alternatives were evaluated for efficacy on kochia. Differences in efficacy based on percent cover ratings were found between the rail yard and the guiderail test sites. Treatments containing Karmex XP, Payload, Pendulum AquaCap, or Endurance were not effective against the vigorous kochia at the guiderail site. Throttle XP provided effective kochia control at both test sites.


### INTRODUCTION

Roadside and railroad trials conducted by the Penn State Vegetation Management Team in Pennsylvania have produced documentation of sulfometuron-resistant kochia. Among the herbicides currently employed by PennDOT, diuron has proven to provide the best control against kochia[1]. However, several Midwestern and Western States have reported diuron-resistant kochia[2]. Alternatives to diuron are needed to provide rotation options for PennDOT's guiderail bareground program and to help prevent the development of diuron-resistant kochia.

Current candidate herbicides for kochia control in bareground settings are flumioxazin and sulfentrazone, both of which are PPO-inhibitors. In addition, pendimethalin and prodiamine, which inhibit cell division, are potential options for the program.

The objective of this experiment was to compare herbicide mixtures that contain diuron, flumioxazin, sulfentrazone, pendimethalin, and prodiamine. Sulfentrazone is currently only available as a component of the product Throttle XP. Throttle XP is a blend of Landmark XP plus formulated sulfentrazone (75 percent active) at 4.5 plus 8 oz per 12.5 oz of material. Consequently, all treatments included Landmark XP at 4.5 oz/ac as the broad spectrum residual component. This provided a rigorous test of the added herbicides on kochia because Landmark XP has not shown efficacy against kochia in previous research.

### MATERIALS AND METHODS

The experiment was established at the Norfolk Southern rail yard in Enola, PA, and on a guiderail site along SR 322 W in State College, PA. The treatments at each site included an untreated check; GlyPro Plus alone at 64 oz/ac; Landmark XP at 4.5 oz/ac plus GlyPro Plus at 64 oz/ac alone, or in combination with Karmex XP at 128 oz/ac, Payload at 8 oz/ac, Pendulum

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[1] Evaluation of Herbicides for Control of Kochia Under Guiderails. 2000. Roadside Vegetation Management Research Report – Fifteenth Year Report. http://vm.cas.psu.edu/2000/final2000.pdf

[2] Mengistu, LW et al. 2005. A psbA mutation in Kochia scoparia (L) Schrad from railroad rights-of-way with resistance to diuron, tebuthiuron and metribuzin. Pest Mngmt Science 61(11): 1035-1042.

AquaCap at 134 oz/ac, or Endurance at 24 oz/ac; and Throttle XP at 12.5 oz/ac plus GlyPro Plus at 64 oz/ac.

The treatments were applied to the Enola site on May 25 to 9-by-20-ft plots arranged in a randomized complete block with three replications, using a $CO_2$-powered, hand-held spray boom equipped with TeeJet XR8002VS tips delivering 20 gal/ac at 32 psi. Kochia was 1 to 3 inches tall and the plots ranged from 5 to 20 percent kochia cover.

The State College trial was established May 29, using 6-by-15-ft plots arranged in a randomized complete block with three replications. Plots were located behind the guiderail. Treatments were applied using a $CO_2$-powered, hand-held spray boom equipped with XR8003VS tips, delivering 20 gal/ac at 30 psi. Kochia was 1 to 6 inches tall within the plots, and ranged from 1 to 44 percent cover.

The roadside of the guiderail was treated by the PennDOT contractor earlier in May with Oust Extra, Karmex XP, Arsenal, and Aquaneat at 3.5, 128, 8, and 24 oz/ac, respectively. The first 2 ft behind the guiderail was free of weeds.

Both sites were rated for total vegetative cover and cover from kochia. The Enola trial was rated on May 25, July 3, July 24, August 6, and September 6, 2007. The State College site was rated May 29, July 9, July 30, August 13, and September 21, 2007. All data were subjected to analysis of variance, and means were compared using Fisher's Protected LSD. The State College data analysis also included a single degree-of-freedom contrast comparing Throttle XP to the other herbicide treatments.

## RESULTS AND DISCUSSION

Plots treated with herbicides had less kochia cover than the untreated plots on each rating date at the Enola trial (Table 1). Cover by kochia changed little at this site with untreated plots starting at 15 percent on May 29 and finishing at 25 percent on September 6. Total plant number per plot appeared to decrease as plant size increased. Kochia cover in the herbicide-treated plots ranged from 2 to 10 percent over the same period of time.

The kochia was much more vigorous at the State College site. Cover from kochia increased in the untreated plots from 17 percent on May 29 to 86 percent on September 21 (Table 2). On July 9 there was a significant treatment effect for total and kochia cover. On this date, treated plots ranged from 0 to 9 percent kochia compared to the untreated plots with 25 percent kochia cover.

Kochia cover increased dramatically in all plots except those treated with Throttle XP. Treatment effect was not significant on August 13, but the single degree-of-freedom contrast comparing Throttle XP to the other herbicide treatments was significant. Plots treated with Throttle XP averaged 2 percent kochia cover while plots treated with the other herbicide treatments averaged from 27 to 60 percent kochia cover. By September 21 there was a significant difference in both treatment effect and single degree-of-freedom contrast comparing Throttle XP to the other herbicide treatments. Plots treated with Throttle XP still averaged 2 percent kochia cover. Only the combination of Landmark XP, Payload, plus GlyPro Plus was similar, with 33 percent kochia cover. All other herbicide treatments ranged from 52 to 78 percent cover by kochia and were not significantly different than the untreated check at 86 percent.

At the State College site, a PennDOT contractor had treated adjacent operational areas earlier in the season while performing bareground weed control services in front of the guiderail. The contractor applied a mixture of 3.5 oz/ac Oust Extra, 8 lb/ac Karmex DF, 8 oz/ac Arsenal, 24 oz/ac Aquaneat, and 1 qt/100 gal Peptoil, surfactant. The operationally treated areas were relatively kochia free despite having similar weed pressure as the trial area. The difference in kochia growth between these adjacent operationally treated areas and the study plots is curious, considering the similarity of treatments. Assuming the operationally treated area received the intended dosage, the primary difference is timing. The authors did not observe the trial plots prior to the first rating, 40 days after treatment, and thus cannot confirm if the kochia in the study area was eliminated at treatment. The timing of the application for the study was later than ideal, but the kochia was still relatively small and should have been removed by each treatment, forcing new growth to emerge from seed.

## CONCLUSIONS

Throttle XP was the only treatment that performed effectively at both sites. It is unclear why the other treatments were ineffective at the State College site while the adjacent operational treatment, which was applied by PennDOT's contractor earlier in the season, was effective.

## MANAGEMENT IMPLICATIONS

Throttle XP appears to be a leading candidate to be integrated into the bareground program rotation. The manufacturer does caution that this combination is weak against marestail and would require additional ingredients in the mix when marestail is targeted.

Table 1. Herbicide treatments were applied to a kochia infestation in a rail yard in Enola, PA on May 25, 2007. Visual ratings of total vegetative cover and kochia cover were taken May 25, July 3, July 24 (not reported), August 6, and September 6, 2007. Total cover is not reported past May 25 because kochia became the dominant species after treatment. Column means followed by the same letter are not significantly different (p=0.05). Each value is the mean of three replications.

| Product | Product Rate | - - May 25 - - Total | Kochia | July 3 Kochia | Aug 6 Kochia | Sep 6 Kochia |
|---|---|---|---|---|---|---|
| | oz/ac | -------------------------% cover | | | | --------------------------- |
| Untreated | | 15 | 15 | 10 | 16 | 25 a |
| GlyPro Plus | 64 | 18 | 18 | 2 | 6 | 10 b |
| Landmark XP<br>GlyPro Plus | 4.5<br>64 | 15 | 15 | 1 | 3 | 6bc |
| Throttle XP<br>GlyPro Plus | 12.5<br>64 | 15 | 15 | 1 | 4 | 5bc |
| Landmark XP<br>Karmex XP<br>GlyPro Plus | 4.5<br>128<br>64 | 15 | 13 | 1 | 2 | 2 c |
| Landmark XP<br>Payload<br>GlyPro Plus | 4.5<br>8<br>64 | 13 | 12 | 0 | 1 | 2 c |
| Landmark XP<br>Pendulum AquaCap<br>GlyPro Plus | 4.5<br>134<br>64 | 15 | 9 | 0 | 1 | 2 c |
| Landmark XP<br>Endurance<br>GlyPro Plus | 4.5<br>24<br>64 | 17 | 16 | 1 | 1 | 2 c |
| Protected LSD (p=0.05) | | n.s. | n.s. | 3 | 5 | --- |

Table 2. Herbicide treatments were applied to a roadside kochia infestation near State College, PA, on May 29, 2007. Visual ratings of total vegetative cover and kochia cover were taken May 29, July 9, July 30 (not shown), August 13, and September 21, 2007. Total cover is not reported past May 29 because kochia became the dominant species after treatment. The analysis of variance included an orthogonal contrast comparing Throttle XP/GlyPro Plus with the other herbicide treatments. Each value is the mean of three replications.

| Product | Product Rate | - - May 29 - - Total | Kochia | July 9 Kochia | Aug 13 Kochia | Sep 21 Kochia |
|---|---|---|---|---|---|---|
| | oz/ac | % cover | | | | |
| Untreated | | 24 | 17 | 25 | 75 | 86 |
| GlyPro Plus | 64 | 33 | 27 | 4 | 60 | 70 |
| Landmark XP<br>GlyPro Plus | 4.5<br>64 | 29 | 21 | 9 | 58 | 78 |
| Throttle XP<br>GlyPro Plus | 12.5<br>64 | 37 | 30 | 0 | 2 | 2 |
| Landmark XP<br>Karmex XP<br>GlyPro Plus | 4.5<br>128<br>64 | 30 | 21 | 3 | 53 | 68 |
| Landmark XP<br>Payload<br>GlyPro Plus | 4.5<br>8<br>64 | 33 | 27 | 3 | 27 | 33 |
| Landmark XP<br>Pendulum AquaCap<br>GlyPro Plus | 4.5<br>134<br>64 | 38 | 23 | 2 | 60 | 78 |
| Landmark XP<br>Endurance<br>GlyPro Plus | 4.5<br>24<br>64 | 22 | 9 | 1 | 27 | 52 |
| Protected LSD (p=0.05) | | n.s. | n.s. | 11 | n.s. | 40 |
| p-value (Throttle XP vs. others) | | n.s. | n.s. | n.s. | 0.01 | 0.00 |

## PAYLOAD HERBICIDE EFFECTIVENESS IS NOT REDUCED UP TO 96 HOURS AFTER MIXING

Herbicide trade and common chemical names: Payload (*flumioxazin*).
Plant common and scientific names: Canada thistle (*Cirsium arvense*), kochia (*Kochia scoparia*), marestail (*Conyza canadensis*).


### ABSTRACT

Payload herbicide was mixed in slightly alkaline water (pH 8.0) at intervals of 0, 24, 48, or 96 hours prior to application at 8 oz/ac to determine if enough degradation occurred to reduce efficacy. Application to two sites dominated by kochia demonstrated significant differences between Payload-treated plots and the untreated control. No significant differences were found among the Payload treatments.


### INTRODUCTION

Payload herbicide is being evaluated for use in PennDOT's bareground program as a rotation option for management of the annual weed kochia. Kochia is resistant to herbicides with modes of action including ALS inhibitors, photosystem II inhibitors, and synthetic auxins[1/], which encompass most of the herbicides currently used in the bareground program. Payload is a PPO-inhibitor which offers an alternative mode of action. However, the Payload label states that it should be used within 24 hours of mixing. It is standard practice to mix only the materials to be used each day, but circumstances certainly arise where spray operations are temporarily halted and resumed the next day or after a weekend.

This experiment evaluated the effect of mixing Payload immediately prior to application and 24, 48, or 96 hours (hereafter referred to 1, 2, or 4 days) prior to application. If the herbicide maintains less than a 24-hour shelf-life after mixing, its utility to the Department will be limited.

### MATERIALS AND METHODS

Aliquots of tap water from the Penn State University Park campus water system were collected and stored in opaque, 10 L, high-density polyethylene containers with caps and maintained at room temperature under natural light. Table 1 summarizes water quality characteristics for the samples. This water was used to mix Payload treatments 4, 2, or 1 days prior to application, and immediately prior (0 days). The Payload dosage was 8 oz/ac in 20 gal/ac of water with a non-ionic surfactant at 0.25 % v/v.

Treatments were applied June 6, 2007 to guiderail sites near Millerstown and State College, PA, using a $CO_2$-powered, hand-held sprayer. The Millerstown treatments were applied June 6 to 3-by-25-ft plots with a spray wand equipped with a single TeeJet OC-08 off-center flat fan tip, and the State College treatments were applied June 6 to 6-by-15-ft plots using a hand-held boom equipped with TeeJet XR8003VS tips. Kochia at Millerstown ranged from seedling to 24 inches tall, and marestail was up to 30 inches tall. At State College, kochia ranged from 1 to 8 in tall, and Canada thistle was vegetative and up to 14 inches tall. Visual ratings of total vegetative cover and cover from kochia were taken June 6 and July 3 at Millerstown and June 5 and July 9 at State College. Visual ratings of percent injury to kochia and marestail were taken June 15 at

[1/] http://www.weedscience.org

Millerstown, and percent injury to kochia and Canada thistle was rated at State College on June 18. Data were subjected to analysis of variance and means compared using Fisher's Protected LSD (p=0.05).

## RESULTS AND DISCUSSION

All Payload treatments caused significant injury to evaluated species and significantly reduced total cover and cover from kochia, relative to untreated plots, at both sites. There were no significant differences among Payload treatments (Table 2 and 3). Payload caused more severe injury to kochia than to marestail or Canada thistle.

## CONCLUSIONS

Payload did not degrade enough to lose potency in slightly alkaline tap water when mixed 4 days prior to application.

## MANAGEMENT IMPLICATIONS

Premixing days in advance is not ideal; however, the results of this study indicate that under extreme circumstances when mixed solutions cannot be applied immediately, there appears to be no detrimental effect on the efficacy of Payload on kochia if application is delayed up to four days after mixing. Under these circumstances, there is no reason to discount Payload for use in the Department's bareground program.

Table 1. Samples of tap water were drawn from the Penn State, University Park Campus water system and stored in 10 L, opaque jugs at room temperature under natural light. This water was used to mix Payload herbicide treatments. A water quality analysis was performed at the Penn State Ag Analytical Services laboratory.

| Analysis | Unit | Water Quality Characteristic | Normal Range |
|---|---|---|---|
| pH | - - | 8.0 | 6.0 - 7.5 |
| Total alkalinity (as $CaCO_3$) | mg/L | 159 | 80-100 |
| Bicarbonates ($HCO_3$) | mg/L | 194 | 80 - 100 |
| Carbonates ($CO_3$) | mg/L | 0 | |
| Hardness as $CaCO_3$ | mg/L | 189 | |
| Electrical conductivity | mmhos/cm | 0.4 | 0.0 - 0.6 |
| Total dissolved solids | mg/L | 281 | |

Table 2. Payload herbicide was applied at 8 oz/ac, 0, 1, 2, or 4 days after being mixed in water, to emerged vegetation in a guiderail site near Millerstown, PA, on June 6, 2007. Cover from the total vegetation and kochia (KCHSC) was rated June 6 and July 3, and percent injury to KCHSC and marestail (CONCA) was visually rated June 15, 2007. Each value is the mean of three replications.

| | - - - June 6 - - - | | - - - June 15 - - - | | - - - July 3 - - - | |
|---|---|---|---|---|---|---|
| Interval | Total Cover | KCHSC Cover | KCHSC Injury | CONCA Injury | Total Cover | KCHSC Cover |
| | ---------------------------------- % ---------------------------------- | | | | | |
| Untreated | 72 | 44 | 0 | 0 | 92 | 52 |
| 0 days | 72 | 56 | 80 | 40 | 18 | 2 |
| 1 days | 65 | 49 | 77 | 40 | 18 | 4 |
| 2 days | 65 | 53 | 73 | 40 | 20 | 6 |
| 4 days | 82 | 53 | 77 | 43 | 20 | 5 |
| Prot. LSD (p=0.05) | n.s. | n.s. | 9 | 5 | 15 | 22 |

Table 3. Payload herbicide was applied at 8 oz/ac, 0, 1, 2, or 4 days after being mixed in water, to emerged vegetation in a guiderail site near State College, PA, on June 6, 2007. Cover from the total vegetation and kochia (KCHSC) was rated June 5 and July 9, and percent injury to KCHSC and Canada thistle (CIRAR) was visually rated June 18, 2007. CIRAR was not present in all plots, so analysis of variance was not performed. Each value is the mean of three replications.

| | - - - June 5 - - - | | - - - June 18 - - - | | - - - July 9 - - - | |
|---|---|---|---|---|---|---|
| Interval | Total Cover | KCHSC Cover | KCHSC Injury | CIRAR Injury | Total Cover | KCHSC Cover |
| | ---------------------------------- % ---------------------------------- | | | | | |
| Untreated | 32 | 27 | 0 | 0 | 47 | 42 |
| 0 days | 30 | 28 | 92 | 32 | 7 | 6 |
| 1 days | 30 | 28 | 90 | 32 | 6 | 4 |
| 2 days | 22 | 19 | 87 | 35 | 7 | 5 |
| 4 days | 32 | 28 | 95 | 28 | 8 | 5 |
| Prot. LSD (p=0.05) | n.s. | n.s. | 8 | - - | 6 | 5 |

**SEED MIX ESTABLISHMENT IMPLEMENTATION WORK PLAN**
**Spring 2008 Deployment**

Plant common and scientific names: alfalfa (*Medicago sativa*), annual ryegrass (*Lolium multiflorum*), big bluestem (*Andropogon gerardii*), Canada wildrye (*Elymus canadensis*), crownvetch (*Coronilla varia*), hard fescue (*Festuca trachyphylla*), Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparius*), spring oats (*Avena sativa*).

## INTRODUCTION

PennDOT Publication 408, *Specifications*, lists several seeding formulas that provide groundcover based on site conditions and intended future maintenance. Formula C, a crownvetch plus annual ryegrass seed mix, is suited for use on poor soils (e.g., post-construction). This mix is conventionally used on newly developed sites or to rehabilitate sloped, difficult-to-mow roadsides. Crownvetch has been used successfully for 50 years but has gained a reputation as a weedy and "invasive" plant. The objective of this demonstration is to test the performance of Formula A (tentative composition)(Table 1). Formula A relies on native grasses and alfalfa as the permanent component and spring oats and hard fescue as the short-term and intermediate-term components. As part of the demonstration, two application methods will be employed to determine versatility of Formula A as an alternative seed mix. This secondary evaluation will compare conventional hydroseeding to a compost blanket-based application.

## MATERIALS AND METHODS

The demonstration will be established in April 2008 along SR I-80W, Montour County, and at a stockpile along SR 56 near Homer City, PA. Each site has a slope with poor quality soil. These areas will be planted to Formula A and divided into two sections. Half the site will be planted using a 2-inch compost blanket applied with a FINN Bark Blower or similar unit, and the other half will be hydroseeded. The compost-seed application will involve injecting the seed mix into the compost as the compost is applied to the plots. Amendments will be added according to PennDOT Pub. 408, section 804 specifications (Table 2). The plots will be evaluated for percent cover, species composition, integrity of the surface, and establishment success in 2008 and 2009.

Table 1. Formula A seed mix (tentative) for the Montour County and Homer City slope rehabilitation project. Components followed by an "*" are reported as lb/ac pure live seed (PLS). Seed will be injected into the compost stream for the blanket plots.

| Common Name | Scientific Name | lb/ac |
|---|---|---|
| Big bluestem | *Andropogon gerardii* | 5* |
| Little bluestem | *Schizachyrium scoparius* | 5* |
| Indiangrass | *Sorghastrum nutans* | 5* |
| Canada wildrye | *Elymus canadensis* | 5* |
| Hard fescue | *Festuca trachyphylla* | 20 |
| Spring oats | *Avena sativa* | 40 |
| Alfalfa | *Medicago sativa* | 12 |

Table 2. Soil supplements applied to the plots. EcoAegis BFM is only used with the compost blanket plots. Amendment rates are reported in lb/1000 sq. yds (MSY) and lb/ac.

| Amendment | lb/MSY | lb/ac |
|---|---|---|
| Pulverized ag lime | 800 | 3872 |
| 10-20-20 | 140 | 678 |
| 38-0-0 | 50 | 242 |
| EcoAegis BFM | 164 | 792 |

## BROADLEAF HERBICIDE COMPARISON

Herbicide trade and common names: Escort XP (*metsulfuron*), Garlon 3A (*triclopyr*), Milestone VM (*aminopyralid*), Milestone VM Plus (*aminopyralid + triclopyr*), Overdrive (*dicamba + diflufenzopyr*), Transline (*clopyralid*), Triplet (*2,4-D + MCPP + dicamba*), Telar XP (*chlorsulfuron*), Vanquish (*dicamba*), Weedestroy (*2,4-D*).

Plant common and scientific names: black locust (*Robinia pseudoacacia*), boneset (*Eupatorium perfoliatum*), yellow woodsorrel (*Oxalis stricta*), crownvetch (*Coronilla varia*), goldenrod (*Solidago* spp.), spotted knapweed (*Centaurea biebersteinii*), sweetclover (*Melilotus* spp).


### ABSTRACT

This study evaluated the success of several postemergence broadleaf (dicot) herbicides applied alone at common usage rates. The herbicide treatments produced apparent differences in control. At 19 days after treatment (DAT), Garlon 3A, Milestone VM Plus, Triplet, and Weedestroy produced significantly greater injury to all dicot species than Escort XP and Telar XP. Vanquish, Overdrive, Milestone VM, and Transline caused intermediate levels of injury. Among five broadleaf species treated, Milestone VM Plus, Triplet, and Weedestroy produced the greatest injuries across the species. By 49 DAT, all treatments had dramatically reduced cover by dicots, and no statistical differences were found among the treatments. These results illustrate the individual spectrum of control offered by ten common herbicides. Overall, Milestone VM Plus, Triplet, and Weedestroy caused the greatest injury to all dicots and provided the best spectrum of control for the five target species evaluated in this trial. It is imperative to use herbicides that are effective on the predominant target species. Herbicide tank mixes will help to broaden the spectrum of control as needed.


### INTRODUCTION

The weed and brush program is an essential component of the overall roadside vegetation management program. Tank mixes that will control a wide range of brush and herbaceous broadleaf weeds (dicots) are needed to effectively push back the encroaching border of vegetation along many roadways. In addition to controlling dicots, the mixes must be safe for the grasses that exist in treated areas. Implementation of an appropriate weed and brush program twill lead to a desirable grass groundcover with minimal intrusion from dicots.

Several postemergence broadleaf herbicides were applied alone, at common usage rates, to determine the spectrum of weed control each provides. By evaluating the efficacy of individual products, applicators will have the information required to formulate appropriate tank mixes that will provide broad spectrum control depending on predominant weed species on site.

### MATERIALS AND METHODS

The study was established in the infield at the interchange of SR 81 S and SR 11/15 N. Treatments included 32 oz/ac Garlon 3A, 32 oz/ac Vanquish, 6 oz/ac Overdrive, 0.5 oz/ac Escort XP, 0.5 oz/ac Telar XP, 5 oz/ac Milestone VM, 8 oz/ac Transline, 96 oz/ac Milestone VM Plus, 64 oz/ac Triplet, and 64 oz/ac Weedestroy. All treatments included 0.25% v/v Activator 90, surfactant. Treatments were applied on July 19, 2007 to 9-by-25-ft plots, arranged in a randomized complete block design, using a $CO_2$-powered, backpack sprayer equipped with a 9-ft boom and TeeJet 8004 VS spray tips. Application volume was 35 gallons per acre.

Percent total vegetative cover and cover by dicots was rated at the initiation of the trial on July 19, 2007, zero days after treatment (DAT). Injuries to all dicots and to five species—crownvetch, goldenrod, spotted knapweed, black locust, and sweetclover—were evaluated on August 6, 2007, 18 DAT. Injury was scored on a scale from 0 to 10, where "0" = no injury or visible symptoms and "10" = dead. Percents total cover and dicot cover were evaluated on September 6, 2007, 49 DAT. The application cost per acre for each herbicide was calculated based on the 2008 DGS Herbicide Contract, except for Telar XP and Weedestroy (2007 pricing). Milestone VM costs were not available.

## RESULTS AND DISCUSSION

At the initiation of the study, 0 DAT, percent total vegetative cover and dicot cover ranged from 42 to 62 and 36 to 57 percent, respectively (Table 1). At 18 DAT, injury ratings for all dicots varied from 5 to 9 (Table 2). Garlon 3A, Milestone VM Plus, Triplet, and Weedestroy produced significantly greater injury to all dicot species than Escort XP and Telar XP. Vanquish, Overdrive, Milestone VM, and Transline caused intermediate levels of injury. Considering each of the five target broadleaf species in Table 2, the herbicides that performed poorly against at least one species, producing less than a level-5 injury, included Garlon 3A, Overdrive, and Escort XP (spotted knapweed) as well as Telar XP (spotted knapweed and black locust). In addition, treatments of Escort XP and Telar XP caused far less injury to crownvetch than the other treatments at this early rating, 18 DAT. Overall, Milestone VM Plus, Triplet, and Weedestroy produced the greatest initial injuries to the five target species. These three products received both the highest overall dicot injury rating (9) and target species injury values ranging from 7 to 10. By 49 DAT (Table 1), all treatment plots showed dramatically reduced dicot cover values ranging from 1 to 19 percent, and no statistical differences were found among the treatments. Among dicots, woodsorrel, and to a lesser degree sweetclover and boneset, prevailed within the study area.

## CONCLUSIONS

These results illustrate the individual spectrum of control offered by 10 common herbicides. Overall, Milestone VM Plus, Triplet, and Weedestroy caused the greatest injury to all dicots and provided the best spectrum of control for the five target species evaluated in this trial (Table 2). From a cost/benefit perspective, a Weedestroy application is an economical alternative as a tank mix component compared to Triplet, which costs over twice as much.

In the long-term, there were no significant differences in dicot cover among the herbicides tested (Table 1); however, all of the products, as expected, showed relative weakness toward one or more target species (Table 2). Considering spotted knapweed, Garlon 3A, Overdrive, Escort XP, and Telar XP failed to achieve acceptable control. These data can be used to help develop appropriate tank mixes for site-specific target species.

## MANAGEMENT IMPLICATIONS

There are many herbicide options available to control broadleaf weeds. The products tested all provide some level of control over a range of species, although there are distinct weaknesses. Targeting a specific weed species with a single herbicide will work when the product and use rate have demonstrated effectiveness. Tank mixing two products is necessary to ensure a broader spectrum of control when a program targets a wide range of species. The results of this research should assist applicators in making decisions on individual products and possible tank mix combinations for controlling some of the more difficult roadside weeds.

Table 1: Summary of percent total vegetative cover and dicot cover after applying herbicides on July 19, 2007. Ratings were taken July 19 and September 6, 2007, or 0 and 49 days after treatment, respectively. Each value represents the mean of three replications. Costs are based on the 2008 DGS Herbicide Contract, except Telar XP and Weedestroy (2007 pricing) and Milestone VM plus (not available).

| | | | 0 DAT | | 49 DAT | |
|---|---|---|---|---|---|---|
| Product | Rate | Cost | Total Cover | Dicot Cover | Total Cover | Dicot Cover |
| | (oz/ac) | ($/ac) | (---------------------------- | % | ----------------------------- | ) |
| Garlon 3A | 32 | 15 | 47 | 38 | 32 | 9 |
| Vanquish | 32 | 14 | 42 | 36 | 23 | 2 |
| Overdrive | 6 | 13 | 60 | 52 | 31 | 15 |
| Escort XP | 0.5 | 3 | 58 | 52 | 17 | 3 |
| Telar XP | 0.5 | 9 | 60 | 54 | 19 | 8 |
| Milestone VM | 5 | 11 | 57 | 51 | 22 | 9 |
| Transline | 8 | 18 | 53 | 47 | 28 | 19 |
| Milestone VM Plus | 96 | n/a | 62 | 57 | 12 | 1 |
| Triplet | 64 | 12 | 57 | 52 | 16 | 1 |
| Weedestroy | 64 | 5 | 57 | 53 | 20 | 6 |
| Protected LSD (p=0.05) | | | n.s. | n.s. | n.s. | n.s. |

Table 2: Summary of injury to all dicots and individual species after applying herbicides on July 19, 2007. Ratings were taken August 6, 2007, 18 days after treatment. Injury was rated on a scale from 0 to 10, where 0 = no injury and 10 = dead. Each value represents the mean of three replications; however, individual species were missing from some plots. Species evaluated for injury included crownvetch (*Coronilla varia*, CZRVA), goldenrod species (*Solidago* spp., SOLXX), spotted knapweed (*Centaurea biebersteinii,* CENMA), black locust (*Robinia pseudoacacia*, ROBPS), and sweetclover (*Melilotus* spp, MELXX). Costs are based on the 2008 DGS Herbicide Contract, except Telar XP and Weedestroy (2007 pricing) and Milestone VM plus (not available).

| | | | Injury Values | | | | | |
|---|---|---|---|---|---|---|---|---|
| Product | Rate | Cost | Dicots | CZRVA | SOLXX | CENMA | ROBPS | MELXX |
| | (oz/ac) | ($/ac) | (------------------------0-10 scale-------------------------) | | | | | |
| Garlon 3A | 32 | 15 | 8 | 9 | 9 | 4 | 10 | 5 |
| Vanquish | 32 | 14 | 7 | 10 | 8 | 9 | 10 | 7 |
| Overdrive | 6 | 13 | 6 | 9 | 8 | 4 | 8 | 6 |
| Escort XP | 0.5 | 3 | 5 | 6 | 5 | 3 | 7 | 7 |
| Telar XP | 0.5 | 9 | 5 | 6 | 6 | 3 | 3 | 8 |
| Milestone VM | 5 | 11 | 7 | 10 | 5 | 7 | m[a] | 8 |
| Transline | 8 | 18 | 6 | 9 | 8 | 8 | 10 | 7 |
| Milestone VM Plus | 96 | n/a | 9 | 10 | 9 | 9 | 10 | 9 |
| Triplet | 64 | 12 | 9 | 10 | 8 | 8 | 10 | 9 |
| Weedestroy | 64 | 5 | 9 | 10 | 7 | 9 | 9 | 9 |
| Protected LSD (p=0.05) | | | 2 | --- | --- | --- | --- | --- |

[a]m=species missing from all three replicate plots

## LATE SEASON BAREGROUND DEMONSTRATION

Herbicide trade and common names: Aquaneat (*glyphosate*), Karmex XP (*diuron*), Krovar I (*diuron + bromacil*), Oust Extra (*sulfometuron + metsulfuron*), Payload (*flumioxazin*), Pendulum AQ (*pendimethalin*), Plateau (*imazapic*), Sahara DG (*imazapyr + diuron*), Throttle XP (*chlorsulfuron + sulfometuron + sulfentrazone*).
Plant common and scientific names: common ragweed (*Ambrosia artemisiifolia*), kochia (*Kochia scoparia*), marestail (*Conyza canadensis*), mugwort (*Artemisia vulgaris)*, prickly lettuce (*Lactuca serriola*).


### ABSTRACT

This demonstration highlighted several proven herbicide mixes used in the 7712, or bareground program. The materials were applied late in the season. Considering the lateness of the application, it was decided to halve the normal rates of the herbicides, except Aquaneat, used in each combination. The site chosen for this demonstration was heavily infested with kochia. The postemergence component, Aquaneat, controlled most of the existing weed population, but some plants remained. Total vegetative cover and cover by kochia remained relatively low through 39 days after treatment (DAT). By 68 DAT, plots that had received treatments without *diuron* showed unacceptable control and ranged from 30 to 50 percent cover by kochia. Treatments containing *diuron* ranged from 2 to 20 percent cover by kochia.


### INTRODUCTION

The 7712, or bareground program, is designed to control and prevent the development of weeds in unwanted areas around guiderails, signposts, along curblines, within concrete cracks and crevices, and around obstacles where no vegetation is desired. These areas are often programmed for treatment every year, sometimes every other, in order to minimize development of hard-to-control perennial plants. Treatments applied in the spring are intended to control existing vegetation with *glyphosate* or postemergence components and rely on the broad-spectrum residual and preemergence herbicides in the tank mix to prevent weed seed germination. The goal is to have enough residual herbicide activity to last for the entire growing season.

This demonstration highlights some of the common tank mixes used for bareground treatments in guiderail areas. In an effort to simulate the behavior of these treatments late in the season, the authors applied them at half the typical rate because about half of the growing season had elapsed prior to application. The preferred approach would be to apply these treatments early in the program window.

### MATERIALS AND METHODS

This demonstration was established at the pull-off area along SR 22 E in Perry County, near the Juniata County line. The study site consisted primarily of kochia, marestail, mugwort, common ragweed, and prickly lettuce. Treatments included 2 oz/ac Oust Extra plus either 64 oz/ac Karmex XP, 4 oz/ac Payload, or 67 oz/ac Pendulum AquaCap; 64 oz/ac Krovar I; 6.25 oz/ac Throttle XP; 80 oz/ac Sahara DG; and 6 oz/ac Plateau plus 64 oz/ac Karmex XP. All treatments included 48 oz/ac Aquaneat and 0.25% v/v Activator 90 surfactant. Treatments were applied on June 15, 2007 to 3-by-100-ft plots using a $CO_2$-powered backpack sprayer with a single TeeJet OC-12 spray tip. A 5-ft untreated buffer was left between each plot.

Percent total vegetative cover and cover by kochia were rated on June 15, July 3, and July 24, 2007, which corresponds to 0, 18 and 39 days after treatment, DAT. Percent cover by kochia was rated on August 22, 2007, 68 DAT.

## RESULTS AND DISCUSSION

The late timing of the application required that the herbicides target larger, more established plants. The *glyphosate*, while effective, did not completely eliminate the existing vegetation. At18 DAT, between 2 and 5 percent total vegetative cover remained within the plots. There was little or no increase in total cover at 39 DAT, with values from 3 to 6 percent. Nearly all the vegetative cover within the plots was comprised of kochia, with the exception of the standard Oust Extra + Karmex XP and Krovar I treatments. The treatments containing *diuron* inhibited kochia more than the other treatments. *Diuron* is a component of Karmex XP, Krovar I, and Sahara DG. Tremendous growth of kochia occurred within the study area from 39 to 68 DAT. At 68 DAT cover by kochia ranged from 2 to 50 percent; however, treatments containing *diuron* reduced the kochia coverage range by half to 2 to 20 percent.

## CONCLUSIONS

All the treatments, when used at normal rates (i.e., double the rates used in this demonstration), have proven to be excellent mixes for the bareground program. It is imperative to avoid late-season treatments due to the resistance of mature vegetation. If late-season treatments are required, the herbicides should be used at fully recommended rates when longer than 60 days of the growing season remains.

Considering choices for bareground herbicide mixes, glyphosate is an excellent postemergence herbicide that will control most plants. The other ingredients, preemergence herbicides, prevent weed seeds from developing. In this study, pre-emergence herbicides containing diuron proved the most effective against kochia. In order to prevent resistance, herbicides used in mixes should be rotated occasionally. Treatments should be made frequently enough, annually or biannually depending on the route and its priorities, to avoid the development of hard-to-control perennial plants.

Table 1: Bareground herbicide treatments were applied June 15, 2007. Ratings were taken June 15, July 3, July 24, and August 22, at 0, 18, 39, and 68 days after treatment, DAT, respectively.

| Treatment | Application Rate | Total Vegetative Cover | | | Cover by Kochia | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 DAT | 18 DAT | 39 DAT | 0 DAT | 18 DAT | 39 DAT | 68 DAT |
| | oz/ac | % | | | | | | |
| Oust Extra<br>Karmex XP | 2<br>64 | 70 | 3 | 3 | 46 | 1 | 2 | 15 |
| Krovar I | 64 | 70 | 4 | 4 | 28 | 1 | 2 | 20 |
| Throttle XP | 6.25 | 70 | 5 | 6 | 28 | 5 | 6 | 50 |
| Oust Extra<br>Payload | 2<br>4 | 60 | 5 | 5 | 39 | 5 | 5 | 30 |
| Oust Extra<br>Pendulum AQ | 2<br>67 | 70 | 5 | 6 | 67 | 5 | 6 | 50 |
| Sahara DG | 80 | 45 | 2 | 2 | 41 | 2 | 2 | 10 |
| Plateau<br>Karmex XP | 6<br>64 | 40 | 2 | 2 | 38 | 2 | 2 | 2 |

## OFFSITE HERBICIDE MOVEMENT DEMONSTRATION

Herbicide trade and common names: Aquaneat (*glyphosate*), Arsenal (*imazapyr*), Authority (*sulfentrazone*), Escort (*metsulfuron*), Karmex XP (*diuron*), Krovar I (*diuron + bromacil*), Oust XP (*sulfometuron*), Payload (*flumioxazin*), Plateau (*imazapic*), Sonora SC (*prometon*), Spike 80W (*tebuthiuron*), Telar XP (*chlorsulfuron*).
Plant common and scientific names: annual dropseed (*Sporobolus neglectus*), giant foxtail (*Setaria faberi*), yellow foxtail (*Setaria pumila*), quackgrass (*Elymus repens*), tall fescue (*Festuca arundinacea*).

### ABSTRACT

This demonstration was initiated to show the potential offsite movement of several bareground herbicides. These herbicides included Oust XP, Telar XP, Escort XP, Krovar I, Spike 80W, Arsenal, Sonora SC, Karmex XP, Authority, Payload, Plateau, and Aquaneat. The treatments were applied on June 15, 2007. Percent total vegetative cover and percent cover by annual and perennial grasses were rated on June 15, July 3, and July 24, 2007 which corresponds to 0, 18, and 39 days after treatment (DAT). Indications of herbicide movement were assessed during the July 3 and July 24 visits. Added observations were made during a field day on August 23, 2007, 69 DAT.

Compared to other treatments, Telar XP, Authority, Payload, and Plateau provided less control of the species present at the site. Percent total vegetative cover ranged from 10 to 20 percent for these four products at 39 DAT with at least 50 percent annual grasses; all other products were between 1 and 5 percent total vegetative cover. Movement to the adjoining tall fescue stand was apparent with Oust XP, Krovar I, and Spike 80W at both 18 and 39 DAT. Arsenal and Plateau showed subtle signs of movement during at least one rating date. Observations taken at 69 DAT revealed striking damage to turf adjacent to the Arsenal plot. At this time it is not known whether the damage was solely from Arsenal or if one of the adjoining plots containing Spike 80W and Krovar I contributed to the damage. Water movement across these plots and into the Arsenal plot with a heavy rain event cannot be discounted.

### INTRODUCTION

Residual herbicides used for the bareground program must provide soil activity for a broad spectrum of weed species and persist long enough in the soil to offer season-long control. The herbicides and use rates evaluated in this demonstration are common for bareground tank mixes. A concern for the vegetation manager is keeping the herbicide on the site of application without lateral movement by water runoff causing damage to adjoining desirable groundcovers. Some herbicides have a greater potential for transport. This demonstration provided a side-by-side comparison of the potential movement of 12 herbicides with the flow of surface runoff.

### MATERIALS AND METHODS

This study was established on the gravel shoulder at the interchange of SR 81 S and SR 11/15 N. Individual herbicides were applied at common bareground use rates. Treatments included 3 oz/ac Oust XP, 1.5 oz/ac Telar XP (a component of Throttle XP), 1 oz/ac Escort XP (a component of Oust Extra), 128 oz/ac Krovar I, 64 oz/ac Spike 80W, 48 oz/ac Arsenal, 397 oz/ac Sonora SC, 128 oz/ac Karmex XP, 8 oz/ac Authority (a component of Throttle XP), 8 oz/ac Payload, 12 oz/ac Plateau, and 48 oz/ac Aquaneat. Treatments were applied on June 15, 2007.

Treatments were applied to 5-by-25-ft plots along the edge of a mowed infield using a $CO_2$-powered backpack sprayer equipped with a single TeeJet OC-12 spray tip. The treated gravel shoulder and adjoining turf area were sloped toward the grass to allow for the movement of herbicides. Percent total vegetative cover and percent cover by annual and perennial grasses were rated on June 15, July 3, and July 24, 2007, which corresponds to 0, 18, and 39 days after treatment (DAT). Indications of herbicide movement were assessed on July 3 and July 24.

## RESULTS AND DISCUSSION

The products used in this study are meant for a tank mix. Therefore, the observed percent total vegetative cover reflects weaknesses expected when the products are used alone. Telar XP, Authority, Payload, and Plateau did not control the weed species present at the site. This does not mean they will not perform effectively in tank mixes. Percent total vegetative cover ranged from 10 to 20 percent for these four products at 39 DAT with at least 50 percent annual grasses. All other products reduced total vegetation cover to between 1 and 5 percent at 39 DAT. Species present in the treated areas included annual dropseed, giant foxtail, yellow foxtail, quackgrass and tall fescue.

Movement to the adjoining tall fescue stand was apparent for Oust XP, Krovar I, and Spike 80W at both 18 and 39 DAT. Arsenal and Plateau showed subtle signs of movement during at least one rating date. Oust XP, Krovar I, Spike 80W, Arsenal, and Sonora SC were among the products most likely to show some lateral movement. These products also offer a broad spectrum of weed control. During the Roadside Vegetation Management Conference field day tour to this site on August 23 (69 DAT), observable damage to turf adjacent to the Arsenal plot was striking. At this time it is not known whether the damage was solely caused by Arsenal or was due to runoff from one of the adjoining plots containing Spike 80W or Krovar I. Water movement across these plots and into the Arsenal plot with a heavy rain event cannot be discounted.

All of these products are useful tools as tank mix partners in the bareground program. Caution must be used when deciding where to apply these herbicides. The rate of material, length of control needed, target surface conditions (e.g., surface type, slope, potential for water flow), spectrum of weeds, and neighboring desirable plant material are factors that must be considered when selecting herbicides for tank mixing in a bareground program.

## CONCLUSIONS

This demonstration confirms that some herbicides have the potential for offsite movement. Caution and care should be taken when working with Oust XP, Krovar I, Spike 80W, and Arsenal. Sonora SC did not move in this demonstration but has the potential for offsite movement. The subtle signs of injury from Plateau could be attributed to drought stress on the turf due to previous weather conditions in the region. Further studies to confirm the suspicious and extreme late-season injury observed near the Arsenal plot and the subtle injury near the Plateau plot are recommended.

## MANAGEMENT IMPLICATIONS

The compacted, gravelly surface of the shoulders and heavy water flow from the roadway promote lateral movement of herbicides. There is often little substrate for the herbicides to bind. This demonstration shows that herbicide movement does occur and must be considered when choosing products and rates. Oust XP, Krovar I, Spike 80W, Arsenal, and Sonora SC (although not evident in this demonstration) have the potential for movement with heavy water flow. These materials are often used in various mixes for the 7712 or bareground program. These products are an integral component of the bareground progam but should be avoided in areas with a history of offsite damage or where an impervious layer or steep slope exists and movement beyond the treated area cannot be accepted.

Table 1: Summary of total vegetative cover and herbicide movement after applying herbicides on June 15, 2007. Ratings were taken June 15, July 3, and July 24 corresponding to 0, 18, and 39 days after treatment (DAT), respectively. 'Y' = herbicide movement was observed, 'N' = no visible herbicide movement, and 'S' = subtle symptoms noted on turf at interface with treated shoulder.

| Treatment | Application Rate | Total Vegetative Cover | | | Herbicide Movement | |
|---|---|---|---|---|---|---|
| | | 0 DAT | 18 DAT | 39 DAT | 18 DAT | 39 DAT |
| | (oz/ac) | (---------- | ---------- | ----% | ---------- | ----------) |
| Oust XP | 3 | 8 | 5 | 5 | Y | Y |
| Telar XP | 1.5 | 20 | 15 | 20 | N | N |
| Escort XP | 1 | 10 | 8 | 4 | N | N |
| Krovar I | 128 | 20 | 1 | 1 | Y | Y |
| Spike 80W | 64 | 1 | 1 | 1 | Y | Y |
| Arsenal | 48 | 2 | 1 | 1 | S | Y |
| Sonora SC | 397 | 1 | 1 | 1 | N | N |
| Karmex XP | 128 | 2 | 1 | 1 | N | N |
| Authority | 8 | 5 | 8 | 10 | N | N |
| Payload | 8 | 5 | 8 | 15 | N | N |
| Plateau | 12 | 15 | 17 | 20 | N | S |
| Aquaneat | 48 | 15 | 1 | 2 | N | N |

## ROADSIDE PLANTING RESTORATION OF THE CAPITAL BELTWAY BEAUTIFICATION PROJECT

Herbicide trade and common chemical names: Snapshot (*trifluralin* + *isoxaben*), RoundUp (*glyphosate*).

Plant common and scientific names: black locust (*Robinia pseudoacacia)*, boxelder (*Acer negundo*), Canada thistle (*Cirsium arvense*), crown vetch (*Coronilla varia*), green ash (*Fraxinus pennsylvanica*), mile-a-minute (*Ipomoea cairica*), poison hemlock (*Conium maculatum*), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), wild grape (*Vitis* spp.)


### ABSTRACT

Roadside ornamental plantings may provide aesthetic enhancement and wildlife habitat. In addition to proper landscape planning and installation, regular maintenance is essential to avoid the loss of ornamental plantings and encroachment by undesired and invasive species. In July 2007, restoration activities began on the Capital Beltway Beautification Project (CBBP), eight years after initial landscaping. A five-person crew spent 4 hours on site for the initial cleanup, including removal of leftover stakes, unwanted and dead trees, brush, and vines, and one worker spent an additional 1.5 hr applying pre- and post-emergence herbicides. Loss of original plantings on the site amounted to $2,751. Costs for the restoration were $377.97 and $43.84 for labor and herbicides, respectively, for a total of $421.81. Regular maintenance of landscape plantings is necessary to avoid costs due to poor public image, plant materials, and restoration.


### INTRODUCTION

Roadside ornamental plantings may provide aesthetic enhancement and wildlife habitat when properly implemented and maintained. Results from a 2006 survey indicated that although about one-quarter of Pennsylvania residents highly regarded the state's landscaping efforts, over two-thirds ranked the quality of roadside beautification as average or below (Environmental Synopsis Vol. 7, No. 6, Joint Legislative Air and Water Pollution Control and Conservation Committee, Harrisburg, PA). Unfortunately, inhospitable roadside environments pose a major challenge for landscaping. In addition, budgets are often limited and unstable, and the initial investment required for a beautification project risks partial to complete loss without regular maintenance. The Capital Beltway Beautification Project (CBBP) is an intensively landscaped highway interchange with mixed plantings that was not adequately maintained. The site was restored in 2007, eight years after initiation. This report describes the scope and expenses of the restoration project.

### MATERIALS AND METHODS

The Capital Beltway Beautification Project (CBBP) is located at the I-81/US 322 interchange near Harrisburg, PA. The site was originally landscaped in 1999 with a budget of $200,000 per year, for three years. A landscape architect from DCNR had designed plans (Figure 1) to fulfill the following goals: move away from unsuccessful wildflower seeding, create mixed landscape plantings including trees, shrubs, and wildflower plugs, establish primarily low-maintenance natives, establish group plantings for effect and stability (i.e., reduced weed invasion), and increase impact by planting small areas that have high visibility. CBBP planning included the identification of goal partners to assist with maintenance on the site, such as Dauphin Co. Juvenile Courts.

In 2007, CBBP was targeted for restoration. The site was surveyed for undesired plant species as well as losses from original plantings, and two plots were established (Figure 2). Plots 1 and 2 were a 120-by-108-ft triangle and a 113-by-191-ft uneven rectangle, respectively. A five-person crew performed initial maintenance and recovery on July 5, 2007. The crew removed all leftover stakes from both plots and then removed unwanted and dead trees, brush, and vines. A pushmower, Kubota tractor with flail mower, and weed eater were used. Following cleanup, herbicides were applied to a quarter acre area on July 27, 2007. Snapshot was applied to bed areas and around tree mower protection zones for pre-emergence control. For post-emergence control, RoundUp at 3 qt/ac was applied using a solo backpack sprayer. Overall, 35 lb of Snapshot and 0.15 gal of RoundUp were used. Time and labor costs were calculated for the two-day restoration effort.

## RESULTS AND DISCUSSION

Eight years after initial landscaping, undesired plants found on the CBBP site included grape, poison ivy, and Virginia creeper as well as invasives such as Canada thistle, crown vetch, mile-a-minute, and poison hemlock. Volunteer tree species on the site included black locust, green ash, and boxelder. Many original plantings on the site were lost, overgrown by vines, or accidentally mowed. Total losses amounted to $2,751 (Table 1).

A five-person crew spent 4 hr on site for cleanup activities on July 5, 2007. Labor on Plot 1 included pushmower (2 hr), Kubota with flail mower (45 min), weed eater (30 min), and removal of stakes and five dead trees (1 hr with 2 people). For Plot 2, most of the effort was directed toward brush and vine removal (3 hr with 3 people) with other cleanup by pushmower (30 min) and Kubota with flail mower (2.75 hr). A total of 30 trees were removed from the site with 8 greater than 2 inches in diameter. Herbicide application on July 27, 2007 required an additional 94 min of labor by one person. Total time spent on site was about 5.5 hr. Labor costs at the site were $86.84 for two wage payroll employees ($10 per hr plus fringe benefits) plus $291.13 for three salaried employees (plus fringe) for a total of $377.97. The cost of herbicide application was $39.75 for Snapshot (25 lb x $1.59 per lb state contract) plus $4.09 for RoundUp (0.15 gal x $27.27 per lb state contract) for a total of $43.84. Table 2 shows the combined cost of labor and herbicides for the restoration effort, which amounted to $421.81.

## CONCLUSIONS

In order to restore the CBBP, a five-person crew spent 4 hr on site for the initial cleanup, including removal of leftover stakes, unwanted and dead trees, brush, and vines, and one worker spent an additional 1.5 hr applying pre- and post-emergence herbicides. Loss of original plantings on the site amounted to $2,751. Costs for the restoration were $377.97 and $43.84 for labor and herbicides, respectively, for a total of $421.81. Regular maintenance of landscape plantings is necessary to avoid costs due to poor public image, plant materials, and restoration.

## MANAGEMENT IMPLICATIONS

Proper landscape planning and roadside beautification must account for site characteristics (e.g., level of visibility and presence or absence of "natural" beauty/scenery), budgets, and maintenance schedules. For example, high-visibility sites are mainly located near major economic centers and attractions or entries to the state on major highways. These locations are a priority for extensive projects, such as mixed planting beds surrounded by turf. However, mixed plantings required significantly more maintenance than grassed infields alone or grass infields with interspersed trees. Project selection must take into account the initial landscaping investment as well as the cost of required, scheduled maintenance. At a minimum, maintenance activities should include the following: plant establishment (e.g., irrigation), stake removal (after first year), mowing, weed control (beds and tree rings) using both a preemergence herbicide (two applications: Fall=August/September and Spring=April/May) and postemergence herbicide (two to three applications per year depending on pressure and invasives), pruning broken and poorly structured branches, and mulching beds and tree rings (may be recycled from brushing program).

Table 1. Summary of losses from original landscape plantings at the Capital Beltway Beautification Project over an 8-year period (1999-2007).

| Plant Name | Original Plantings | Plantings Lost | Cost per Plant ($) | Total Loss ($) |
|---|---|---|---|---|
| Mockorange | 11 | 2 | 34 | 68 |
| Bayberry | 9 | 6 | 10.50 | 63 |
| Mugo pine | 45 | 13 | 35 | 455 |
| Norway Spruce | 34 | 18 | 75 | 1350 |
| Redbud | 9 | 5 | 55 | 275 |
| Flowering quince | 80 | 30 | 18 | 540 |
| Total | | | | 2751 |

Table 2. Summary of restoration costs (labor + herbicides) as of July 2007 for the Capital Beltway Beautification Project. Work on the site included 4 hr cleanup by a five-person crew and 1.5 hr herbicide application by one worker.

| Description | Cost ($) |
|---|---|
| Labor – two wage payroll workers ($10 per hour plus fringe benefits) | 86.84 |
| Labor – three salaried employees plus fringe | 291.13 |
| Herbicide – Snapshot (25 lb x $1.59 per lb state contract) | 39.75 |
| Herbicide – RoundUp (0.15 gal x $27.27 per lb state contract) | 4.09 |
| Total | 421.81 |

Figure 1. Original landscape plans for the Capital Beltway Beautification Project initiated in 1999.

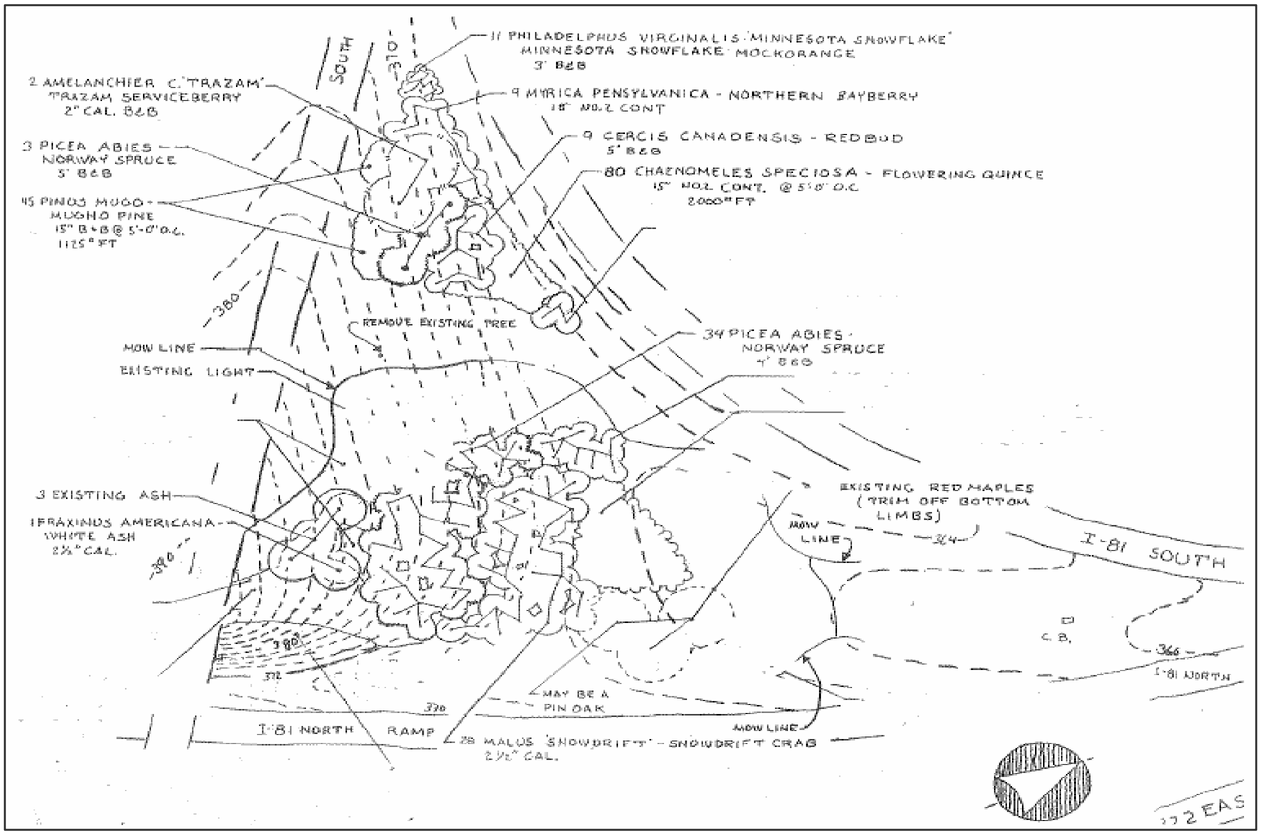

Figure 2. Plantings remaining on site at the Capital Beltway Beautification Project in 2007, 8 years after initial landscaping. The locations of restoration Plot 1 (120-by-108-ft triangle) and Plot 2 (113-by-191-ft uneven rectangle) are marked.