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DEPARTMENT OF TRANSPORTATION

ROADSIDE VEGETATION MANAGEMENT
RESEARCH REPORT
THIRD YEAR REPORT

THE PENNSYLVANIA STATE UNIVERSITY
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PENNSTATE

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INTRODUCTION

In October of 1985, members of the Pennsylvania State University began a cooperative research project with the Pennsylvania Department of Transportation to investigate several aspects of roadside vegetation management. This report represents data from the third year of research. The original research objectives included the investigation of several control techniques for roadside brush, herbaceous weed/Canada thistle control in crownvetch areas, and the evaluation of plant growth regulators for roadside turf. The research objectives have since expanded to include the evaluation of bare ground control products for use under guiderails and signposts, low maintenance vegetation, and wildflowers for use on Pennsylvania's roadsides. The experiments involved in all of theses studies are described in the report. information from the earlier studies can be found in Report #PA 87-021 + 85-08, and #PA 86-018 + 85-08, available from the National Technical Information Service, Springfield, VA.

The herbicides are referred to in this report as product names for ease of reading. The products utilized in each study are listed at the beginning of each section by product name, common name, formulation, and manufacturer. Whenever possible, the cost of each treatment in an experiment is calculated based on prices from the Pennsylvania State Agency bid list. If the products used in the experiment did not appear on the bid list, an approximate cost was obtained from the manufacturer or distributor. The 1988 Pennsylvania State Agency herbicide bid list is located below in Table 1.

Table 1: Products, formulations and prices of the herbicides from the Pennsylvania DOT bid list for 1988.

TRADE NAME	ACTIVE INGREDIENTS	FORMULATION (LB/GAL OR %)	MINIMUM SHIPMENT	UNIT PRICE (GAL, LB, QT, OZ)
Arborchem Clean-Cut + Pine			2 x 2.5 GAL	$7.75
Clean-Cut + Citrus			1 x 5 GAL	$9.94
Arsenal	Imazapyr	2.0	2 x 5 GAL	$131.69
Banvel	Dicamba (DMA Salt)	4.0	4 x 5 GAL	$51.17
Banvel 720	Dicamba + 2,4-D	1.0 + 1.9	4 x 2.5 GAL	$19.56
Banvel 720	Dicamba + 2,4-D	1.0 + 1.9	1 x 30 GAL	$17.87
Diquat	Diquat	2.0	1 x 1 GAL	$54.26
Embark	Melfuidide	2.0	8 x 1 GAL	$66.67
Escort	Metsulfuron methyl	60%	8 x 8 GAL	$23.32
Garlon 3A	Triclopyr amine	3.0	6 x 5 GAL	$45.22
Garlon 4	Triclopyr ester	4.0	6 x 5 GAL	$59.92
Karmex DF	Diruon	80%	24 x 4 LB	$2.81
Krenite S	Fosamine ammonium	4.0	6 x 5 GAL	$37.47
Krenite S	Fosamine ammonium	4.0	2 x 30 GAL	$37.07
Krovar I DF	Bromacil + Diuron	40% + 40%	8 x 6 LB	$6.34
Oust	Sulfometuron methyl	75%	3 x 3 LB	$111.17
Princep 80W	Simazine	80%	12 x 5 GAL	$2.10
Roundup	Glysophate	4.0	8 x 1 GAL	$72.50
Roundup	Glysophate	4.0	4 x 2.5 GAL	$59.20
Spike 40P	Tebuthiuron	40%	3 x 20 LB	$8.98
Spike DF	Tebuthiuron	80%	12 x 4 LB	$16.16
Surflan AS	Oryzalin	4.0	10 x 5 GAL	$47.18
Tordon 101R	Picloram + 2,4-D	0.27 + 1.0	12 x 2.5 GAL	$13.31
Velpar L	Hexazinone	2.0	10 x 1 GAL	$40.77

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The contents of this report reflect the views on 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 Commonwealth of Pennsylvania at the time of publication. This report does not constitute a standard, specification, or regulation.

PLANT GROWTH REGULATOR STUDY

Objective

Develop plant growth regulator treatments that will suppress seedhead and vegetative growth of roadside tall fescue turf without causing significant reductions in vigor, and provide effective control of broadleaf and annual grass weeds.

Introduction

Several experiments have been conducted during the past two years to investigate the use of plant growth regulators (PGR) on roadside turf. The main objective of this program was to suppress the seedhead growth of K-31 tall fescue (Festuca arundinacea Schreb., var. 'Kentucky 31'). In addition, a PGR treatment should suppress the vegetative growth of tall fescue, although some vegetative growth can be tolerated if the seedhead is suppressed. Any comprehensive PGR research program must also address the other plant species that can exist along a typical Pennsylvania roadside. These include broadleaf weeds, crownvetch, and annual grassy weeds. Chemically suppressing tall fescue in the presence of competing species could favor the development of undesirable species. This change in species may significantly decrease the integrity and function of the roadside stand.

Materials and Methods

The treatment list for the 1988 experiments was based upon information obtained from previous studies. Embark was used as a standard because of consistent seedhead suppression over a wide variety of turfgrasses. Embark is also known to discolor turf for some time after application, so to relieve some of the discoloration symptoms, an iron supplemented liquid fertilizer (Ferromec) was evaluated. Embark at half the label rate was combined with a surfactant (Cidekick) to compare its efficacy with the recommended rate without surfactant. Because Embark has little activity of broadleaf weeds, a treatment including Banvel was included. Previous research has shown that PGR treated roadsides have a potential for severe annual grass encroachment (Philadelphia 1987). To address this problem, the pre-emergent herbicide Stomp was also combined with Embark. In previous studies, Embark combined with Escort has given very good PGR activity and broadleaf weed control, but also produced unacceptable injury to tall fescue. In 1988, the rates of each product were decreased in an attempt to reduce the severity of the injury. Embark combined with Telar has also shown potential in previous studies. Escort and Telar are both from the sulfonylurea family, and the combination of Embark with Telar may provide good PGR activity without the degree of injury found for Escort. Banvel was also included to enhance the broadleaf weed control spectrum of Telar. The last of the Embark treatments was a combination with XE-1019, an experimental growth regulator. This combination has provided promising results in previous studies. Treatments of Event, and Manage plus Telar were also included in the experiment. The trade name, common name, formulation, and manufacturer.of each compound used in the experiment is listed in Table 1.

Table 1: Trade name, common name, formulation, and manufacturer for each of the compounds used in the plant growth regulator experiment.

Trade Name	Common Name	Formulation	Manufacturer
Banvel	dicamba	4 lb/gal	Sandoz
Ferromec	ferrous iron-urea fertilizer	8 lb/gal[1]	PBI Gordon
Embark	mefluidide	2 lb/gal	PBI Gordon
Escort	metsulfuron methyl	60%	DuPont
Event	imazethapyr plus imazapyr	1.54 lb/gal	American Cyanamid
Manage	glyphosate	75%	Monsanto
Stomp	pendimethalin	4 lb/gal	American Cyanimid
Telar	chlorsulfuron	75%	DuPont
XE-1019	uniconazole	10%	Valent

1/ Fertilizer analysis is 15 - 0 - 0 - 6 - 4; N, P_2O_5, K_2O, Fe, S, respectively

Two experiments were designed to evaluate these compounds and combinations for their seedhead and foliar growth suppression, broadleaf weed and annual grass control, and effects on the quality of K-31 tall fescue roadside turf. The first experiment was located near Edinboro, Erie County, and the second was located near State College, Centre County. The State College experiment was prematurely terminated when the treated turf was removed by PennDOT maintenance operations. Therefore, only the Edinboro experiment will be discussed. Specific combinations, treatment rates, and costs are listed in Table 2. Costs were calculated from the PennDOT 1988 herbicide bid list, or contractors when a product was not on the PennDOT list, and do not include the cost of application.

Treatments were applied to a shoulder run containing primarily tall fescue on May 11, 1988, using a turf utility vehicle-mounted CO_2 powered spray boom with flat fan nozzles, delivering the equivalent of 35 gallons of water per acre. The plots were 10 by 30 feet, replicated three times and arranged in a randomized complete block design. The soil temperature at 0, 0.5, 1, 3, and 6 inches was 17, 18, 16, 12, and 12 C respectively.

Treatments were evaluated for their effects on turf color, seedhead suppression, broadleaf weed control, and overall turf quality. The color of each plot was visually determined on a scale from 0 to 9, with (0) being brown grass and (9) being vigorous, green turf. A rating less than (6) represents unacceptable color for roadside turf. Each plot was then evaluated for the presence of tall fescue seedheads and broadleaf weeds. The number of plots which displayed unacceptable levels of either seedheads or weeds are noted in the rating tables. The overall quality rating is the most important aspect for evaluation and is a combination of turf color, uniformity of PGR activity, and the presence of tall fescue seedheads or broadleaf weeds. A negative impact of any of these sources will reduce the overall quality rating for the plot. The quality rating along with the color, seedhead, and broadleaf evaluations provide a comprehensive description for each treatment.

The experiment was evaluated on May 27, (2 weeks after treatment, 2 WAT), June 14 (4 WAT), July 14 (9 WAT), and September 27 (20 WAT).

Table 2: PGR treatments and application rates in product/acre, pounds active ingredient/acre, and costs per acre.

	Treatment	Application Rate (product/acre)	Application Rate (lb ai/acre)	Treatment Cost ($/acre)
1.	Embark	1.5 pints	0.375	12.50
2.	Embark + Cidekick	0.75 pints + 0.25% (v/v)	0.188 + 0.25%	7.12
3.	Embark + Ferromec	1.5 pints+ 2 gal	0.375 + 2 gal	28.50
4.	Embark + Ferromec + Banvel	1.5 pints + 2 gal + 1 pint	0.375 + 2 gal + 0.5	34.90
5.	Embark + Ferromec + Banvel + Stomp	1 pint + 2 gal + 1 pint + 1.5 qt	0.25 + 2 gal + 0.5 + 1.5	43.41
6.	Embark + Escort	0.5 pint + 0.125 oz	0.125 + 0.008	7.08
7.	Embark + Telar + Banvel	0.5 pint + 0.25 oz + 0.5 pint	0.125 + 0.016 + 0.25	11.38
8.	Embark + XE-1019	0.38 pint+ 4.8 oz	0.094 + 0.03	*
9.	Event	0.5 pint	0.09	14.69
10.	Manage + Telar	4 oz + 0.25 oz	0.188 + 0.016	13.38
11.	Untreated Check	- - -	- - -	

***** The cost of XE-1019 was not available and further commercial development of the material is unlikely.

Results and Discussion

On May 27, (2 WAT) each plot was rated for turf color, overall turf quality, and the presence of tall fescue seedheads. It was too early in the season for broadleaf weeds to be rated (Table 3).

Turf color ratings for the three treatments that contained a sulfonylurea compound (Telar or Escort) were significantly lower than for all other treatments. The remaining treatments were not different from the check.

Tall fescue seedheads were noted in all of the check plots and in two of three replications of treatments containing Ferromec. An incompatibility occurred at the time of mixing for most treatments that included Ferromec, particularly the treatments that contained Banvel. In many cases, a coarse precipitate formed in the spray canister. This reaction may have affected the efficacy of those treatments. Evaluation of the Embark plus Ferromec treatments show a reduction in performance when Banvel is added. These complications will be overcome before it is included in further testing.

The untreated check received low quality ratings primarily because of the presence of tall fescue seedheads. Other treatments received low quality ratings due to seedheads, poor color, or a combination of both factors. Event provided the highest quality rating on this date, and although it was not considered statistically different from the check, it was statistically better than Embark plus Escort or Embark plus Ferromec, Banvel and Stomp. Embark plus Escort received the lowest quality rating which was due to foliar injury and subsequent poor color.

Table 3: Ratings of Turf Color, Seedheads, and Turf Quality for PGR treatments on May 27, 1988 (2 WAT).

	Treatment	Application Rate (Product/Acre)	Turf Color[1]		Seed-heads[2]	Turf Quality[3]	
1.	Embark	1.5 pint	5.7	a-d[4]	1	5.7	ab
2.	Embark + Cidekick	0.75 pint + 0.25%	7.0	a	1	5.7	ab
3.	Embark + Ferromec	1.5 pints + 2 gal	6.7	ab	2	5.7	ab
4.	Embark + Ferromec + Banvel	1.5 pints + 2 gal + 1 pint	6.0	abc	2	5.3	ab
5.	Emb. + Ferr. + Ban. + Stomp	1 pint + 2 gal + 1 pint + 1.5 qt	6.0	abc	2	4.7	b
6.	Embark + Escort	0.5 pint + 0.125 oz	4.0	d	0	4.3	b
7.	Embark + XE-1019	0.38 pint + 4.8 oz	6.3	abc	1	5.3	ab
8.	Embark +Telar + Banvel	0.5 pint + 0.25 oz + 0.5 pint	4.7	cd	0	5.3	ab
9.	Event	0.5 pint	6.0	abc	0	6.7	a
10.	Manage + Telar	4 oz + 0.25 oz	5.0	bcd	0	5.3	ab
11.	Untreated Check	- - -	7.3	a	3	5.0	ab

1/ Turf Color was rated on a 0 to 9 scale, 0=dead turf, 9=superior color. A rating less than 6 is unacceptable.
2/ Seedhead and Broadleaves values indicate the number of plots in which they occur.
3/ Turf Quality was rated on a 0 to 9 scale, 0=dead turf, 9=superior color, and no seedheads. A rating less than 6 is unacceptable.
4/ Means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

4 WAT

Four weeks after treatment, broadleaf weeds had encroached enough to be considered a factor in the quality ratings. Turf color, the number of plots containing tall fescue seedheads or broadleaf weeds, and turf quality ratings are listed in Table 4.

Two treatments were rated as having better color than the check. They were Event and Embark plus Escort. Color ratings of these two treatments were different from the check, but not different when compared to the other treatments. The color of Event plots was nearly the same as when rated at 2 WAT, Embark plus Escort improved, and the check decreased compared to the earlier rating. The significant difference in color between these treatments was the result of partial recovery from the Embark plus Escort treatment, and a decline in color for the untreated areas.

Tall fescue seedheads were apparent in all Embark plots that did not contain Escort or Telar, and in all check plots. The Ferromec incompatibility problem may have contributed to the low efficacy of some of the treatments, but poor seedhead control of treatments containing Embark alone indicates that the timing of application was marginal. It may also indicate that the use of a sulfonylurea product with Embark may extend the window of application slightly.

Turf quality ratings of all treatments were no different than the check. Event however, received the highest quality rating and was statistically higher than Embark plus Escort and Embark plus Ferromec, Banvel, and Stomp. Even though the turf in the Embark plus Escort had improved color, the turf canopy lacked the uniformity and consistency found for turf treated with Event.

Table 4: Ratings of Turf Color, Seedheads, Broadleaves, and Turf Quality for PGR treatments on June 14, 1988 (4 WAT).

	Treatment	Application Rate (Product/Acre)	Turf Color[1]		Seed-heads[2]	Broad-leaves[2]	Turf Quality[3]	
1.	Embark	1.5 pints	4.3	ab[4]	3	2	5.7	ab
2.	Embark + Cidekick	0.75 pint + 0.25%(v/v)	5.3	ab	3	1	5.7	ab
3.	Embark + Ferromec	1.5 pints + 2 gal	4.7	ab	3	1	5.7	ab
4.	Emb. + Ferr. + Banvel	1.5 pints + 2 gal + 1 pint	4.7	ab	3	1	5.3	ab
5.	Emb. + Ferr. + Ban.+ Stomp	1 pint +2 gal +1 pint +1.5 qt	5.0	ab	3	0	4.7	b
6.	Embark + Escort	0.5 pint + 0.125 oz	5.7	a	0	0	4.3	b
7.	Embark + XE-1019	0.38 pint + 4.8 oz	4.0	b	3	2	5.3	ab
8.	Embark + Telar + Banvel	0.5 pint + 0.25 oz + 0.5 pint	5.3	ab	0	0	5.3	ab
9.	Event	0.5 pint	5.7	a	1	1	6.7	a
10.	Manage + Telar	4 oz + 0.25 oz	5.3	ab	0	0	5.3	ab
11.	Untreated Check	- - -	4.0	b	3	2	5.0	ab

1/ Turf Color was rated on a 0 to 9 scale, 0=dead turf, 9=superior color. A rating less than 6 is unacceptable.
2/ Seedhead and Broadleaves values indicate the number of plots in which they occur.
3/ Turf Quality was rated on a 0 to 9 scale, 0=dead turf, 9=superior color, no seedheads, and no broadleaf weeds. A rating less than 6 is unacceptable.
4/ Means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

9 WAT

Nine weeks after treatment there was no difference in turf color between any of the treatments (Table 5).

By this date, Manage plus Telar still provided seedhead suppression in all plots, while Event, Embark plus Escort, and Embark plus Telar and Banvel provided seedhead suppression in two of three replications. Seedheads were not suppressed by any other treatment on this date.

Manage plus Telar, and Embark plus Telar and Banvel plots were relatively free of broadleaf weeds while all other treatments had at least one replication with an unacceptable amount of broadleaf encroachment.

For the turf quality rating at this date, four treatments had significantly higher quality ratings when compared to all other treatments. They were Embark plus Escort, Embark plus Telar, Manage plus Telar, and Event. These treatments still provided some degree of seedhead control and had the highest degree of broadleaf weed control when compared to other treatments.

Table 5: Ratings of Turf Color, Seedheads, Broadleaves, and Turf Quality for PGR treatments on July 14,1988 (9 WAT).

	Treatment	Application Rate (Product/Acre)	Turf Color[1]		Seed-heads[2]	Broad-leaves[2]	Turf Quality[3]	
1.	Embark	1.5 pints	5.3	a[4]	3	2	4.3	b
2.	Embark + Cidekick	0.75 pint + 0.25%(v/v)	5.3	a	3	2	4.0	b
3.	Embark + Ferromec	1.5 pints + 2 gal	5.3	a	3	2	4.0	b
4.	Emb. + Ferr. + Banvel	1.5 pints + 2 gal + 1 pint	5.3	a	3	2	3.7	b
5.	Emb. + Ferr. + Ban.+ Stomp	1 pint + 2 gal + 1 pint + 1.5 qt	5.3	a	3	1	4.0	b
6.	Embark + Escort	0.5 pint + 0.125 oz	5.3	a	1	1	5.3	a
7.	Embark + XE-1019	0.38 pint + 4.8 oz	5.7	a	3	2	3.7	b
8.	Embark +Telar + Banvel	0.5 pint + 0.25 oz + 0.5 pint	5.7	a	1	0	5.7	a
9.	Event	0.5 pint	5.3	a	1	1	5.7	a
10.	Manage + Telar	4 oz + 0.25 oz	5.7	a	0	0	6.0	a
11.	Untreated Check	- - -	5.7	a	3	3	3.7	b

1/ Turf Color was rated on a 0 to 9 scale, 0=dead turf, 9=superior color. A rating less than 6 is unacceptable.
2/ Seedhead and Broadleaves values indicate the number of plots in which they occur.
3/ Turf Quality was rated on a 0 to 9 scale, 0=dead turf, 9=superior color, no seedheads, and no broadleaf weeds. A rating less than 6 is unacceptable.
4/ Means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

20 WAT

The treatments were rated 20 WAT for overall turf quality and broadleaf weed invasion. The rating procedure utilized at this date was different than ratings for previous dates. The treatments were ranked within each replication for turf quality and broadleaf weeds. For turf quality, treatments were ranked from highest quality (1) to poorest quality (11), based on color and uniformity in each replication. For broadleaf weed invasion, plots were ranked from to the lowest degree of invasion (1) to the highest degree of invasion (11) in each replication. The means of the rankings are reported in Table 6.

Treatments which contained Escort or Telar were ranked the highest for turf quality while the check received the lowest quality ranking in most replications. Those treatments that contained Banvel, Escort, or Telar displayed the lowest degree of broadleaf weed invasion.

Conclusion

The treatment that best addressed the objectives of the experiment was the combination of Embark plus Ferromec, Banvel, and Stomp. Ferromec reduced discoloration commonly associated with Embark, although in roadside situations slight discoloration can be tolerated. It was added for comparison to the standard Embark treatment and for possible use in higher visibility turf areas. Unfortunately, the incompatibility problems of Ferromec may have decreased the PGR activity of this treatment. The area in which the experiment was conducted did not have the pressure from annual grass invasion that was experienced in the Philadelphia area the previous year. Although the need for the pre-emergent herbicide was not documented in the Edinboro area, its use should be considered for those areas where annual grasses, particularly foxtails (Setaria spp.), are a problem.

Table 6: Average Ranking for Turf Quality and Broadleaf invasion for PGR treatments on Sept. 27, 1988 (20 WAT).

	Treatment	Application Rate (Product/Acre)	Turf[1] Quality		Broadleaf[1] Invasion	
1.	Embark	1.5 pints	7.7	abc[2]	8.3	abc
2.	Embark + Cidekick	0.75 pint + 0.25%	8.7	ab	8.7	ab
3.	Embark + Ferromec	1.5 pints + 2 gal	7.3	abc	8.0	abc
4.	Emb. + Ferr.. + Banvel	1.5 pints + 2 gal + 1 pint	5.3	cd	2.0	e
5.	Emb. + Ferr. + Ban. + Stomp	1 pint + 2 gal + 1 pint + 1.5 qt	6.3	bc	2.7	de
6.	Embark + Escort	0.5 pint + 0.125 oz	1.3	e	3.3	de
7.	Embark + XE-1019	0.38 pint + 4.8 oz	9.3	ab	8.3	abc
8.	Embark +Telar + Banvel	0.5 pint + 0.25 oz + 0.5 pint	2.0	e	2.7	de
9.	Event	0.5 pint	5.0	cd	5.7	bcd
10.	Manage + Telar	4 oz + 0.25 oz	2.7	de	5.3	cd
11.	Untreated Check	- - -	10.3	a	11.0	a

1/ The treatments within each replication were ranked for turf quality and broadleaf invasion. The reported value represents the mean ranking for three replications.
2/ Means followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Four treatments from this experiment had an acceptable degree of PGR and weed control activity:

Event
Manage plus Telar
Embark plus Escort
Embark plus Telar and Banvel

Event provided good suppression of seedheads and acceptable weed control throughout the season. In other tests however, it has been weak on seedhead suppression of species other than tall fescue, particularly Kentucky bluegrass. It has also been weak in other tests on broadleaf weed control and has no activity on crownvetch. In 1989, Event will be combined with Embark and Banvel to provide a broader spectrum of seedhead and broadleaf weed activity.

Mange plus Telar provided acceptable activity most of the season. In tests of previous years it has caused unacceptable injury in the beginning of the season and has the potential for severe damage when overapplied.

Embark plus Escort also provided good seedhead suppression and weed control throughout the season. However, it caused the poorest color for the first rating period. In previous tests, it was found to have the most potential for injury compared to other treatments. Rates for both products have been decreased with successive experimentation, and will be reduced again in 1989. The potential for injury to tall fescue remains a major concern for the use of this combination.

Embark plus Telar and Banvel was a promising treatment in 1988. It had good PGR activity and broadleaf weed control and seemed to have a lower potential for injury when compared to Escort. Considerable testing is planned for this combination in 1989.

HERBACEOUS WEED CONTROL STUDY

Objective

Develop herbicide treatments for the selective control of Canada thistle and other herbaceous weeds in crownvetch.

Materials and Methods

One experiment consisting of 50 treatments was established in State College, Centre County. The experimental design was a randomized complete block with three replications. Treatments were applied May 25 and June 15. The treatments were applied with a CO_2 powered hand-boom delivering 40 gallons of water per acre. On May 25, the air temperature was 80°F. Crownvetch height was 6 to 24 inches, and Canada thistle height was 8 to 24 inches. For the June 15 applications the air temperature was 98°F, crownvetch was 6 to 30 inches tall and in bloom, and Canada thistle was 8 to 30 inches tall and in bud. The plots were 6 by 25 feet. The herbicides used are listed in Table 1, and the treatment combinations are listed in Table 2.

Table 1: Trade name, common name, formulation, and manufacturer information for the herbicides used in the Canada thistle control study.

Trade Name	Common Name	Formulation	Manufacturer
atrazine	atrazine	80% WP	Various
BAS 433 10H	experimental	- - -	BASF
BAS 433 11H	experimental	- - -	BASF
Basagran	bentazon	4 lb/gallon	BASF
Blazer	acifluorfen	2 lb/gallon	BASF
crop oil	emulsifiable crop oil	- - -	Various
Dash	proprietary sufactant	- - -	BASF
Garlon 3A	triclopyr amine	3 lb/gallon	Dow
Garlon 4	triclopyr ester	4 lb/gallon	Dow
Laddok	bentazon + atrazine	3.33/lb gallon	BASF
Transline	2,4-D + clopyralid	2.38 lb/gallon	Dow
UAN	urea, ammonium nitrate	30% Nitrogen	Various
Velpar L	hexazinone	2 lb/gallon	DuPont
XRM-3972	clopyralid	3 lb/gallon	Dow

The site was an infield at the interchange of US 322 and Park Avenue. The predominant vegetation included crownvetch, Canada thistle, red fescue, Kentucky bluegrass, quackgrass, bitter nightshade, reed canarygrass, yellow toadflax, and wild garlic. Canada thistle was present in all plots. Injury and control data were collected on June 28 and August 2. The June 28 data consisted of 0 to 5 rating scale, with 0 = no injury; 1 = slight injury; 2 = moderate injury; 3= severe injury, recovery likely; 4 = severe injury, mortality likely; and 5 = complete kill. The results for June 28 are reported in Table 3. Data collected on August 2 consisted of a 0 or 1 (no/yes) rating scale for injury and regrowth characteristics of crownvetch and Canada thistle. Crownvetch was rated for mortality, acceptability of appearance based on herbicide injury, and regrowth. Canada thistle was rated for mortality, axillary regrowth, basal regrowth, and new regrowth. August 2 crownvetch results are in Table 4 and Canada thistle results are in Table 5.

Table 2: Treatment list and application rates for the 1988 Canada thistle control study.

No.	Treatment	Product/Acre	Active Ingredient/Acre	Application Date
1.	Untreated Check	- - -	- - -	- - -
2.	Basagran + Crop Oil	1.5 pt + 1 qt	0.75 + 1 qt	May 25
3.	Basagran + Crop Oil + UAN	1.5 pt + 1 qt + 4 qt	0.75 + 1 qt + 4 qt	May 25
4.	Basagran + Crop Oil	3 pt + 1 qt	1.5 + 1 qt	May 25
5.	Basagran + Crop Oil	1.5 pt + 1 qt	0.75 + 1 qt	May 25 + June 15
6.	Basagran + Crop Oil + UAN	1.5 pt + 1 qt + 4 qt	0.75 + 1 qt + 4 qt	May 25 + June 15
7.	Basagran + Crop Oil	3 pt + 1 qt	1.5 + 1 qt	May 25 + June 15
8.	Basagran + Dash	1.5 pt + 1 qt	0.75 + 1 qt	May 25
9.	Basagran + Dash + UAN	1.5 pt + 1 qt + 4 qt	0.75 + 1 qt + 4 qt	May 25
10.	BAS 433 11H + Crop Oil	0.86 lb ai + 1 qt	0.86 + 1 qt	May 25
11.	BAS 433 10H	1.12 lb ai	1.12	May 25
12.	Basagran + Triclopyr	1.5 pt + 1 pt	0.75 + 0.5	May 25
13.	Blazer	1.5 pt	0.38	May 25
14.	Basagran + Blazer	1.5 pt + 1.5 pt	0.75 + 0.38	May 25
15.	Laddok + Crop Oil	2.5 qt + 1 qt	2.0 + 1 qt	May 25
16.	Garlon 4	1 pt	0.5	May 25
17.	Garlon 4	1 qt	1	May 25
18.	XRM-3972	5 oz	0.12	May 25
19.	XRM-3972	10 oz	0.24	May 25
20.	XRM-3972	20 oz	0.48	May 25
21.	Garlon 4 + XRM-3972	1 pt + 5 oz	0.5 + 0.25	May 25
22.	Garlon 4 + XRM-3972	1 pt + 10 oz	0.5 + 0.5	May 25
23.	Garlon 4 + XRM-3972	1 qt + 5 oz	1.0 + 0.25	May 25
24.	Garlon 4 + XRM-3972	1 qt + 10 oz	1.0 + 0.5	May 25
25.	Transline	2.5 pt	0.12 + 0.62	May 25
26.	Transline	5 pt	0.24 + 1.25	May 25
27.	Transline	5 qt	0.48 + 2.5	May 25
28.	Transline + Garlon 4	2.5 pt + 1 pt	0.12 + 0.62 + 0.5	May 25
29.	Transline + Garlon 4	5 qt + 1 pt	0.48 + 2.5 + 0.5	May 25
30.	Transline + Garlon 3A	2.5 pt + 1 qt	0.12 + 0.62 + 1.0	May 25
31.	Transline + Garlon 3A	5 qt + 1 qt	0.48 + 0.62 + 1.0	May 25
32.	Velpar L	2 qt	1	May 25
33.	Garlon 4	1 pt	0.5	June 15
34.	Garlon 4	1 qt	1	June 15
35.	XRM-3972	5 oz	0.12	June 15
36.	XRM-3972	10 oz	0.24	June 15
37.	XRM-3972	20 oz	0.48	June 15
38.	Garlon 4 + XRM-3972	1 pt + 5 oz	0.5 + 0.25	June 15
39.	Garlon 4 + XRM-3972	1 pt + 10 oz	0.5 + 0.5	June 15
40.	Garlon 4 + XRM-3972	1 qt + 5 oz	1.0 + 0.25	June 15
41.	Garlon 4 + XRM-3972	1 qt + 10 oz	1.0 + 0.5	June 15
42.	Transline	2.5 pt	0.12 + 0.62	June 15
43.	Transline	5 pt	0.24 + 1.25	June 15
44.	Transline	5 qt	0.48 + 2.5	June 15
45.	Transline + Garlon 4	2.5 pt + 1 pt	0.74 + 0.5	June 15
46.	Transline + Garlon 4	5 qt + 1 pt	2.98 + 0.5	June 15
47.	Transline + Garlon 3A	2.5 pt + 1 qt	0.74 + 1.0	June 15
48.	Transline + Garlon 3A	5 qt + 1 qt	2.98 + 1.0	June 15
49.	Velpar L	2 qt	1	June 15
50.	Atrazine + Crop Oil	4 qt + 1 qt	4.0 + 1 qt	June 15

Results and Discussion

Injury ratings for the untreated check on June 28 were 1 for Canada thistle, and 0 for crownvetch (Table 3). Untreated Canada thistle was exhibiting necrotic pinpoint spotting on its leaves, resembling insect feeding injury. This injury did not seem to have a significant effect on the thistle as the affected plants were between two and three feet tall, in flower and producing seed.

On June 28, treatments including Basagran caused little injury to crownvetch, except for the combination with Garlon 4 (Treatment 12). Most Basagran combinations also exhibited little activity on Canada thistle. Notable exceptions were the split application of Basagran plus crop oil (T5), and Laddok plus crop oil (T15) which severely injured thistle. The growth hormone type herbicides (XRM-3972, Transline, or Garlon), were equally injurious to Canada thistle and crownvetch. The May 25 application of these products exhibited more injury to both species than the June 15 application, which is reasonable as they had three more weeks to affect the plants. Velpar applied May 25 (T32) was rated as causing severe injury to Canada thistle and moderate injury to crownvetch, while the June 15 application (T49) was rated as causing severe injury to both species. Atrazine plus crop oil applied June 15 (T50) was also rated as causing severe injury to both species.

Crownvetch rated on August 2 (Table 4) showed little injury from the treatment combinations including Basagran. Of the 48 plots treated on May 25 with growth hormone type herbicides, only one plot was rated as having an acceptable appearance. Nine of these applications caused complete mortality of crownvetch in at least two of three plots. The June 15 applications of the growth hormone type herbicides showed slightly less injury to the crownvetch. Crownvetch was regrowing in all of the Velpar and atrazine treated plots, and showed little unacceptable injury.

Canada thistle was rated on August 2 for mortality of treated plants and presence of regrowth, categorized as axillary, basal, or new (Table 5). Axillary regrowth is regrowth from the axils of existing plants, basal regrowth is a sprout from the vertical rootstock at the base of an existing stem, and new regrowth is a plant separate from existing stems that has sprouted from horizontal rootstocks. In the untreated check, no thistle mortality was observed, axillary regrowth was observed in all three plots, basal regrowth was observed in one plot,and new regrowth was not observed in any of the plots. Two treatment combinations including Basagran (T5, T9) provided complete mortality of the treated thistle. No other combination with Basagran provided complete kill of treated thistle. All May 25 applied growth hormone type herbicide treatments (T16-31), except Garlon 4 alone, gave complete kill of treated thistle, and only five of the 16 treatments had thistle regrowth. Based on mortality ratings, the June 15 applied growth hormone type herbicide treatments (T33-48) were less active on Canada thistle than the May 25 applications. However, fewer of the June 15 plots had thistle regrowth. Plants in many of these plots were erect and defoliated, but were not dead. In addition, there was no axillary or basal resprouting, Plots where Velpar was applied June 15 showed more regrowth than those with May 25 applications. Atrazine plus crop oil applied June 15 gave complete control of the treated thistle, but basal and new regrowth were observed.

Conclusion

The treatments in this study were applied with a boom sprayer, so conclusions about the effectiveness of treatments should not be extended to spot treatments such as hand-gun applications. Field studies will be conducted in 1989 to evaluate treatments using spot-type as well as broadcast applications. The plots were rated for Canada thistle regrowth on October 3, and nearly every plot had new sprouts of Canada thistle. Therefore, the results from this year should be viewed as an evaluation of suppression treatments.

Applications of Basagran may have potential in situations where Canada thistle is the primary weed in crownvetch. Basagran provides safety to crownvetch, and with certain adjuvants should provide the necessary activity on thistle. Where other perennial species are present, Basagran may not provide the control spectrum necessary to be useful. In this study a split application 1.5 pints plus crop oil (T5) provided the best control. A single application of 1.5 pints plus Dash and UAN (T9) provided complete kill of the treated thistle, but did not suppress the regrowth as well as the split application.

Growth hormone type herbicides were applied in 32 combinations (T16-31, 33-48). Treatments that merit further evaluation are XRM-3972 at rates between 0.24 and 0.48 lb ai/A, applied when thistle is near bud stage (T36,37). These same treatments applied May 25 caused unacceptable injury to crownvetch. Combinations that included Garlon or Transline caused excessive injury to crownvetch.

Velpar applied May 25 and June 15 provided control of treated thistle, but the earlier application provided better regrowth suppression. When rated for regrowth on August 2, plots treated June 15 had basal regrowth of Canada thistle, suggesting that the treatment provided only top kill. Basal regrowth was not observed in any of the Velpar plots treated May 25.

Atrazine plus crop oil applied June 15 (T50) gave complete control of treated thistle, but observations of basal regrowth on August 2 indicate that little translocation took place under the conditions of this study.

Velpar is the only treatment used in this study that is labelled for Canada thistle control in crownvetch, and is therefore the only treatment that can be recommended. Velpar does provide knock-down of Canada thistle, and crownvetch recovers completely by late summer. To this point, no treatments have been identifed to provide season-long control of Canada thistle in crownvetch. It seems likely that no single application will ever be identified to provide selective season-long control, leaving the roadside specialist with a selection of treatments that will suppress Canada thistle, but not provide significant reductions in stand. We must decide whether to continue evaluating single-application treatments which will have to be applied annually to suppress thistle, or pursue a program of several applications per year that will substantially reduce the Canada thistle stands in crownvetch. The multi-application approach would certainly be more costly in the short term, but may be economically beneficial in the long term.

Table 3: Injury ratings for crownvetch and Canada thistle on June 28, 1988.

No.	Treatment	Application Rate	Application Date	Canada Thistle[1/] Injury	Crownvetch[1/] Injury
1.	Untreated Check	- - -	- - -	1	0
2.	Basagran + Crop Oil	1.5 pt + 1 qt	May 25	1.67	0.67
3.	Basagran + Crop Oil + UAN	1.5 pt + 1 qt + 4 qt	May 25	2	0.33
4.	Basagran + Crop Oil	3 pt + 1 qt	May 25	1.33	0.33
5.	Basagran + Crop Oil	1.5 pt + 1 qt	May 25 + June 15	3.67	2.33
6.	Basagran + Crop Oil + UAN	1.5 pt + 1 qt + 4 qt	May 25 + June 15	3	3
7.	Basagran + Crop Oil	3 pt + 1 qt	May 25 + June 15	3	3
8.	Basagran + Dash	1.5 pt + 1 qt	May 25	2	0.5
9.	Basagran + Dash + UAN	1.5 pt + 1 qt + 4 qt	May 25	2	0.67
10.	BAS 433 11H + Crop Oil	0.86 lb ai + 1 qt	May 25	1.67	1.67
11.	BAS 433 10H	1.12 lb ai	May 25	2.33	1.67
12.	Basagran + Garlon 4	1.5 pt + 1 pt	May 25	3	3.33
13.	Blazer	1.5 pt	May 25	1.67	1.33
14.	Basagran + Blazer	1.5 pt + 1.5 pt	May 25	2	1.33
15.	Laddok + Crop Oil	2.5 qt + 1 qt	May 25	3.33	2
16.	Garlon 4	1 pt	May 25	2.33	3.33
17.	Garlon 4	1 qt	May 25	3.67	3.5
18.	XRM-3972	0.12 lb ai	May 25	3	2.67
19.	XRM-3972	0.24 lb ai	May 25	3	2.33
20.	XRM-3972	0.48 lb ai	May 25	3.67	3
21.	Garlon 4 + XRM-3972	1 pt + 0.25 lb ai	May 25	4.33	3
22.	Garlon 4 + XRM-3972	1 pt + 0.5 lb ai	May 25	4.33	4
23.	Garlon 4 + XRM-3972	1 qt + 0.25 lb ai	May 25	4.33	4.33
24.	Garlon 4 + XRM-3972	1 qt + 0.5 lb ai	May 25	4.67	3.5
25.	Transline	2.5 pt	May 25	3.67	3
26.	Transline	5 pt	May 25	4.67	3
27.	Transline	5 qt	May 25	5	4.33
28.	Transline + Garlon 4	2.5 pt + 1 pt	May 25	3.33	3
29.	Transline + Garlon 4	5 qt + 1 pt	May 25	4.33	4.67
30.	Transline + Garlon 3A	2.5 pt + 1 qt	May 25	4	3
31.	Transline + Garlon 3A	5 qt + 1 qt	May 25	4.67	4.33
32.	Velpar L	2 qt	May 25	4.33	2.33
33.	Garlon 4	1 pt	June 15	2.67	2.67
34.	Garlon 4	1 qt	June 15	3	2.67
35.	XRM-3972	0.12 lb ai	June 15	2.67	1.67
36.	XRM-3972	0.24 lb ai	June 15	2.67	2
37.	XRM-3972	0.48 lb ai	June 15	3	2.33
38.	Garlon 4 + XRM-3972	1 pt + 0.25 lb ai	June 15	2.33	3
39.	Garlon 4 + XRM-3972	1 pt + 0.5 lb ai	June 15	2.67	3
40.	Garlon 4 + XRM-3972	1 qt + 0.25 lb ai	June 15	2.33	3
41.	Garlon 4 + XRM-3972	1 qt + 0.5 lb ai	June 15	2.67	3.33
42.	Transline	2.5 pt	June 15	2	3
43.	Transline	5 pt	June 15	2	3
44.	Transline	5 qt	June 15	3	3
45.	Transline + Garlon 4	2.5 pt + 1 pt	June 15	2.67	3
46.	Transline + Garlon 4	5 qt + 1 pt	June 15	3	2.67
47.	Transline + Garlon 3A	2.5 pt + 1 qt	June 15	2	2.67
48.	Transline + Garlon 3A	5 qt + 1 qt	June 15	2.67	2.67
49.	Velpar L	2 qt	June 15	3.33	3
50.	Atrazine + Crop Oil	4 qt + 1 qt	June 15	3	3

1/ Injury ratings are based on a scale of 0 to 5. 0=no injury; 1=slight injury; 2=moderate injury; 3=severe injury with recovery expected; 4=severe injury with plant death expected, 5=dead plants.

Table 4: August 2, 1988 ratings for crownvetch mortality, appearance, and regrowth.

No.	Crownvetch[3] Treatment	Application Rate	Application Date	Crownvetch[1] Mortality	Crownvetch[2] Appearance	Regrowth
1.	Untreated Check		- - -	0	3	3
2.	Basagran + Crop Oil	1.5 pt + 1 qt	May 25	0	3	3
3.	Basagran + Crop Oil + UAN	1.5 pt + 1 qt + 4 qt	May 25	0	3	3
4.	Basagran + Crop Oil	3 pt + 1 qt	May 25	0	3	3
5.	Basagran + Crop Oil	1.5 pt + 1 qt	May 25 + June 15	0	3	3
6.	Basagran + Crop Oil + UAN	1.5 pt + 1 qt + 4 qt	May 25 + June 15	0	3	3
7.	Basagran + Crop Oil	3 pt + 1 qt	May 25 + June 15	0	3	3
8.	Basagran + Dash	1.5 pt + 1 qt	May 25	0	3	3
9.	Basagran + Dash + UAN	1.5 pt + 1 qt + 4 qt	May 25	0	3	3
10.	BAS 433 11H + Crop Oil	0.86 lb ai + 1 qt	May 25	0	3	3
11.	BAS 433 10H	1.12 lb ai	May 25	0	2	3
12.	Basagran + Triclopyr	1.5 pt + 1 pt	May 25	1	2	2
13.	Blazer	1.5 pt	May 25	0	3	3
14.	Basagran + Blazer	1.5 pt + 1.5 pt	May 25	0	3	3
15.	Laddok + Crop Oil	2.5 qt + 1 qt	May 25	0	3	3
16.	Garlon 4	1 pt	May 25	0	0	2
17.	Garlon 4	1 qt	May 25	0	0	3
18.	XRM-3972	0.12 lb ai	May 25	0	1	3
19.	XRM-3972	0.24 lb ai	May 25	0	0	2
20.	XRM-3972	0.48 lb ai	May 25	2	0	2
21.	Garlon 4 + XRM-3972	1 pt + 0.25 lb ai	May 25	0	0	3
22.	Garlon 4 + XRM-3972	1 pt + 0.5 lb ai	May 25	3	0	0
23.	Garlon 4 + XRM-3972	1 qt + 0.25 lb ai	May 25	2	0	1
24.	Garlon 4 + XRM-3972	1 qt + 0.5 lb ai	May 25	2	0	0
25.	Transline	2.5 pt	May 25	0	0	2
26.	Transline	5 pt	May 25	3	0	0
27.	Transline	5 qt	May 25	3	0	0
28.	Transline + Garlon 4	2.5 pt + 1 pt	May 25	0	0	3
29.	Transline + Garlon 4	5 qt + 1 pt	May 25	3	0	0
30.	Transline + Garlon 3A	2.5 pt + 1 qt	May 25	2	0	2
31.	Transline + Garlon 3A	5 qt + 1 qt	May 25	3	0	1
32.	Velpar L	2 qt	May 25	0	2	3
33.	Garlon 4	1 pt	June 15	0	0	2
34.	Garlon 4	1 qt	June 15	2	0	0
35.	XRM-3972	0.12 lb ai	June 15	0	1	1
36.	XRM-3972	0.24 lb ai	June 15	0	2	3
37.	XRM-3972	0.48 lb ai	June 15	0	2	2
38.	Garlon 4 + XRM-3972	1 pt + 0.25 lb ai	June 15	1	0	1
39.	Garlon 4 + XRM-3972	1 pt + 0.5 lb ai	June 15	0	0	0
40.	Garlon 4 + XRM-3972	1 qt + 0.25 lb ai	June 15	0	0	0
41.	Garlon 4 + XRM-3972	1 qt + 0.5 lb ai	June 15	3	0	0
42.	Transline	2.5 pt	June 15	0	2	2
43.	Transline	5 pt	June 15	2	0	3
44.	Transline	5 qt	June 15	2	0	0
45.	Transline + Garlon 4	2.5 pt + 1 pt	June 15	1	0	1
46.	Transline + Garlon 4	5 qt + 1 pt	June 15	3	0	0
47.	Transline + Garlon 3A	2.5 pt + 1 qt	June 15	1	0	1
48.	Transline + Garlon 3A	5 qt + 1 qt	June 15	1	0	0
49.	Velpar L	2 qt	June 15	0	3	3
50.	Atrazine + Crop Oil	4 qt + 1 qt	June 15	0	2	3

1/ Value indicates the number of plots (0-3) in which the crownvetch was dead.
2/ Value indicates the number of plots (0-3) in which the crownvetch appearance was acceptable.
3/ Value indicates the number of plots (0-3) in which crownvetch regrowth was apparent.

Table 5: Canada thistle regrowth ratings for August 2, 1988

No.	Treatment	Application Rate	Application Date	Mortality	Axillary[1]	Basal[1]	New[1]
1.	Untreated Check		- - -	0	3	1	0
2.	Basagran + Crop Oil	1.5 pt + 1 qt	May 25	1	2	2	1
3.	Basagran + Crop Oil + UAN	1.5 pt + 1 qt + 4 qt	May 25	0	3	3	1
4.	Basagran + Crop Oil	3 pt + 1 qt	May 25	1	2	1	2
5.	Basagran + Crop Oil	1.5 pt + 1 qt	May 25 + June 15	3	0	0	0
6.	Basagran + Crop Oil + UAN	1.5 pt + 1 qt + 4 qt	May 25 + June 15	1	2	1	0
7.	Basagran + Crop Oil	3 pt + 1 qt	May 25 + June 15	1	2	1	2
8.	Basagran + Dash	1.5 pt + 1 qt	May 25	0	3	2	1
9.	Basagran + Dash + UAN	1.5 pt + 1 qt + 4 qt	May 25	3	0	1	2
10.	BAS 433 11H + Crop Oil	0.86 lb ai + 1 qt	May 25	1	2	2	2
11.	BAS 433 10H	1.12 lb ai	May 25	1	2	2	1
12.	Basagran + Triclopyr	1.5 pt + 1 pt	May 25	0	3	2	2
13.	Blazer	1.5 pt	May 25	0	3	3	3
14.	Basagran + Blazer	1.5 pt + 1.5 pt	May 25	0	3	2	2
15.	Laddok + Crop Oil	2.5 qt + 1 qt	May 25	1	2	2	1
16.	Garlon 4	1 pt	May 25	0	3	3	3
17.	Garlon 4	1 qt	May 25	1	2	2	2
18.	XRM-3972	0.12 lb ai	May 25	3	0	0	1
19.	XRM-3972	0.24 lb ai	May 25	3	0	1	0
20.	XRM-3972	0.48 lb ai	May 25	3	0		
21.	Garlon 4 + XRM-3972	1 pt + 0.25 lb ai	May 25	3	0	0	0
22.	Garlon 4 + XRM-3972	1 pt + 0.5 lb ai	May 25	3	0	1	1
23.	Garlon 4 + XRM-3972	1 qt + 0.25 lb ai	May 25	3	0	0	0
24.	Garlon 4 + XRM-3972	1 qt + 0.5 lb ai	May 25	3	0	0	0
25.	Transline	2.5 pt	May 25	3	0	1	1
26.	Transline	5 pt	May 25	3	0	0	0
27.	Transline	5 qt	May 25	3	0	0	0
28.	Transline + Garlon 4	2.5 pt + 1 pt	May 25	3	0	1	1
29.	Transline + Garlon 4	5 qt + 1 pt	May 25	3	0	0	0
30.	Transline + Garlon 3A	2.5 pt + 1 qt	May 25	3	0	0	0
31.	Transline + Garlon 3A	5 qt + 1 qt	May 25	3	0	0	0
32.	Velpar L	2 qt	May 25	2	1	0	1
33.	Garlon 4	1 pt	June 15	1	1	2	1
34.	Garlon 4	1 qt	June 15	2	0	0	1
35.	XRM-3972	0.12 lb ai	June 15	2	0	0	0
36.	XRM-3972	0.24 lb ai	June 15	2	0	0	0
37.	XRM-3972	0.48 lb ai	June 15	3	0	0	0
38.	Garlon 4 + XRM-3972	1 pt + 0.25 lb ai	June 15	2	0	0	0
39.	Garlon 4 + XRM-3972	1 pt + 0.5 lb ai	June 15	2	0	0	0
40.	Garlon 4 + XRM-3972	1 qt + 0.25 lb ai	June 15	1	0	0	0
41.	Garlon 4 + XRM-3972	1 qt + 0.5 lb ai	June 15	3	0	0	0
42.	Transline	2.5 pt	June 15	3	0	0	0
43.	Transline	5 pt	June 15	3	0	0	0
44.	Transline	5 qt	June 15	3	0	0	0
45.	Transline + Garlon 4	2.5 pt + 1 pt	June 15	3	0	0	2
46.	Transline + Garlon 4	5 qt + 1 pt	June 15	3	0	0	0
47.	Transline + Garlon 3A	2.5 pt + 1 qt	June 15	3	0	0	1
48.	Transline + Garlon 3A	5 qt + 1 qt	June 15	3	0	0	0
49.	Velpar L	2 qt	June 15	3	0	3	3
50.	Atrazine + Crop Oil	4 qt + 1 qt	June 15	3	0	2	3

1/ Values indicate the number of plots in which the specified regrowth was observed.

BRUSH CONTROL STUDY

The brush control study consisted of several experiments. They included the following:

- Fall Foliar Experiment
- Dormant Stem Experiment
- Resprout Control Experiment
- Three Basal Bark Experiments

The products utilized in the brush control study are listed in Table 1.

Table 1: Trade name, common name, formulation and manufacturer information for the products used in the brush control study.

Trade Name	Common Name	Formulation	Manufacturer
Garlon 4	triclopyr ester	4 lb/gallon	Dow
Tordon 101	picloram + 2,4-D	0.54 + 2.0 lb/gallon	Dow
Krenite S	fosamine ammonium	4 lb/gallon	DuPont
Escort	metsulfuron methyl	60 DF	DuPont
Roundup	glyphosate	4 lb/gallon	Monsanto
Arsenal	imazapyr	2 lb/gallon	American Cyanamid
Chopper	imazapyr	2 lb/gallon	American Cyanamid
Banvel 720	dicamba + 2,4-D	1 + 1.9 lb/gallon	Sandoz
Cidekick I	crop oil	--	J.L.B. International
Clean Cut + Pine	crop oil	--	Arborchem Products Inc.
Basal Oil	penetrant	--	Arborchem Products Inc.
Rite-Way Mineral Oil	penetrant	--	N.G. Gilbert

Fall Foliar Experiment

Objective

To compare the efficacy of Krenite S applied alone and in combination with several other products for controlling several species of brush.

Introduction

Roadside managers in Pennsylvania perform a high percentage of their brush control operations in the late summer / early fall with Krenite as the primary herbicide. Krenite has several advantages which include:

• application can continue until leaf color changes,

• Krenite is only active on the portion of the plant that it contacts, which produces a "sidetrimming" effect, and

• when applied late in the season, Krenite does not produce objectionable "brown out" of the foliage.

However, a disadvantage of exclusively using Krenite is that tolerant species will not be controlled and will be released.

The treatments, rates, and product costs are listed in Table 2. Product costs reflect prices from the Pennsylvania state bid list and do not include application costs.
The rates are listed as percent of total solution, and pounds of active ingredient per acre to accommodate two different types of application. Generally, a handgun is used to control sparse stands of brush and the herbicide rate is calculated as a percentage of total volume because the spray volume applied per acre varies with brush density. For uniform stands of brush a standard hydraulic sprayer with an O.C. nozzle or advanced equipment such as Cibolo, Cross, or the Radiarc nozzle systems produce a constant and consistent pattern. For this type of equipment, rates can be calculated on the basis of units per acre. It is important when recommending a rate of application for Krenite to understand the relationship between spot applications made with a handgun and those made to deliver a certain amount per acre. A 2% rate applied at 200 gallons per acre with a handgun equals 16 quarts of Krenite per acre, while a 2% rate applied in 75 gallons of water per acre equals only 6 quarts of Krenite per acre. It is important to maintain the correct per acre rate of Krenite when using equipment that will provide consistent patterns in lower volumes of water.

Materials and Methods

The experiment was established on a roadside stand of mixed brush in Crawford County, Pennsylvania. Treatments were applied using a Radiarc nozzle system which delivered the equivalent of 75 gallons of water per acre. Plots were 100' in length and area calculations were based on a 15' swath pattern. The first four treatments were applied on September 10, 1988, and the remaining treatments were applied on September 11 (Table 2). Rain fell on the plot area September 11, approximately four hours after application.

Table 2: Application rates for foliar applied brush control treatments. Treatments were applied in the equivalent of 75 gallons per acre. The crop oil used was Cidekick I.

Treatment	product/75 gallons	lbs ai/acre	cost/acre ($)
Krenite S	2.0%	6.0	55.60

Krenite S + Crop Oil	1.5% + 0.25%	4.5 + 24 oz	43.56
Krenite S + Garlon 4	1.5% + 0.5%	4.5 + 1.5	64.17
Krenite S + Garlon 4 + Crop Oil	1.0% + 0.5% + 0.25%	3.0 + 1.5 + 24 oz	52.13
Roundup	1.0%	3.0	44.40
Krenite S + Banvel 720	1.5% + 0.5%	4.5 + 1.1	48.40
Krenite S + Escort	1.5% + 1 oz	4.5 + 0.038	65.02
Krenite S + Arsenal	1.5% + 8 oz	4.5 + 0.12	49.93
Krenite S + Arsenal	1.5% + 16 oz	4.5 + 0.25	58.16
Arsenal	8 oz	0.12	8.23
Arsenal	16 oz	0.25	16.46

The brush treated included red maple (Acer rubrum L.), oak (Quercus spp.), ash (Fraxinus spp.), cucumber tree (Magnolia acuminata,L.), beech (Fagus spp.), poplar (Populus spp.), and black cherry, (Prunus serotina, J.F.Ehrh.). Not every species was present within each plot. The treatments were rated for control on July 14, 1989 approximately ten months after application. Each species within the plot was rated on a scale from 1-7. A rating of (1) indicates there was no treatment effect and a rating of (5) was awarded if all of the portions of the plant that were contacted by the treatment were controlled. The (5) rating is considered the objective of a successful Krenite operation. A rating of six (6) indicates that there was herbicide activity beyond the treated area, and a rating of seven (7) indicates complete control of the whole plant. A blank space in the rating table indicates that particular species was not present in the plot.

Results and Discussion

Control ratings for this experiment are listed in Table 3. Krenite applied alone at 2% and Krenite 1.5% + crop oil (Cidekick I) produced similar control of maple, oak, and ash. Both treatments controlled all contacted portions of oak, while some resprouting was evident on maple and ash.

Krenite (1.5%) + Garlon (0.5%) and Krenite (1.0%) + Garlon (0.5%) + crop oil provided control that was equal to or better than control provided by Krenite applied alone on maple, oak, and ash. Both treatments provided complete control of all contacted portions of oak and ash, and provided some control beyond the contacted area on maple.

Roundup (1%) provided complete control of all contacted portions of ash, yet control of oak and maple was poor. Rain fell on the plot area approximately four hours after treatment and may have contributed to the poor performance of this treatment.

Krenite + Banvel 720 provided complete control of oak, but poor control of maple and magnolia.

The addition of Escort to Krenite provided control past the treated area on maple, oak, and ash. The degree of control of all three species was better than that provided by Krenite alone.

Krenite + Arsenal at either rate provided complete control of maple and poplar, and activity was noted well beyond the treatment area in oak, magnolia, beech, and cherry. Arsenal applied alone at either rate provided similar results on the same species with the exception of magnolia which was only slightly injured. The combination of Krenite with Arsenal provided more consistent and complete control of magnolia when compared to Arsenal alone. Arsenal provided complete control of all maples, some of which were over 25' tall. Activity was also noted far beyond the treated area in large ash and beech. The degree of control achieved with the high rate of Arsenal was similar to the low rate when applied alone or in combination with Krenite. Lower rates should be investigated to determine the most cost effective rate.

Table 3: Control ratings for foliar applied brush control treatments.

		Control Ratings July 14, 1988[1]						
Treatment	Product/75 gallons	Maple	Oak	Ash	Magnolia	Beech	Poplar	Cherry
Krenite S (K-S)	2.0%	4	5	4			4	
K-S + Crop Oil (CO)	1.5% + 0.25%	4	5	4				
K-S + Garlon 4 (G-4)	1.5% + 0.5%	6	5	5		5		
K-S + G-4 + C-O	1.0% + 0.5% + 0.25%	6	5	5		5		5
Roundup	1.0%	2	2	5				
K-S + Banvel 720	1.5 + 0.5%	4	7		3			
K-S + Escort	1.5% + 1 oz	6	6	6				
K-S + Arsenal	1.5% + 8 oz	7	6					6
K-S + Arsenal	1.5% + 16 oz	7	5		6	6	7	6
Arsenal	8 oz	7	5	6	3	6		
Arsenal	16 oz	7	5	6	3	6		6

1/ Rating Scale used was 1 to 7, 1=no injury; 2=slight injury; 3=contacted branches are severely stunted and chlorotic,recovery expected; 4=some dead tips on contacted branches with some resprouting; 5=all or most of the contacted branches are dead; 6=some branches not contacted by the herbicide are severely injured or dead; 7=entire plant is dead.

Conclusion

The addition of 0.25% crop oil to Krenite at 1.5% provided control similar to Krenite at 2% applied alone. The 1.5% and 2.0% rates correspond to approximately 4.5 and 6.0 lbs. per acre of fosamine ammonium, respectively. This rate is below the label recommendations for Krenite but in this test serves as a basis for comparison of Krenite applied alone with Krenite plus other products.

The addition of Garlon, Escort, or Arsenal resulted in more effective broad spectrum control than applications of Krenite alone. Control of contacted foliage was improved, and there was increased activity beyond the treated area. The Arsenal rates used in this experiment were too high to be safe for most roadside uses. Arsenal is active by absorption through the roots as well as the foliage. The rates in this study can potentially cause off target injury through root pickup by vegetation off of the right of way. Rates have been reduced to 2 and 4 ounces of product per acre in the most recent study that was applied in the fall of 1988. These rates will provide a greater margin of safety and the efficacy will be compared to other treatments.

Roadside managers must determine if increased herbicide activity beyond the contacted area would be desirable. One advantage of Krenite is the ability to "sidetrim" a stand of brush without causing injury beyond the contacted area. Combining additional herbicides with Krenite results in "brownout" effects caused by the other herbicides. The roadside manager must determine the objectives of their brush control program and whether the benefits of increased activity and spectrum of control gained by adding other herbicides to Krenite will outweigh the problems associated with their use.

Dormant Stem Experiment

Objective

To evaluate the efficacy of Garlon 4 and Crop Oil (Clean Cut + Pine) applied at two different timings on controlling roadside brush.

Introduction

Dormant stem treatments can provide the roadside manager an alternative to the fall foliar brush control method. The treatment is applied during the dormant season by broadcasting the solution onto the stems of the target brush. The advantages of this method are:

- spray solutions penetrate into dense stands of brush better when no foliage is present,
- no crops are growing at the time of application so there is less risk of injury from drift, and
- manpower and equipment are more available at this time of the season.

The disadvantages of dormant stem treatments are somewhat higher costs than fall applications, severe weather may regularly interfere with applications, and results can be inconsistent.

Information from previous studies indicated that a broadcast application of Garlon at 5% v/v in March was more effective than application in December. The intent of this experiment was to examine lower rates of Garlon, in combination with two rates of crop oil to determine if lower cost treatments are possible. In addition, all treatments were applied in February and in March to more closely bracket the most efficient timing.

Materials and Methods

Garlon 4 was applied at 1.5%, 2.0%, and 2.5% v/v in combination with crop oil at 2.0% or 3.0% v/v. The crop oil utilized in this experiment was Clean Cut + Pine. Rates and combinations, and herbicide costs based on the state bid prices are listed in Table 4. Treatments were applied on February 11, and March 17, 1988, using a Radiarc nozzle system which delivered the equivalent of 75 gallons of water per acre over a 15' swath width. The air and soil temperature on Feb. 11 was -0.5 and -1° C, respectively, and there was 6-10" of snow throughout the treatment area. The air and soil temperature on March 17, 1988, was 4 and 0° C, respectively. The major brush species present within the test area were oak (Quercus spp.) sassafras (Sassafras albidum, Nutt.), red maple (Acer rubrum, L.), and American chestnut (Castanea dentata, Marsh.). Not all species were present in each plot.

Treatments were rated June 17, 1988 on a scale from 0 to 10, with (0) indicating no control within the contacted area and (10) indicating total control of all contacted branches.

Table 4: Application rates and herbicide cost of dormant stem treatments applied in 75 gallons/acre.

Treatment	Percent Volume	Quarts Product/Acre	Cost/Acre ($)
Garlon 4 + Crop Oil	1.5 + 2.0	4.5 + 6.0	82.33
Garlon 4 + Crop Oil	1.5 + 3.0	4.5 + 9.0	89.79
Garlon 4 + Crop Oil	2.0 + 2.0	6.0 + 6.0	104.80
Garlon 4 + Crop Oil	2.5 + 2.0	7.5 + 6.0	127.27
Garlon 4 + Crop Oil	2.5 + 3.0	7.5 + 9.0	134.73

Results and Discussion

The degree of control of all species tended to be slightly higher for treatments applied on March 17 than treatments applied on February 11 (Table 5). It was noted that control was more uniform throughout the treatment area for those treatments applied on March 17. It is not known whether the physiological state of the plant or the effects of the lower temperature on the spray solution caused the difference. Garlon (1.5%) plus crop oil (2.0) applied on February 11 provided good initial control of oak, sassafras, and chestnut, but all species were resprouting within the treatment area. When the same treatment was applied in March, control of oak was nearly the same, while less sprouting was evident on contacted portions of sassafras. There were ice problems in the spray head with the application of Garlon (2.0%) + crop oil (2.0%) on February 11 which resulted in an inconsistent spray pattern. Consequently, control ratings for this treatment were not performed. Garlon (2.5%) + crop oil (2.0%) provided nearly the same control when applied at either date while control of oak and sasafrass with Garlon (2.5%) + crop oil (3.0%) increased when applied March 17 compared to February 11.

In most cases, the degree of control increased when the crop oil was increased from 2.0% to 3.0%. Control of oak, sassafras, and chestnut by 1.5% Garlon was increased when the rate of crop oil was increased from 2.0% to 3.0% at either application date. When applied Feb. 11, contol of oak and sassafras by 2.5% Garlon was nearly the same regardless of the rate of crop oil. But for the March 17 application, the level of control increased when the rate of crop oil was increased.

Some injury was noted to the understory vegetation. The degree of injury increased as the rate of Garlon increased and was more severe for the March 17 application.

Table 5: Dormant Stem treatments and control ratings for June 17, 1988.

Garlon 4 (%)	Crop Oil (%)	Application Date	Control Ratings June 17, 1988[1] Oak	Sassafras	Maple	Chestnut
1.5	2	2/11/88	8	8		8
1.5	2	3/17/88	8	9		
1.5	3	2/11/88	9	9	9	9
1.5	3	3/17/88	9	10		
2.0	2	2/11/88	Application Problems - No Ratings			
2.0	2	3/17/88	9	10	10	
2.5	2	2/11/88	9	9		
2.5	2	3/17/88	9	9		
2.5	3	2/11/88	9	9	9	9
2.5	3	3/17/88	10	10		

1/ Ratings were made on a 1-10 scale, 1 = no treatment effect, 10 = complete control of contacted tissue.

Conclusion

By using a relatively low rate of Garlon and a higher rate of crop oil, very good brush control can be achieved at a reasonable cost. Though the time during which treatments can be applied may be more restrictive than had been hoped.

A study will be initiated in 1989 to further evaluate the potential of increasing control by increasing the concentration of crop oil in the spray solution.

Resprout Control Experiment

Objective

To evaluate the efficacy of several herbicides on controlling resprouts of roadside brush within the same year of the cutting operation.

Introduction

The use of powerful "boom-arm mowers" has increased in recent years. These machines can be used to mow all vegetation including brush up to 5-6" caliper. This is an effective tool for removing the initial brush, but species can vigorously resprout from the stump and grow several feet in one season. For this operation to be an efficient management alternative, the resprouts must be controlled or a new brush population can occur that may be a bigger problem than the original. The semantics of this treatment are somewhat confusing because it refers to operations that are termed stump control, cut stubble, and broadcast foliar. The most important aspect is that the application was performed after resprouting had occurred, and within the same season of cutting.

The experiment was placed in Venango County near Cochranton where a boom arm mower has been used to clear a stand of mixed brush in early June, 1987 . The resprouts were treated in mid-September of the same season.

Materials and Methods

The treatment area contained several brush species which included ash (Fraxinus spp.), cherry (Prunus spp.), oak (Quercus spp.), sassafras (Sassafras albidum), maple (Acer spp.), elm (Ulmus spp.), poplar (Populus spp.), sumac (Rhus spp.), multiflora rose (Rosa spp.), and brambles (Rubus spp.). Not all species were present within each plot area. All of these species had resprouted at the time of application with resprouts of ash and maple producing approximately 3' of growth. Treatments were applied on September 14, 1987, approximately 3.5 months after the cutting operation. A Radiarc nozzle was utilized and delivered the equivalent of 50 gallons of water per acre. Treatment plots were 100' x 15' and replicated twice. The treatments and rates are listed in Table 6.

Table 6: Treatments applied to brush regrowth three months after boom-arm mower cutting. Treatments were applied in the equivalent of 50 gallons per acre.

Treatment	product/acre	lb ai/acre
Garlon 4	2 qt	2.0
Banvel 720	2 qt	1.45
Tordon 101	2 qt	1.27
Tordon 101 + Garlon 4	2 qt + 2 qt	1.27 + 2.0
Roundup	2 qt	2.0
Banvel 720 + Garlon 4	3 pt + 3 pt	1.1 + 1.5

Results and Discussion

All treatments were evaluated for control on July 14, 1988. Control comments are listed below for each treatment.

Garlon 4 - This treatment provided the best overall control. It was very effective on initial resprouts of sassafras, ash,sumac, and cherry, yet all of these species were resprouting again from the stump. Cherry is the most prolific resprouting species at this date. The understory which contained mostly broadleaf weeds showed symptoms of injury. There seems to be some effect on the grass understory, but there was not enough present at the time of application to make a confident evaluation. A patch of daylilies within the plot seemed to be unaffected by the treatment.

Banvel 720 - This treatment provided the poorest overall control. The species within the plot areas were maple, ash, cherry, sumac, and brambles. Sumac was controlled while all other species resprouted, with cherry and brambles the most vigorous.

Tordon 101 - Tordon was included because it has root activity as well as foliage activity. The species present were poplar, oak, ash, sassafras and maple. The treatment controlled the original resprouts of most species, but had no effect on ash. All others resprouted from the stump the second season. Root uptake was noted on brush outside of the original treatment area. More grass understory was noted in these plots when compared to plots treated with Tordon + Garlon.

Roundup - Species growing within the treatment area included maple, ash, cherry, and multiflora rose. Roundup was effective in controlling multiflora rose and some maple resprouts but did not control cherry or ash. Existing vegetation on maple and ash displayed typical Roundup symptoms of chlorotic, malformed leaves and clumped bud growth.

Garlon + Tordon 101 - Species growing within the treatment area included maple, ash, cherry, and sassafras. This treatment varied between the two replications. The first replication displayed very good control of all species except ash, while control was variable for all species in the second replication. Root pickup was noted in sassafras. This treatment provided better control than the combination of Garlon + Banvel, but the addition of Tordon did not seem to enhance the control provided by Garlon applied alone.

Garlon + Banvel 720 - Maple, ash, cherry and sassafras were burned, but have resprouted. The addition of Banvel did not enhance the control of Garlon applied alone.

Conclusion

The degree of control from any treatment was dependent on the species present. Several treatments provided good control of a particular species, while offering poor control of others. Generally, the treatments had some effect on the existing resprouts yet many species were able to produce a second flush of resprouts from the stump. The treatments may have simply "burned" the foliage of the initial resprouts and stored reserves in the root system enabled the plant to produce another flush of growth. The proportion of foliage present to the surviving root system is dramatically lower when compared to a tree that has not been cut. There may not be enough foliage available on first year resprouts to absorb the amount of herbicide required to control the extensive root system of the plant. Application the second year after cutting may be more effective because more foliage would be available for herbicide absorption.

BASAL BARK EXPERIMENTS

The basal bark technique is being used extensively by utility companies for brush control on their right-of-ways and it could also be an effective tool for roadside managers. It can be applied during the dormant season, has minimal potential for off-target damage, and can be used to manipulate the composition of a roadside community by selectively controlling the undesirable species thus releasing the desirable species. The basal application procedure has been refined in recent years. In the past, application involved a 1-5% herbicide solution mixed with fuel oil and applied in a relatively high volume to the lower 18" of the target stem until the solution puddled at the soil surface. This required a large tank and the applicators were required to drag a hose from the tank throughout the treatment area. Advancements in equipment and technique in recent years now allow the application to be performed with a backpack sprayer as a low volume of solution is misted onto the target stem. The herbicide concentration is higher (20-50%) and there are several diluents available for use as an alternative to diesel fuel. These include Basal Oil from Arborchem Products Inc. which is a refined petroleum product and Rite Way Mineral Oil from N. G. Gilbert which is a refined mineral oil.

Two basal bark experiments were initiated in 1987 and two in 1988 to investigate several products, rates, and diluents for use in controlling various brush species. The experiments are listed below.

1. In 1987 a screening test was conducted to evaluate two rates of Garlon 4 combined with two different diluents, and one rate of Chopper on controlling green ash, black birch, and red maple .

2. In 1987, an experiment was conducted to more exactly determine the amount of Garlon 4 required to control ash or birch by applying 0.5, 1, or 2 ml of basal solution per inch of tree circumference.

3. In 1988, an experiment was conducted to compare two rates of Garlon 4 with several other products and two diluents. The diluents were diesel fuel and N.G. Gilbert Rite Way Mineral Oil.

Experiment I - 1987

Objective

This experiment was conducted to evaluate the efficacy of Garlon 4, Chopper, and two diluents on controlling green ash (Fraxinus pennsylvanica Marsh.), black birch (Betula lenta L.) and red maple (Acer rubrum L.).

Materials and Methods

Garlon 4 was applied at 5% and 20% v/v using diesel fuel and Basal Oil as diluents. Chopper was applied at 6.25% v/v using diesel fuel as the diluent. An average of 40 stems per treatment were utilized for ash, 30 stems per treatment for maple, and 20 stems per treatment for birch. The application was made in March 1987, using a B&G Extenda-Ban Valve and a Spraying Systems #5500 Cone Jet Nozzle with a Y-2 tip adjusted to produce a fine mist. The treatment was applied to the bottom 6" to 12" of the stems which ranged from 0.5" to 6" in caliper for each species. During application to the ash and birch, the air temperature was 55º F and the soil temperature at a 6" depth was 30º F. During application to maple the air temperature was 14º F and the soil temperature was 28º F. Each stem was rated for control on a scale of 0-5 where a (0) indicates no treatment effect and a (5) indicates the stem was dead. Treatments were rated on August 19, 1987 and June 17, 1988.

Results and Discussion

The number of stems present in each rating category (0-5) is located in Table 7. Garlon at 20% killed more stems of ash than Garlon at 5%. There was no apparent difference in control between diluents for this species at either rate of Garlon. By June 17, 1988, all ash stems treated with Chopper were dead. The only herbicide injury apparent in the foliage of the surviving ash treated with Garlon was canopy thinning. The portion of the stem that was contacted with the treatment however, was severely injured. The cambium and phloem tissues in the bark were dead and easily peeled from the stem. On August 19, 1987, surviving plants treated with Chopper displayed small, malformed, chlorotic leaves which were clustered at the buds. The portions of the stem that were contacted with the solution did not display the severe injury associated with those plants treated with Garlon. It was noted that understory growth was controlled adjacent to several stems treated with Chopper.

On August 19, 1987, several black birch plants treated with Garlon were defoliated and appeared to be dead so they were awarded a "5" rating. When the same stems were rated on June 17, 1988, the number of plants receiving this rating declined for all four Garlon treatments. Plants that appeared to be dead when rated on August 19, 1987 apparently were not and had partially recovered by June 17, 1988. It is difficult to accurately determine whether a woody plant is completely dead. Birch is particularly difficult. If there was no foliage present and no green tissue apparent in the buds, a rating of "5" was awarded. This experiment will be evaluated again during the 1989 season in order to further examine these trends. There were more dead black birch stems for Garlon at 5% when mixed with diesel fuel than with Basal Oil at both rating dates. On August

19, 1987, Garlon 20% with diesel fuel provided 14 stems with a rating of "5" and Basal oil provided 13 stems with the same rating. On June 17, 1988 however, 13 stems treated with diesel fuel were rated a "5" while only 7 stems treated with Basal Oil were given a "5" rating. Chopper provided very poor control of black birch. By June 17, 1988, 9 stems showed no treatment effects and the rest showed only minor canopy loss.

Red maple was completely controlled on August 19, 1987 by all Garlon treatments except Garlon 5% with Basal Oil which controlled all but 4 stems. On June 17, 1988, two of those stems that had been rated a "5" for this treatment had some foliage. There was no recovery of stems treated with all other Garlon combinations. On August 19, 1987, 18 maple stems treated with Chopper obtained a "5" rating, yet by June 17, 1988 several had recovered and only 3 stems retained that same rating.

Garlon at 20% provided better broad spectrum control than Garlon at 5% or Chopper. The use of diesel fuel as a carrier resulted in control as good as with Basal Oil. Though Chopper provided excellent control of ash, and good control of maple, it was very weak on birch.

Table 7: - Number of stems of green ash, black birch and red maple in each rating category (0-5) with a (0) indicating no treatment effect and a (5) indicating a dead stem. Stems were treated in March of 1987, and rated on August 19, 1987 and June 17, 1988. An average of 40 stems per treatment were utilized for ash, 30 stems per treatment for maple, and 20 stems per treatment for birch.

CONTROL RATING	GARLON 4 5% BASAL OIL		GARLON 4 5% DIESEL		GARLON 4 20% BASAL OIL		GARLON 4 20% DIESEL		CHOPPER 6.25% BASAL OIL	
Green Ash	8/19/87	6/17/88	8/19/87	6/17/88	8/19/87	6/17/88	8/19/87	6/17/88	8/19/87	6/17/88
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	1	0	0	0	0	0	0	0
3	2	1	2	0	0	0	0	0	0	0
4	12	7	12	8	3	0	1	1	3	0
5	26	32	25	32	37	40	39	39	37	40
Black Birch										
0	0	0	0	0	0	0	0	0	0	10
1	0	1	0	0	0	0	0	0	2	9
2	1	2	0	0	0	0	0	0	10	0
3	5	5	0	1	1	3	0	1	7	0
4	6	7	8	11	5	9	4	4	0	0
5	4	1	12	8	13	7	14	13	0	0
Red Maple										
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	2	2	0	0	0	0	0	0	0	0
4	2	4	0	0	0	0	0	0	2	14
5	28	26	30	30	30	30	30	30	18	5

Experiment II - 1987

Objective

This experiment was conducted to more precisely determine the amount of Garlon 4 required to control green ash and black birch. Experiment I was applied using commercial equipment and it was difficult to determine the amount of solution that was delivered to each stem. By measuring the exact amount of solution per inch circumference that is delivered to the stem, the amount of herbicide required to control these two species can be more accurately described.

Materials and Methods

A solution of 20% Garlon 4 and 80% Basal Oil was applied at the rate of 0.5, 1.0, or 2.0 ml per inch circumference to approximately 15 stems of green ash (Fraxinus pennsylvanica, Marsh.), and black birch (Betula lenta L.). The diameter of each stem was measured, caliper was determined, and the appropriate dose was calculated. The solution was applied evenly around the stem at a height of 12-16" using a hypodermic needle and syringe on March 5, 1987. Each stem was rated for control on August 19,1987 approximately five months after treatment, and on June 17, 1988 approximately 15 months after treatment. The rating scale was from 0-5, with a (0) being no treatment effect and (5) indicating the stem was dead.

Results and Discussion

The number of stems within each rating category for both rating dates are listed below in Table 8. Green ash at the 0.5 ml rate was injured on August 19, 1987, but only 3 stems died. By June 17, 1988 the degree of injury increased for those stems that were still alive, yet the number of dead stems was still the same. The number of dead stems for black birch however, increased from one in 1987 to eight in 1988.

On August 19, 1987, the 1.0 ml rate provided similar control of both species. Half of the stems treated were dead for both ash and birch. By June 17, 1988, the number of dead stems had increased to 11 for both species, yet not all stems were totally controlled.

Ash was susceptible to rapid kill at the 2.0 ml rate. All but one treated stem was dead on August 19, 1987. On the same date, only 7 birch stems were dead. By June 17, 1988 however, all stems were dead for both species.

Black birch has proven to be one of the more difficult species to control with basal bark applications of herbicides. However, when 2 ml of Garlon at 20% in Basal Oil was uniformly applied around the stems, it killed all treated birch. At 1.0 ml/inch, control was good, but some stems survived, while the control provided by 0.5 ml/inch was unacceptable.

Table 7 - Number of stems of green ash and black birch in each rating category (0-5) with a (0) indicating no treatment effect and a (5) indicating the stem was dead. Plants were treated with measured amounts of a solution containing 20% Garlon 4 and 80% Basal Oil on March 5, 1987, and rated on August 19, 1987 and June 17, 1988.

CONTROL RATING 3/	0.5 ml Solution / Inch Circumference		1.0 ml Solution / Inch Circumference		2.0 ml Solution / Inch Circumference	
	RATING DATES		RATING DATES		RATING DATES	
	AUG. 19,'87	JUNE 17,'88	AUG. 19,'87	JUNE 17,'88	AUG. 19,'87	JUNE 17,'88
	NUMBER OF STEMS		NUMBER OF STEMS		NUMBER OF STEMS	
GREEN ASH						
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	6	3	0	0	0	0
3	6	5	4	1	0	0
4	1	5	3	3	1	0
5	3	3	8	11	14	15
BLACK BIRCH						
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	6	0	0	0	1	0
4	7	6	7	3	7	0
5	1	8	7	11	7	15

Conclusion

In experiment one, the same solution (Garlon 20% + Basal Oil 80%) was applied to ash and birch. The application was performed with a commercial wand and 12-16" of the stems were treated with the solution. The degree of control on birch was not as effective as the control achieved with the 2.0 ml rate used in this experiment. Performance on ash however, was very similar between the two experiments. The differences in reaction to the treatments may be due to the bark characteristics of the two species. Green ash has a dry corky bark compared to the bark of black birch which has a shiny, waxy bark. The ash bark rapidly may rapidly absorb the solution while the birch bark initially repels the solution. A recommendation of treating the lower 12-16" for birch may not provide an adequate amount of herbicide to control the plant. To obtain control on birch, the application may require a wider treatment band.

Experiment III - 1988

Objective

To determine the efficacy of two rates of Garlon, two rates of Access, one rate of Chopper, and two diluents on controlling black locust, boxelder maple, and tree of heaven.

Materials and Methods

Garlon 4 was applied at 5% and 20%, Access at 5% and 20%, and Chopper at 6.25%, v/v, to black locust (Robinia pseudo-acacia), boxelder maple (Acer negundo), and tree of heaven (Ailanthus altissima). Garlon at 5% and 20% were diluted in diesel fuel or N.G. Gilbert Mineral Oil to compare the efficacy of the two diluents. The other treatments were diluted only in diesel fuel. The application to black locust and boxelder was performed on 4/5/88 and application to tree of heaven was performed on 3/17/88. On 4/5/88 the air and soil temperature at 5" were 75º F and 52º F respectively. The air and soil temperature on 3/17/88 was 61º F and 54º F, respectively. Approximately 20 stems of black locust received the Garlon (5% & 20%) treatments in diesel. Approximately 10 stems of black locust were used for all other treatments. Approximately 35 stems of boxelder and tree of heaven were utilized for each treatment. Treatments were applied to the bottom 6" to 12" of the stem using a B&G Extenda-Ban Valve and a Spraying Systems #5500 Cone Jet Nozzle with a Y-2 tip adjusted to produce a fine mist. Boxelder and tree of heaven stems were rated for control on August 4, 1988 and the black locust were rated on September 9, 1988. The rating was on a scale of (0-5) with (0) indicating no treatment effects and (5) indicating the stem was dead.

Results and Discussion

Due to the nature of basal bark studies, results at this time are considered preliminary and control comments will be discussed as general trends. The evaluation of this experiment will continue into the 1989 season. The number of stems within each rating category on September 9, 1988 are listed in Table 9.

Black locust was well controlled by either rate of Garlon or Access. The few surviving plants in each treatment may die in 1989. Chopper provided poor control of locust. All stems of boxelder were completely controlled by all treatments of Garlon or Access. The use of diesel fuel or Mineral Oil for these two species did not seem to be a factor. However, Mineral Oil seemed to provide better control for both rates of Garlon on tree of heaven when compared to diesel fuel. Control of tree of heaven using Access seemed to be better at the higher rate. Chopper was the weakest treatment for all three species. It had the most activity on boxelder, followed by tree of heaven, and had the lowest degree of activity on black locust.

Table 9: - Number of stems of black locust, boxelder maple, and tree of heaven in each rating category (0-5) with a (0) indicating no treatment effect and a (5) indicating a dead stem. Stems of boxelder and black locust were treated on April 4, 1988 and tree of heaven was treated on 3/17/88. Black locust was rated on Sept. 9, 1988, boxelder and tree of heaven were rated on August 4, 1988. Approximately 20 stems of black locust received the Garlon (5% & 20%) treatments in diesel. Approximately 10 stems of black locust were used for all other treatments. Approximately 35 stems of boxelder and tree of heaven were utilized for each treatment.

Control Rating	Garlon 5% Diesel Fuel	Garlon 5% Mineral Oil	Garlon 20% Diesel Fuel	Garlon 20% Mineral Oil	Access 5% Diesel Fuel	Access 20% Diesel Oil	Chopper 6.25% Diesel Fuel
	Number of Stems						
Black Locust							
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	7
2	0	0	0	0	0	0	2
3	1	1	1	2	2	0	0
4	0	1	0	0	0	0	0
5	16	8	19	8	8	10	1
Boxelder Maple							
0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	3
2	0	0	0	0	0	0	5
3	0	0	0	0	0	0	6
4	0	0	0	0	0	0	13
5	39	34	31	33	36	30	11
Tree of Heaven							
0	0	0	0	0	0	0	6
1	1	0	0	0	0	0	8
2	6	0	0	0	0	0	5
3	3	0	3	0	1	0	7
4	4	1	5	0	14	4	12
5	10	34	34	40	17	28	4

TOTAL VEGETATION CONTROL STUDY

Objective

To determine the spectrum and length of control provided by several treatments for the control of vegetation underneath guide rails and around signposts.

Materials and Methods

Two experimental sites were selected because they represented two distinct ecosystems. The first was a length of guide rail on an unused portion of US Route 220 South, past the Grazierville exit in Blair County. The second site was a fenceline at the Pennsylvania State University Horticulture Research Farm in Rock Springs, Centre County. The treatments were applied April 21 at Rock Springs, and April 22 at Grazierville, with a CO_2 powered test plot sprayer. A single 8004E nozzle was used to deliver the equivalent of 31.5 gallons of water per acre. Treatments were arranged in a randomized complete block design with three replications and a plot size of 3 by 25 feet. The products used are listed in Table 1 and the treatment combinations are listed in Table 2.

Table 1: Trade name, common name, formulation, manufacturer, and potential for surface or leaching loss for products evaluated.

Trade Name	Common Name	Formulation	Manufacturer	Runoff[1] Potential	Leaching[1] Potential
Arsenal	imazapyr	2 lb/gallon	American Cyanimid	small	large
Diquat	diquat	2 lb/gallon	Valent	large	small
Karmex	diuron	80% DF	DuPont	large	medium
Krovar I	bromacil + diuron	80% DF	DuPont	large	large
Oust	sulfometuron	75% DF	DuPont	medium	large
Princep	simazine	80% WP	Ciba-Geigy	medium	large
Roundup	glyphosate	4 lb/gallon	Monsanto	large	small
Surflan	oryzalin	4 lb/gallon	Elanco	large	small
Stomp	pendimethalin	4 lb/gallon	American Cyanimid	large	small
Velpar	hexazinone	2 lb/gallon	DuPont	small	large

1/ From the Soil Conservation Service Pesticide Database

The Grazierville study was inadvertantly oversprayed before any data could be collected, so the results will deal solely with the Rock Springs site. It should be pointed out that the Rock Springs site is not representative of a roadside guide rail area. The soil is mapped as a Hagerstown silt loam, a deep, well drained, inherently fertile soil series formed from limestone parent material. Organic matter content is typically in the 1.5 to 3 percent range. Such a soil may have much more capacity to bind herbicides than a soil under a guide rail, which could affect activity and movement have an effect on the action of the herbicide. Additionally, the Rock Springs site would not experience the same surface flow during a rain event when compared to a guide rail site. The Rock

Springs site was level, and though it was adjacent to PA Route 45, there was about 15 feet of turf between the road's edge and the study site.

Table 2: Application rates and cost/acre of the bare ground treatments.

Chemical	product/acre	active ingredient/acre	cost/acre ($)
Arsenal	2 qt	1	65.85
Arsenal	4 qt	2	131.69
Arsenal + Surflan	2 qt + 2 qt	1 + 2	89.44
Arsenal + Stomp	2 qt + 3 qt	1 + 3	82.88
Arsenal + Surflan + Diquat	2 qt + 2 qt + 1 pt	1 + 2 + 0.25	96.22
Oust	6 oz	0.28	41.69
Oust	12 oz	0.56	83.38
Oust + Surflan	6 oz + 2 qt	0.28 + 2	65.28
Oust + Stomp	6 oz + 3 qt	0.28 + 3	58.72
Oust + Surflan + Diquat	6 oz + 2 qt + 1 pt	0.28 + 2 +0.25	72.06
Princep + Surflan + Diquat	4 qt + 3 qt + 1 pt	4 + 3 + 0.25	52.66
Princep + Surflan + Roundup	4 qt + 3 qt + 3 pt	4 + 3 + 1.5	90.28
Karmex	10 lb	8	28.10
Karmex	20 lb	16	56.20
Krovar	10 lb	8	63.40
Krovar	20 lb	16	126.80
Velpar	3 gal	6	122.31
Velpar	6 gal	12	244.62
Untreated Check	- - -	- - -	- - -

Results and Discussion

Data collected for this experiment consisted of visual ratings of percent vegetative cover taken on four dates - June 17 (8 weeks after treatment [WAT]), July 12 (12 WAT), August 3 (15 WAT), and September 21 (22 WAT). The weed species present within each plot were also recorded. The most prevalent species are listed in Table 3. The results for each rating date are reported in Table 4.

The study area was essentially bare at the time of treatment because a hedgerow had been removed the previous summer to make way for the fence. In the first, second, and third week after treatment, the site received 0.16, 0.36, and 1.38 inches of rainfall, respectively. The untreated check was rated at 42 percent cover 8 WAT, 77 percent 12 WAT, 98 percent 15 WAT, and 100 percent 22 WAT.

Table 3: Common and scientific names of the most commonly occurring weed species at the Rock Springs total vegetation control study site.

Common Name	Scientific Name
tumble pigweed	Amaranthus albus
witchgrass	Panicum capillare
smooth crabgrass	Digitaria ischaemum
crownvetch	Coronilla varia
dandelion	Taraxacum officinale
redroot pigweed	Amaranthus retroflexus
yellow foxtail	Setaria lutescens

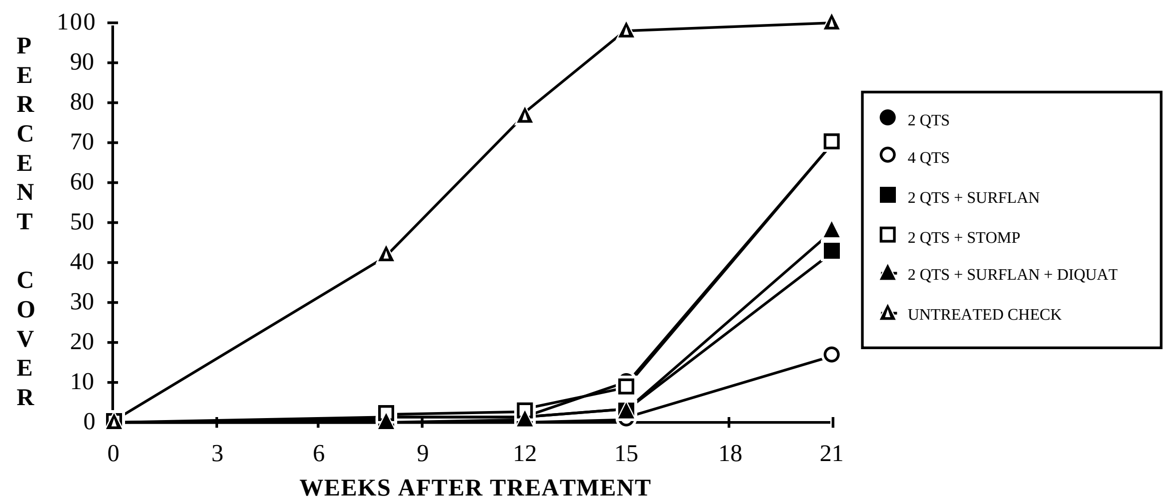
Table 4: Percent weed cover on four rating dates. Each value is the mean of three replications.

		Percent Weed Cover			
Treatment	Product Application Rate	6/17/88 (8 WAT)	7/12/88 (12 WAT)	8/3/88 (15 WAT)	9/21/88 (22 WAT)
Arsenal	2 qt	1 b[1]	1 c	10 cd	70 abc
Arsenal	4 qt	0 b	0 c	1 d	17 e-h
Arsenal + Surflan	2 qt + 2 qt	1 b	1 c	3 d	43 c-f
Arsenal + Stomp	2 qt + 3 qt	2 b	3 c	9 cd	70 abc
Arsenal + Surflan + Diquat	2 qt + 2 qt + 1 pt	0 b	1 c	3 d	48 cde
Oust	6 oz	0 b	1 c	1 d	6 gh
Oust	12 oz	0 b	0 c	0 d	1 h
Oust + Surflan	6 oz + 2 qt	0 b	0 c	1 d	4 gh
Oust + Stomp	6 oz + 3 qt	0 b	0 c	1 d	9 fgh
Oust + Surflan + Diquat	6 oz + 2 qt + 1 pt	0 b	0 c	1 d	3 h
Princep + Surflan + Diquat	4 qt + 3 qt + 1 pt	4 b	24 bc	52 b	90 ab
Princep + Surflan + Roundup	4 qt + 3 qt + 3 pt	3 b	18 bc	37 bc	72 abc
Karmex	10 lb	9 b	32 b	53 b	73 abc
Karmex	20 lb	2 b	9 c	17 cd	40 c-g
Krovar	10 lb	2 b	4 c	12 cd	9 fgh
Krovar	20 lb	1 b	1 c	2 d	1 h
Velpar	3 gal	7 b	13 bc	27 bcd	55 bcd
Velpar	6 gal	1 b	3 c	13 cd	22 d-h
Untreated Check	- - -	42 a	77 a	98 a	100 a

1/ Column means followed by the same letter are not significantly at the 5% level according to Duncan's Multiple Range Test.

Through 15 WAT, all treatments including Arsenal provided excellent control. They were all rated at 10 percent or less weed cover, with no significant difference between any of the different rates or combinations. Between 15 and 22 WAT, the activity of Arsenal seemed to degrade significantly, as shown in Figure 1. When rated at 22 WAT, Arsenal at 2 quarts alone, or with 3 quarts of Stomp had 70 percent weed cover. This was not significantly greater than the Arsenal treatments which included 2 quarts of Surflan (43 and 48 percent). Arsenal at 4 quarts was rated at 17 percent cover. This was significantly better than Arsenal at 2 quarts alone or with Stomp, but not significantly different than the combinations with Surflan. Weeds present in Arsenal treated plots 22 WAT included annual grasses and broadleaves, and perennials such as Canada thistle and crownvetch.

Figure 1: Percent cover for Arsenal treatments on four rating dates compared to the untreated check.



Treatments including Oust provided excellent control throughout the season. At 22 WAT, all Oust treatments were rated at less than 10 percent weed cover. Most of the weeds present in Oust treated plots were seedlings, the most common being crownvetch and smooth crabgrass. Under the conditions of this study, using the high rate of 12 ounces or adding Surflan or Stomp to the 6 ounce rate did not provide any benefit over using 6 ounces of Oust alone (Figure 2). Future studies must include lower rates, as the rates used did not provide an estimate of the minimum amount of product needed to provide season long control. In view of the surface loss and leaching potentials for Oust (Table 1), 6 ounces may be excessive on a guide rail area due to the high amounts of surface flow and coarse texture of the surface soil.

The combination of Princep plus Surflan is commonly used in nursery situations, but proved to be ineffective under the conditions of this study (Figure 3). This combination was applied with Diquat or Roundup to provide burn-down of existing vegetation. However, since the site was essentially bare when treated, it is doubtful that the burn-down materials contributed to the effectiveness of the treatments. These treatments were rated at 90 and 72 percent cover 22 WAT, respectively. Weeds present included annual grasses and broadleaves, and crownvetch and Canada thistle. A mid-May application of Princep, Surflan, and Roundup provided excellent control on a portion of the fenceline outside the study area, indicating that this treatment may be effective if applied after the weeds are well established.

Figure 2: Percent cover for Oust treatments on four rating dates compared to the untreated check.

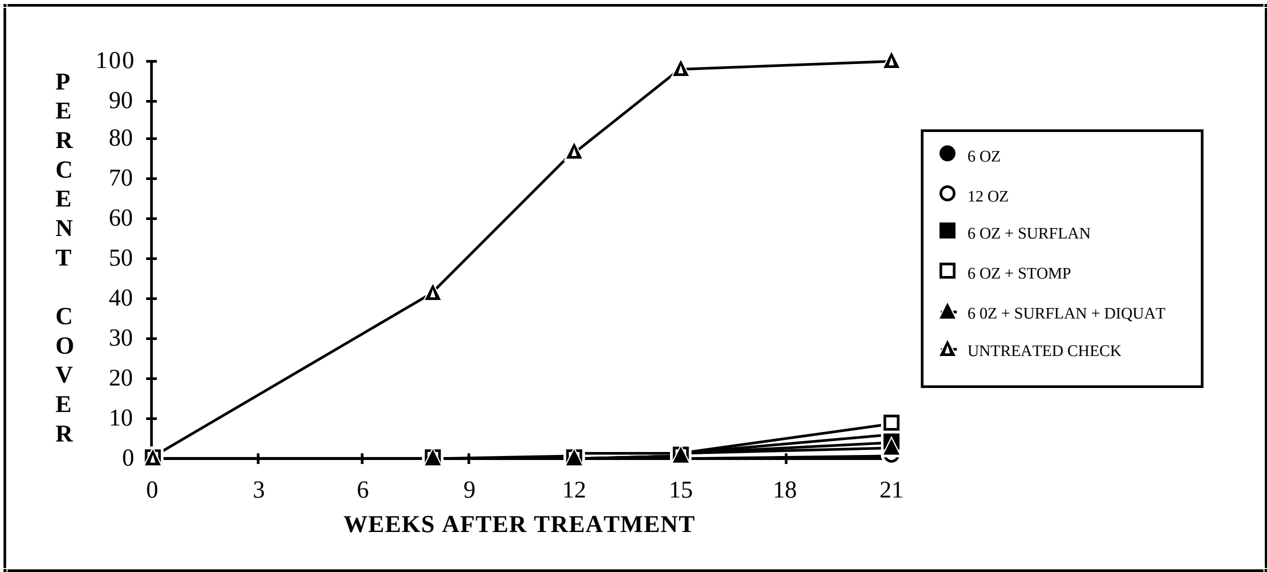
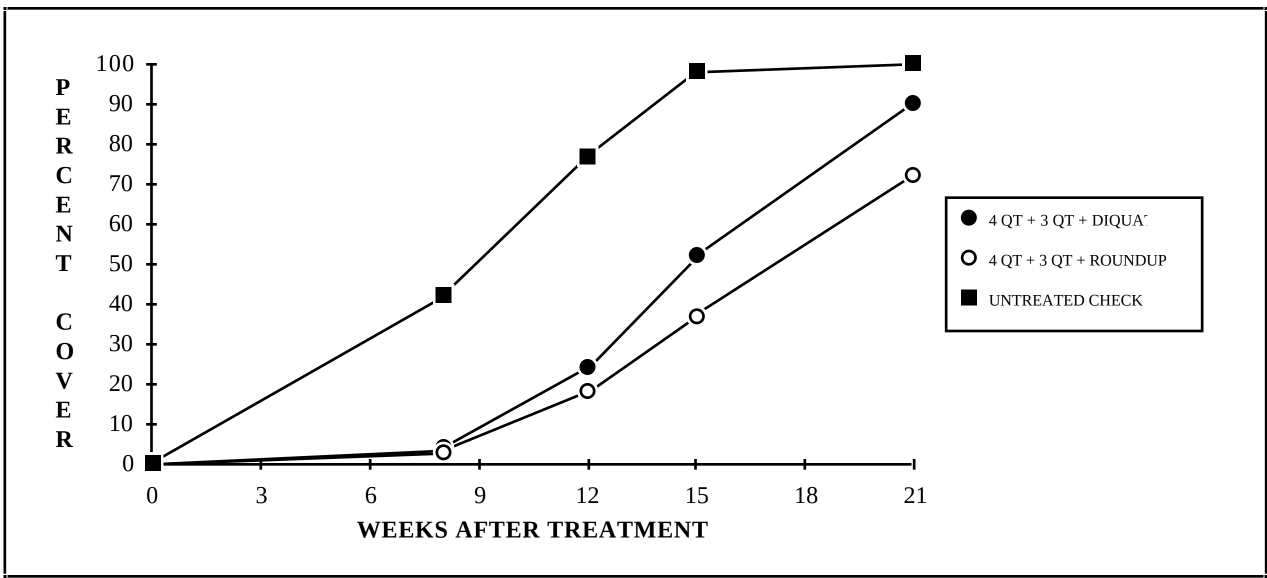
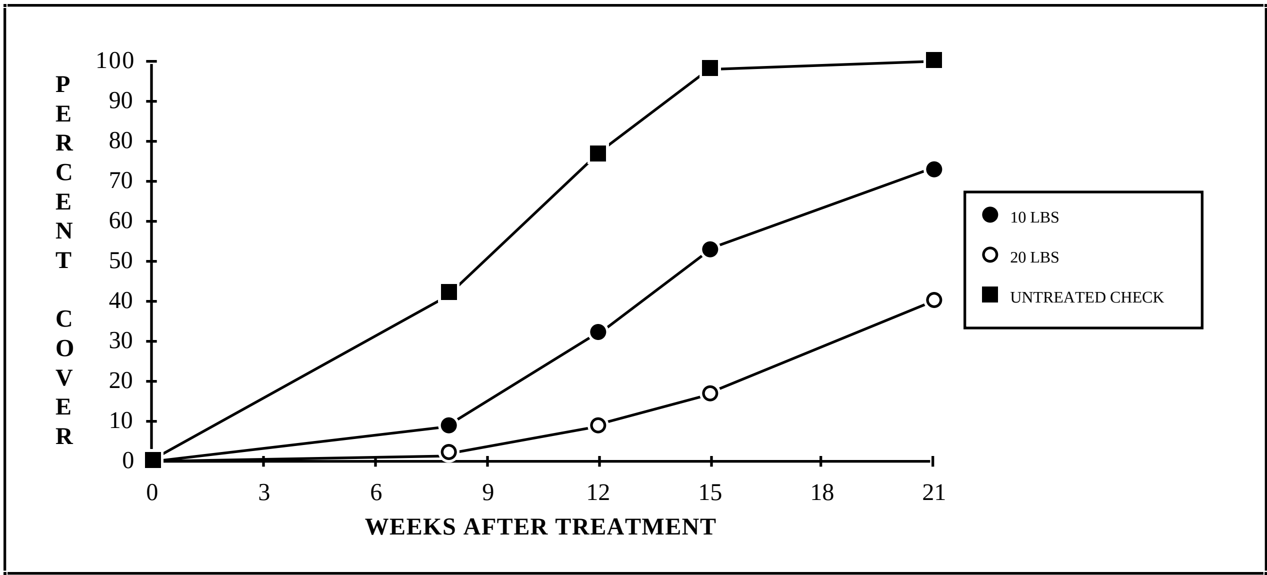


Figure 3: Percent cover for Princep plus Surflan treatments on four rating dates compared to the untreated check.



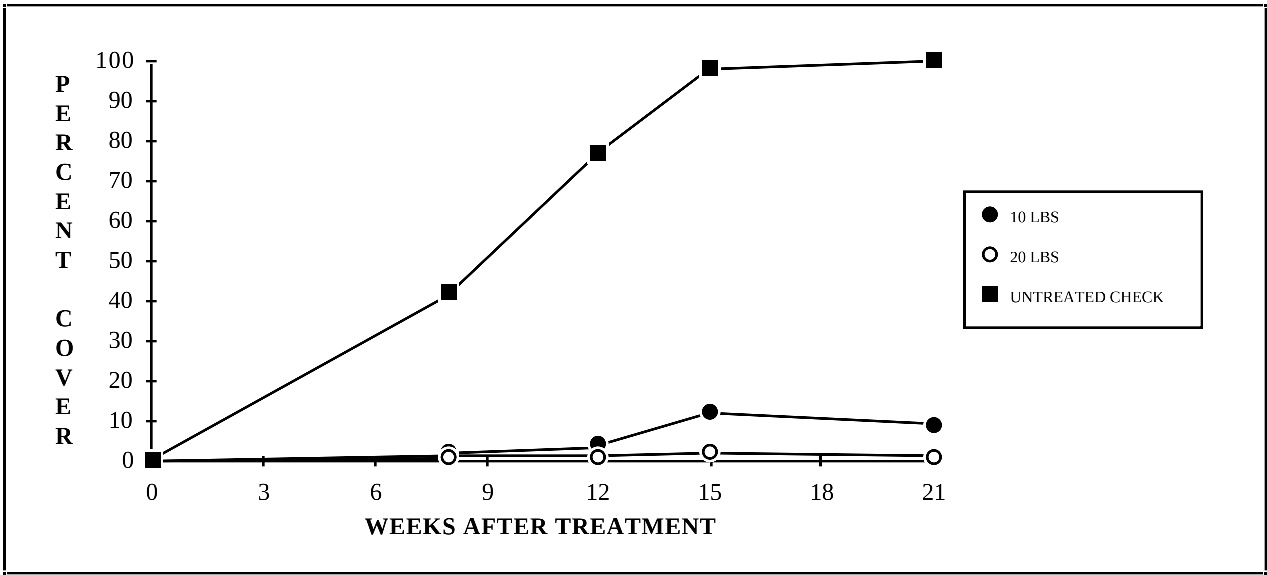
Applying Karmex alone at rates of 10 or 20 pounds per acre did not provide season-long weed control (Figure 4). The 10 pound application was rated at 73 percent cover 22 WAT, which was not significantly different than the untreated check. The 20 pound application was rated at 40 percent cover 22 WAT, and was significantly different than the untreated check, but not significantly different than the 10 pound rate. Crownvetch and tumble pigweed were the most common weeds in Karmex treated plots.

Figure 4: Percent cover for Karmex treatments on four rating dates compared to the untreated check.



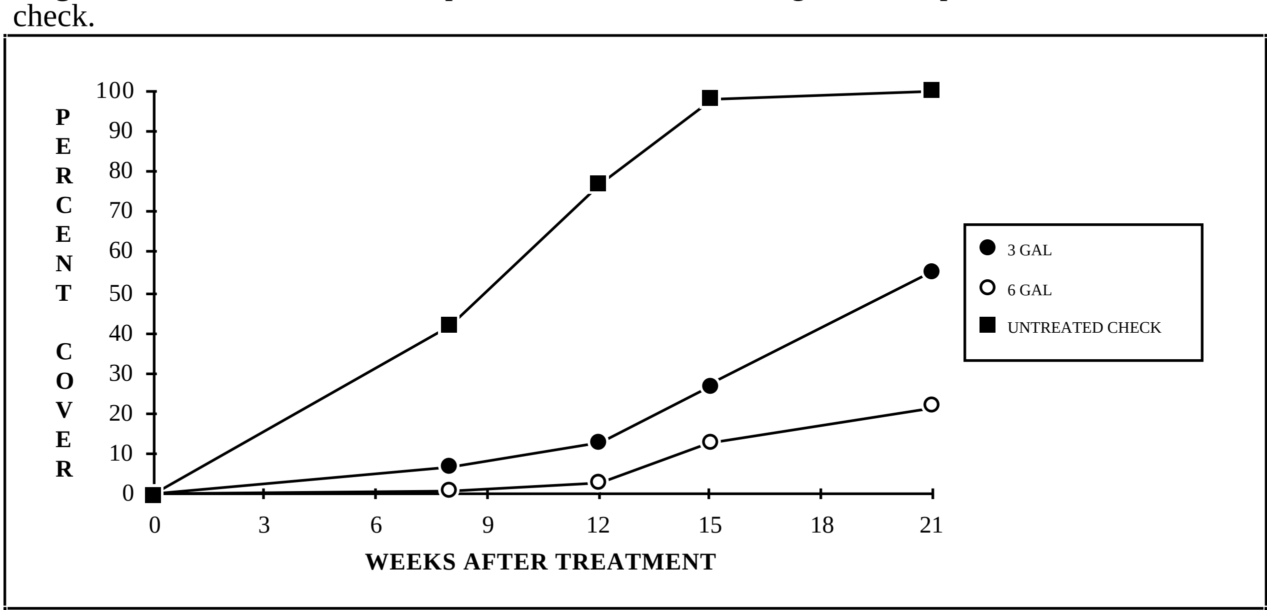
Krovar applied alone at 10 and 20 pounds per acre provided excellent control for the entire growing season (Figure 5), with only small amounts of crownvetch found in the treated plots.. The 20 pound rate did not provide significantly better performance than the 10 lb rate. Lower rates of Krovar need to be examined to determine the minimum rate needed for season long control. Krovar has a high potential for surface runoff and leaching (Table 1), and any over-application on a site with the surface flow and leaching potential of a guide rail area may result in off-site movement. Based on the performance of Karmex in this trial, it seems that most of the activity of the Krovar treatments is due to the bromacil component. In the future, Krovar should be compared with Hyvar X (bromacil, 80% DF) at equal rates of bromacil to determine the contribution of diuron to the effectiveness of the Krovar treatment.

Figure 5: Percent cover for Krovar treatments on four rating dates compared to the untreated check.



When applied alone, Velpar does not appear to have the residual activity necessary to economically provide season-long weed control (Figure 6). Velpar at 6 gallons per acre was rated at 22 percent cover 22 WAT, which was not significantly different from the best rated treatments, Oust and Krovar. Velpar applied at 3 gallons per acre was rated at 55 percent cover 22 WAT. This was not significantly different than the 6 gallon rate, but was significantly greater than the Oust and Krovar treatments. Using Velpar alone as a bare ground treatment is cost prohibitive, and possibly ineffective in areas where crownvetch is growing under the guide rail as crownvetch invaded plots where Velpar was applied at either rate.

Figure 6: Percent cover for Velpar treatments for four rating dates compared to the untreated check.



Conclusion

Due to the finer soil texture and the less intense surface flow of water across the site, Rock Springs represents a potentially more stable site than a typical guide rail area. Off-site movement of herbicides due to surface flow or leaching may have been lower on this site than a typical roadside, and conclusions reached from the Rock Springs data must take this into account. The most obvious information available is the relative residual activity of the herbicides used. Based on the rates used and time applied, Oust and Krovar provided residual activity for at least one growing season. Arsenal, Velpar, Karmex, and Princep plus Surflan did not provide full season control under the soil and environmental conditions of this study.

Future research must include work on actual roadside sites so that treatments can be evaluated for their stability when subjected to extreme surface flow of water and rapid movement of water through the soil profile due to coarse soil texture. Emphasis on individual herbicides should continue so that the range of safely applied rates and their relative effectiveness can be determined for each product. With this information, the roadside specialist can make decisions about combinations that best suit the particular conditions of each district.

WILDFLOWER EVALUATION STUDY

Objective

To identify wildflower species that provide aesthetic benefits to the roadside while being easy to establish and able to survive under a variety of environmental conditions.

Materials and Methods

As part of the 1988 Crystal Rose Fricker Memorial Barbeque and Wildflower Test, 50 species of wildflowers were evaluated for their growth characteristics, flowering ability, and competitiveness with weeds. The 50 species consisted of 24 annuals and 26 perennials. The species listing is in Table 1, with annual species numbered 1 to 24 and perennials numbered 25 to 50. The species were seeded April 20, 1988 at the Landscape Management Research Center of the Pennsylvania State University. The area used was in alfalfa in 1987, and was treated with Roundup plus 2,4-D on April 11, 1988. On the day of seeding the site was mowed and the soil surface was scarified with the PTO vertical cut unit of an Olathe seeder. The vertical cut unit produces grooves about one half inch deep and three inches apart. Each species was hand seeded into three 5 by 5 foot plots, arranged in a randomized complete block design. The seed was suspended in 100 grams of Milorganite in one quart canning jars with perforated lids, and shaken on to each plot. A 30 inch high wind screen was placed around each plot as it was seeded. Approximate rainfall on the site for each month following seeding is summarized below:

Month	Rainfall (inches)
April 20-30	0.48
May	5.03
June	1.13
July	6.18
August	6.41
September	3.47
October	1.69

After seeding, there were no further inputs to the plots. Ratings were taken on June 13, June 27, July 12, August 9, and September 28. The plots were visually rated for percent cover of the wildflower species, percent weed cover, and percent of plants in bloom.

Results and Discussion

Neatly categorizing the growth characteristics of 50 species of plants is not practical, and the space required to do so does not exist in this report. The data collected is presented numerically with statistical analysis in Tables 2 through 4, and graphically in Figures 1 through 6. The results will be summarized separately for annuals and perennials.

Percent cover of annual wildflower species is summarized in Table 2 and Figure 1. The species were assigned to parts a through d in Figure 1 by summing the coverage results of the five rating dates for each species, and then ranking the species based on this summed coverage result. The 24 annual species were divided into four groups of six each. The six species with the highest sum of coverage values is presented in Figure 1a, the species with the next six highest coverage sums are presented in Figure 1b, and so on. Examination of Figure 1 shows several seasonal growth trends. Most of the species in Figure 1a established quickly, and remained established throughout the season. Some species established less quickly, but increased their coverage as the season progressed, such as Cosmos (Fig. 1a) and Lemon Mint (Fig. 1d). A third type of growth pattern was an early season peak in coverage followed by decline. Examples of this type of growth are Clarkia and Corn Poppy (Fig. 1c), and Tidy Tips (Fig. 1d). The drought may have affected species such as Catchfly (Fig. 1b) and Pimpernel (Fig. 1c), which declined after the June 13 rating, but increased in coverage thereafter.

The perennial species tended to establish more slowly than the annuals (Table 2, Figure 2). The same type of growth patterns are evident, but peak coverage values were usually lower and later in the season. This is best shown by comparing Figures 1c with 2c, and 1d with 2d.

The flowering response of the annual species (Table 3, Figure 3) shows tremendous diversity. Species differed in the time, magnitude, and number of peak bloom periods. Clarkia (Fig. 3c) and Farewell-to-Spring (Fig. 3b) bloomed intensely for a short time. Tall Plains Coreopsis, Indian Blanket (Fig. 3a),Globe Gila,and Catchfly (Fig. 3b) bloomed for most of the season without exhibiting any sharp peaks in flowering. Cosmos (Fig. 3a) and Lemon Mint (Fig. 3b) showed a steady increase in flower show as the season progessed. Baby's Breath and Sweet Alyssum (Fig. 3a) flowered early in the season, declined in bloom during the drought, and then steadily increased in flower show for the remainder of the season.

The perennial species were much less diverse than the annual species in flowering response (Table 3, Figure 4). Twelve of the perennial species did not bloom at all. The only perennial to show a distinct peak in flowering activity was Blanketflower (4a). Most of the blooming perennials gave a flower show that was steady, or gradually increased. The level of flowering was generally much less than that of the annual species. The 1989 season should be more indicative of the flowering potential of the perennial species, as many perennial species will not flower the year of establishment.

Table 1: Common name, scientific name, and seeding rate in pounds per acre for the wildflower species evaluated in 1988.

No.	Common Name	Scientific Name	Seeding Rate (lb/a)
1.	African Daisy	Dimorphotheca aurantiaca	41
2.	Garland Chrysanthemum	Chrysanthemum coronarium	76
3.	Baby's Breath	Gypsophila elegans	20
4.	Blue Bells	Mertensia virginica	19
5.	Catchfly	Silene armeria	20
6.	Corn Poppy	Papaver rhoeas	20
7.	Dwarf Cornflower	Centaurea cyanus dwf.	20
8.	Tidy Tips	Layia platyglosa	20
9.	Globe Gilia	Gilia capitata	19
10.	Clarkia	Clarkia unguiculata	20
11.	Mountain Phlox	Linanthus grandiflorus	24
12.	Pimpernel	Anagallis arvensis	24
13.	Rocket Larkspur	Delphinium ajacis	20
14.	Scarlet Flax	Linum grandiflorum rubrum	50
15.	Spurred Snapdragon	Linaria maroccana	20
16.	Sweet Alyssum	Lobularia maritima	32
17.	Tall Plains Coreopsis	Coreopsis tinctoria	20
18.	Lemon Mint	Monarda citriodora	31
19.	Cosmos	Cosmos bipinnatus	19
20.	Scabiosa	Scabiosa stellata	40
21.	California Poppy	Eschscholzia californica	20
22.	Indian Blanket	Gaillardia pulchella	22
23.	Baby Blue Eyes	Nemophila menziesii	22
24.	Farewell to Spring	Clarkia amoena	21
25.	Black-Eyed Susan	Rudbeckia hirta	19
26.	Blue Flax	Linum perenne lewisii	20
27.	Dwarf Columbine	Aquilegia vulgaris	25
28.	English Wallflower	Cheiranthus cheiri	22
29.	Johnny Jump Up	Viola cornuta	21
30.	Dwarf-Lance-Leaved Coreopsis	Coreopsis lanceolata dwf.	23
31.	Maiden Pinks	Dianthus deltoides	19
32.	Missouri Primrose	Oenothera missouriensis	20
33.	Wild Thyme	Thymus serpyllum	19
34.	Prairie Coneflower	Ratibida columnifera	42
35.	Purple Coneflower	Echinacea purpurea	51
36.	Siberian Wallflower	Cheiranthus allionii	19
37.	Sweet William	Dianthus barbatus	19
38.	Rocky Mountain Penstemon	Penstemon strictus	20
39.	Soapwort	Saponaria ocymoides	19
40.	Snow in Summer	Cerastium biebersteinii	20
41.	Blanketflower	Gaillardia aristata	21
42.	White Yarrow	Achillea millefolium	20
43.	Dames Rocket	Hesperis matronalis	20
44.	Forget-me-not	Myosotis sylvatica	23
45.	Creeping Zinnia	Sanvitalia procumbens	21
46.	Evening Primrose	Oenothera Lanarkiana	19
47.	Small Burnet	Sanguisorba minor	20
48.	Red Yarrow	Achillea millefolium rubra	23
49.	Standing Cypress	Ipomopsis rubra	20
50.	Chamomile	Anthemis tinctoria	39

Table 2: Wildflower species coverage for five rating dates. Each value is the mean of three replications.

	Wildflower Species	Percent Wildflower Cover June 13		June 27		July 12		Aug 9		Sept 28	
1.	African Daisy	63	b-h	67	b-g	63	a-i	68	a-g	57	e-h
2.	Garland Chrysanthemum	98	a	90	ab	88	a	93	ab	100	a
3.	Baby's Breath	88	ab	92	ab	87	a	77	a-e	50	f-i
4.	Blue Bells	47	g-l	47	e-k	35	i-r	7	mn	0	l
5.	Catchfly	72	a-g	53	e-j	45	f-o	77	a-e	70	b-f
6.	Corn Poppy	97	a	82	a-d	77	a-f	15	lmn	0	l
7.	Dwarf Cornflower	82	a-d	70	a-f	77	a-f	67	b-g	40	g-j
8.	Tidy Tips	77	a-f	63	b-g	52	b-l	15	lmn	0	l
9.	Globe Gilia	88	ab	80	a-d	72	a-g	78	a-d	77	a-f
10.	Clarkia	98	a	97	a	75	a-f	22	k-n	0	l
11.	Mountain Phlox	55	d-j	58	c-h	75	a-f	38	h-l	25	i-l
12.	Pimpernel	58	c-i	33	h-n	37	i-r	53	d-i	57	e-h
13.	Rocket Larkspur	27	l-p	25	j-n	35	i-r	67	b-g	20	jkl
14.	Scarlet Flax	45	g-m	32	h-n	50	c-m	85	ab	98	ab
15.	Spurred Snapdragon	78	a-e	78	a-d	83	ab	43	g-k	0	l
16.	Sweet Alyssum	88	ab	72	a-f	78	a-e	87	ab	92	a-d
17.	Tall Plains Coreopsis	83	abc	72	a-f	78	a-e	95	a	100	a
18.	Lemon Mint	6	p	25	j-n	43	g-p	57	c-h	68	c-f
19.	Cosmos	50	f-k	53	e-j	53	b-k	92	ab	93	a-d
20.	Scabiosa	17	nop	33	h-n	33	i-r	45	f-j	12	kl
21.	California Poppy	80	a-e	75	a-e	80	a-d	78	a-d	88	a-d
22.	Indian Blanket	38	h-n	53	e-j	78	a-e	90	ab	93	a-d
23.	Baby Blue Eyes	28	k-p	25	j-n	12	pqr	0	n	0	l
24.	Farewell to Spring	83	abc	92	ab	92	a	50	e-j	18	jkl
25.	Black-Eyed Susan	18	m-p	23	k-n	32	i-r	80	a-d	93	a-d
26.	Blue Flax	15	nop	25	j-n	32	i-r	82	abc	92	a-d
27.	Dwarf Columbine	4	p	4	n	5	r	3	n	2	l
28.	English Wallflower	70	a-g	60	c-h	62	a-j	78	a-d	92	a-d
29.	Johnny Jump Up	13	nop	12	lmn	7	qr	23	j-n	0	l
30.	Dwarf Lance Leaved Coreopsis	20	m-p	22	k-n	35	i-r	45	f-j	68	c-f
31.	Maiden Pinks	22	m-p	22	k-n	13	o-r	27	i-n	7	l
32.	Missouri Primrose	7	p	12	lmn	20	l-r	23	j-n	7	l
33.	Wild Thyme	12	nop	12	lmn	12	pqr	37	h-l	3	l
34.	Prairie Coneflower	20	m-p	40	g-l	50	c-m	72	a-f	37	h-k
35.	Purple Coneflower	10	op	20	k-n	15	n-r	33	h-m	20	jkl
36.	Siberian Wallflower	30	j-p	28	i-n	38	h-q	78	a-d	80	a-e
37.	Sweet William	53	e-k	55	d-i	47	e-n	53	d-i	37	h-k
38.	Rocky Mt. Penstemon	4	p	10	mn	23	k-r	25	j-n	7	l
39.	Soapwort	7	p	13	lmn	18	m-r	33	h-m	15	jkl
40.	Snow in Summer	32	i-p	33	h-n	37	i-r	25	j-n	10	kl
41.	Blanketflower	87	ab	80	a-d	82	abc	70	a-g	57	e-h
42.	White Yarrow	75	a-f	85	abc	87	a	87	ab	90	a-d
43.	Dames Rocket	75	a-f	65	b-g	68	a-h	88	ab	93	a-d
44.	Forget-me-not	45	g-m	43	f-k	30	j-r	15	lmn	3	l
45.	Creeping Zinnia	5	p	18	k-n	23	k-r	55	c-h	65	d-g
46.	Evening Primrose	65	b-h	38	g-m	48	d-m	73	a-e	73	a-f
47.	Small Burnet	13	nop	22	k-n	18	m-r	35	h-l	68	c-f
48.	Red Yarrow	55	d-j	70	a-f	72	a-g	90	ab	93	a-d
49.	Gilia	35	i-o	47	e-k	50	c-m	55	c-h	72	a-f
50.	Chamomile	82	a-d	80	a-d	80	a-d	92	ab	97	abc

1/ Column means followed by the same letter are not significantly different at the 5% probability level according to Duncan's Multiple Range Test.

Table 3: Percent Bloom results for four rating dates. Each value is the mean of three replications.

	Treatment	Percent Bloom June 13		June 27		Aug 9		Sept 28	
1.	African Daisy	55	bcd[1]	20	gh	10	g-k	12	g-k
2.	Garland Chrysanthemum	23	fgh	53	cd	10	g-k	2	jk
3.	Baby's Breath	87	a	13	h-l	47	a	20	g-j
4.	Blue Bells	32	efg	2	l	0	k	0	k
5.	Catchfly	4	i	37	e	30	c-f	50	de
6.	Corn Poppy	37	ef	3	kl	1	k	0	k
7.	Dwarf Cornflower	40	def	62	bc	20	e-h	12	g-k
8.	Tidy Tips	63	bc	1	l	0	k	0	k
9.	Globe Gilia	0	i	30	ef	50	a	40	ef
10.	Clarkia	93	a	5	jkl	0	k	0	k
11.	Mountain Phlox	32	efg	50	d	13	g-k	7	h-k
12.	Pimpernel	7	hi	7	i-l	0	k	0	k
13.	Rocket Larkspur	0	i	8	h-l	33	bcd	7	h-k
14.	Scarlet Flax	17	ghi	15	h-k	7	h-k	17	g-k
15.	Spurred Snapdragon	40	def	5	jkl	1	k	0	k
16.	Sweet Alyssum	30	fg	3	kl	32	b-e	73	abc
17.	Tall Plains Coreopsis	0	i	50	d	47	a	82	a
18.	Lemon Mint	0	i	10	h-l	40	abc	50	de
19.	Cosmos	1	i	13	h-l	50	a	77	ab
20.	Scabiosa	0	i	0	l	13	g-k	0	k
21.	California Poppy	48	cde	10	h-l	18	f-i	22	ghi
22.	Indian Blanket	5	hi	65	b	47	a	60	cd
23.	Baby Blue Eyes	8	hi	0	l	0	k	0	k
24.	Farewell to Spring	0	i	80	a	13	g-k	7	h-k
25.	Black-Eyed Susan	0	i	7	i-l	40	abc	52	de
26.	Blue Flax	0	i	0	l	5	ijk	8	h-k
27.	Dwarf Columbine	0	i	0	l	0	k	0	k
28.	English Wallflower	0	i	0	l	0	k	0	k
29.	Johnny Jump Up	7	hi	1	l	7	h-k	0	k
30.	Dwarf Lance Leaved Coreopsis	0	i	0	l	0	k	0	k
31.	Maiden Pinks	0	i	0	l	0	k	0	k
32.	Missouri Primrose	0	i	1	l	0	k	0	k
33.	Wild Thyme	0	i	0	l	1	k	3	jik
34.	Prairie Coneflower	0	i	18	ghi	10	g-k	2	jk
35.	Purple Coneflower	0	i	0	l	0	k	0	k
36.	Siberian Wallflower	17	ghi	28	efg	43	ab	63	bcd
37.	Sweet William	0	i	0	l	0	k	0	k
38.	Rocky Mt. Penstemon	0	i	0	l	0	k	0	k
39.	Soapwort	0	i	0	l	0	k	0	k
40.	Snow in Summer	0	i	0	l	0	k	0	k
41.	Blanketflower	70	b	8	h-l	22	d-g	27	fg
42.	White Yarrow	0	i	0	l	3	jk	13	g-k
43.	Dames Rocket	0	i	0	l	0	k	0	k
44.	Forget-me-not	0	i	0	l	0	k	0	k
45.	Creeping Zinnia	7	hi	17	g-j	17	g-j	23	gh
46.	Evening Primrose	0	i	3	kl	13	g-k	13	g-k
47.	Small Burnet	0	i	0	l	0	k	0	k
48.	Red Yarrow	0	i	0	l	4	jk	15	g-k
49.	Gilia	0	i	0	l	0	k	25	fgh
50.	Chamomile	0	i	4	jkl	7	h-k	7	h-k

1/ Column means followed by the same letter are not significantly differerent at the 5% probability level according to Duncan's Multiple Range Test.

Table 4: Percent weed cover results for five rating dates. Each mean is the mean of three replications.

	Wildflower Species	Percent Weed Cover									
		June 13		June 27		July 12		Aug 9		Sept 28	
1.	African Daisy	5	b-f[1]	8	f-j	7	h-k	17	f-k	43	efg
2.	Garland Chrysanthemum	0	f	0	j	0	k	0	k	0	k
3.	Baby's Breath	4	c-f	4	hij	4	ijk	15	f-k	50	ef
4.	Blue Bells	12	a-e	22	b-h	17	d-k	73	ab	100	a
5.	Catchfly	10	a-f	18	c-j	18	d-k	20	f-k	30	f-j
6.	Corn Poppy	4	c-f	2	ij	1	jk	35	d-i	92	abc
7.	Dwarf Cornflower	2	def	4	hij	4	ijk	7	ijk	43	efg
8.	Tidy Tips	4	c-f	10	e-j	7	h-k	38	d-h	100	a
9.	Globe Gilia	7	b-f	10	e-j	7	h-k	8	ijk	23	f-k
10.	Clarkia	1	ef	0	j	2	jk	13	g-k	92	abc
11.	Mountain Phlox	4	c-f	5	hij	5	ijk	30	e-j	67	cde
12.	Pimpernel	6	b-f	18	c-j	13	e-k	40	d-g	70	b-e
13.	Rocket Larkspur	7	b-f	8	f-j	10	g-k	27	f-k	80	a-d
14.	Scarlet Flax	11	a-e	18	c-j	28	a-h	10	h-k	2	jk
15.	Spurred Snapdragon	2	def	3	hij	1	jk	17	f-k	90	a-d
16.	Sweet Alyssum	7	b-f	11	d-j	10	g-k	12	g-k	8	h-k
17.	Tall Plains Coreopsis	7	b-f	9	e-j	5	ijk	3	jk	0	k
18.	Lemon Mint	13	a-d	28	a-e	25	b-i	38	d-h	32	f-i
19.	Cosmos	3	def	4	hij	3	jk	2	jk	0	k
20.	Scabiosa	7	b-f	15	c-j	13	e-k	40	d-g	88	a-d
21.	California Poppy	4	c-f	4	hij	4	ijk	15	f-k	12	h-k
22.	Indian Blanket	12	a-e	27	a-f	8	g-k	10	h-k	7	h-k
23.	Baby Blue Eyes	8	a-f	28	a-e	28	a-h	77	ab	100	a
24.	Farewell to Spring	4	c-f	4	hij	5	ijk	23	f-k	82	a-d
25.	Black-Eyed Susan	4	c-f	12	d-j	17	d-k	17	f-k	7	h-k
26.	Blue Flax	8	a-f	15	c-j	17	d-k	17	f-k	8	h-k
27.	Dwarf Columbine	7	b-f	22	b-h	28	a-h	85	a	98	ab
28.	English Wallflower	5	b-f	7	g-j	12	f-k	17	f-k	8	h-k
29.	Johnny Jump Up	12	a-e	25	a-g	33	a-f	73	ab	100	a
30.	Dwarf Lance Leaved Coreopsis	15	abc	27	a-f	22	c-k	55	b-e	32	f-i
31.	Maiden Pinks	15	abc	25	a-g	30	a-g	63	a-d	93	abc
32.	Missouri Primrose	8	a-f	17	c-j	18	d-k	72	ab	93	abc
33.	Wild Thyme	17	ab	42	a	45	ab	63	a-d	97	ab
34.	Prairie Coneflower	10	a-f	32	abc	23	c-j	27	f-k	63	de
35.	Purple Coneflower	18	a	30	a-d	35	a-e	63	a-d	78	a-d
36.	Siberian Wallflower	4	c-f	12	d-j	10	g-k	22	f-k	20	g-k
37.	Sweet William	8	a-f	27	a-f	47	a	43	c-f	63	de
38.	Rocky Mt. Penstemon	10	a-f	22	b-h	28	a-h	72	ab	93	abc
39.	Soapwort	17	ab	40	ab	37	a-d	63	a-d	85	a-d
40.	Snow in Summer	8	a-f	18	c-j	42	abc	70	abc	90	a-d
41.	Blanketflower	3	def	4	hij	5	ijk	17	f-k	43	efg
42.	White Yarrow	3	def	4	hij	4	ijk	13	g-k	10	h-k
43.	Dames Rocket	5	b-f	7	g-j	5	ijk	12	g-k	7	h-k
44.	Forget-me-not	5	b-f	12	d-j	15	d-k	73	ab	97	ab
45.	Creeping Zinnia	12	a-e	25	a-g	23	c-j	40	d-g	35	fgh
46.	Evening Primrose	4	c-f	8	f-j	13	e-k	23	f-k	27	f-k
47.	Small Burnet	8	a-f	20	c-i	22	c-k	63	a-d	32	f-i
48.	Red Yarrow	5	b-f	7	g-j	7	h-k	10	h-k	7	h-k
49.	Gilia	10	a-f	17	c-j	22	c-k	43	c-f	28	f-k
50.	Chamomile	4	c-f	8	f-j	7	h-k	6	ijk	3	ijk

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The weed species coverage ratings for annuals (Table 4, Figure 5) and perennials (Table 4, Figure 6) are similar, and will be considered together. The most common weeds were pigweeds (Amaranthus spp), fall panicum (Panicum dichotomiflorum), common lambsquarters (Chenopodium album), and velvetleaf (Abutilon theophrasti). The wildflower species displayed a wide range a weed suppression behavior. Figures 5a and 6a show almost complete weed suppression, while Figures 5d and 6d indicate almost no weed suppression. Several of the species in Figure 5c, such as Clarkia, Spurred Snapdragon, and Corn Poppy, established quickly, flowered early in the season, and provided weed suppression. After these species set seed and died, the weeds filled in the plots.

Summary and Conclusions

This is the first of several years data to be collected from this study site. Data collected in 1989 will provide information about the flowering potential of the perennial species as well as the reseeding capabilities.of the annual species. The same species will also be reseeded again to provide a second year of establishment data.

In the roadside environment, wildflowers will be used most often in mixes of several species to provide a diversity of color and plant form, and to extend the blooming period of the stand. Due to the large number of possible mixes that could be developed, most of the research effort devoted to wildflowers by this project will be towards characterizing the individual species that are available. When the characteristics of individual species are known, they can be combined in a complementary manner. With this idea in mind, the roadside specialist should not look to find the 'best' wildflower from this data, but develop a mix that best suits a given situation.

LOW MAINTENANCE VEGETATION STUDY

Objective

To investigate several grass species alone and in combinations for low maintenance roadside cover.

Introduction

Most of Pennsylvania's roadside turf areas have been planted with a grass combination in which the largest percentage of the mix is K-31 tall fescue (Festuca arundinacea Schreb., var. 'Kentucky 31'). This has been the utility grass of choice for many years because of its ability to withstand heat and drought stress and is relatively free of many insect and disease pests. However, it produces coarse upright leaf blades and a seedhead stalk that can reach over three feet in height which can impede sight distance. There may be other species available as an alternative to K-31 tall fescue that would provide good cover, weed suppression, and soil stabilization, yet would not produce as much vertical growth. Several species of cool season and warm season grasses were evaluated for cover and weed suppression.

Material and Methods

Two nurseries were established in the fall of 1987. Each site was located along a roadside in which K-31 tall fescue was the existing vegetation. The sites were treated with Roundup and a Olathe verti-cut unit was used to cut half inch deep slits 3" on center into the killed sod. Each species was then seeded using a Gandy drop spreader. Plots were 12' x 30', replicated three times and arranged in a randomized compete block design. The species, combinations and seeding rates for treatments planted at both locations are listed in Tables 1a and 1b.

Table 1a: Common name, scientific name and seeding rate per acre of cool season grasses planted at each nursery site.

COMMON NAME	SCIENTIFIC NAME	POUNDS SEED/ACRE
COOL SEASON GRASES		
1. Kentucky 31 Tall Fescue	Festuca arundinacea Schreb.	100
2. Turf Type Tall Fescue	Festuca arundinacea Schreb.	100
-Lesco Transition Blend (Cimarron, Bonanza, Olympic)		
3. Ensylva Red Fescue	Festuca rubra ssp. rubra L.	100
4. Aurora Hard Fescue	Festuca ovina ssp. duriuscula (L.) Koch.	100
5. Ruebens Canada Bluegrass	Poa compressa L.	100
6. Perennial Ryegrass	Lolium perenne L.	100
-Lesco Combination Mix (Citation II, Birdie II, Omega II)		
7. Red Fescue/Hard Fescue (70/30)		100
8. Hard Fescue/Turf Type Tall Fescue (90/10)		100
9. Hard Fescue/Perennial Rye (90/10)		100
10. Hard Fescue/Turf Type Tall Fescue/R.Fescue (80/10/10)		100
11. Turf Type Tall Fescue/Perennial Rye (70/30)		100
12. Tioga Deertongue Grass		

Table 1b: Common name, scientific name and seeding rate per acre of warm season grasses planted at each nursery site.

COMMON NAME	SCIENTIFIC NAME	LBS. PURE LIVE SEED/ACRE
	WARM SEASON GRASSES	
13. Alamo Switchgrass	Panicum virgatum	8
14. Shelter Switchgrass	Panicum virgatum	8
15. Niagara Big Bluestem	Andropogon gerardii	10
16. Lometta Indiangrass	Sorghastrum nutans	10
17. Haskell Side Oats Grama	Bouteloua curtipendula	10
18. Texoka 77 Buffalograss	Buchloe dactyloides	16
19. Vaughn Sideoats	Bouteloua gracilis	10
20. Niner Sideoats	Bouteloua gracilis	10
21. Bluegrama	Bouteloua curtipendula	3
22. Hachita Bluegrama	Bouteloua curtipendula	3
23. Llano Indiangrass	Sorghastrum nutans	10

One of the nursery sites was located along the shoulder run of an unused portion of Rt. 220, south of Tyrone. The cool season grasses were planted on 9/24/87 and the warm season grasses were planted on 6/2/88. The other nursery site was located near Landisville in the Rt. 283/230 interchange. The cool season species were planted on 9/29/87 and the warm season grasses were planted 5/27/88.

The selective herbicide Trimec (2,4-D, dicamba, MCPP) was applied to the cool season portion of Tyrone site on 6/17/88 and to the Landisville site on 7/5/88. The warm season grasses at the Landisville site was mowed to a height of 5" on 8/26/88. The Tyrone site was not mowed.

Both sites were rated four times during the 1988 season for percent turf cover and percent weed cover.

Results and Discussion

The data presented here is from the first season of evaluation and are considered preliminary. The performance of these species will continue to be evaluated for several seasons.

The germination and growth of the warm season grasses was very poor at both sites and no ratings were taken at any time during the season for these species. The drought conditions that were experienced throughout the state may have affected the performance of these species. Tioga deertongue grass in the cool season test did not germinate in any of the plots and was also eliminated from all ratings. All other cool season grasses were rated for percent cover and percent weed encroachment. The results from each site will be discussed separately.

LANDISVILLE NURSERY

Percent cover and percent weed encroachment were rated on 4/8/88, 6/3/88, 7/5/88, and 9/26/88. Results of these ratings are located in Tables 2 and 3. On 4/8/88, perennial ryegrass (rye) had the highest cover rating of all the species but was only significantly better than K-31 tall fescue (K-31), red fescue, and the combinations of rye with tall fescue or hard fescue.

On 6/3/88, K-31 had the lowest cover rating and was significantly lower than hard fescue, rye, Canada bluegrass, and the hard fescue combinations that contained rye, red fescue, or K-31.

On 7/5/88, K-31 had significantly lower cover than all other treatments except the combination of K-31 and rye. All other treatments were no different than each other.

By 9/26/88 however, the K-31 cover had increased and the cover ratings of all the treatments were not significantly different from each other.

Table 2: Grass species cover means for four rating dates at the Landisville site.

Species	4/4/88	6/3/88	7/5/88	8/26/88
1. K-31 Tall Fescue	60 b[1]	55 c	67 b	87 a
2. Turf Tall Fescue (TF)	67 ab	72 abc	80 a	85 a
3. Red Fescue (RF)	63 b	67 abc	85 a	70 a
4. Hard Fescue (HF)	70 ab	77 ab	93 a	67 a
5. Canada Bluegrass	73 ab	83 a	87 a	87 a
6. Perennial Ryegrass (PR)	83 a	77 ab	90 a	82 a
7. HF / RF (70/30)	70 ab	83 a	93 a	78 a
8. HF / TF (90/10)	68 ab	78 ab	93 a	77 a
9. HF / PR (90/10)	60 b	82 a	92 a	83 a
10. HF / TF / RF (80/10/10)	73 ab	75 ab	90 a	77 a
11. TF / PR (70/30)	57 b	58 bc	62 b	92 a

1/ Column means followed by the same letter are not significantly different at the 5% probability level according to Duncan's Multiple Range Test.

On 4/8/88, red fescue had the lowest degree of weed encroachment, but was only significantly different than K-31, which had the highest degree of weed encroachment. On 6/3/88, red fescue still had the fewest weeds, but was only significantly different than hard fescue, which had the most.

On 6/5/88, hard fescue still had the most weeds and was significantly higher than red fescue, rye, and the combination of hard fescue and red fescue. There was no difference between any of the other treatments.

By 9/26/88, K-31 had the fewest weeds, but was only different than perennial rye which had the most weed. Weed cover for the remaining treatments were statistically the same.

Table 3: Percent weed cover means for four rating dates at the Landisville site.

	Species	4/4/88	6/3/88	7/5/88	8/26/88
1.	K-31 Tall Fescue	22 a[1]	22 ab	30 ab	7 b
2.	Turf Tall Fescue (TF)	8 ab	27 ab	20 ab	20 ab
3.	Red Fescue (RF)	7 b	10 b	13 b	22 ab
4.	Hard Fescue (HF)	15 ab	47 a	43 a	18 ab
5.	Canada Bluegrass	15 ab	32 ab	28 ab	18 ab
6.	Perennial Ryegrass (PR)	8 ab	30 ab	7 b	12 ab
7.	HF / RF (70/30)	10 ab	12 ab	12 b	37 a
8.	HF / TF (90/10)	10 ab	42 ab	42 a	22 ab
9.	HF / PR (90/10)	12 ab	28 ab	23 ab	20 ab
10.	HF / TF / RF (80/10/10)	8 ab	27 ab	22 ab	18 ab
11.	TF / PR (70/30)	8 ab	32 ab	20 ab	10 ab

1/ Column means followed by the same letter are not significantly different at the 5% probability level according to Duncan's Multiple Range Test.

TYRONE NURSERY

Percent grass cover, and percent weed cover were rated for the Tyrone site on 3/11/88, 5/20/88, 7/4/88, and 9/31/88. Percent grass cover for each plot was rated as one unit on 3/11/88 and 5/20/88. By 7/4/88 however, there was a distinct difference in grass cover between the upper and lower half of many plots. The downslope half of the plot displayed better cover than the upslope half which may have been caused by the movement of the grass seed downslope with the water flow. Therefore, percent grass cover was rated separately for the upper and lower sections of each plot for the rest of the season. The percent grass cover and percent weed cover is listed in Tables 4 and 5 respectively.

K-31, turf type tall fescue and combinations which included these grasses had the lowest cover ratings of all treatments throughout the season. On 4/11/88, rye had the highest cover but was only significantly better than Canada bluegrass, red fescue and both tall fescue treatments. On 5/20/88, hard fescue had the highest cover, but was not significantly different than rye, the combination of hard fescue and red fescue, or the combination of hard, red, and tall fescue.

On 7/4/88, only three treatments had slightly increased cover compared to 5/20/88. The cover of all other treatments decreased or remained the same. The poor performance for that six week period could be due in part to the drought conditions which were at their peak during that period. On 7/4/88, the lower section of plots for all treatments had between 50-65% cover with the exception of those mixes that contained over 10% tall fescue, which were 43% or below.

On 9/31/88, K-31 and turf type tall fescue had only slightly increased cover on the lower portion of the plots when compared to 7/4/88. Canada bluegrass had the highest cover rating but was only significantly different than K-31, turf type tall fescue, and the combinations of hard and red fescue, and tall fescue and rye.

Table 4: Grass species coverage means for four rating dates at the Tyrone site.

	Species	4/11/88	5/20/88	Upper[1] 7/4/88	Lower 7/4/88	Upper 9/31/88	Lower 9/31/88
1.	K-31 Tall Fescue	20 d[2]	37 f	37 cd	30 c	33 d	37 c
2.	Turf Tall Fescue (TF)	32 c	43 ef	23 d	32 c	32 d	35 c
3.	Red Fescue (RF)	35 bc	57 cd	55 ab	62 a	43 cd	63 ab
4.	Hard Fescue (HF)	42 ab	72 a	62 a	65 a	57 a-d	70 ab
5.	Canada Bluegrass	35 bc	48 de	50 abc	50 ab	77 a	82 a
6.	Perennial Ryegrass (PR)	45 a	67 ab	43 bc	53 ab	53 a-d	68 ab
7.	HF / RF (70/30)	42 ab	65 abc	60 a	60 a	63 abc	53 bc
8.	HF / TF (90/10)	37 abc	57 cd	57 ab	57 ab	73 ab	63 ab
9.	HF / PR (90/10)	38 abc	62 bc	53 ab	60 a	57 a-d	70 ab
10.	HF / TF / RF (80/10/10)	38 abc	63 abc	65 a	65 a	72 abc	75 ab
11.	TF / PR (70/30)	40 abc	58 bc	37 cd	43 bc	45 bcd	52 bc

1/ Ratings for July 4 and August 31 were taken for the upper and lower half of each plot due to observed coverage differences possibly caused by downhill movement of seed.
2/ Column means followed by the same letter are not significantly different at the 5% probability level according to Duncan's Multiple Range Test.

On 4/11/88, broadleaf weeds were not a problem in any of the treatments. By 5/20/88, K-31 and turf type tall fescue had significantly more weed cover than nearly all other treatments. On 6/17/88, a broadleaf herbicide was applied to the plot area and the weed cover ratings on 7/4/88 were lower for all treatments when compared to 5/20/88. Hard fescue and perennial rye had the lowest weed cover but were only significantly lower than K-31 or turf type tall fescue. The results were nearly the same on 9/31/88 as the tall fescues tended to have higher weed cover than all other treatments.

Table 5: Percent weed cover means for four rating dates for the Tyrone site.

	Species	4/11/88	5/20/88	7/4/88	8/31/88
1.	K-31 Tall Fescue	3 a[2]	38 a	23 a	25 a
2.	Turf Tall Fescue (TF)	3 a	32 ab	22 a	25 a
3.	Red Fescue (RF)	3 a	17 cd	13 ab	15 abc
4.	Hard Fescue (HF)	3 a	12 cd	6 b	12 bc
5.	Canada Bluegrass	3 a	15 cd	13 ab	8 bc
6.	Perennial Ryegrass (PR)	3 a	7 d	5 b	7 c
7.	HF / RF (70/30)	3 a	20 c	13 ab	15 abc
8.	HF / TF (90/10)	3 a	22 bc	12 ab	12 bc
9.	HF / PR (90/10)	3 a	18 cd	15 ab	12 bc
10.	HF / TF / RF (80/10/10)	3 a	22 bc	13 ab	12 bc
11.	TF / PR (70/30)	3 a	17 cd	13 ab	18 ab

1/ The July 4 ratings were taken on the upper and lower half of the plots.
2/ Column means followed by the same letter are not significantly different at the 5% probability level according to Duncan's Multiple Range Test.

Conclusion

These experiments will continue to be evaluated for several seasons and results at this time are preliminary.

Perennial rye was the quickest to establish and produced the best cover in the early ratings at both sites. All treatments established as well or better than K-31 or turf type tall fescue at each site. The tall fescues had better overall performance in Landisville than in Tyrone. All single species treatments show promise at this time as an alternative roadside groundcover.

It was noted that the combination of 10% tall fescue with 90% fine fescue (red or hard fescue) was not compatible. The is too great a contrast between the blade height and growth habit of the species. The blades of fine fescue tend to lodge or fall over while the blades of tall fescue are erect and the result was a very inconsistent canopy height. The combination of any of the other species with hard fescue did not seem to be better than hard fescue alone at this time. The combination of tall fescue and perennial rye (TF 70 / PR 30) shows promise. The mix seemed to contain too much tall fescue however. Another nursery was planted in the fall of 1988 near the Penn State campus. The combination of tall fescue and perennial rye has been refined for that planting.