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Roadside Vegetation Management Research – 2014 Report

ANNUAL REPORT

June 30, 2014

By Jon M. Johnson, David A. Despot, and James C. Sellmer

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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: Investigating Herbicide Tank Mixes for Control of Morrow's Honeysuckle (*Lonicera morrow*ii) – Second Year Results, Further Investigation of Herbicide Tank Mixes for Control of Morrow's Honeysuckle (*Lonicera morrowii*), Evaluation of the Herbicides Streamline® and Viewpoint® for Control of Black Birch (*Betula lenta*), Evaluation of Foliar Applications of Streamline® and Viewpoint® to Resprouting Brush Following Mowing, Conversion of Canada Thistle Infested Crownvetch Groundcover to Fine Fescue Turf, Examining Potential Turf Phytotoxicity Caused by Escort XP, Krenite S, and MAT28, Evaluation of Native Seed Mixes for Roadside Application – Year Three, Native Seed Mix Establishment Implementation – Year Five, Slopemaster Seed Mix Demonstration – Fourth Year Results, Evaluating the Efficacy of Esplanade in Bareground Tank Mixes and Compared to Proclipse, Pendulum EC, and Diuron.

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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 2013 season: E.I. DuPont de Nemours & Co., Bayer Environmental Science, and NuFarm Specialty Products.

This work was sponsored by the Pennsylvania Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration, U.S. Department of Transportation, or the Commonwealth of Pennsylvania at the time of publication. This report does not constitute a standard, specification, or regulation.

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INTRODUCTION

In October 1985, personnel at Penn State began a cooperative research project with the Pennsylvania Department of Transportation (PennDOT) to investigate several aspects of roadside vegetation management. An annual report has been submitted each year that 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

Report # PA-2008-003-PSU 005 Roadside Vegetation Management Research Report - Twenty-second Year Report

Report # PA-4620-08-01 / LTI 2009-23 Roadside Vegetation Management Research Report - Twenty-third Year Report

Report # PA-2010-005-PSU-016 Roadside Vegetation Management Research Report - Twenty-fourth Year Report

Report # PA-2011-006-PSU RVM Roadside Vegetation Management Research – 2011 Report

Report # PA-2012-007-PSU RVM Roadside Vegetation Management Research – 2012 Report

Report # PA-2013-008-PSU RVM Roadside Vegetation Management Research – 2013 Report

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

Use of Statistics in This Report

Many of the individual reports in this document make use of statistical analysis, particularly techniques involved in the analysis of variance. The use of these techniques allows for the establishment of criteria for significance. Numbers are said to be significantly different when the differences between them are most likely due to the different treatments, rather than chance. We 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. Once this level of certainty is reached with the analysis of variance, Tukey's HSD separation test is employed to separate the treatments into groups that are significantly different from each other. In many of our results tables, there is/are a letter or series of letters following each number and a notation which states, 'within each column, numbers followed by the same letter are not significantly different at the 0.05 level'. In addition, absence of letters within a column or the notation 'n.s.' indicates that the numbers in that column are not significantly different from each other at the 0.05 level.

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 additional information for products referred to in this report. DF = dry flowable, EC=emulsifiable concentrate, ME=microencapsulated, RTU = ready to use, S=water soluble, SC = soluble concentrate, WG, WDG=water-dispersible granules.

Trade Name	Active Ingredients	Formulation	Manufacturer
Aquasweep	2,4-D + triclopyr	34.2 + 15.2 S	Nufarm Americas Inc.
Arsenal	imazapyr	2 S	BASF Corporation
Diuron	diuron	80 WDG	Drexel Chemical Company
DMA 4 IVM	2,4-D	3.8 S	Dow AgroSciences LLC
Escort XP	metsulfuron methyl	60 WDG	E.I. DuPont de Nemours & Co.
Esplanade	indaziflam	200 SC	Bayer Environmental Science
Garlon 3A	triclopyr amine	3 S	Dow AgroSciences LLC
Garlon 4	triclopyr ester	4 EC	Dow AgroSciences LLC
Imazapyr (research sample)	imazapyr	75 WG	E.I. DuPont de Nemours & Co. (supplier)
Krenite S	fosamine	4 S	E.I. DuPont de Nemours & Co.
MAT28, Method 50SG	aminocyclopyrachlor	50 WDG	E.I. DuPont de Nemours & Co.
Milestone VM	aminopyralid	2 S	Dow AgroSciences LLC
Opensight	aminopyralid + metsulfuron	62.13 + 9.45 WDG	Dow AgroSciences LLC
Oust Extra	sulfometuron +metsulfuron	56.25 + 15 WDG	E.I. DuPont de Nemours & Co.
Oust XP	sulfometuron	75 DG	E.I. Dupont de Nemours & Co.
Pathfinder II	triclopyr ester	13.6 RTU	Dow AgroSciences LLC
PennDOT Blend (or PDT Custom Blend)	aminocyclopyrachlor + metsulfuron	47.9 + 2.5 DF	E.I. DuPont de Nemours & Co.
Pendulum Aquacap (AC)	pendimethalin	3.8 ME	BASF Corporation
Perspective	aminocyclopyrachlor + chlorsulfuron	39.5 + 15.8 DF	E.I. DuPont de Nemours & Co.
Proclipse	prodiamine	65 WDG	Nufarm Americas Inc.
Roundup Original Max	glyphosate	5.5 S	Monsanto Company
Roundup Pro Concentrate	glyphosate	5 S	Monsanto Company
Roundup Power Max	glyphosate	5.5 S	Monsanto Company
Stalker	imazapyr	2 S	BASF Corporation
Streamline	aminocyclopyrachlor + metsulfuron	39.5 + 12.6 DF	E.I. DuPont de Nemours & Co.
Tordon K	picloram	2 S	Dow AgroSciences LLC
Transline	clopyralid	3 S	Dow AgroSciences LLC
Triplet LO	2,4-D + mecoprop-p + dicamba	47.3 + 8.2 + 2.3 S	NuFarm Americas Inc.
Vanquish	dicamba-glycolamine	4 S	Syngenta Crop Protection LLC
Viewpoint	aminocyclopyrachlor + metsulfuron + imazapyr	22.8 + 7.3 + 31.6 DF	E.I. DuPont de Nemours & Co.
Weedar 64	2,4-D	3.8 S	NuFarm Inc.

INVESTIGATING HERBICIDE TANK MIXES FOR CONTROL OF MORROW'S HONEYSUCKLE (LONICERA MORROWII) – SECOND YEAR RESULTS

Herbicide trade and common names: Aquasweep (*2,4-D + triclopyr*); Escort XP (*metsulfuron*); Garlon 3A (*triclopyr* amine); Roundup Pro Concentrate (*3.7 lb ae glyphosate/gal*); MAT28 (*aminocyclopyrachlor*); Milestone VM (*aminopyralid*); Opensight (*aminopyralid + metsulfuron*); PennDOT Blend, Streamline (*aminocyclopyrachlor + metsulfuron*); 2,4-D (*2,4-D*); Vanquish (*dicamba*).

Plant common and scientific names: amur honeysuckle (*Lonicera maackii*), Morrow's honeysuckle (*Lonicera morrowii*), smooth brome (*Bromus inermis*), tatarian honeysuckle (*Lonicera tatarica*).

ABSTRACT

Exotic shrub honeysuckle, including Morrow's honeysuckle, has become more prevalent along Pennsylvania's roads with the repeated use of similar herbicide tank mixes within PennDOT's brush control program. The herbicide 'glyphosate' has demonstrated effectiveness using foliar applications but is non-selective and damaging to the understory. A tank mix that is both effective at controlling Morrow's honeysuckle and safe to grasses would be an ideal complement to the current weed and brush program. Both newer (aminocyclopyrachlor and aminopyralid) and older (2,4-D) chemistry may offer a potential solution to this problem. This experiment investigated ten herbicide tank mixes utilizing the previously mentioned active ingredients for control of this species and the impact to the understory. Herbicide mixes containing glyphosate or 2,4-D resulted in the best control of Morrow's honeysuckle with 83 to 99 percent control nearly one year after treatment. All treatments caused some injury to both the grass and forb understory. Tank mixes that included 8 oz/ac PennDOT Blend or 4 oz/ac PennDOT Blend with 0.5 oz/ac Escort XP and glyphosate combinations had the greatest impact on the grass understory compared to other treatments tested while the forbs were equally damaged by all of the treatments.

INTRODUCTION

Exotic shrub honeysuckles are introduced woody plants that have become widespread along Pennsylvania's roads. The most common species within this region of the U.S. include tatarian, Morrow's, and amur honeysuckle. These plants are difficult to control with the herbicide tank mixes and rates commonly utilized by PennDOT and their contractors for brush control treatments, resulting in an expansion of existing stands along many corridors. Glyphosate has demonstrated effectiveness on controlling exotic shrub honeysuckle but is non-selective and harms the grass understory. Selective chemistry that controls exotic shrub honeysuckle but does not injure grasses would be ideal. Newer chemistry such as aminocyclopyrachlor (ACP) and aminopyralid has shown effectiveness on a host of woody species and are selective to grasses. [1][2][3]

[1] Johnson et al. 2010. Response of Black Locust to Foliar Applications of Aminocyclopyrachlor. Roadside Vegetation Management Research – 2010 Report. pp. 4-5.

[2] Johnson et al. 2009. Response of Black Locust, Red Oak, and Tulip Poplar to Foliar Applications of DPX-KJM44. Roadside Vegetation Management Research – 2009 Report. pp. 11-13.

The active ingredient aminocyclopyrachlor is available in several premix combinations. Two forms were tested in this experiment, including PennDOT Blend and Streamline containing aminocyclopyrachlor (MAT28) and metsulfuron (Escort XP) at different ratios. An 8 oz rate of the PennDOT Blend equates to 7.67 oz of MAT28 (50% ACP) and 0.33 oz Escort XP while 2.5 oz Streamline is equivalent to 1.97 oz MAT28 (50% ACP) and 0.52 oz Escort XP. In addition, an older chemistry, 2,4-D, which showed promise in a 2011 demonstration on controlling shrub honeysuckle was included. This experiment was designed to determine and compare the efficacy of these products in combination with other broadleaf selective herbicides for foliar applied control of Morrow's honeysuckle.

MATERIALS AND METHODS

The experiment was established in close proximity to the interchange of I-99 and I-80 near Bellefonte, PA. Ten herbicide treatments were tested including: 8 oz/ac PennDOT Blend; 8 oz/ac PennDOT Blend plus 0.25 oz/ac Escort XP; 64 oz/ac Garlon 3A plus 4 oz/ac PennDOT Blend and 0.5 oz/ac Escort XP; 64 oz/ac Garlon 3A plus 2.5 oz/ac Streamline; 64 oz/ac Garlon 3A plus 3.3 oz/ac Opensight; 64 oz/ac Garlon 3A plus 64 oz/ac 2,4-D; 64 oz/ac Garlon 3A plus 104 oz/ac Roundup Pro Concentrate[4]; 32 oz/ac Garlon 3A plus 32 oz/ac Vanquish and 7 oz/ac Milestone VM; 104 oz/ac Roundup Pro Concentrate alone; 96 oz/ac Aquasweep plus 0.5 oz/ac Escort XP; and an untreated check. All herbicide treatments included a non-ionic surfactant at 0.25 percent v/v. Plots 10 by 25 feet in size were arranged in a randomized complete block design with four replications. Herbicides were applied at 50 gal/ac on July 10, 2012, using a CO_2 powered backpack sprayer equipped with a GunJet spray gun and single Boomjet XP 20L nozzle.

Percent injury (0 = no injury, 100 = complete necrosis) to Morrow's honeysuckle and the grass and forb understory was evaluated on August 9, 2012, 30 days after treatment, DAT. Percent control (based on percent canopy loss) to Morrow's honeysuckle was evaluated on June 27, 2013, 352 DAT. All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

Initial injury to Morrow's honeysuckle ranged from 29 to 96 percent for the herbicide treatments at 30 days after treatment, DAT. Treatments containing 2,4-D or Roundup Pro Concentrate caused 94 to 96 percent injury. All other treatments included either aminocyclopyrachlor (PennDOT Blend or Streamline) or aminopyralid (Milestone VM or Opensight) in combination with other herbicides and resulted in injury values of 29 to 54 percent.

At 352 DAT, the same trends continued for the herbicide treatments. Control of Morrow's honeysuckle ranged from 19 to 99 percent. Treatments containing 2,4-D or Roundup Pro Concentrate provided 83 to 99 percent control. These treatments included Garlon 3A plus 2,4-D

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[3] Johnson et al. 2009. Grass-safe Herbicide Mixes for Woody Vegetation Control. Roadside Vegetation Management Research – 2009 Report. pp. 6-10.

[4] Roundup Pro Concentrate (3.7 lb ae glyphosate/gal), Monsanto Co., St. Louis, MO. 104 oz Roundup Pro Concentrate contains the equivalent amount of glyphosate acid as found in 128 oz Roundup Pro.

or Roundup Pro Conc.; Roundup Pro Conc. alone; and Aquasweep plus Escort XP. The Aquasweep plus Escort XP combination yielded the lowest mean control rating among this group (i.e., 83 percent); however, one plot demonstrated uncharacteristically poor control (60 percent) while other plots were rated 90, 95, and 80 percent. In plots with treatments containing 2,4-D or Aquasweep, some sprouting was observed at the base of Morrow's honeysuckle plants. All other herbicide treatments continued to offer poor to mediocre control with values from 19 to 51 percent.

Though the grass understory was comprised almost exclusively of smooth brome, the injury ratings were taken collectively for all grass species present. The most dramatic injury to these grasses occurred with combinations containing the PennDOT Blend or Roundup Pro Conc. and varied from 54 to 100 percent. Garlon 3A plus 2,4-D or Streamline provided moderate injury to grasses at 50 and 52 percent and were statistically different than either the untreated check (0 percent) or Roundup Pro Conc. alone (100 percent). Treatments that included Garlon 3A and aminopyralid (Milestone VM or Opensight) or Aquasweep plus Escort XP caused the least injury to grasses from 19 to 46 percent. All treatments caused similar injury to the forb understory and ranged from 62 to 99 percent.

CONCLUSIONS

Tank mixes of Garlon 3A plus 2,4-D or Roundup Pro Conc.; Roundup Pro Conc. alone; and Aquasweep plus Escort XP at the rates tested in this trial caused nearly complete defoliation of Morrow's honeysuckle. Some resprouting from the base of the Morrow's honeysuckle shrubs can be expected using 2,4-D or Aquasweep following a single application. Herbicide treatments containing aminocyclopyrachlor (e.g., PennDOT Blend or Streamline) or aminopyralid (e.g., Milestone VM or Opensight) at the rates evaluated in this trial provide only marginal control of Morrow's honeysuckle. Carrier volume is critical to achieving control[5] and 50 gallons per acre seemed sufficient for control with the most effective treatments.

The observed understory damage demonstrated that tank mixes that included 8 oz/ac PennDOT Blend or 4 oz/ac PennDOT Blend with 0.5 oz/ac Escort XP and treatments containing Roundup Pro Conc. had a significant impact on the grass (mainly smooth brome) understory. Forbs that were over sprayed were equally damaged by all of the treatments.

Further testing of 2,4-D and Aquasweep in progressive rates and within label guidelines in combination with other herbicides is planned for future work.

MANAGEMENT IMPLICATIONS

Tank mixes that include 64 oz/ac Garlon 3A plus 64 oz/ac 2,4-D or 96 oz/ac Aquasweep plus 0.5 oz/ac Escort XP offer an option to control Morrow's honeysuckle in carrier volumes of 50 gal/ac. Increasing rates of 2,4-D or Aquasweep may enhance control, but further work is needed to confirm this point. Though these mixes will result in injury to both the grass and forb understory, the impact is not completely devastating to the grasses and is transient for many grass species.

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[5] Gover et al. 2008. Grass-safe Herbicide Mixes for Woody Vegetation Control - *ongoing*. Roadside Vegetation Management Research – 2008 Report. pp. 3-6.

Table 1: Percent injury and control of morrow's honeysuckle (*Lonicera morrowii*, LONMO) plus injury to the grass and forb understory. The trial was visually rated for percent injury on August 9, 2012 (30 days after treatment, DAT) and percent control of LONMO on June 27, 2013, 352 DAT. Treatments were applied on July 10, 2012. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		Percent Injury (30 DAT)			Percent Control (352 DAT)
product	rate	LONMO	Grasses	Forbs	LONMO
	(oz/ac)				
Untreated	---	0 a	0 a	0 a	0 a
PennDOT Blend	8	29 b	54 b-e	67 b	41 bc
PennDOT Blend Escort XP	8 0.25	42 b	87 cde	95 b	43 bc
Garlon 3A PennDOT Blend Escort XP	64 4 0.5	50 b	67 cde	84 b	31 abc
Garlon 3A Vanquish Milestone VM	32 32 7	54 b	44 abc	62 b	51 cd
Garlon 3A Streamline	64 2.5	42 b	52 bcd	84 b	26 abc
Garlon 3A Opensight	64 3.3	49 b	46 abc	80 b	19 ab
Garlon 3A 2,4-D	64 64	94 c	50 bc	86 b	89 e
Garlon 3A Roundup Pro Conc.	64 104	95 c	97 de	99 b	97 e
Roundup Pro Conc.	104	95 c	100 e	99 b	99 e
Aquasweep Escort XP	96 0.5	96 c	19 ab	67 b	83 de

FURTHER INVESTIGATION OF HERBICIDE TANK MIXES FOR CONTROL OF MORROW'S HONEYSUCKLE (LONICERA MORROWII)

Herbicide trade and common names: Aquasweep (*2,4-D + triclopyr*); Escort XP (*metsulfuron*); Garlon 3A (*triclopyr* amine); Roundup Pro Concentrate (*3.7 lb ae glyphosate/gal*); MAT28 (*aminocyclopyrachlor*); PennDOT Blend (*aminocyclopyrachlor + metsulfuron*); 2,4-D, DMA 4 IVM, Weedar 64 (*2,4-D*).

Plant common and scientific names: amur honeysuckle (*Lonicera maackii*), Morrow's honeysuckle (*Lonicera morrowii*), tatarian honeysuckle (*Lonicera tatarica*).

ABSTRACT

The proliferation of exotic shrub honeysuckle species including tatarian, amur, and Morrow's honeysuckle has become a common problem along the roads of Pennsylvania. Exotic shrub honeysuckle as with other woody species invading transit corridors, need to be controlled because they limit sight distance and interfere with highway maintenance activities. We have observed that herbicide tank mixes commonly used as foliar sprays to manage other encroaching tree and shrub species are often ineffective at controlling the exotic shrub honeysuckles. Glyphosate has been effective, however, it readily damages the understory. Control of Morrow's honeysuckle was achieved in a previous trial using 2,4-D. The goal of this experiment was to use progressive rates of this active ingredient and identify grass safe herbicide tank mix partners that are effective at controlling Morrow's honeysuckle while offering the potential to control a broad spectrum of other woody species. A total of eight herbicide combinations were tested. All treatments containing 96 oz/ac or greater of 2,4-D or Aquasweep resulted in significant injury with values from 90 to 98 percent. However, these results are preliminary and ratings taken in 2014 will better determine whether any treatment provided long-term control.

INTRODUCTION

The very nature of construction and maintenance of roadways creates disturbed, open areas that provide an ideal setting for the establishment of exotic and invasive species. Low growing shrubs, like exotic shrub honeysuckle, are able to colonize these sites, quickly gain a foothold, and spread aggressively. Unfortunately, the herbicide tank mixes commonly used by PennDOT in controlling woody plants have had minimal impact on exotic shrub honeysuckle species along Pennsylvania's roads. A trial to identify chemistry that is not only safe to the grass understory but also effective at controlling exotic shrub honeysuckle was established in 2012. This work identified promising results using 2,4-D or Aquasweep (2,4-D plus triclopyr).[1] Tank mix partners would be needed to ensure a broader spectrum of control of other woody species encountered in an operational program. One potential tank mix partner, the PennDOT Blend, contains MAT28 (aminocyclopyrachlor, ACP) and Escort XP (metsulfuron). An 8 oz rate of the PennDOT Blend equates to 7.67 oz of MAT28 (50% ACP) and 0.33 oz Escort XP. Other possible candidates are Garlon 3A or Escort XP. Further testing of 2,4-D and Aquasweep in progressive rates and within label guidelines in combination with other herbicides for foliar applied control of Morrow's honeysuckle was the focus of this trial.

[1] Johnson, J.M. et al 2014. Investigating Herbicide Tank Mixes for Control of Morrow's Honeysuckle (Lonicera Morrowii) – Second Year Results. Roadside Vegetation Management Research – 2014 Report. pp 1-4.

MATERIALS AND METHODS

The experiment was established in close proximity to the interchange of I-99 and I-80 near Bellefonte, PA. Eight herbicide treatments were tested including: 8 oz/ac PennDOT Blend plus 96 oz/ac 2,4-D; 1 oz/ac Escort XP plus 128 oz/ac 2,4-D; 64 oz/ac Garlon 3A plus 64 oz/ac 2,4-D; 64 oz/ac Garlon 3A plus 128 oz/ac 2,4-D; 64 oz/ac Garlon 3A plus 104 oz/ac Roundup Pro Concentrate[2]; 104 oz/ac Roundup Pro Conc. alone; 96 oz/ac Aquasweep plus 0.75 oz/ac Escort XP; 184 oz/ac Aquasweep plus 0.5 oz/ac Escort XP; and an untreated check. All herbicide treatments included a non-ionic surfactant at 0.25 percent v/v. Plots 10 by 25 feet in size were arranged in a randomized complete block design with four replications. Herbicides were applied at 50 gal/ac on August 2, 2013, using a CO_2 powered backpack sprayer equipped with a GunJet spray gun and single Boomjet XP 20R nozzle.

Percent injury (0 = no injury, 100 = complete necrosis) to Morrow's honeysuckle was visually rated on September 12, 2013, 41 days after treatment, DAT. All data were subjected to analysis of variance, and when treatment effect F-tests were significant ($p \leq 0.05$), treatment means were compared using Tukey's HSD separation test.

RESULTS AND DISCUSSION

Initial injury to Morrow's honeysuckle ranged from 56 to 98 percent for the herbicide treatments at 41 days after treatment, DAT. All treatments containing 96 oz/ac or greater of 2,4-D or Aquasweep resulted in significant injury with values from 90 to 98 percent. Other treatments that included either 64 oz/ac 2,4-D or Roundup Pro Conc. resulted in injury values of 56 to 72 percent.

CONCLUSIONS

Tank mixes of 64 oz/ac Garlon 3A plus 64 oz/ac 2,4-D or 104 oz/ac Roundup Pro alone or combined with 64 oz/ac Garlon 3A did not provide the same initial injury symptoms observed in last year's trial.[3] However, these early injury values do suggest that increased rates of 2,4-D or Aquasweep of 96 oz/ac or greater offer enhanced activity on Morrow's honeysuckle. Tank mixes of 2,4-D plus PennDOT Blend, Escort XP, or Garlon 3A; or Aquasweep plus Escort XP at the higher rates tested in this trial may offer a broader spectrum of control when targeting other woody species. It should be noted that some 2,4-D labels limit the amount of product per acre that can be applied to 64 oz/ac in non-crop areas (e.g., Weedar 64) so proper product selection is crucial to maintain legal compliance.[4] The more liberal 2,4-D products stipulate amounts not exceed 128 oz/ac in non-crop areas (e.g., DMA 4 IVM)[5], while Aquasweep allows 184 oz/ac as

[2] Roundup Pro Concentrate (3.7 lb ae glyphosate/gal), Monsanto Co., St. Louis, MO. 104 oz Roundup Pro Concentrate contains the equivalent amount of glyphosate acid as found in 128 oz Roundup Pro.
[3] Johnson, J.M. et al 2014. Investigating Herbicide Tank Mixes for Control of Morrow's Honeysuckle (Lonicera Morrowii) – Second Year Results. Roadside Vegetation Management Research – 2014 Report. pp 1-4.
[4] NuFarm, Inc. Weedar 64 Herbicide. Online. Internet. February 5, 2014.
[5] Dow AgroSciences LLC. DMA 4 IVM. Online. Internet. February 5, 2014.

the maximum application rate.[6] These results are preliminary and control ratings taken in 2014 will better determine whether any treatment provided complete and lasting control.

MANAGEMENT IMPLICATIONS

Tank mixes that include 96 to 128 oz/ac 2,4-D plus either 8 oz/ac PennDOT Blend or 64 oz/ac Garlon 3A; or 96 to 184 oz/ac Aquasweep plus 0.5 to 0.75 oz/ac Escort XP show initial promise for control of Morrow's honeysuckle. These tank mixes should control a spectrum of other common brush species while minimizing impact to the grass understory. The 2,4-D plus Escort XP combination may prove to be weak on controlling other woody species. Roundup Pro Conc. alone and in combination has offered excellent brush control, including Morrow's honeysuckle in past work, but is damaging to grasses. Unless it is a targeted application or the site contains no desirable understory vegetation, tank mixes containing glyphosate should be avoided to preserve desirable groundcover. Second year data still needs to be collected and other trials investigating these tank mixes on a host of brush species should first be pursued to validate these claims.

[6] NuFarm Americas, Inc. Aquasweep Herbicide. Online. Internet. February 5, 2014.

Table 1: Percent injury of morrow's honeysuckle (*Lonicera morrowii*, LONMO). The trial was visually rated for percent injury on September 12, 2013 (41 days after treatment, DAT). Treatments were applied on August 2, 2013. All treatments included 0.25 percent v/v non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		Percent Injury (41 DAT)
product	rate	LONMO
	(oz/ac)	
Untreated	---	0 a
PennDOT Blend 2,4-D	8 96	94 c
Escort XP 2,4-D	1 128	94 c
Garlon 3A 2,4-D	64 64	68 bc
Garlon 3A 2,4-D	64 128	95 c
Garlon 3A Roundup Pro Conc.	64 104	56 b
Roundup Pro Conc.	104	72 bc
Aquasweep Escort XP	96 0.75	90 c
Aquasweep Escort XP	184 0.5	98 c

EVALUATION OF THE HERBICIDES STREAMLINE® AND VIEWPOINT® FOR CONTROL OF BLACK BIRCH (BETULA LENTA)

Herbicide trade and common names: Escort XP (*metsulfuron*); Garlon 3A (*triclopyr* amine); Imazapyr 75WG (*imazapyr*); MAT28 50 SG (*aminocyclopyrachlor*); Streamline (*aminocyclopyrachlor* + *metsulfuron*); Viewpoint (*aminocyclopyrachlor* + *metsulfuron* + *imazapyr*).

Plant common and scientific names: black birch (*Betula lenta,* BETLE), flattened oatgrass (*Danthonia compressa*, DANCO), tapered rosette grass (*Dicanthelium acuminatum*).

ABSTRACT

Unwanted trees and shrubs can quickly invade the roadsides of Pennsylvania where they can create potential hazards such as limited sight distance, obstacles, and falling limbs. Black birch is among the many undesirable species that encroach along the roadway corridors. Herbicide programs are implemented that target these plants before they attain sizes that require mechanical removal. New herbicides with varying modes of action are continually investigated to help prevent resistance and find the most effective chemistry and tank mixes available for control of these woody targets. Also important is selectivity to the understory, mainly grasses, which offer cultural control by hindering the development of unwanted, taller growing plants.

Aminocyclopyrachlor has shown efficacy in control of a number of tree species on the roadside. DuPont has released three new herbicide premixes containing the active ingredient *aminocyclopyrachlor* that received EPA registration in 2011 and two (i.e., Streamline and Viewpoint) are labeled for general weed and brush control along highway rights-of-way. This experiment was established to investigate the efficacy of these products at various rates compared to the standard Garlon 3A plus Escort XP combination using foliar applications for control of black birch and safety to grasses.

Preliminary data collected 55 days after treatment, DAT, showed injury symptoms to black birch and flattened oatgrass, the predominate grass species present. All herbicide treatments caused moderate initial injury to black birch with a rating of 43 to 70 percent injury. Data collected next season should offer insight on the long-term efficacy of the treatments. Viewpoint at the highest and lowest rates tested showed the greatest injury to the understory grass, but also include *imazapyr* that would be expected to damage the understory.

INTRODUCTION

The goal of managing roadsides in Pennsylvania is to maintain a stable, low growing plant community adjacent to travel lanes, which provides a buffer from standing trees and the hazards associated with them, such as collision targets, falling limbs, and limited sight distance. Trees and shrubs, especially early successional species, quickly gain a foothold in these areas and targeted spraying or removal is used to keep the roadways safe. Herbicide programs are implemented using a variety of tank mixes to target unwanted trees and shrubs while avoiding resistance and ensuring broad spectrum weed control. Two relatively new products in the marketplace are Streamline and Viewpoint. These herbicides are labeled for brush control in foliar roadside applications and they control a host of common woody species. This experiment examines several rates of each product in foliar applications to control black birch and to

determine their affect on understory plants compared to the standard Garlon 3A plus Escort XP herbicide treatment.

MATERIALS AND METHODS

An experiment was established within the right-of-way of SR 322 near Port Matilda, PA. Treatments included Streamline at 7.5, 9.5, and 11.5 oz/ac; Viewpoint at 13, 16.5, and 20 oz/ac; Garlon 3A at 64 oz/ac plus Escort XP at 0.5 oz/ac; and an untreated check. Methylated seed oil was added to all treatments at 1% v/v. The experiment was established as a randomized complete block design with three replications. Plots were 10 by 30 ft. in size. Black birch had a maximum height of approximately 10 ft and averaged 6 ft tall. Treatments were applied using a CO2-powered sprayer equipped with an AA30 GunJet spray gun, TeeJet adjustable ConeJet nozzle, and X-6 tip operating at 30 psi. An application volume of 25 gallons per acre was targeted. The black birch was treated on July 2, 2013. A brief rain shower with large droplets began while spraying the last plot with enough rain to wet the pavement but ended quickly and was not considered to have impacted the treatments.

Percent injury to black birch was evaluated August 26, 2013, 55 days after treatment, DAT. Percent injury to black birch was a reflection of the percentage of defoliation. Percent injury to the understory, in particular ferns and two grass species, flattened oatgrass and tapered rosette grass, were also evaluated August 26, 2013, 55 DAT. However, only flattened oatgrass was present in enough quantity to yield sufficient data for reporting.

RESULTS AND DISCUSSION

Injury to black birch was statistically similar and ranged from 43 to 70 percent for the herbicide treatments. Streamline herbicide applied at 9.5 oz/ac, Viewpoint at 16.5 or 20 oz/ac, and Garlon 3A at 64 oz/ac plus Escort XP at 0.5 oz/ac resulted in the greatest injury with rating values from 57 to 70 percent. All other treatments including Streamline at 7.5 or 11.5 oz/ac and Viewpoint at 13 oz/ac resulted in injury values of 43 to 47 percent. Moderate injury to flattened oatgrass occurred with Viewpoint at its lowest and highest rates tested within this trial (13 and 20 oz/ac) with 63 and 53 percent injury, respectively. All other herbicide treatments caused less injury to this grass species from 20 to 37 percent and were not significantly different from the untreated check.

CONCLUSIONS

A moderate level of initial injury can be expected on black birch with the various rates of Streamline and Viewpoint tested in this trial. These products and rates are comparable in their initial injury symptoms to the standard Garlon plus Escort XP tank mix commonly used in PennDOT's weed and brush program (7713). There did appear to be greater injury to the grass understory with Viewpoint compared to Streamline or Garlon plus Escort XP though not statistically different than the other herbicide treatments. This would be expected with the addition of *imazapyr* found in Viewpoint. However, evaluations made at one year after treatment, will better determine whether any treatment provided complete and lasting control of the black birch or permanent loss of the understory grasses.

MANAGEMENT IMPLICATIONS

It is too early to suggest operational use of any of the treatments tested for control of black birch. Next season's evaluation will provide insight on which herbicides and rates performed best over the long term. However, all the herbicide treatments evaluated at the rates described in this experiment will result in both initial discoloration and defoliation of the black birch and injury to the understory.

Table 1: Percent injury to black birch (*Betula lenta*, BETLE) plus injury to flattened oatgrass (*Danthonia compressa*, DANCO) found within the understory. The trial was visually rated for percent injury on August 26, 2013, 55 days after treatment, DAT. Treatments were applied on July 2, 2013. All treatments included 1 percent v/v methylated seed oil. Each value is the mean of three replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Product	rate	Percent Injury BETLE	Percent Injury DANCO
	(oz/ac)		
Untreated	---	0 a	0 a
Streamline	7.5	45 ab	20 ab
Streamline	9.5	58 b	27 ab
Streamline	11.5	43 ab	27 ab
Viewpoint	13	47 ab	63 b
Viewpoint	16.5	57 b	30 ab
Viewpoint	20	63 b	53 b
Garlon 3A Escort XP	64 0.5	70 b	37 ab

EVALUATION OF FOLIAR APPLICATIONS OF STREAMLINE AND VIEWPOINT TO RESPROUTING BRUSH FOLLOWING MOWING

Herbicide trade and common chemical names: Arsenal or Stalker (*imazapyr*), 2,4-D (2,4-D), Escort XP (*metsulfuron*); Garlon 4 (*triclopyr ester*), Krenite S (*fosamine*); MAT28 50 SG (*aminocyclopyrachlor*), Milestone (*aminopyralid*), Streamline (*aminocyclopyrachlor + metsulfuron*); Tordon K (*picloram*), Viewpoint (*aminocyclopyrachlor + metsulfuron + imazapyr*).
Plant common and scientific names: black locust (*Robinia pseudoacacia*), black walnut (*Juglans nigra*), cherry (*Prunus* spp.), exotic shrub honeysuckle (*Lonicera spp.*), goldenrod (*Solidago spp.*), smooth sumac (*Rhus glabra*).

ABSTRACT

Mowing is an effective way to remove dense stands of brush and small caliper trees from the right-of-way. Without herbicide treatment, many stems will resprout and rapidly revegetate the area. Where stem density is high, allowing the cut stems to resprout and treating the emerging stems and leaves with a foliar application may be an effective alternative to cut stump treatment. This experiment was designed to evaluate the performance of a foliar application of Viewpoint and Streamline, two products that contain the active ingredient *aminocyclopyrachlor*, alone and in combination with other brush control herbicides on resprouting woody vegetation following mowing. Preliminary data suggests that tank mixing with older chemistries (i.e., 2,4-D, Garlon 4, Escort XP) controlled exotic shrub honeysuckle equally as well as the best performing treatments containing *aminocyclopyrachlor*. There were no statistical differences between levels of defoliation provided by the herbicide treatments. A mixture of Tordon K and Garlon 4 provided the highest level of defoliation to exotic shrub honeysuckle with a rating of 95 percent.

INTRODUCTION

Mowing is cost effective at to removing woody vegetation along the right-of-way when stems are too dense for basal stem treatments yet small enough for cutting with a brush mower. Many of the cut stems will resprout if not treated with an herbicide. Cut stump treatments are labor intensive when high stem densities are encountered and require a relatively high concentration of herbicide to be effective. Another way to treat cut stems is to allow them to resprout and apply an herbicide to the developing leaves and stems. This experiment was established to evaluate the performance of two aminocyclopyrachlor products (i.e.,Viewpoint and Streamline) alone and in combination with other brush control herbicides as a foliar application to control resprouting woody vegetation following mowing.

MATERIALS AND METHODS

A trial was established within the right-of-way of I-80 westbound near Lamar, PA. Treatments included Streamline at 9.5 and 11.5 oz/ac with or without Krenite S at 128 oz/ac; Viewpoint at 13 and 16.5 oz/ac; Viewpoint at 9.5 oz/ac plus Streamline at 6 oz/ac; Tordon K at 64 oz/ac plus Stalker at 16 oz/ac plus Milestone at 7 oz/ac; Tordon K at 64 oz/ac plus Garlon 4 at 128 oz/ac; Garlon 4 at 64 oz/ac plus 2,4-D at 64 oz/ac plus Escort XP at 0.5 oz/ac; and an

untreated check. Methylated seed oil was added to all treatments at 1% v/v. The experiment was established as a randomized complete block design with four replications. Plots were 20 by 30 ft. in size. Target species included mainly exotic shrub honeysuckle; however, other species such as cherry, walnut, black locust, and smooth sumac were scattered in lesser numbers throughout the trial area. Treatments were applied using a CO_2-powered sprayer equipped with a six foot boom and four (4) 8004 VS nozzles operating at 30 psi. An application volume of 50 gallons per acre was targeted. The trial area was cut/mowed by PennDOT personnel during the winter of 2012/2013 and herbicide treatments applied on May 30, 2013.

Percent defoliation to exotic shrub honeysuckle (*Lonicera spp*., LONXX) and other woody species present within each plot was evaluated September 19, 2013, 112 days after treatment, DAT. Percent injury to the goldenrod (*Solidago spp*., SOLXX) understory was also evaluated September 19, 2013, 112 DAT.

RESULTS AND DISCUSSION

At 112 DAT, defoliation of bush honeysuckle ranged from 73 percent for the Tordon K, Arsenal, Milestone mix to 95 percent for Tordon K plus Garlon 4, with no statistically significant differences between herbicide treatments. Only 3 treatments failed to provide at least 80 percent control, Streamline at 9.5 oz/ac; Streamline at 9.5 oz/ac plus Krenite at 128 oz/ac; and Tordon K at 64 oz/ac plus Arsenal at 16 oz/ac, and Milestone at 7 oz/ac. Injury to goldenrod understory was high (97.5 to 100 percent) and almost uniform across herbicide treatments.

CONCLUSION

Preliminary results generated from first year data show that the tank mix using the older chemistries (i.e., 2,4-D, Garlon 4, Escort XP) controlled exotic shrub honeysuckle as well as the best performing mix that contained *aminocyclopyrachlor*. Data collected one year after treatment will help identify the herbicide or tank mixes that provide long-term control.

MANAGEMENT IMPLICATIONS

Tordon K is not used by PennDOT because of the restricted use label. All other herbicide treatments tested produced at least 79 percent defoliation of exotic shrub honeysuckle sprouts after one season. Results are preliminary and recommendations on which, if any, herbicide or combination to use cannot be made until future evaluations are conducted.

Table 1. Defoliation to exotic shrub honeysuckle (*Lonicera* spp., LONXX) and injury to goldenrod (*Solidago* spp., SOLXX) understory along I-80 East near Lamar, PA. Trees and brush were mowed during the winter of 2012/2013. Herbicide treatments were applied to regrowth on the cut stubble on May 30, 2013 at 50 gallons per acre. Visual ratings were performed on September 19, 2013 (112 DAT). Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		September 19, 2013 (112 DAT)	
		percent defoliation	percent injury
treatment	rate	exotic shrub honeysuckle	goldenrod
	(oz/ac)		
Streamline	9.5	79 b	100 c
Streamline	11.5	83 b	100 c
Streamline Krenite S	9.5 128	79 b	100 c
Streamline Krenite S	11.5 128	86 b	100 c
Viewpoint	13	88 b	99.8 bc
Viewpoint	16.5	85 b	100 c
Viewpoint Streamline	9.5 6	84 b	100 c
Tordon K Arsenal Milestone	64 16 7	73 b	99.8 bc
Tordon K Garlon 4	64 128	95 b	100 c
Garlon 4 2,4-D Escort XP	64 64 0.5	88 b	97.5 b
Untreated	---	0 a	0 a

CONVERSION OF CANADA THISTLE INFESTED CROWNVETCH GROUNDCOVER TO FINE FESCUE TURF

Herbicide trade and common names: Garlon 3A (*triclopyr*), Milestone VM (*aminopyralid*), PDT Custom Blend (*aminocyclopyrachlor + metsulfuron*), Roundup Pro Concentrate (*glyphosate*), Transline (*clopyralid*), Triplet LO (*2,4-D + mecoprop-p + dicamba*)
Plant common and scientific names: Annual ryegrass (*Lolium multiflorum*), Canada thistle (*Cirsium arvense*), creeping red fescue (*Festuca rubra*), crownvetch (*Coronilla varia*), hard fescue (*Festuca longifolia*), Kentucky bluegrass (*Poa pratensis*), Tall fescue (*Festuca arundinacea*).

ABSTRACT

Crownvetch is an effective groundcover on steep slopes with rocky mineral soils; however, on sites with well-developed topsoil characterized by higher levels of organic matter, this groundcover often becomes overrun with difficult to control broadleaf weeds such as Canada thistle. Herbicides that will spare the crownvetch yet provide some control of broadleaf weeds is limited. Converting an area from crownvetch to fine fescue turf while eliminating the Canada thistle allows for better future broadleaf control. An effective conversion strategy is to use herbicides to control both the Canada thistle and crownvetch followed by the establishment of fine fescue turf. Fine fescue provides a level of allelopathic and competitive control against broadleaf weeds, requires limited to no mowing, and allows for more broad-spectrum broadleaf weed control. Some effective broadleaf herbicides persist in the soil after application and may inhibit the germination of desirable turfgrass seeds during the conversion. This experiment was established to determine the effectiveness of various herbicide treatments to control crownvetch and Canada thistle while defining the best timing for turfgrass seeding after treatment. For this experiment a fall herbicide treatment was applied with a comparison of a same season fall seeding versus a spring seeding to determine the best time for establishing a fine fescue stand and define the effect of a residual herbicide on establishment success. The herbicide treatments included: 1) Milestone VM at 7 oz/ac, 2) Roundup Pro Concentrate at 104 oz/ac + Transline at 8 oz/ac, 3) PDT Custom Blend at 8 oz/ac, 4) PDT Custom Blend at 4 oz/ac + Garlon 3A at 64 oz/ac, and 5) a cut and seed treatment with no herbicide applied. The experiment also included a control treatment in which no herbicides and seeds were applied. The plots were prepared by loosening the soil with a disc harrow immediately prior to seeding to assure good seed-soil contact. Plots were seeded with PennDOT Formula L seed mix (Table 1) at 24 lbs. per 1000 sq. yds. and fertilized according to soil test recommendations at 1 lb. N, 5.0 lbs. P_2O_5, and 0.5 lbs. or 2 lbs. K_2O per 1000 sq. ft. (Old Fort and Thompsontown sites, respectively). The first post treatment Canada thistle stem counted was conducted in June 2013. The stem counts showed that PennDOT Custom Blend at 8 oz/ac, applied in September 2012 followed by a fall or spring seeding, performed best across both sites and produced a 99 to 100 percent reduction in thistle stems. In addition, it appeared that seeding alone aided in suppression of thistle stems at both sites with fall seeding being more effective than spring seeding. Continued monitoring of these sites will help determine the long-term effectiveness of the treatments.

INTRODUCTION

Crownvetch has historically been the low maintenance ground cover of choice for steep slopes where rocky, mineral soils predominate along roadways. Conversely, on sites with adequate organic matter and moderate terrain, crownvetch can contribute to maintenance concerns because it easily becomes infested with difficult to control broadleaf weeds such as Canada thistle. Herbicides that can be used for broadleaf weed control in this crownvetch are limited. Converting crownvetch into turf is an attractive option to simplify ongoing maintenance procedures because more options for broadleaf weed control are available in turf including more frequent mowing cycles and a wider range of herbicide options. Previous research has indicated that a number of herbicide tank mixes have been effective at controlling Canada thistle and crownvetch in turf environments.[1] Some of the herbicides used to remove crownvetch have residual effects in the soil that may inhibit germination of desirable seeds for some time after application. The purpose of this experiment was to evaluate several herbicides or herbicide tank mixes for control of crownvetch and Canada thistle and to determine the best time to seed turf following a fall application of these herbicide treatments.

MATERIALS AND METHODS

The experiment was established at two sites with predominantly crownvetch groundcover infested with Canada thistle, one on the shoulder of SR 322E near the Old Fort exit, 5 miles east of State College and the second in the median of SR 322 near Thompsontown. Both sites were organized into 24 by 30 foot plots in a randomized complete block design with 4 replications.

All plots were mowed on June 21 and 28, 2012, Old Fort and Thompsontown respectively, with a tractor mounted flail mower at a height of 5 inches to replicate the standard maintenance practice used to remove Canada thistle seed heads and reduce seed dispersal. Herbicide treatments were applied on September 5 and September 7 at the Old Fort and Thompsontown sites, respectively. The plots were prepared immediately before seeding using a disc harrow mounted on a Kubota L2500 tractor. Fall and spring seeded plots were broadcast with PennDOT Formula L seed mix (Table 1) at 24 lbs. per 1000 sq. yds. September 26, 2012 or April 11, 2013 and October 5, 2012 or April 16, 2013 for the Old Fort and Thompsontown sites, respectively. The amount of fertilizer applied was based on soil test result recommendations from the Penn State Agricultural Analytical Services Laboratory and was equivalent to 1 lb. N, 5.0 lbs. P_2O_5, and 0.5 lbs. or 2 lbs. K_2O per 1000 sq. yds. on all plots at both sites (Old Fort and Thompsontown, respectively).

The herbicide treatments included: 1) Milestone VM at 7 oz/ac, 2) Roundup Pro Concentrate at 104 oz/ac + Transline at 8 oz/ac, 3) PDT Custom Blend at 8 oz/ac, 4) PDT Custom Blend at 4 oz/ac + Garlon 3A at 64 oz/ac, and 5) a cut only treatment, followed by seeding with no herbicide application. The treatments also included a control plot where no herbicide or seed was applied. All herbicide treatments included a non-ionic surfactant at 0.25 percent v/v and were applied with a CO_2 powered backpack sprayer at 35 psi with a 6 ft. boom equipped with four 8004VS nozzles. Canada thistle stem counts were obtained prior to treatment (August 2012) and two times following treatment (June and October 2013) by counting and averaging the number of stems in three 11 sq. ft. subplots at fixed locations within each plot. A percent

[1] Johnson et al. 2012. Comparison Of Herbicide And Mowing Regimes For Control Of Canada Thistle In A Grass Groundcover. 2012 Roadside Vegetation Management Report. pp. 1-5.

coverage visual rating for Canada thistle, desirable turf (defined as fine fescue and annual rye in the Formula L seed mix and Kentucky bluegrass and tall fescue already present in the plots), and total plot cover were collected for each plot on the same dates as the stem counts. In June 2013, all plots except the unseeded treatment were sprayed with Triplet LO at 64 oz/ac + CWC 90 surfactant at 0.25% v/v to protect the developing turf stands from being overtopped with broadleaf weeds. In October 2013, following the fall rating, all plots were mowed with a tractor mounted flail mower.

Table 1. Formula L seed mix per PennDOT Pub. 408, Section 804 – Seeding and Soil Supplements.

Scientific Name	Common Name	Seeding Rate lbs/1000 sq yd
Festuca longifolia	hard fescue	13.0
Festuca rubra	creeping red fescue	8.5
Lolium multiflorum	annual ryegrass	2.5

RESULTS AND DISCUSSION

For the June 2013 rating, Canada thistle stem counts for all herbicide treatments for both fall and spring seeded plots decreased dramatically from pretreatment values established in August 2012 (Tables 2 and 3). PennDOT Custom Blend at 8 oz. followed by a fall or spring seeding performed best across both sites and produced a 99 to 100 percent reduction in thistle stems, but this treatment did not separate out as statistically different from the other herbicide treatments. The initial number of Canada thistle stems averaged 43 to 48 and declined to an average of 0 to 0.3 by June 2013 for this herbicide treatment with either seeding date. Even the poorest performing herbicide and seeding timing combination (Roundup Pro at 104 oz. + Transline at 8 oz. followed by spring seeding) reduced thistle stem counts from 60 to 14.8 (75% reduction) and from 47 to 13.8 (70% reduction) at Thompsontown and Old Fort, respectively. The Roundup Pro + Transline combination performed better when followed by fall seeding, reducing mean thistle stem counts at Thompsontown from 33 to 2 (94% reduction) and at Old Fort from 41 to 7.8 (81% reduction). Seeding alone appeared to help suppress thistle stem counts at both sites, with Formula L plots established in the fall demonstrating a reduction of thistle plants greater than twice that observed for spring seeded turf. A look at the June thistle counts for the seed only plots showed that on fall seeded plots thistle stem counts decreased 55% (from 40 to 18) and 40% (from 46 to 28) while spring seeded turf produced a reduction of only 13% (32 to 28) and 20% (49 to 39) at Thompsontown and Old Fort, respectively.

The October 2013 thistle stem count data showed a continued reduction of thistle stems across all treatments. The Old Fort site thistle stem counts were uniformly low across all treatments with no significant difference between treatments, including the control. Canada thistle stem counts for the various treatments at the Thompsontown site were not statistical different, but all treatments had relatively low numbers. Perhaps the timing of the ratings in mid to late October (i.e., October 15 for Old Fort and October 22 for Thompsontown, respectively) was too late to allow for accurate thistle counts due to normal fall senescence. The June 2014 stems counts may help to validate the trend. A visual percent cover rating for Canada thistle was also recorded in June 2013 and October 2013 at both sites and closely mirrored the thistle counts reported.

The visual ratings for desirable turf cover collected on June 2013 at the Thompsontown site revealed that fall seeded plots produced a greater percentage of cover than spring seeded plots except where PennDOT Custom blend herbicide at 8 oz. was applied. (Table 4). This outcome should be anticipated because the fall seeded plots had a longer development time than plots seeded the following spring. The October 2013 ratings confirmed that fall seeded plots were continuing to increase in desirable turf across all treatments. The October 2013 rating of spring seeded plots; however, produced unexpected results. Turf cover decreased by an average of 88.5 percent from June 2013 rating levels across all treatments. Some event obviously impacted the newly establishing turf on the spring-seeded plots at the Thompsontown site as the annual ryegrass faded and the perennial fine fescue components were developing.

Plots at the Old Fort site showed a steady progression in cover by desirable turf in 2013, with all treatments containing a higher percentage of desirable turf in October than in June with the exception of Milestone at 7 oz./ac. with spring seeding.

CONCLUSIONS

All of the herbicides selected for fall application in this experiment were known to be somewhat persistent in the soil and active against Canada thistle. All treatments including the seed only plots produced dramatic reduction of Canada thistle stems. It appears that the three pronged approach of mowing or applying an herbicide at bloom time followed by a fall application of a persistent herbicide, in combination with the establishment of a turf groundcover was effective.[2] PennDOT Custom Blend at 8 oz./ac. was most effective at reducing the number of thistle stems present for the June 2013 rating, but this treatment did not separate out statistically from the other herbicide treatments.

For the seed only plots, it is interesting to note the relationship between thistle stem reduction and cover by desirable turf. The seed only, fall seeded treatment (June 2013 rating), reduced thistle stem counts by 55 and 40 percent and produced a 79.3 and 70.8 percent cover by desirable turf at the Thompsontown and Old Fort sites, respectively. For the seed only, spring seeded plots, where turf establishment was slower (June 2013 rating), thistle stem counts dropped by only 13 and 20 percent and cover by desirable turf was lower at 25.3 and 16.3 percent at the Thompsontown and Old Fort sites, respectively, reinforcing the idea that Formula L turf competition is contributing to Canada thistle control in this experiment.

The collapse of the newly developing turf in the spring-seeded treatments during the summer of 2013 at the Thompsontown site is somewhat of a mystery. One possible explanation is that rodents consumed the turf. A large number of rodents were evident when the tractor disturbed the site during mowing. It is possible that the rodents were attracted to the spring seeded plots by the mature seeds produced by the annual ryegrass component of the Formula L seed mix. While in these plots eating the seed, rodents could also have consumed or damaged the fine fescue plants that had germinated. Fall seeded plots had no annual rye seedheads because frost killed the plants before seed could be produced.

[2] Gover et al. 2007. Managing Canada Thistle, Factsheet 1, Conservation Reserve Enhancement Program Technical Assistance Series. http://plantscience.psu.edu/research/projects/vegetative-management/publications.

MANAGEMENT IMPLICATIONS

Current recommendations for managing Canada thistle consist of a herbicide or mowing treatment to prevent seed set and reduce energy reserves in the root system followed by fall application of a herbicide that has some persistent activity. Data from this experiment suggests that establishing a competitive turf groundcover aids in suppression of thistle stems and enhances the effect of other control methods. Continued monitoring and maintenance of sites that were once infested with Canada thistle will be necessary to prevent Canada thistle populations from recovering.

PennDOT Custom Blend at 8 oz./ac. may have caused some inhibition of turf seed (Formula L) germination when seeded at 3 weeks after herbicide application. Other species of turfgrass may vary in tolerance to herbicide residuals in the soil.

Table 2. Canada Thistle Stem Counts per square meter at the Thompsontown site. Each stem count is the mean of 3 subplots in each of 4 repetitions. The initial number of Canada thistle stems was counted on August 28, 2012. Herbicide treatments were applied on September 7, 2012 and plots seeded October 5, 2012 (fall seed) or April 16, 2013 (spring seed). Thistle stems were counted on June 18, 2013 (284 days after treatment, DAT) and October 22, 2013 (410 DAT). The percent reduction in thistle stems from pre-treatment numbers was calculated for the June 2013 thistle stem count. Column means followed by the same letter are not significantly different at $p \leq 0.05$

Treatment	Initial Stem Count 8/28/2012	Stem Count June 2013 284 DAT	Percent Canada Thistle Reduction June 2013 284 DAT	Stem Count Oct 2013 410 DAT
Fall 2012 Seed	40	18.0 bc	55	0.6 ab
Milestone VM 7, Fall Seed	40	2.0 ab	95	0.2 ab
Roundup Pro 104, Transline 8, Fall Seed	33	2.0 ab	94	0.0 a
Custom Blend 8, Fall Seed	43	0.0 a	100	0.0 a
Custom Blend 4, Garlon 64, Fall Seed	36	0.2 a	99	0.3 ab
Spring 2013 Seed	32	28.0 c	13	5.2 bc
Milestone VM 7, Spring Seed	45	0.7 a	98	0.2 ab
Roundup Pro 104, Transline 8, Spring Seed	60	14.8 abc	75	6.3 c
Custom Blend 8, Spring Seed	45	0.2 a	99	0.0 a
Custom Blend 4, Garlon 64, Spring Seed	41	0.8 a	98	0.2 ab
No 2012 herbicide app., No 2012 or 2013 seeding	41	23.0 c	49	6.7 c
	N.S.			

Table 3. Canada Thistle Stem Counts per square meter at the Old Fort site. Each stem count is the mean of 3 subplots in each of 4 repetitions. The initial number of Canada thistle stems was counted on August 27, 2012. Herbicide treatments were applied on September 5, 2012 and plots seeded September 26, 2012 (fall seed) or April 11, 2013 (spring seed). Thistle stems were counted on June 12, 2013 (280 days after treatment, DAT) and October 15, 2013 (405 DAT). The percent reduction in thistle stems from pre-treatment numbers was calculated for the June 2013 thistle stem count. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

Treatment	Initial Stem Count 8/27/2012	Stem Count June 2013 280 DAT	Percent Canada Thistle Reduction June 2013 280 DAT	Stem Count Oct 2013 405 DAT
Fall 2012 Seed	46	27.5 bc	40	1.5
Milestone VM 7, Fall Seed	58	7.4 a	87	1.6
Roundup Pro 104, Transline 8, Fall Seed	41	7.8 ab	81	1.7
Custom Blend 8, Fall Seed	48	0.3 a	99	2.1
Custom Blend 4, Garlon 64, Fall Seed	43	0.3 a	99	0.3
Spring 2013 Seed	49	39.2 c	20	0.8
Milestone VM 7, Spring Seed	49	6.1 a	87	0.0
Roundup Pro 104, Transline 8, Spring Seed	47	13.8 ab	70	2.9
Custom Blend 8, Spring Seed	47	0.0 a	100	0.1
Custom Blend 4, Garlon 64, Spring Seed	44	3.4 a	92	0.4
No 2012 herbicide app., No 2012 or 2013 seeding	49	27.6 b	44	2.2
	N.S.			N.S.

Table 4. Visual rating of percent cover by desirable turf at the Thompsontown site. Herbicide treatments were applied on September 7, 2012 followed by seeding October 5, 2012 (fall seed) or April 16, 2013 (spring seed). The plots were visually rated for cover on June 18, 2013 (284 days after treatment, DAT) and October 22, 2013 (410 DAT). Ratings represent the mean of 4 repetitions. Column means followed by the same letter are not significantly different at p≤0.05.

Treatment	Percent Cover June 2013 284 DAT	Percent Cover October 2013 410 DAT
Fall 2012 Seed	35.0 ab	79.3 b
Milestone VM 7, Fall Seed	50.0 ab	56.0 b
Roundup Pro 104, Transline 8, Fall Seed	70.0 b	85.8 b
Custom Blend 8, Fall Seed	53.8 ab	68.8 b
Custom Blend 4, Garlon 64, Fall Seed	57.3 b	68.8 b
Spring 2013 Seed	25.3 ab	0.5 a
Milestone VM 7, Spring Seed	28.8 ab	8.8 a
Roundup Pro 104, Transline 8, Spring Seed	64.0 b	3.8 a
Custom Blend 8, Spring Seed	57.5 b	1.8 a
Custom Blend 4, Garlon 64, Spring Seed	36.0 ab	5.8 a
No 2012 herbicide app., No 2012 or 2013 seeding	0.0 a	0.0 a

Table 5. Visual rating of percent cover by desirable turf at the Old Fort site. Herbicide treatments were applied on September 5, 2012 followed by seeding September 26, 2012 (fall seed) or April 11, 2013 (spring seed). The plots were visually rated for cover on June 12, 2013 (280 days after treatment, DAT) and October 15, 2013 (405 DAT). Ratings represent the mean of 4 repetitions. Column means followed by the same letter are not significantly different at p≤0.05.

Treatment	Percent Cover June 2013 280 DAT	Percent Cover October 2013 405 DAT
Fall 2012 Seed	26.3 abc	70.8 b
Milestone VM 7, Fall Seed	46.3 bc	75.5 b
Roundup Pro 104, Transline 8, Fall Seed	40.0 abc	79.3 b
Custom Blend 8, Fall Seed	10.0 ab	30.0 ab
Custom Blend 4, Garlon 64, Fall Seed	35.0 abc	57.8 ab
Spring 2013 Seed	16.3 abc	30.3 ab
Milestone VM 7, Spring Seed	55.8 c	35.0 ab
Roundup Pro 104, Transline 8, Spring Seed	53.8 c	72.0 b
Custom Blend 8, Spring Seed	48.8 bc	70.0 b
Custom Blend 4, Garlon 64, Spring Seed	56.0 c	81.3 b
No 2012 herbicide app., No 2012 or 2013 seeding	0.0 a	0.5 a

EXAMINING POTENTIAL TURF PHYTOTOXICITY CAUSED BY ESCORT XP, KRENITE S AND MAT28

Herbicide trade and common names: Escort XP (*metsulfuron*); Krenite S (*fosamine*); MAT28, Method 50SG (*aminocyclopyrachlor*); PennDOT Custom Blend, Streamline (*aminocyclopyrachlor + metsulfuron*).
Plant common and scientific names: tall fescue (*Festuca arundinacea*).

ABSTRACT

Roadside vegetation management programs contain a weed and brush component designed to prevent woody plants from establishing on the right-of-way and to control broadleaf weeds in turf. Additionally, a sidetrimming program is sometimes implemented to target tree limbs encroaching on the road. Some herbicides that are highly effective against woody plants and broadleaf vegetation hold the potential to damage turf. Proper timing and the use of lower application rates lessen the potential for damage. This demonstration was designed to provide a side-by-side comparison of potential turf injury following the application of herbicides that may be used in weed, brush and sidetrimming programs including MAT28, Escort XP, and Krenite S. Various rates of each product were applied and evaluated on established tall fescue turf. Krenite S caused the highest level of damage to turf and was rate dependent, followed by Escort XP which caused short term damage at all rates applied. MAT28 was relatively well tolerated by tall fescue turf, causing only minimal and transitory damage.

INTRODUCTION

Controlling broadleaf weeds in turf and preventing woody plants from encroaching on the right-of-way is necessary to retain sight distance required for safe travel and to prevent unwanted vegetation from interfering with maintenance activities. Some herbicides used for broadleaf weed and brush control along the right-of-way carry cautions on the label concerning damage to turf. The Escort XP and Method 50 SG labels both warn of temporary chlorosis, stunting, and seed head suppression on turf. The Krenite S label carries an even broader statement cautioning against the use of Krenite for control of woody plants on lawns. Escort XP and Krenite S have both demonstrated the potential for damage to turf in past experiments.[1][2][3][4][5] The materials applied were herbicides (i.e., MAT28, Escort XP, and Krenite S), typically used alone or in tank mixes to control broadleaf vegetation and woody plants. This demonstration was designed as a

[1] Watschke T.L., et al. 1991. Response of Three Grass Species to Fall Applied Brush Control Treatments. Roadside Vegetation Management Research Report – Fifth Year Report. pp. 1-4.
[2] Gover, A.E. et al. 1993. Effect of Application Date on Response of Tall Fescue to Telar and Escort. Roadside Vegetation Management Research Report – Seventh Year Report. pp. 36-40.
[3] Gover, A.E. et al. 1993. Effect of Application Date on Response of Fine Fescues to Telar and Escort. Roadside Vegetation Management Research Report – Seventh Year Report. pp. 41-45.
[4] Johnson, J.M. et al. 2011. Evaluation of Aminocyclopyrachlor Tank Mixes Compared to Aminopyralid for Broadleaf Weed Control. Roadside Vegetation Management Research – 2011 Report. pp. 19-23.
[5] Johnson, J.M. et al. 2013. Evaluation of Turf Phytotoxicity Caused by Escort XP, Krenite S., and MAT28. Roadside Vegetation Management Research – 2013 Report. pp. 38-41.

side-by-side comparison of potential turf injury following application of these frequently used right-of-way herbicides at various rates on established tall fescue turf in a roadside situation.

MATERIALS AND METHODS

The demonstration consisted of eleven treatments of three herbicides at varying rates applied to 6 by 15 foot plots on the shoulder of SR322 E, five miles west of State College, PA, near the Old Fort exit. Treatments included MAT28 at 2.0, 3.75, 6.0, and 7.5 oz/ac; Escort XP at 0.5, 1.0, 1.5, and 2.0 oz/ac; Krenite S at 128 and 192 oz/ac; and an untreated check. Treatments were applied at 35 gallons per acre on August 6, 2013 with a CO_2 powered backpack sprayer connected to a 6 ft boom containing four 8004 VS tips. CWC Surfactant 90 at 0.25% v/v was added to treatments containing MAT28 and Escort XP. Cide Kick II surfactant at 0.25% v/v was added to treatments containing Krenite S. Damage to tall fescue turf was rated on a scale of 0 to 10 based on the following criteria: 0 = no apparent symptoms, 5 = moderate chlorosis and stunting, 10 = completely necrotic, dead. Ratings were recorded on August 23, 17 days after treatment (DAT), September 11 (36 DAT), September 28 (53 DAT), and October 15, 2013 (70 DAT). Data was subjected to an analysis of variance and when treatment F-tests were significant ($p \leq 0.05$), Tukey's HSD test was used to separate the treatments into groups that were significantly different from one other.

RESULTS AND DISCUSSION

MAT28 resulted the lowest level of phytotoxicity on tall fescue turf among the three herbicides (Table 1). The highest damage rating of 1.3 for MAT28 was found on plots treated at the 7.5 oz/ac rate at 36 and 53 DAT. A higher injury rating was recorded at 70 DAT on plots treated at half the MAT28 rate (3.75 oz/ac). We believe this was an anomaly based on the ratings found for lower and higher MAT28 applications during the same 70 DAT rating period. Escort XP demonstrated turf damage across all rates tested. The phytotoxicity across treatment levels developed quickly (17 DAT), peaked at 36 DAT and them tapered off to 0.8 or less by 70 DAT. Escort XP at 1.5 oz/ac produced the highest damage rating to tall fescue for this herbicide, 4.8 at 36 DAT. Phytotoxicity caused by Krenite S got progressively worse over time and with higher rates of the herbicide, with ratings of 2.3 and 4.0 at 17 DAT and 5.8 and 8.0 at 70 DAT for 128 and 192 oz/ac, respectively.

CONCLUSIONS

Of the three herbicides tested, MAT28 produced the least damage to tall fescue. In this demonstration, injury by MAT28 was not significantly different from the control plots. Escort XP produced an intermediate level of damage, but did not show a progressive increase in damage as application rates increased. Krenite S demonstrated more damage as rates increased and that damage continued to develop with time at both rates tested.

Right-of-way turf is under stress from various causes during the growing season and separating damage by herbicide application from normal environmental stress is difficult. This demonstration provides a glimpse at the issue, but a more extensive experiment conducted at several sites on consistent stands of tall fescue could provide more conclusive information. In addition, tank mixes of these products were not tested. It is possible that damage to turf could occur at lower rates when combinations of these herbicides are used.

MANAGEMENT IMPLICATIONS

Escort rates above 0.5 oz/ac should be avoided when treating turf for broadleaf weed control or when targeting woody vegetation while attempting to preserve grass understory. Tall fescue appeared to be tolerant to all rates of MAT28 tested. MAT28 is one of the components in herbicides such as Streamline, and PennDOT Custom Blend, labeled for broadleaf weed control in right-of-way situations; however, these products also contain Escort XP. Care should be taken to keep the Escort rates low enough to prevent damage to desirable turf. Results from this demonstration show that tall fescue turf had little tolerance to Krenite S at rates commonly used for brush control, so some loss of understory can be expected with side-trimming operations using this product.

Table 1. Ratings of phytotoxicity to tall fescue turf on the east shoulder of SR322 E near the Old Fort exit, 5 miles west of State College, PA. Treatments were applied on August 6, 2013. Visual ratings were conducted on August 23, 2013, September 11, 2013, September 28, 2013, and October 15, 2013, 17, 36, 53, and 70 days after treatment, DAT. Evaluations are based on a scale where 0 = no damage, 5 = moderate chlorosis and stunting, and 10 = complete necrosis. Ratings shown are the mean of 4 repetitions. Within each column, means followed by the same letter are not significantly different at $p \leq 0.05$

Treatment	oz/ac	8/23/13 17 DAT	9/11/13 36 DAT	9/28/13 53 DAT	10/15/13 70 DAT
Untreated	---	0.0 a	0.0 a	0.0 a	0.0 a
MAT28	2.0	0.0 a	1.0 abc	1.0 ab	0.3 a
MAT28	3.75	0.0 a	0.5 ab	0.8 ab	1.5 a
MAT28	6.0	0.5 a	0.8 abc	1.0 ab	0.5 a
MAT28	7.5	0.8 a	1.3 abc	1.3 ab	0.8 a
Escort XP	0.5	3.5 b	3.3 bcd	2.0 ab	0.3 a
Escort XP	1.0	4.0 b	3.3 bcd	2.0 ab	0.8 a
Escort XP	1.5	4.0 b	4.8 de	2.8 ab	0.3 a
Escort XP	2.0	3.8 b	3.5 cde	2.8 ab	0.3 a
Krenite S	128	2.3 ab	3.5 cde	3.8 b	5.8 b
Krenite S	192	4.0 b	6.3 e	7.0 c	8.0 b

EVALUATION OF NATIVE SEED MIXES FOR ROADSIDE APPLICATION -- YEAR THREE

Plant common and scientific names: annual ryegrass (*Lolium multiflorum*), autumn bentgrass (*Agrostis perennans*), big bluestem (*Andropogon gerardii*), Canada wildrye (*Elymus canadensis*), creeping red fescue (*Festuca rubra*), crownvetch (*Coronilla varia*), exotic shrub honeysuckle (*Lonicera* spp.), hard fescue (*Festuca brevipila*), Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), oats (*Avena sativa*), partridge pea (*Chamaecrista fasciculata*), red maple (Acer rubrum), sheep fescue (*Festuca ovina*), switchgrass (*Panicum virgatum*), tall fescue (*Festuca arundinacea*), wild senna (*Senna hebecarpa*).

ABSTRACT

In 2000, the PA Department of Conservation and Natural Resources classified crownvetch as a "situational invasive" in the publication *Invasive Plants in Pennsylvania*. Since this listing, several demonstration plots have been established to examine the germination and establishment of alternative seed mixes in the roadside environment. Warm-season grasses (WSG) have many attributes that make them suited to this application. They are adapted to the heat, drought, variable pH levels, and low fertility often encountered on these sites. Unfortunately, warm-season grasses commonly take several years to establish. To assure a stable groundcover while the warm-season grasses are developing, a site tolerant, intermediate grass species in combination with an immediate short-term groundcover crop (e.g., oats) would assure site and soil stabilization. To this end, sheep fescue, a perennial, cool-season, bunch-type grass, is a good candidate as the intermediate cover. Sheep fescue is adapted to drought, pH levels from 5.5 to 7.5, and medium fertility. Two demonstration sites (Indiana, PA and I-99 near Port Matilda, PA) were seeded with sheep fescue at two rates at each site (i.e., 10 and 20 lbs/acre) along with oats as the immediate cover crop and big bluestem, little bluestem, Indiangrass, switchgrass, wild senna, and partridge pea as the long-term groundcover component. Both demonstration sites were broadcast seeded by hand. One was covered with an erosion blanket; the other was sprayed with hydromulch immediately after seeding. At the Indiana site, 2.8 years after treatment (YAT), warm season grasses and sheep fescue are establishing on both plots with 23 and 40 percent based on a visual cover rating for WSG and 3 and 30 percent cover for sheep fescue on the FN10 and FN20 plots, respectively. The second site, along I-99 near Port Matilda has shown poor establishment of both WSG and sheep fescue.

INTRODUCTION

Road construction projects often lead to significant site disturbance and often leave exposed subsoil. While it is imperative to establish groundcovers on the roadside, many plant species are not adapted to the poor soil conditions and harsh environment. Crownvetch has been a standard groundcover used in many roadside plantings, especially on steep, droughty, and low nutrient sites. In recent years, crownvetch has come under scrutiny and been labeled as a 'situational invasive' by Pennsylvania's Department of Conservation and Natural Resources.[1] Our search for

[1] Invasive Plants in Pennsylvania. 2006. PA DCNR. 25 Jan. 2012 <http://www.dcnr.state.pa.us/forestry/InvasivePlantBrochure.pdf>

alternative groundcover options has led to warm-season grass mixes. A few species under consideration include big bluestem, little bluestem, Indiangrass, and switchgrass.[2] These plants are adapted to a range of pH levels from 4.5 to 7.8, moderate to high drought tolerance, low to moderate salt tolerance, and full sun.[3] The plants are deep rooted and tall, growing up to 7 feet for some species, under optimum growing conditions. These grasses are meant for areas beyond the typical mow-line, perhaps 30 feet from the road edge or within large interchange areas where sight distance is not sacrificed and mowing will be minimal or not occur. Although they take several years to establish, these warm-season native grasses are competitive once established and provide visual interest and wildlife habitat. The slow development and establishment of native warm-season grasses requires that an immediate and intermediate groundcover stand be planned into the seeding mix deployed along the roadside to protect and anchor the soil. Spring oats acts as the immediate groundcover component. In exploring suitable intermediate groundcover components, previous plots have included Canada wildrye and autumn bentgrass with little success.[4] In this evaluation, two sites were seeded with two rates of sheep fescue along with spring oats and a combination of warm-season grasses to determine its success in establishment. Additionally, two herbaceous perennials, partridge pea and wild senna, were added to the mix to evaluate the germination and growth of these species in a roadside environment.

MATERIALS AND METHODS

The seed mixes were applied at two locations, along SR 422 near Indiana, PA and I-99 near Port Matilda, PA. The Indiana location was a fill site for a recent construction project. The plots were composed of a gravelly substrate that was level across much of the area, but included a steep slope of about 20 feet along the back edge of the site. The parcel was divided into three individual plots. Plot sizes for the Formula N (native warm season grass mix with sheep fescue) designated FN10, FN20, and a control plot consisting of Formula L, a standard cool season grass mix of fine fescue) were 8,242; 9,300; and 10,800 sq ft, respectively. The FN10 and FN20 plots were broadcast, hand-seeded at 64 and 74 lb pure live seed (PLS)/ac on October 21, 2010 (Tables 1, 2). Immediately after seeding, a 3000 gallon capacity T330 Finn Hydroseeder was used to apply mulch and soil amendments. The soil amendments incorporated into the liquid slurry included high calcium pulverized lime at a rate of 2000 lbs, 1000 lbs 10-20-20, and 50 lbs 38-0-0 fertilizers, and 1000 lbs Second Nature recycled paper mulch[5] in a total of 3000 gallons of water. Approximately 1,500 gallons was applied to both Formula N plots totaling 17,542 sq ft. The Formula L seed mix was later added to the slurry and hydro-seeded at 116 lb/ac onto the third plot (Table 3). Percent cover was evaluated on May 24, 2011 (215 days after treatment, DAT), September 19, 2011 (333 DAT), September 20, 2012 (1.9 years after treatment, YAT), and July 24, 2013 (2.8 YAT).

The Port Matilda seeding occurred on a steep slope (2:1). The area was previously seeded to crownvetch during construction of the I-99 corridor several years prior, but was nearly devoid of vegetation and gullied in a few spots through erosion at the time of treatment. On June 21, 2011

[2] Johnson et al. 2009. Native Seed Mix Establishment Implementation. Roadside Vegetation Management Research – 2009 Report. pp. 50-53.
[3] Ernst Conservation Seeds. 2012. Ernst Conservation Seeds. 25 Jan. 2012 <http://www.ernstseed.com>
[4] Johnson et al. 2011. Native Seed Mix Establishment-Year Three. Roadside Vegetation Management Research – 2011 Report. pp.54-58.
[5] Second Nature Paper Fiber Mulch (Central Fiber Corporation, Canton, OH)

the site was divided into two equally sized plots 20 by 70 ft (1400 sq ft). Amendments and seed were broadcast by hand across the plots. Both plots received amendments equal to 100 lb limestone, 5 lb P_2O_5, 2 lb K_2O, 0.7 lb N, and 0.3 lb N slow release per 1000 sq ft as recommended from soil test results derived from samples taken on June 6, 2011. Following the application of soil amendments, the plots were seeded by hand broadcasting FN10 at 64 lb PLS/ac and FN20 at 74 lb PLS /ac. The plots were immediately covered with a straw-based, erosion control blanket.[6] Evaluations based on a visual rating of percent total vegetative cover and percent cover by plants contained in the seed mix were made on September 16, 2011 (87 DAT), September 19, 2012 (1.25 YAT), and September 13, 2013 (2.2 YAT).

RESULTS AND DISCUSSION

At the Indiana site, vegetative cover has increased steadily on all plots since seeding. Total cover was rated at 30 and 85 percent at 2.8 YAT for the FN 10 and FN 20 plots, respectively (Table 4). Most of the vegetative cover on both plots is comprised of species included in the seed mix. Sheep fescue is contributing to the overall cover to a greater degree in the FN20 plot where about 35 percent of the total vegetative cover is sheep fescue, compared to the FN10 plot where sheep fescue makes up only about 10 percent of the total vegetative cover. Warm season grasses were establishing on both plots at a rate of 23 percent and 40 percent at 2.8 YAT on the FN10 and FN20 plots, respectively. The Formula L plot at this site is not represented in the table, but had 90 percent total cover. This plot contained primarily tall fescue, with only a small fraction, approximately 2 percent, fine fescue.

At the Port Matilda site, total vegetative cover has increased on plots seeded to both mixes in the 2.2 years since seeding; however, the cover appeared to have come from development of existing vegetation or species invading the site, rather than species included in the seed mixes. Cover by species within the seed mix has not risen above 1 percent on either the FN10 or FN20 plots (Table 5). The intermediate sheep fescue and long-term, warm season grasses (big bluestem, little bluestem, swithchgrass, Indiangrass) were present in small numbers and appeared to contribute very little to the overall vegetative cover. The most common plant on the site was crownvetch that developed from existing crowns or seed. Some woody species such as red maple and exotic shrub honeysuckle have also invaded the site.

CONCLUSIONS

Warm season grasses and sheep fescue were establishing to a moderate degree on the Indiana site. There appears to be an opportunity for these grasses to coexist with sheep fescue acting as a low growing ground cover between the taller warm season grass plants. The difference in cover between the FN10 and FN20 plots may be due to the amount of soil present. Both plots consisted of a compacted surface layer of crushed stone or finely broken concrete fragments, with soil filling in the gaps. Plants were only able to grow in the soil spaces between the aggregates. The FN20 plot may have a greater proportion of soil on the surface compared to the FN10 plot, allowing for a higher level of plant development.

The Port Matilda site along I-99 showed very poor development of warm season grasses and sheep fescue. The soil on the site was primarily tiny rock fragments on a steep slope, exposed during excavation for the roadbed. The soil may lack the physical properties to support

[6] ECS-1 (East Coast Erosion Control Blanket, LLC, Bernville, PA)

germinating grass seedlings. Additionally, the crownvetch stand that existed at planting quickly expanded and has created significant competition for the seed mixes. Woody plants seeding in from the forest above the slope and crownvetch planted during road construction appear to be the vegetation best adapted to this challenging site.

MANAGEMENT IMPLICATIONS

The formulas offered within the Publication 408, section 804 'Seed and Soil Supplements', should be followed until a suitable mix is identified.[7] Warm-season grasses used within the FN10 and FN20 mix are possible candidates for seeding on some sites. However, it takes three or more years for adequate establishment to occur. It appears that sheep fescue may be suitable as an intermediate cover.

[7] PennDOT. Pub 408, Section 804 – Seed and Soil Supplements.

Table 1: Formula FN10 seed mix for the Indiana and Port Matilda establishment projects. Components are reported as lb/ac pure live seed (PLS). PLS = % germination x % purity/100.

scientific name	common name	seeding rate	
		lb/ac	lb/1000 S.Y.
Avena sativa	spring oats	30	6.0
Festuca ovina	sheep fescue	10	2.0
Andropogon gerardii	big bluestem	6	1.2
Schizachyrium scoparium	little bluestem	6	1.2
Sorghastrum nutans	Indiangrass	6	1.2
Panicum virgatum	switchgrass	2	0.4
Senna hebecarpa	wild senna	2	0.4
Chamaecrista fasciculata	partridge pea	2	0.4
Total		64	12.8

Table 2: Formula FN20 seed mix for the Indiana and Port Matilda establishment projects. Components are reported as lb/ac pure live seed (PLS). PLS = % germination x % purity/100.

scientific name	common name	seeding rate	
		lb/ac	lb/1000 S.Y.
Avena sativa	spring oats	30	6.0
Festuca ovina	sheep fescue	20	4.0
Andropogon gerardii	big bluestem	6	1.2
Schizachyrium scoparium	little bluestem	6	1.2
Sorghastrum nutans	Indiangrass	6	1.2
Panicum virgatum	switchgrass	2	0.4
Senna hebecarpa	wild senna	2	0.4
Chamaecrista fasciculata	partridge pea	2	0.4
Total		74	14.8

Table 3: Formula L seed mix per PennDOT Pub. 408, Section 804-Seeding and Soil Supplements.

scientific name	common name	seeding rate	
		lb/ac	lb/1000 S.Y.
Festuca longifolia	hard fescue mix	63	13.0
Festuca rubra	creeping red fescue	41	8.5
Lolium multiflorum	annual ryegrass	12	2.5
Total		116	24

Table 4. Percent cover at the Indiana site for the FN 10 and FN 20 seed mixes. The site was seeded on October 21, 2010, and evaluated for percent cover on September 19, 2011 (333 days after treatment, DAT), September 20, 2012 (1.9 years after treatment, YAT), and July 24, 2013 (2.8 YAT).

	FN 10			FN 20		
	333 DAT	1.9 YAT	2.8 YAT	333 DAT	1.9 YAT	2.8 YAT
Total Cover	10	20	30	65	75	85
Species from Seed Mix	5	17	26	5	40	70
Warm Season Grasses	2.5	15	23	2.5	30	40
Sheep Fescue	2.5	2	3	2.5	10	30

Table 5. Percent cover at the I-99 Port Matilda site for the FN 10 and FN 20 seed mixes. The site was seeded on June 21, 2011, and evaluated for percent cover on September 16, 2011 (87 days after treatment, DAT), September 19, 2012 (1.25 years after treatment, YAT), and September 13, 2013 (2.2 YAT).

	FN 10			FN 20		
	87 DAT	1.25 YAT	2.2 YAT	87 DAT	1.25 YAT	2.2 YAT
Total Cover	60	70	75	15	60	50
Species from Seed Mix	1	1	1	1	1	1

NATIVE SEED MIX ESTABLISHMENT IMPLEMENTATION – YEAR FIVE

Herbicide trade and common names: Pathfinder II (*triclopyr* ester)
Plant common and scientific names: annual ryegrass (*Lolium multiflorum*), aster (*Aster* spp.), autumn bentgrass (*Agrostis perennans*), big bluestem (*Andropogon gerardii*), black-eyed susan (*Rudbeckia hirta*), black locust (*Robinia pseudoacacia*), brambles (*Rubus* spp.), Canada wildrye (*Elymus canadensis*), coltsfoot (*Tussilago farfara*), creeping red fescue (*Festuca rubra*), crownvetch (*Coronilla varia*), fine fescue (*Festuca rubra*), giant foxtail (*Setaria faberi*), hard fescue (*Festuca brevipila*), Indiangrass (*Sorghastrum nutans*), Japanese knotweed (*Fallopia japonica*), little bluestem (*Schizachyrium scoparius*), multiflora rose (*Rosa multiflora*), ox-eye sunflower (*Heliopsis helianthoides*), partridge pea (*Chamaecrista fasciculata*), spring oats (*Avena sativa*), staghorn sumac (*Rhus typhina*), switchgrass (*Panicum virgatum*)

ABSTRACT

Formula N is a native warm-season grass (WSG) mix designed as an alternative ground cover for use in disturbed sites created during road construction. In this long-term establishment study, Formula N was broadcast and hydro seeded at two locations on steep, coarse, and erosion prone soil in 2008. The observations reported here are from the most recent data collected in June 2013 and represents the fifth year after seeding. Formula N has not established well on either site; although, big bluestem, little bluestem, Indiangrass, and switchgrass were present at both sites and producing seed heads. The seeding at Homer City has established to a greater extent than the Montour County site. The intermediate components of the mix, Canada wildrye and autumn bentgrass have not provided satisfactory cover at either site. In the present formulation, Formula N does not provide adequate cover on many of the most difficult sites using either seeding method tested. Pre-plant soil modifications or the addition of other intermediate species (e.g., cool-season grasses) may offer greater initial establishment and should be and are being investigated in subsequent experiments.

INTRODUCTION

PennDOT has several seed formulas available to use when revegetating sites impacted by disturbance or construction. For steep, low fertility, dry and coarse soil textured sites, Formula C, a blend of crownvetch and annual ryegrass has been the seed mix of choice. However, with the increased sensitivity to the use of invasive species in planting projects and the observed potential invasiveness of crownvetch there has been a greater incentive to examine alternative species mixes for difficult sites.[1] In considering alternative mixes Formula N (Table 1) was designed and in 2008 it was deployed through two application methods, hydroseeding and broadcasting, to explore the versatility of the Formula N mix. Warm season grasses and native herbaceous species often take three to five years to establish after planting. This report constitutes the fifth year of observation after planting

[1] PA Department of Conservation and Natural Resources, Invasive Plants in Pennsylvania, April 2006. <http://www.dcnr.state.pa.us/forestry/InvasivePlantBrochure.pdf>

MATERIALS AND METHODS

This long-term study was initiated in 2008 at two locations, along I-80W in Montour County and at a stockpile along SR56 near Homer City, PA to evaluate whether the seed mix would establish using two common seeding procedures. Both sites were steeply graded slopes with coarse textured, erosion-prone soil. In Montour County, half of the site was broadcast and the other half hydroseeded with Formula N (Table 1) on April 29, 2008. The Homer City site also included broadcast and hydroseeded plots of Formula N and two additional but separate plots consisting of Formula C (i.e., 19 lb/ac crownvetch and 24 lb/ac annual ryegrass) and Formula L (i.e., 63 lb/ac hard fescue, 41 lb/ac creeping red fescue, and 12 lb/ac annual ryegrass) hydroseeded on April 30, 2008. Amendments were applied according to PennDOT Pub. 408, section 804 specifications. Hydroseeding was performed as a one-step process, in which seed, mulch, and soil amendments were mixed and applied together as a slurry. Floc-Lock tackifier (Lesco) was added to the hydroseed mixture at a rate of 3 lb/acre. Broadcast plots included seed and amendments but were not mulched.

Documentation of the seeding procedures and observations on seed establishment at the two sites in Homer City and Montour Co. has been reported in previous annual reports. [2,3,4] The Homer City site has since been visually evaluated for establishment success on September 19, 2011 (3.4 years after treatment, YAT), September 20, 2012 (4.4 YAT), and July 24, 2013 (5.2 YAT). In a similar manner, the Montour County site was evaluated by visual estimation on December 20, 2011 (3.6 YAT), October 4, 2012 (4.4 YAT), and June 28, 2013 (5.2 YAT). On the same day that the visual rating was performed at Homer City in 2013, a basal application of Pathfinder II was applied to woody stems beginning to colonize the site. The application was made with a Spray Systems SP1 backpack sprayer fitted with an adjustable conejet X-6 tip. The Montour County site did not have enough woody species develop to require an herbicide treatment.

RESULTS AND DISCUSSION

At the Montour County site, the cover by species contained within the Formula N seed mix has not exceeded 2 percent using either seeding method even five years after seeding. The total cover has ranged from 25 to 45 percent, bolstered primarily by fine fescue, which was growing on the site at the time of seeding (Table 2). The majority of the established WSGs were found along the upper portion of the slope. At the most recent rating, June 28, 2013, none of the forbs included in the Formula N mix were observed at the Montour County site. The species from the Formula N mix observed at this location included: Indiangrass, little bluestem, Canada wildrye, big bluestem, and switchgrass.

At the Homer City site, there were more native warm-season grass plants present and a greater total vegetative cover compared to the Montour County site. The most recent evaluation, July 24, 2013, showed a 15 and 20 percent cover by species in the Formula N mix and a 65 and

[2] Johnson et al. 2009. Native Seed Mix Establishment Implementation. Roadside Vegetation Management Research Report. pp. 50-53.
[3] Johnson et al. 2010. Native Seed Mix Establishment Implementation – Year Two. Roadside Vegetation Management Research Report. pp. 43-45.
[4] Johnson et al. 2011. Native Seed Mix Establishment Implementation – Year Three. Roadside Vegetation Management Research – 2011 Report. pp. 54-58.

90 percent total cover for the broadcast and hydroseeded plots respectively (Table 3). The species present included: Indiangrass, big bluestem, switchgrass, little bluestem, and Canada wildrye. The broadcast seeded plot was unique in having a substantial amount of partridge pea (7.5 percent of total cover). As with the Montour Co. site, most of the desirable grasses were established along the upper one-third of the slope.

In addition, the Homer City site included plots seeded to fine fescue and crownvetch. The plot seeded to fine fescue was rated at 25 percent total cover with 5 percent cover by fine fescue turf. The plot seeded to crownvetch had a 90 percent total vegetative cover with a 30 percent cover by crownvetch. Common weed species encountered across all plots at Homer City were crownvetch, black locust, staghorn sumac, poplar, multiflora rose, giant foxtail, grape, white sweet clover, aster, brambles, coltsfoot, and Japanese knotweed.

CONCLUSIONS

Five years after seeding, the Montour County site is almost devoid of plants found in the Formula N seed mix. The lack of invasion by woody species and the relatively low total vegetative cover (i.e. 25%) suggests that this site presents challenges to plant establishment and growth. The Homer City site appears to have finer texture soil and better water retention; however, this site still presents challenges to plant establishment including a steep slope and lack of organic matter. The fact that most of the plants that established at these sites occurred on the upper one third of the slope suggests that when the cuts are made into the soil profile, the top of the slope may contain greater amounts of topsoil along with upper layers of subsoil. These upper layers of the soil profile contain properties that are more likely to support seed germination and plant growth. The farther down slope you move, the soil seems likely to be coarser and more devoid of organic matter, making successful seed germination and plant establishment difficult. Sites with soils that are marginal for plant development either need modification and improvement prior to seeding or an intermediate component to the seed mix identified that will establish in poor quality soils.

MANAGEMENT IMPLICATIONS

Formula N is slow to establish on average to good sites and perhaps unable to establish on sites with soil that lacks the physical properties necessary for good seed germination, for example, water retention. Presently there are no reasonable substitutes for the PennDOT Formulas currently available. Formulas D and L should be utilized where grasses are the desired groundcover and soil conditions will likely support these turf species. Formula C is still an option for sites with little and/or poor quality soils that require a plant species that will branch and spread by its aboveground parts.

Table 1. Formula N seed mix for the Montour County and Homer City slope rehabilitation projects. Components followed by an "*" are reported as lb/ac pure live seed (PLS). PLS = % germination x % purity / 100.

Common name	Scientific name	lb/ac
big bluestem	*Andropogon gerardii*	5.3*
little bluestem	*Schizachyrium scoparius*	5.3*
Indiangrass	*Sorghastrum nutans*	5.3*
switchgrass	*Panicum virgatum*	1.1*
Canada wildrye	*Elymus Canadensis*	5.3*
autumn bentgrass	*Agrostis perennans*	11
spring oats	*Avena sativa*	64
partridge pea	*Chamaecrista fasciculate*	2.1
black-eyed susan	*Rudbeckia hirta*	0.53
ox eye sunflower	*Heliopsis helianthoides*	0.53
Total		100

Table 2. Percent cover at the Homer City site for warm season grass mixes planted by hydroseed and broadcast seeding methods. The site was seeded on April 30, 2008, and evaluated for percent cover on September 19, 2011 (3.4 years after treatment, YAT), September 20, 2012 (4.4 YAT), and July 24, 2013 (5.2 YAT).

	Hydroseeded			Broadcast Seeded		
	3.4 YAT	4.4 YAT	5.2 YAT	3.4 YAT	4.4 YAT	5.2 YAT
Total Cover	75	75	90	50	60	65
Species from Seed Mix	5	10	20	5	20	15

Table 3. Percent cover at the I-80 Montour County site for warm season grass mixes planted by hydroseed and broadcast seeding methods. The site was seeded on April 29, 2008, and evaluated for percent cover on December 20, 2011 (3.6 years after treatment, YAT), October 4, 2012 (4.4 YAT), and June 28, 2013 (5.2 YAT).

	Hydroseeded			Broadcast Seeded		
	3.6 YAT	4.4 YAT	5.2 YAT	3.6 YAT	4.4 YAT	5.2 YAT
Total Cover	35	45	25	35	35	25
Species from Seed Mix	1	1	1	2	2	1

SLOPEMASTER SEED MIX DEMONSTRATION – FOURTH YEAR RESULTS

Herbicide trade and common names: DMA 4 IVM (*2,4-D*).
Plant common and scientific names: chewings fescue (*Festuca rubra*), foxtail millet (*Setaria italica*), hard fescue (*Festuca brevipila*), perennial ryegrass (*Lolium perenne*), sericea lespedeza (*Lespedeza cuneata*), tall fescue (*Festuca arundinacea*), white clover (*Trifolium repens*) yellow sweet clover (*Melilotus officinalis*).

ABSTRACT

Revegetating disturbed sites on the roadside is important to roadside vegetation managers. A seed mix must establish rapidly and thrive under the broad environmental conditions encountered on the right-of-way. Slopemaster, a 'Durana' white clover based seed mix is designed for rapid establishment, durability, and low maintenance (Pennington Seed Inc., Madison, GA). Two forms of Slopemaster were evaluated; one that contains fine fescue and another that contains tall fescue as the primary component. A demonstration area was established where both mixes were seeded on a previously disturbed construction site. Clover and turf components established for both mixes. Clover cover peaked at 20 percent within 1 year after seeding (YAS) and 30 percent by 3 YAS for the fine and tall fescue mixes respectively then declined to 0 percent at 4.4 YAS for both mixes. A moderate amount of desirable turf established by 1 YAS with 45 and 70 percent cover by fine and tall fescue, respectively. Both turf types reached the highest amount of cover by the last rating at 4.4 YAS. Cover by fine fescue was 70 percent and cover by tall fescue was 74 percent. This demonstration comparison represents a preliminary experiment and was not replicated at this site to confirm statistical differences.

INTRODUCTION

Slopemaster is a white clover based seed mix (Pennington Seed Inc., Madison, GA) designed for erosion control, ease of establishment, and low maintenance. The unique component of Slopemaster is 'Durana' white clover, a perennial, medium leafed, intermediate type white clover, promoted for its ability to produce 97 stolons per square foot, fix 150 lbs. of nitrogen per acre per year, and form a permanent ground cover. Two mixes, each containing 10% 'Durana' clover were evaluated with one incorporating 60% 'Predator' hard fescue, 20% '7 Seas' chewings fescue, and 10% 'T-3' perennial ryegrass and another consisting of 70% 'Greystone' tall fescue, 10% 'T-3' perennial ryegrass, 5% sericea lespedeza and 5% foxtail millet. These mixes can be planted using a seed drill, broadcast equipment, or hydroseeding unit. A preliminary demonstration was designed to compare the success of establishment and development of these two seed mixes on a roadside site following disturbance by construction.

MATERIALS AND METHODS

The trial was established on a gently sloping fill site on the shoulder of I-99 northbound west of State College, PA. The two seed mixes were broadcast by hand over an area of 2500 sq. ft. each on April 22, 2009. The seeding rates were approximately 90 and 125 lb/ac for the fine fescue and the tall fescue mixes, respectively. The seed mix arrived pre-inoculated with Germax seed treatment (Rhizokote XL and Apron XL) and coated with MYCO Advantage (mycorrhizal fungi). Soil amendments and straw mulch were added according to PennDOT Pub. 408 specifications, Sections 804 and 805. The plots were evaluated for vegetative cover on August 9, 2009 (109 days after seeding, DAS), May 26, 2010 (1 year after seeding, YAS), September 16, 2011 (2.4 YAS), May 9, 2012 (3 YAS), September 19, 2012 (3.4 YAS), May 23, 2013 (4 YAS), and September 13, 2013 (4.4YAS).

On July 18, 2012, the plots were mowed with a string trimmer at height of 12 to 18 inches to reduce the cover created by yellow sweet clover, a biennial weed that was present on the site. On July 1, 2013, a broadleaf herbicide, DMA 4 IVM at 32 oz/ac plus CWC 90 surfactant at 0.25 v/v, was spot sprayed with a Solo backpack sprayer and adjustable conejet nozzle to control crownvetch and various broadleaf weeds.

RESULTS AND DISCUSSION

For the fine fescue mix, the white clover component established to a cover level of 20 percent by May 26, 2010 (1 YAS), representing the highest percentage reached for this seed mix (Table 1). Cover by white clover then began a steady decline that ended with a rating of 0 percent cover on September 13, 2013 (4.4 YAS). The fine fescue in this mix established a cover of 45 percent by 1 YAS and maintained a cover ranging from 34 to 45 percent to 3.4 YAS. The most recent rating on September 13, 2013 (4.4 YAS) provided 70 percent cover by fine fescue.

For the tall fescue mix, the story is similar (Table 2). The white clover component established, colonized to a moderate degree (30 percent cover at 3 YAS), and declined to 0 percent cover at (4.4 YAS). The tall fescue grass established relatively quickly (70 percent cover at 1 YAS) and maintained that level of cover for the duration of the trial (74 percent cover at 4.4 YAS).

During the 2012 and 2013 growing seasons, vegetative cover was rated in both the spring and fall to pick up any seasonal differences in the vigor of the grass and clover components. The seasonal differences for percent cover by clover were slight by 2013, with ratings of 0.5 and 0.25 percent in the spring and 0 and 0 percent in the fall for the fine and tall fescue mixes respectively.

CONCLUSIONS

The clover and the grass components of these two mixes initially established; however, the clover faded with time. In approximately 4.5 years, the clover is nearly absent from the site. The grass components of the mixes, both the tall fescue and the fine fescue, have maintained a reasonable cover. Perhaps some maintenance such as mowing or broadleaf weed control applied earlier in the trial may have helped the clover compete with the taller vegetation growing on the site.

The use of mixes such as these in a roadside setting has advantages and disadvantages. A significant advantage is the clover's ability to fix atmospheric nitrogen and make this essential element available to the grasses. One area of concern is with sericea lespedeza, also referred to as Chinese lespedeza, which has been noted for its potential for being highly invasive in some areas, including Pennsylvania.[1,2] Sericea lespedeza has not demonstrated utility in these seed mixes and should not be included in future evaluations.

MANAGEMENT IMPLICATIONS

PennDOT currently utilizes mixes that contain primarily tall fescue (Formula D) and fine fescue (Formula L). If either Slopemaster mix has a significant value to the vegetation management program, it would be in the introduction of 'Durana' white clover as a low growing, perennial groundcover component. Results at approximately 4.4 years after seeding indicate that the clover is not able to compete on this site. This demonstration comparison represents a preliminary experiment and was not replicated at this site to confirm statistical differences. Results might be different on another location or under different conditions.

[1] USDA/NRCS, "Plant Fact Sheet: Chinese Lespedeza, *Lespedeza cuneata*," 24 May 2006. 29 May 2012. <http://plants.usda.gov>.
[2] The Bugwood Network et al., "Mid-Atlantic Exotic Pest Plant Council Plant List," 24 Jan. 2005. 29 May 2012. <http://www.invasive.org/maweeds.cfm>.

Table 1. Summary of percent cover for the major components of the fine fescue Slopemaster seed mix planted along I-99 northbound, 5 miles west of State College, PA. The site was seeded on April 22, 2009. Visual evaluations were conducted August 6, 2009, 106 days after seeding (DAS); May 26, 2010, 1 year after seeding (YAS); September 16, 2011 (2.4 YAS); May 9, 2012 (3 YAS); September 19, 2012 (3.4 YAS); May 23, 2013 (4 YAS); and September 13, 2013 (4.4 YAS). This trial was a demonstration with no replications on site.

	8/6/09 106 DAS	5/26/10 1 YAS	9/16/11 2.4 YAS	5/9/12 3 YAS	9/19/12 3.4 YAS	5/23/13 4 YAS	9/13/13 4.4 YAS
White Clover	NA	20	10	4	0	0.5	0
Fine Fescue	NA	45	39	34	45	50	70
Total Species from Seed Mix	50	65	49	38	45	50.5	70
Other Species Present	NA	NA	49	47	45	44	28
Total Cover	NA	NA	98	85	90	95	98

NA indicates data not available

Table 2. Summary of percent cover for the major components of the tall fescue Slopemaster seed mix planted along I-99 northbound, 5 miles west of State College, PA. The site was seeded on April 22, 2009. Visual evaluations were conducted August 6, 2009, 106 days after seeding (DAS); May 26, 2010, 1 year after seeding (YAS); September 16, 2011 (2.4 YAS); May 9, 2012 (3 YAS); September 19, 2012 (3.4 YAS); May 23, 2013 (4 YAS); and September 13, 2013 (4.4 YAS). This trial was a demonstration with no replications on site.

	8/6/09 106 DAS	5/26/10 1 YAS	9/16/11 2.4 YAS	5/9/12 3 YAS	9/19/12 3.4 YAS	5/23/13 4 YAS	9/13/13 4.4 YAS
White Clover	NA	2	20	30	1	0.25	0
Tall Fescue	NA	70	28	30	70	65	74
Total Species from Seed Mix	85	72	48	60	71	65.25	74
Other Species Present	NA	NA	32	30	1	14	1
Total Cover	NA	NA	80	90	85	80	75

NA indicates data not available

EVALUATING THE EFFICACY OF ESPLANADE IN BAREGROUND TANK MIXES AND COMPARED TO PROCLIPSE, PENDULUM EC, AND DIURON

Herbicide trade and common names: Diuron (*diuron*); Escort XP (*metsulfuron*); Esplanade (*indaziflam*); MAT28 50SG (*aminocyclopyrachlor*); Milestone (*aminopyralid*); Oust Extra (*sulfometuron + metsulfuron*); Oust XP (*sulfometuron*); Pendulum AC (*pendimethalin*); Perspective (*aminocyclopyrachor + chlorsulfuron*); Proclipse (*prodiamine*); Roundup Power Max, Roundup Original Max (*glyphosate*); Streamline, PennDOT Custom Blend (*aminocyclopyraclor + metsulfuron*).

Plant common and scientific names: common evening primrose (*Oenothera biennis*, OEOBI), common ragweed (*Ambrosia artemisiifolia*, AMBAR), kochia (*Kochia scoparia*, KCHSC), marestail (*Conyza canadensis*, ERICA), prostrate spurge (*Euphorbia supina*, EPHMA), sweetclover (*Melilotus* spp., MEUXX).

ABSTRACT

For maintenance purposes the roadside is divided into defined vegetation management zones with each zone requiring a unique management strategy. The areas beneath guiderails, around signposts and other fixed obstacles, and within storage yards are typically maintained as bareground. Roadside vegetation managers often rely on herbicides to keep areas free of vegetation. The goal of herbicide tank mixes used in these programs is to control existing vegetation while preventing the germination and development of weeds for the duration of the growing season. Among the tank mix partners are postemergence, broad-spectrum residual, and preemergence herbicides. Esplanade is a preemergence herbicide that has been evaluated in previous experiments with excellent results. This experiment, repeated at two locations, evaluated Esplanade at two rates and combined with a variety of broad-spectrum residual herbicides for season-long weed control. Additionally, Esplanade was compared to the preemergence herbicides Proclipse and Pendulum AC mixed with either the PennDOT Custom Blend or Oust Extra. Overall, significant differences in total vegetation cover and kochia cover were found among all of the treatments from one to over five months after treatment. Esplanade continued to demonstrate excellent bareground weed control when combined with products containing either *aminocyclopyrachlor* (i.e., Streamline, Perspective, PennDOT Custom Blend) or Milestone (*aminopyralid*). Tank mixes of Proclipse or Pendulum AC and the PennDOT Custom Blend showed similar control over the range of weed species on site. However, Esplanade plus Oust Extra was weak in controlling kochia. Though not statistically different Proclipse, Pendulum AC, or the standard Diuron mixed with Oust Extra were even less effective in control of kochia than the Esplanade plus Oust Extra treatment.

INTRODUCTION

Bareground areas are maintained under guiderails and around signposts using a mixture of herbicides. Three components are commonly combined within a bareground tank mix, including a postemergence, broad-spectrum residual, and preemergence herbicide. There are several considerations in selecting herbicides including: cost, availability, safety, rotation of products having different modes of action, duration of control, and effectiveness on the weed species present at the site. Esplanade (i.e., *indaziflam*) has been evaluated and showed promise as a

preemergence component in bareground tank mixes in previous experiments.[1,2] This experiment, repeated at two locations, compares the efficacy of Esplanade in combination with commonly used broad-spectrum residual materials on a variety of weed species. The experiment also compares Esplanade to other preemergence herbicides including Proclipse, Pendulum AC, and the standard Diuron.

MATERIALS AND METHODS

Two sites were established under guiderails along I99 at the SR26 overpass (hereafter referred to as SR26), near Pleasant Gap, PA with a second site along SR322 W (Skytop) near Port Matilda, PA. Fifteen treatments were applied including Roundup Power Max at the SR26 site or Roundup Original Max at the SR 322 W site alone at 64 oz/ac; Roundup Power Max or Roundup Original Max at 64 oz/ac was combined and applied with all preemergence and broad spectrum herbicide combinations that follow including Esplanade at 5 oz/ac alone or combined with Milestone at 7 oz/ac and Oust Extra at 4 oz/ac, Streamline at 8 oz/ac, PennDOT Custom Blend at 8 oz/ac, Perspective at 8 oz/ac, or Oust Extra at 4 oz/ac; Esplanade at 3.5 oz/ac mixed with Streamline at 4.75 oz/ac and Oust XP at 3 oz/ac or Oust Extra at 4 oz/ac; Proclipse at 32 oz/ac plus PennDOT Custom Blend at 8 oz/ac or Oust Extra at 4 oz/ac; Pendulum AC at 134 oz/ac plus PennDOT Custom Blend at 8 oz/ac or Oust Extra at 4 oz/ac; and Diuron at 128 oz/ac plus Oust Extra at 4 oz/ac. The experiment included an untreated check. All treatments included Induce, a non-ionic surfactant, at 0.25% v/v. The treatments were applied to 4 by 23 ft plots with four replications at each location. The carrier volume was 50 gal/ac. Treatments were applied on April 23 and 25, 2013, at SR26 and SR322 W sites, respectively. Equipment used in applying treatments included a CO_2-powered backpack sprayer equipped with an ultra low volume wand and single OC-08 spray nozzle. The first notable rainfall occurred nearly six days and four days, respectively following treatment with total precipitation amounts of approximately 0.01 inches at SR26 and SR322 W(http://www.wunderground.com). Rainfall was observed one day after treatment at the SR26 site, however, rainfall amounts were not recorded for that date.

The SR26 site was visually rated for percent total vegetative cover and cover by kochia (KCHSC) on April 27, May 24, July 23, and September 23, 2013, (4, 31, 91, and 153 days after treatment, DAT). Other predominate species at this location included marestail and prostrate spurge. The SR322 W site was evaluated for percent total vegetative cover on April 27, May 27, July 25, and September 27, 2013 (2, 32, 91, and 155 DAT). Predominate annual and biennial species at this location included sweetclover, common evening primrose, and common ragweed.

RESULTS AND DISCUSSION

Prior to treatment on April 27 (4 DAT) the SR26 site had a total vegetative cover rating of 1 to 12 percent (Table 1). On May 24 (31 DAT) the untreated check plots averaged 26 percent and the herbicide treatments averaged 0 to 1 percent total vegetative cover. By July 23 (91 DAT) the Roundup only and Proclipse plus Oust Extra herbicide treatments had 32 and 26 percent vegetative cover and were not significantly different than the untreated check (45 percent).

[1] Johnson et al. 2012. Indaziflam as a Preemergence Component in a Bare Ground Weed Control Program. Roadside Vegetation Management Research Report – 2012 Report. pp. 24-27.
[2] Johnson et al. 2013. Evaluation of Indaziflam, Pendimethalin, and Prodiamine in Tank Mixes for Baregournd Weed Control. Roadside Vegetation Management Research Report – 2013 Report. pp. 48-52.

Treatments containing *aminocyclopyrachlor* (Streamline, Perspective, or PennDOT Blend) or Milestone produced the least vegetative cover of 0 to 1 percent. Treatments of Esplanade alone or those containing Oust Extra, while statistically similar to the best treatments, tended to have greater vegetative cover from 10 to 18 percent. Kochia was the primary weed species contributing to the vegetative cover for nearly all treatments (Table 2).

The SR322 W site started with a vegetative cover rating of 1 to 3 percent at 2 DAT (Table 3). For the entire length of the experiment all herbicide treatments maintained excellent and similar control of the weed population with vegetative cover ratings of 0 to 4 percent through 155 DAT. The only exception was Roundup alone having similar vegetative cover to the untreated check at all rating dates. By 155 DAT the untreated and Roundup plots averaged 25 and 21 percent vegetative cover, respectively.

CONCLUSIONS

The tank mixes and rates used in this experiment that contained Esplanade combined with *aminocyclopyrachlor* (Streamline, Perspective, or PennDOT Blend) or Milestone provided excellent season-long control of a variety of plant species, including kochia. The preemergence herbicides Esplanade, Proclipse, and Pendulum AC performed equally well when combined with PennDOT Blend. In making decisions between these preemergence herbicides for tank mixing in bareground settings the cost, availability, manufacturer support, and physical characteristics would be the important factors to consider in choosing a product. Although Esplanade performed equally well at both the 3.5 and 5 oz/ac rates, the higher rate has been more thoroughly tested and is recommended. Esplanade should not be used alone for long-term bareground weed control in roadside settings. Treatments using Oust Extra in combination with the preemergence herbicides Esplanade, Proclipse, Pendulum AC, or Diuron controlled a large spectrum of weed species for the entire season, but were less effective on kochia control.

MANAGEMENT IMPLICATIONS

Esplanade tank mixed with any of the broad-spectrum herbicides tested should offer season-long control of common weed species in a bareground program. However, where kochia is present Oust Extra should be avoided in favor of one of the other bareground residual components (e.g., Milestone, Streamline, Perspective, or PennDOT Custom Blend). Other active ingredients should be rotated into the program to avoid the development of resistance. Both Proclipse and Pendulum AC offer alternatives as the preemergence component in bareground tank mixes and are reliable substitutes when combined with the PennDOT Custom Blend or other products containing *aminocyclopyrachlor*.

Some important considerations should be noted with the use of the herbicides utilized in this trial. Caution is advised with the use of products containing *aminopyralid* or *aminocyclopyrachlor* where concerns exist for uptake of these materials by the root system of trees within the right-of-way. Also, Oust Extra has recently been reregistered and changes within the label restrict the use of this product in a roadside setting. Language in the label requires a

directional buffer of 25 ft. from bodies of water or crops with liquid broadcast applications of this herbicide on the roadside.[3]

[3] E.I. du Pont de Nemours and Company. Oust Extra Herbicide. Online. Internet. February 17, 2014. Available www.cdms.net.

Table 1: Percent total vegetative cover ratings for the I99/SR26 (i.e., SR26) study site near Pleasant Gap, PA. The trial was visually rated for percent total vegetative cover on April 27, May 24, July 23, and September 23, 2013 (4, 31, 91, and 153 days after treatment, DAT). Treatments were applied on April 23, 2013. All herbicide treatments included Roundup Power Max at 64 oz/ac and 0.25 percent v/v Induce, non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		percent total vegetative cover			
product	rate	4/27/13	5/24/13	7/23/13	9/23/13
	(oz/ac)				
untreated	---	12	26 a	45 a	56 a
Roundup Power Max	64	2	0 b	32 ab	44 ab
Esplanade	5	4	0 b	18 bc	26 b-e
Esplanade Milestone Oust Extra	5 7 4	2	0 b	1 c	4 def
Esplanade Streamline	5 8	2	0 b	0 c	1 f
Esplanade Streamline Oust XP	3.5 4.75 3	5	0 b	1 c	1 f
Esplanade PennDOT Blend	5 8	2	0 b	0 c	0 f
Esplanade Perspective	5 8	2	0 b	0 c	0 f
Esplanade Oust Extra	3.5 4	3	0 b	12 bc	15 c-f
Esplanade Oust Extra	5 4	2	0 b	10 bc	18 c-f
Proclipse PennDOT Blend	32 8	1	0 b	0 c	3 ef
Proclipse Oust Extra	32 4	11	1 b	26 ab	36 abc
Pendulum AC PennDOT Blend	134 8	2	0 b	1 c	3 ef
Pendulum AC Oust Extra	134 4	12	1 b	16 bc	26 bcd
Diuron Oust Extra	128 4	4	0 b	17 bc	29 bc
Sign. Level ($p \leq 0.05$)		n.s	---	---	---

Table 2: Percent cover by kochia (*Kochia scoparia*, KCHSC) ratings for the I99/SR26 (i.e., SR26) study site near Pleasant Gap, PA. The trial was visually rated for percent cover kochia on April 27, May 24, July 23, and September 23, 2013 (4, 31, 91, and 153 days after treatment, DAT). Treatments were applied on April 23, 2013. All herbicide treatments included Roundup Power Max at 64 oz/ac and 0.25 percent v/v Induce, non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		percent cover by kochia			
product	rate	4/27/13	5/24/13	7/23/13	9/23/13
	(oz/ac)				
untreated	---	12	25 a	42 a	50 a
Roundup Power Max	64	1	0 b	28 ab	32 ab
Esplanade	5	2	0 b	18 bc	25 bc
Esplanade Milestone Oust Extra	5 7 4	1	0 b	1 c	4 cd
Esplanade Streamline	5 8	1	0 b	0 c	1 d
Esplanade Streamline Oust XP	3.5 4.75 3	4	0 b	1 c	1 d
Esplanade PennDOT Blend	5 8	2	0 b	0 c	0 d
Esplanade Perspective	5 8	2	0 b	0 c	0 d
Esplanade Oust Extra	3.5 4	3	0 b	12 bc	15 bcd
Esplanade Oust Extra	5 4	1	0 b	10 bc	18 bcd
Proclipse PennDOT Blend	32 8	0	0 b	0 c	0 d
Proclipse Oust Extra	32 4	8	1 b	26 ab	34 ab
Pendulum AC PennDOT Blend	134 8	2	0 b	0 c	0 d
Pendulum AC Oust Extra	134 4	10	1 b	16 bc	26 bc
Diuron Oust Extra	128 4	2	0 b	15 bc	26 bc
Sign. Level ($p \leq 0.05$)		n.s.	---	---	---

Table 3: Percent total vegetative cover ratings for the SR322 W (Skytop) study site near Port Matilda, PA. The trial was visually rated for percent total vegetative cover on April 27, May 27, July 25, and September 27, 2013 (2, 32, 91, and 155 days after treatment, DAT). Treatments were applied on April 25, 2013. All herbicide treatments included Roundup Original Max at 64 oz/ac and 0.25 percent v/v Induce, non-ionic surfactant. Each value is the mean of four replications. Column means followed by the same letter are not significantly different at $p \leq 0.05$.

		percent total vegetative cover			
product	rate	4/27/13	5/27/13	7/25/13	9/27/13
	(oz/ac)				
untreated	---	1	4 a	19 a	25 a
Roundup Original Max	64	3	3 ab	19 a	21 a
Esplanade	5	2	1 b	3 b	4 b
Esplanade Milestone Oust Extra	5 7 4	1	0 b	0 b	1 b
Esplanade Streamline	5 8	1	0 b	1 b	1 b
Esplanade Streamline Oust XP	3.5 4.75 3	1	0 b	0 b	1 b
Esplanade PennDOT Blend	5 8	2	2 ab	1 b	2 b
Esplanade Perspective	5 8	1	0 b	1 b	1 b
Esplanade Oust Extra	3.5 4	1	0 b	1 b	1 b
Esplanade Oust Extra	5 4	1	1 b	1 b	1 b
Proclipse PennDOT Blend	32 8	1	0 b	1 b	2 b
Proclipse Oust Extra	32 4	1	0 b	0 b	1 b
Pendulum AC PennDOT Blend	134 8	1	1 b	2 b	3 b
Pendulum AC Oust Extra	134 4	1	1 b	1 b	1 b
Diuron Oust Extra	128 4	1	0 b	1 b	1 b
Sign. Level ($p \leq 0.05$)		n.s.	---	---	---