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DEPARTMENT OF TRANSPORTATION

ROADSIDE VEGETATION MANAGEMENT RESEARCH REPORT

FOURTH YEAR REPORT

THE PENNSYLVANIA STATE UNIVERSITY
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The fourth year report on a cooperative roadside vegetation management research project between the Pennsylvania Department of Transportation and The Pennsylvania State University focusing on six project areas.

1) Brush control research which includes experiments evaluating fall foliar applications, dormant stem applications, and low volume basal bark applications.

2) Bare ground research evaluating herbicide combinations for preemergence applications, postemergence applications, giant foxtail control, and enhanced burndown of vegetation with postemergence applications.

3) Wildflower evaluations which include evaluation of individual species over two years, and formulation of a wildflower mix for state-wide use.

4) Plant growth regulator research for seedhead and growth suppression of tall fescue turf on roadsides. Studies include a screening study of potential new compounds, an evaluation of the effect of applica- tion timing of Embark and Escort combinations, and a comparison of PGR effects on 'Kentucky 31' and turf type fescues.

5) Low maintenance grass research evaluating turf varieties for roadside conditions. Studies are being conducted at three locations.

6) Herbaceous weed control research with studies on Canada and plumeless thistle control in crownvetch, comparison of growth hormone type herbicides and a screening study for broadleaf weed control, and enhanced establishment of birdsfoot trefoil with Arsenal herbicide.

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Thomas L. Watschke	Professor of Turfgrass Science, Project Manager
Larry J. Kuhns	Professor of Ornamental Horticulture
Nathan L. Hartwig	Professor of Weed Science
Gregory T. Lyman	Project Assistant
Arthur E. Gover	Sr. Research Technologist

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INTRODUCTION

In October 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. An annual report has been submitted each year, which describes the research activities and presents the data. The previous reports can be obtained from The National Technical Information Service, Springfield, VA, and are listed as follows:

- •Report # PA86-018 + 85-08 - Roadside Vegetation Management Research Report
- •Report # PA87-021 + 85-08 - Roadside Vegetation Management Research Report - Second Year Report
- •Report # PA89-005 + 85-08 - Roadside Vegetation Management Research Report - Third Year Report

This report includes information from studies investigating roadside brush control, total vegetation control for use under guiderails, wildflower species evaluation, plant growth regulators for roadside turf, low maintenance grass evaluation, and herbaceous weed control. Several experiments have been conducted within each one of these studies.

The herbicides are referred to as product names in this report for ease of reading. The herbicides used in each study are listed at the beginning of the section by product name, common name, formulation, and manufacturer. In many cases the cost of each treatment is calculated from the Pennsylvania State Agency bid list. If the products do not appear on the list, an approximate cost was obtained from the manufacturer or distributor. The 1989 Pennsylvania State Agency bid list is located in Table 1.

Table 1: Products, formulations, and prices of herbicides used in 1989. Information is from the PennDOT bid list, or from the manufacturer.

TRADE NAME	ACTIVE INGREDIENTS	FORMULATION	MINIMUM SHIPMENT	UNIT PRICE
ACCESS	TRICLOPYR + PICLORAM	3 OS		$120.00
ARSENAL	IMAZAPYR	2.0	2 X 5 GAL	$134.02
BANVEL 720	DICAMBA + 2,4-D	1.0 + 1.9	4 X 2.5 GAL	$18.74
BANVEL 720	DICAMBA + 2,4-D	1.0 + 1.9	1 X 30 GAL	$17.05
CIDEKICK II	NONIONIC ADJUVANT		5 X 1 GAL	$8.93
CLEAN-CUT CITRUS	NON IONIC ADJUVANT		1 X 5 GAL	$9.45
DIQUAT	DIQUAT	2.0	1 X 1 GAL	$54.23
EMBARK	MEFLUIDIDE	2.0	8 X 1 GAL	$58.00
ESCORT	METSULFURON METHYL	60%	8 X 8 OZ	$23.81
EVENT	IMAZETHAPYR + IMAZAPYR	1.45		$235.00
GARLON 3A	TRICLOPYR T.E.A.	3.0	6 X 5 GAL	$45.09
GARLON 4	TRICLOPYR B.E.E.	4.0	6 X 5 GAL	$59.69
HI-DEP	2,4-D	4.0		$14.00
INTERAG DMA 4	2,4-D AMINE	4.0	2 X 30 GAL	$7.32
KARMEX DF	DIURON	80%	24 X 4 LB	$2.81
KRENITE S	FOSAMINE AMMONIUM	4.0	6 X 5 GAL	$41.82
KRENITE S	FOSAMINE AMMONIUM	4.0	3 X 30 GAL	$41.29
KROVAR I DF	BROMACIL + DIURON	40% + 40%	8 X 6 LB	$6.69
OUST	SULFOMETURON	75%	3 X 3 LB	$119.88
POLY CONTROL 2	DRIFT CONTROL		12 X 1 QT	$7.49
ROUNDUP	GLYPHOSATE	4.0	8 X 1 GAL	$68.00
ROUNDUP	GLYPHOSATE	4.0	4 X 2.5 GAL	$54.00
SPIKE DF	TEBUTHIURON	80%	12 X 4 LB	$14.65
STOMP	PENDIMETHALIN	4.0		$22.70
SURFLAN AS	ORYZALIN	4.0	10 X 5 GAL	$47.52
TELAR	CHLORSULFURON	75%		$15.00
TROOPER	DICAMBA (DMA SALT)	4.0	4 X 2.5 GAL	$51.58
VELPAR L	HEXAZINONE	2.0	10 X 1 GAL	$40.77
WEEDAR 64	2,4-D AMINE	4.0	10 X 2.5 GAL	$7.54

BRUSH CONTROL STUDIES

The 1989 brush control research included several experiments and three different application techniques - basal bark, dormant stem, and fall foliar methods. The basal bark section includes preliminary results from an experiment applied in April 1989, and additional data from several experiments conducted in 1987 and 1988. The dormant stem section involves a review of the data from 1986 through 1988, and a presents the data from the 1989 experiment. The fall foliar section presents data collected in 1989 from the experiment applied in September of 1988. A list of the herbicides, surfactants, and diluents utilized in the brush control study is presented in Table 1.

TABLE 1: Product name, formulation, active ingredient, and manufacturer of herbicides and adjuvants used for the brush control research in 1989.

Product	Formulation	Active Ingredient	Manufacturer
Access	3 OS	triclopyr+picloram	DowElanco
Arsenal	2 S	imazapyr	American Cyanamid
Chopper	2 EC	imazapyr	American Cyanamid
Escort	60 DF	metsulfuron methyl	DuPont
Garlon	4 EC	triclopyr (ester)	DowElanco
Krenite S	4 S	fosamine ammonium	DuPont
Roundup	4 S	glyphosate	Monsanto
Basal Oil		---	Arborchem Products
Cidekick I		---	JLB International
Clean Cut + Pine		---	Arborchem Products
Diesel Fuel		---	
Penetrator Plus		---	Helena Chemical
Sox-Dex		---	Helena Chemical

FOLIAR BRUSH CONTROL STUDIES

Fall Foliar Brush Control Study 1989

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's advantages include:

- it is only active on the portion of the plant it contacts, which produces a "sidetrimming" effect,
- when applied at the proper time, Krenite does not produce objectionable "brown out" of the foliage.

A disadvantage of using Krenite alone is that tolerant species will eventually become the dominant species within the treated area. Several experiments have been performed since 1986 to combine Krenite with other herbicides and surfactants to increase the spectrum of control while lowering the cost of the application. In 1989, several rates of Krenite were examined in combination with Arsenal, Escort, Garlon 4, and Roundup.

In previous years, application was performed using a Radiarc spray head, while in 1989 a Cibolo SwingLok Model A spray rig was utilized. When a handgun is used to control sparse stands of brush, the herbicide rate is calculated as a percentage of total volume because the amount applied per acre varies with brush density. For instance, 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 1.5 gallons of Krenite per acre. When equipment such as Cibolo, Cross, or the Radiarc nozzle is used to apply the herbicide, a consistent pattern can be produced. For this type of equipment, rates can be calculated on the basis of units per acre because the output is constant and the spray swath can be measured. 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 broadcast a certain amount per acre. Since a Cibolo unit was used for this study, rates are discussed as product per acre.

OBJECTIVE

To compare the efficacy of Krenite S applied alone to combinations of Krenite and other herbicides for controlling roadside brush.

MATERIALS AND METHODS

Krenite S was applied alone and in combination with Arsenal, Escort, Garlon 4, and Roundup to a mixed stand of roadside brush on September 2, 1988. The rates, combinations and herbicide costs are listed in Table 2. Treatments were applied with a Cibolo Model A spray rig which was the same unit utilized for all of brush work for District 2-0 in the fall of 1988. The herbicides were injected into the delivery system and applied in the equivalent of approximately 55 gallons of water per acre. The area calculations were based on an 18' vertical swath width.

The brush growing in the treatment area included sassafras (Sassafras albidum, Nutt.), hackberry (Celtis occidentalis L.), black walnut (Juglans nigra L.), oak (Quercus spp.), red maple (Acer rubrum L.), black cherry (Prunus serotina, Ehrh.), blackhaw viburnum (Viburnum prunifolium L.), American elm (Ulmus americana L.) and flowering dogwood (Cornus florida L). All species were not present in every plot area.

All species treated within each plot area were rated for control using a 1-7 scale on September 15, 1989. A "1" indicates no treatment effect and a "5" indicates complete control of all branches contacted by the treatment. A "6" indicates injury in portions of the plant that were not contacted by the treatment, and a "7" indicates control of the whole plant.

TABLE 2: Treatments applied on September 2, 1988 using a Cibolo SwingLok Model A sprayer. All rates are based on an 18 foot vertical swath width and total spray volume of approximately 55 GPA. The costs are calculated from the current Pennsylvania state herbicide contract.

Treatment	Product Rate/Acre	Material Cost/Acre
Krenite S	6.0 qts	$61.94
Krenite S Arsenal	3.0 qts 4.0 oz	$33.06
Krenite S Arsenal	4.5 qts 2.0 oz	$48.54
Krenite S Arsenal	4.5 qts 4.0 oz	$50.64
Krenite S Escort	3.0 qts 1.0 oz	$54.78
Krenite S Escort	4.5 qts 1.0 oz	$70.26
Krenite S Garlon 4	4.5 qts 1.5 qts	$68.83
Krenite S Roundup	4.5 qts 1.5 qts	$66.70

RESULTS AND DISCUSSION

Krenite at 6.0 qts had no effect on sassafras and only slightly injured hackberry. Most of the contacted area of walnut was controlled, but some minor resprouting occurred. All of the contacted area of elm was controlled. Control of viburnum ranged from complete control of contacted stems to control beyond the contacted area. Oak was controlled beyond the contacted area.

All treatments that contained Krenite plus Arsenal provided equal or better control than Krenite applied alone. Control of sassafras with all Arsenal treatments ranged from activity well beyond contacted stems to complete control of the plant. Several stems in these treatments were over 20' foot tall. Hackberry treated with Krenite (3.0 qts) plus Arsenal (4 oz) displayed some minor resprouting in the contacted area When Krenite was increased to 4.5 qts, control of hackberry ranged from minor resprouting in the contacted area to control beyond the contacted area. Walnut was controlled within the contacted area by Krenite (4.5 qts) plus Arsenal (2 oz). When the rate of Arsenal was increased to 4.0 oz, the entire stem was killed. Oak was controlled beyond the contacted area with Krenite (4.5 qts) plus Arsenal (2 oz). When Arsenal was increased to 4.0 oz, oak control ranged from injury beyond the contacted area to complete kill of the plant. Maple was controlled beyond the contacted area with Krenite 3.0 qts plus Arsenal (4 oz). When Krenite was increased to 4.5 qts, control increased and some maple stems were completely controlled. Krenite (4.5 qts) plus Arsenal (4 oz) provided complete kill of all maple stems. Walnut was controlled within the contacted area with Krenite (4.5 qts) plus Arsenal (2 oz), and when Arsenal was increased to 4 oz, complete control of the stem was achieved. Krenite (3.0 qts) plus Arsenal (4.0 oz) provided total control within the contacted area of elm and caused injury beyond the contacted area of viburnum.

Krenite 3.0 qts plus Escort (1 oz) provided complete control contacted stems of walnut and cherry. Treated stems of hackberry and viburnum were severely injured, while sassafras was totally killed. Injury to maple varied from slight to severe. When Krenite was increased from 3 to 5 qts in combination with Escort, the degree of control increased for maple, cherry, viburnum, and walnut, decreased for sassafras, and was unchanged for hackberry.

Krenite plus Garlon 4 provided control of all stems within the contacted area of sassafras, cherry, and viburnum, and provided control past the contacted area of walnut and elm.

Krenite plus Roundup provided control of the contacted area of walnut and oak. Control past the contacted area was achieved on sassafras, hackberry, and dogwood, and complete control was achieved on elm. Control of maple ranged from control within the contacted area to beyond the treated area.

While control can be enhanced when combining Arsenal, Garlon, Escort or Roundup with Krenite, there is potential for damage to the understory plants and "brownout" symptoms will occur with the combination treatments.

TABLE 3: Control ratings for brush treatments applied September 2, 1988 with a Cibolo Model A spray rig with a SwingLok head using an 18 foot vertical swath width for the area calculation. The total spray volume was approximately 55 GPA. Treatments were rated on August 15, 1989.

		Control [1/]								
Treatment	Rate Product/ac	Sass-afrass	Hack-berry	Walnut	Oak	Maple	Cherry	Vib-rnum	Elm	Dog-wood
Krenite S	6.0 qts	1	1-2[2/]	4	6	X[3/]	X	5-6	5	X
Krenite S Arsenal	3.0 qts 4.0 oz	6-7	4	7	7	6	6	5	5	6
Krenite S Arsenal	4.5 qts 2.0 oz	6-7	4-6	5	6	6-7	7	X	X	6
Krenite S Arsenal	4.5 qts 4.0 oz	6-7	4-6	7	6-7	7	X	X	X	X
Krenite S Escort	3.0 qts 1.0 oz	7	4	5	X	2-6	5	4	X	X
Krenite S Escort	4.5 qts 1.0 oz	4-6	4	6	5	5-6	6-7	6	X	X
Krenite S Garlon 4	4.5 qts 1.5 qts	5	X	6	X	X	5	5	6	X
Krenite S Roundup	4.5 qts 1.5 qts	6	6	5	5	5-6	X	X	7	6

1/ - Rating Scale: 1 - No injury
2 - Slight injury to contacted branches
3 - Contacted branches are severely stunted and chlorotic, recovery expected
4 - Some dead tips on contacted branches with some resprouting
5 - All of contacted branches are dead
6 - Some branches not contacted by the treatment are injured or dead
7 - Entire plant is dead

2/ - A hyphenated rating describes the range of treatment activity on multiple plants within a plot area.

3/ - Species not present in plot area.

DORMANT STEM BRUSH CONTROL STUDIES

INTRODUCTION

The dormant stem brush control method is a broadcast application to the stems of brush during the dormant season of growth. The stems of the target brush should be thoroughly covered for best results. The advantages of this method are:

- spray solutions penetrate further into dense stands of brush 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.

Research activity using dormant stem applications began in 1986 and has continued with each successive season. These investigations have examined several herbicides, penetrants, rates, and application timings to determine the most cost effective application. A review of all of the work beginning with 1987, and ending with this seasons experiment is listed below. It is important to note the method of application and the corresponding rate of herbicide applied per acre. During 1987 and 1988, a Radiarc nozzle system was used to apply the treatments. When using this system, the rates are presented as a percent solution, and that is related to a rate of herbicide per acre based on the total amount of solution applied per acre. This can easily be calculated when using a Radiarc nozzle because the swath width and pattern is quite consistent and can be easily measured. In 1989, a Cibolo Jr. application system was used and rates are only described in corresponding rates per acre. The rating systems also vary somewhat from year to year. In 1986, activity was rated as percent control of the treated area. In 1987, 1988 and 1989, control was rated on a scale that varied from 1-5, 1-10, or 1-7. The reader should carefully examine the materials and methods of each experiment to determine the application method and rating system utilized.

1986 Dormant Stem Study

OBJECTIVES

- To determine the effectiveness of 1% and 5% solutions of Garlon 4 and combinations of Garlon 4 with Roundup and Escort; and
- To compare the effectiveness of three penetrants.

MATERIALS AND METHODS

All treatments (Table 4) were applied in March 1986 in Perry Co. with a Radiarc nozzle system in the equivalent of 80 gallons of water per acre. This rate of solution per acre was determined to provide adequate coverage of the target stems. Control was rated in June of 1987 approximately 15 months after treatment by estimating the percent kill of the contacted vegetation.

Boxelder maple (Acer negundo L.), red maple (Acer rubrum L.), ash spp. (Fraxinus spp.), hickory spp. (Carya spp.), oak spp. (Quercus spp.), privet spp.(Ligustrum spp.) redbud (Cercis canadensis L.), hackberry (Celtis occidentalis L.), cherry spp.(Prunus spp.), elm spp.(Ulmus spp.), mulberry (Morus alba L.), and sumac spp.(Rhus spp.), viburnum spp.(viburnum spp), ostyra spp. (Ostrya spp), grew within the plot areas. The understory consisted of perennial grasses and herbaceous weeds.

RESULTS AND DISCUSSION

Garlon at 5% provided excellent results regardless of crop oil treatment (Table 4). Garlon at 5% controlled almost all brush contacted with the exception of some minor resprouting of maple and marginal control of cherry. Some treatments of Garlon at 5% were effective in controlling stems well beyond the treated area.

All treatments of Garlon at 1% provided less control that Garlon at 5%. When applied with 1% Garlon, the Cidekick + Garlon provided less control than the other crop oil treatments. Brush treated with Garlon at 1% resprouted and the long term control was unacceptable. Resprouting was noted on stems greater than 1" in diameter of cherry, maple, ash, ostrya, and redbud. The addition of Escort or Roundup to Garlon at 1% did not increase the level of control over Garlon (1%) alone. All treatments damaged the understory plants with the degree of damage increasing as the rate of Garlon increased.

Table 4: Percent control of roadside brush treated in March, 1986, and rated in June 1987. All treatments were applied in the equivalent of 80 gallons of water per acre.

Chemical	Rate	Surfactant	Percent Control
Garlon 4	1 %	Cidekick	50
Garlon 4	1 %	Clean Cut + Pine	90
Garlon 4	1 %	Booster Plus E	80
Garlon 4	5 %	Cidekick	95
Garlon 4	5 %	Clean Cut + Pine	99
Garlon 4	5 %	Booster Plus E	99
Garlon 4 +	1 %	Booster Plus E	50
Escort	1oz./100 gal. water		
Garlon 4 +	1 %	Booster Plus E	75
Roundup	1 %		

1987 Dormant Stem Study

INTRODUCTION

Since the 5% rate of Garlon 4 provided superior activity in 1986, the rates of Garlon 4 were refined in 1987 to 1% and 3% to further bracket the rate in order to increase the cost efficiency of the treatment. Banvel 520 was evaluated alone and in combination with Garlon 4. Another timing was added to the experiment to begin to determine the most effective application window.

OBJECTIVES

- To determine the effects of Garlon 4 at 1% and 3%, Banvel 520, or a combination of Garlon and Banvel 520; and
- To determine the effects of two separate application timings.

MATERIALS AND METHODS

Plots were established along a roadside in Chester County PA. The brush was treated with Garlon at two rates, Banvel 520, or a combination of Garlon and Banvel 520 (Table 5). All treatments were applied on December 16, 1986 and March 12, 1987 using a Radiarc nozzle system in the equivalent of 75 gallons of water per acre. All treatments contained the emulsifiable crop oil Clean Cut + Pine at the rate of 2% v/v. Control was rated on September 27, 1987, on a 1-5 scale with (1) indicating no treatment effect, and (5) indicating total control of the contacted area. Boxelder maple (Acer negundo L.), ash spp. (Fraxinus spp.), butternut (Juglans cinerea L.), hickory spp. (Carya spp.), oak spp. (Quercus spp), hackberry (Celtis occidentalis L.), cherry spp.(Prunus spp.), elm spp.(Ulmus spp.), mulberry (Morus alba L.), grew within the study areas. The understory consisted of perennial grasses, herbaceous weeds, poison ivy (Toxicodendron radicans L.), and periwinkle (Vinca minor L.).

RESULTS AND DISCUSSION

None of the treatments applied in December provided adequate brush control for roadsides (Table 5). Garlon at 1% applied in March provided good control of boxelder, butternut, and hickory. All contacted stem tips were killed, but some resprouting occurred on the stem below the branch tip. Garlon + Banvel provided adequate control of hackberry and poison ivy and marginal control of oak, but was not effective on elm or hickory.

Garlon at 3% provided excellent control of ash, boxelder, hackberry, mulberry, cherry, and elm, with some minor resprouting noted on ash. Treatments including Garlon killed the broadleaf understory vegetation. The amount of understory vegetation controlled increased as the rate of Garlon increased. Banvel 520 alone provided little or no control when applied to dormant stems.

Table 5: Control ratings of roadside brush treated with Garlon 4 and Banvel 520, alone or in combination, in December 1986, and March 1987. All treatments were applied in the equivalent of 75 gallons of water per acre and contained 2% by volume of the emulsifiable crop oil Clean Cut + Pine. Treatments were rated on September 27,1987.

		Application Time and Control Rating[1/]	
Chemical	Rate (%)	December '86	March '87
Garlon 4	1.0	1	4.0
Garlon 4	3.0	2	4.75
Garlon 4 + Banvel 520	1.5 0.75	2	3.5
Banvel 520	1.5	1	1.5

1/ - Control Rating: 0 = No Effects, 5 = Dead

1988 Dormant Stem Study

INTRODUCTION

In 1988, Garlon 4 was the only herbicide utilized as all others tested in previous years provided inadequate control. The rates of Garlon 4 were further refined from 1987 to continue to evaluate the most cost effective treatment. Two rates of crop oil were tested to investigate its efficacy at a higher rate than tested in 1987. The application timing was also refined in 1988 to further bracket the most effective treatment. Since the December timing in 1987 provided poor control when compared to the March timing, the first application was performed in February and the second remained in March.

OBJECTIVE

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

MATERIALS AND METHODS

Garlon 4 was applied at 1.5%, 2.0%, and 2.5% v/v in combination with Clean Cut + Pine at 2.0% or 3.0% v/v. Rates and combinations, and herbicide costs are listed in Table 6. The herbicide costs were calculated from the 1988 state bid list which included Garlon 4 at $59.92 per gallon and Clean Cut + Pine at $7.75 per gallon. Treatments were applied on February 11, and March 17, 1988, using a Radiarc nozzle system that 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. The understory consisted of herbaceous broadleaves and perennial grasses.

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 6: Application rates and herbicide cost of dormant stem treatments applied in 75 gallons/acre in February and March 1988.

Treatment	Percent Volume	Quarts Product/Acre	Material 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 and more uniform throughout the treatment area for treatments applied on March 17 than treatments applied on February 11 (Table 7). It is not known whether the physiological state of the plant or the effects of the lower temperature on the spray solution that was responsible for 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 sassafras 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, control 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.

The time during which treatments can be applied may be more restrictive than had been hoped. In 1987, poor control was demonstrated when applied in December. This test indicates adequate brush control when applied in February, but the best activity is still achieved when applied in March.

There seems to be an increased response by using a higher rate of surfactant. By using the low rate of Garlon and the high rate of crop oil, very good brush control can be achieved at a reasonable cost.

Table 7: Control ratings of roadside brush treated with Garlon 4 and Clean Cut + Pine performed on June, 17 1988. All treatments were applied with a Radiarc nozzle in the equivalent of 75 gallons of water per acre on February 11, and March 17, 1988.

			Control Ratings June 17, 1988[1]			
Garlon 4	Crop Oil	Application Date	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.

1989 Dormant Stem Study

OBJECTIVE

To further evaluate the potential of increased control by increasing the concentration of emulsifiable crop oil in the spray solution.

MATERIALS AND METHODS

Five treatments combining Garlon 4 with the emulsifiable crop oil Clean Cut + Pine were applied to a mixed stand of roadside brush on April 6, 1989. Rates, combinations, and herbicide costs are listed in Table 8. The product costs per acre were based on the 1989 PA state bid list which describes Garlon 4 at $59.69 per gallon and Clean Cut + Pine at $7.75 per gallon. Application was performed with a Cibolo Jr. spray rig equipped with a SwingLok spray head. The treatments were injected into the spray stream and area calculations were based on a 12' vertical swath width. The total solution applied was approximately 75 gallons per acre.

Brush present within the treatment area included oak (Quercus spp.), sassafras (Sassafras albidum, Nutt.), red maple (Acer rubrum L.), striped maple (Acer pensylvanicum L.), common witchhazel (Hamamalis virginiana Ehrh.), black cherry (Prunus serotina, Ehrh.), honeysuckle (Lonicera spp.), American beech (Fagus grandifolia Ehrh.), and flowering dogwood (Cornus florida

L.). Not all brush species were present within each plot area. The understory was a mixed stand of herbaceous broadleaves, grasses and ferns. The brush was dormant at the time of application and temperatures of the air, soil surface, and soil at 15 cm were 5°, 4°, and 2° C, respectively.

Each species within the plot areas were rated for control on a 1-7 scale on October 3, 1989. A "1" indicates no treatment effect and a "5" indicates complete control of all branches contacted by the treatment. A "6" indicates injury in portions of the plant that were not contacted by the treatment and a "7" indicates control of the whole plant.

Table 8: Application rates and costs of dormant stem treatments applied on April 6, 1989.

Treatment	Rate	Material Cost
Garlon 4	4.0 qts	$78.59
Clean Cut + Pine	4.0 qts	
Garlon 4	4.0 qts	$97.59
Clean Cut + Pine	8.0 qts	
Garlon 4	8.0 qts	$138.28
Clean Cut + Pine	4.0 qts	
Garlon 4	8.0 qts	$157.18
Clean Cut + Pine	8.0 qts	
Garlon 4	0.0	$37.80
Clean Cut + Pine	8.0 qts	

RESULTS AND DISCUSSION

Garlon at 4 qts plus Clean Cut + Pine (C.C.+P.) at 4 qts provided control of all contacted branches on oak. Stems within the contacted area of red maple, striped maple, and sassafras were severely injured, but not totally controlled. Control of witchhazel ranged from severe injury to total control of contacted stems. Control of dogwood ranged from severe injury to control past the contacted area. Control of beech ranged from moderate to severe injury within the contacted area. Honeysuckle was the least affected by this treatment and control ranged from no effect to moderated injury within the contacted area.

Garlon at 4 qts plus 8 qts C.C.+P. provided control similar to Garlon at 4 qts plus 4 qts C.C.+P. on oak, witchhazel, honeysuckle, and dogwood. Control of red and striped maple increased to complete control of all contacted branches. Control of beech also increased to range from severe injury within the contacted area to control beyond the contacted area.

Garlon at 8 qts plus 4 qts C.C.+P. controlled all contacted portions of oak, red maple, and witchhazel. Honeysuckle was severely injured, but not all contacted stems were completely controlled. Control of beech ranged from severe injury of contacted stems to injury beyond the contacted area. Dogwood control ranged from complete control within the contacted area to injury beyond the contacted area.

Garlon at 8 qts plus 8 qts C.C.+P. controlled all contacted stems of oak and witchhazel. A range from complete control of contacted area to control beyond the contacted area was displayed on red maple, beech, and dogwood.

Clean Cut plus Pine. at 8 qts applied alone had no effect on oak, red maple, sassafras, witchhazel, honeysuckle, beech, or dogwood. Severe understory damage was noted on all treatments containing Garlon.

Table 9: Control ratings for treatments applied April 6, 1989 with a SwingLok Jr. sprayer. A 12 foot vertical swath width was used for the area calculation. The total spray volume was approximately 70 GPA. Treatments were rated on October 3, 1989.

		CONTROL 1/							
Treatment	Rate qts/acre	Oak	Red Maple	Striped Maple	Sass-afrass	Witch-hazel	Honey-suckle	Beech	Dog wood
Garlon 4 Clean Cut + Pine	4.0 4.0	5	4	4	4	4-5[2]	1-3	3-4	4-6
Garlon 4 Clean Cut + Pine	4.0 8.0	5	5	5	X[3]	4-5	1-3	4-6	4-6
Garlon 4 Clean Cut + Pine	8.0 4.0	5	5	X	X	5	4	4-6	5-6
Garlon 4 Clean Cut + Pine	8.0 8.0	5	5-6	X	X	5	X	5-6	5-6
Garlon 4 Clean Cut + Pine	0.0 8.0	1	1	X	1	1	1	1	1

1/ - Rating Scale: 1 - No injury
2 - Slight injury to contacted branches
3 - Contacted branches are severely stunted and chlorotic, recovery expected
4 - Some dead tips on contacted branches with some resprouting
5 - All of contacted branches are dead
6 - Some branches not contacted by the treatment are injured or dead
7 - Entire plant is dead

2/ - A hyphenated rating describes the range of treatment activity on multiple plants within the plot area.

3/ - X = Species not present in plot area.

CONCLUSION

In all studies from 1986 through 1989, the high rates of Garlon 4 have been effective in controlling brush when applied during March. When applied in December or February, the response of all treatments dramatically decreased. None of the other herbicides tested (Roundup, Escort, Banvel 520) were as effective as using Garlon 4 alone.

In 1986, three crop oils were tested and at the high rate of Garlon (5% v/v), no difference in control was apparent. At the low rate however (1% v/v), Booster + E and Clean Cut + Pine provided better control than Cidekick. No response was evident in 1989 when C.C.+P was applied alone.

In 1989, brush control was increased when the amount of crop oil increased. The best brush control was demonstrated with Garlon 8.0 qts and C.C.+P at 8.0 qts, yet it was also the most expensive at $157.18 per acre. The most cost efficient treatment was Garlon 4.0 qts and C.C.+P at 8.0 qts, which was $97.59 per acre. This treatment provided good control of all species except honeysuckle.

In all experiments where Garlon 4 was used, injury to the understory of both grasses and broadleaves was noted. If used in a dense growth of brush however, the understory will be sparse. The potential for damage to the understory should be a major consideration for roadside managers when choosing the site for this technique.

The best treatment for use by roadside managers would be Garlon 4 at 4-6 qts per acre in combination with a crop oil at 8 qts per acre. The treatment should be applied in March up to the time of leaf emergence and the solution should cover as much of the stem as possible. Minimizing spray contact to the understory will reduce damage.

BASAL BARK BRUSH CONTROL STUDIES

INTRODUCTION

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 throughout the treatment area. Advancements in equipment and technique in recent years now allow the application to be performed with a backpack sprayer. The herbicide concentration is higher (20-50%) and the solution is misted onto the base of the stem, which requires much less total volume. There are several diluents that have been developed for use as an alternative to diesel fuel. These include Basal Oil from Arborchem Products Inc., which is a refined petroleum product and a mineral oil product available from N.G. Gilbert Corporation or CWC Chemical Inc.

All of the experiments from 1987 through 1989 are discussed below. In 1987, two experiments were performed to describe the activity of Garlon 4 and Chopper on green ash (Fraxinus pennsylvanica Marsh.), black birch (Betula lenta L.) and red maple (Acer rubrum L.). These species were chosen because maple is regarded as a relatively easy to control, black birch relatively difficult, and ash somewhat moderate. The first experiment utilized Garlon 4 at two rates and combined with two diluents; basal oil and diesel fuel. Chopper was also included at one rate and combined with only diesel fuel. The second experiment was performed to define the critical amount of Garlon 4 required to control ash and birch. This was accomplished by applying 0.5, 1.0, or 2.0 ml of basal solution per inch of caliper. Data from 1987, 1988, and 1989 are described below.

In 1988, two more basal bark experiments were initiated. The first was conducted to compare the efficacy of Garlon 4 diluted in basal oil or mineral oil, and to compare it with Access and Chopper. The second experiment compared the efficacy of applying Garlon 4 to the base of the target plant with applying the solution at the height of four foot on the stem. Data from 1988 and 1989 for experiment one and data from 1989 for experiment two are described below.

In 1989, one experiment was conducted to compare the efficacy of Garlon 4 with several diluents. They are diesel fuel, basal oil (Arborchem Basal Oil) , mineral oil (Rite Way Mineral Oil), soybean oil (Helena Chemical Soy-Dex), and a paraffinic oil (Helena Chemical Penetrator Plus). Preliminary results from 1989 are discussed below.

The rating system is the same for all of the basal bark experiments. Each stem is rated for control on a scale of 0-5 where a "0" indicates no treatment effect and a "5" indicates the stem has no visible green, living tissue. It is difficult to accurately determine whether a woody plant is completely dead, and birch is particularly difficult. In 1987, stems were rated a "5" after visual inspection and appeared dead, yet several were rated as a "4" the following season because it recovered and was able to produce some leaves. The tables below summarize the number of stems that occur in each rating category (0-5).

1987 Basal Bark Study

Experiment I

OBJECTIVE

To evaluate the efficacy of Garlon 4, Chopper, and two diluents on controlling green ash, black birch, and red maple.

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 for maple, and 20 stems 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 55° F and the soil temperature at a 6" depth was 30° F. During application to maple the air temperature was 14° F and the soil temperature was 28° F. Each stem was rated for control on a scale of 0-5 where a (0) indicates no treatment effect and a (5) indicates no visible living tissue. Treatments were rated on August 19, 1987, June 17, 1988, and September 5, 1989.

RESULTS AND DISCUSSION

The number of stems present in each rating category (0-5) is located in Table 10. There was no apparent difference in control between diluents for this species at either rate of Garlon. By September 5, 1989, control of ash with 5% Garlon was similar to control with 20% Garlon. The 20% rate however, was much more effective at the earlier rating dates. 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. By June 17, 1988, all ash stems treated with Chopper were dead. 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. By June 1988, all ash stems treated with Chopper were dead.

On August 19, 1987, several black birch plants treated with Garlon were defoliated and appeared to be dead and qualified for 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. On Sept. 5, 1989, the number of stems rated a "5" approached the 1987 levels for most treatments. Only 20% Garlon 4 in diesel fuel surpassed its 1987 levels as all treated stems were granted a "5" rating. There were more dead black birch stems for Garlon at 5% when mixed with diesel fuel than with Basal Oil at all rating dates. 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. By 1989, this level of control was nearly the same. 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. By June 17, 1988, several stems had recovered and by 1989 only 7 stems received a "5" rating.

The use of diesel fuel as a carrier resulted in control as good and in some cases better than with Basal Oil. Though Chopper provided excellent control of ash, marginal control of maple, and was very weak on birch.

Table 10: Injury off stems of green ash, black birch and red maple treated with basal bark applications with a variety of diluents. Each stem was rated on a 0 to 5 scale with a '0' indicating no treatment effect and a '5' indicating no visible living tissue. Stems were treated in March 1987, and rated on August 19, 1987, June 17, 1988, and September 5, 1989. 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	Garlon 4 5% Basal Oil			Garlon 4 5% Diesel			Garlon 4 20% Basal Oil			Garlon 4 20% Diesel			Chopper 6.25% Basal Oil		
Rating	8/87	6/88	9/89	8/87	6/88	9/89	8/87	6/88	9/89	8/87	6/88	9/89	8/87	6/88	9/89
0-5	number of stems														
Green Ash															
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
3	2	1	-	2	-	-	-	-	-	-	-	-	-	-	-
4	12	7	1	12	8	3	3		-	1	1	1	3	-	-
5	26	32	39	25	32	37	37	40	40	39	39	39	37	40	40
Total	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Black Birch															
0	-	-	-	-	-	-	-	-	-	-	-	-	-	10	2
1		1	1	-	-	-	-	-	-	-	-	-	2	9	7
2	1	2	4	-	-	-	-	-	1	-	-	-	10	-	8
3	5	5	5	-	1	4	1	3	5	-	1	-	7	-	2
4	6	7	1	8	11	5	5	9	1	4	4	-	-	-	-
5	4	1	5	12	8	11	13	7	12	14	13	18	-	-	-
Total	16	16	16	20	20	20	19	19	19	18	18	18	19	19	19
Red Maple															
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	2	2	-	-	-	-	-	-	-	-	-	-	-	-	3
4	2	4	4	-	-	-	-	-	-	-	-	-	2	15	10
5	28	26	30	30	30	30	30	30	30	30	30	30	18	5	7
Total	32	32	32	30	30	30	30	30	30	30	30	30	20	20	20

1987 Basal Bark Study
Experiment II

OBJECTIVE

To more precisely determine the amount of Garlon 4 required to control green ash and black birch.

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, and black birch. 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, June 17, 1988, and

September 5, 1989 on a rating scale was from 0-5, with a (0) being no treatment effect and (5) indicating no visible living tissue.

RESULTS AND DISCUSSION

The number of stems within each rating category for the rating dates are listed below in Table 11. All stems of green ash at the 0.5 ml rate were injured on August 19, 1987, but only 3 stems obtained a "5" rating. By June 17,1988 the degree of injury increased for those stems that were still alive. In 1989, the degree of injury was similar to 1988 and only four stems were rated as "5". The number of dead stems for black birch however, increased from one in 1987, to eight in 1988, to ten in 1989. The degree of injury decreased for the remaining stems in 1989 when compared to the previous ratings.

On August 1987, the 1.0 ml rate provided similar control of ash and birch. Half of the treated stems were dead. By June 1988, the number of dead stems had increased to 11 for both species, and by 1989, all of the birch and all but one of the ash were dead.

Ash was rapidly killed at the 2.0 ml rate. All but one treated stem was dead on August 1987, while only 7 birch stems were dead at this same time. By June 1988, 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. However, application of 2 ml/ inch circumference of solution killed all treated birch and ash. The 1.0 ml/inch, killed all birch stems and all but one ash stem, but the kill was slower and required three seasons to determine the final degree of control. The control provided by 0.5 ml/inch was unacceptable.

Table 11: Control of green ash and black birch from basal bark treatments applied at rates of 0.5, 1.0, or 2.0 ml/inch of stem circumference. Plants were treated with measured amounts of a solution containing 20% Garlon 4 and 80% Basal Oil. Rating was on a 0 to 5 scale with a '0' indicating no treatment effect and a rating of '5' indicates death of the treated plant. Treatments were applied on March 5, 1987, and rated on August 1987, June 1988, and September 1989.

Control	0.5 ml/in			1.0 ml/in			2.0 ml/in		
Rating	8/19/97	6/17/88	9/5/89	8/19/97	6/17/88	9/5/89	8/19/97	6/17/88	9/5/89
0 -5	number of stems								
Green Ash									
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	6	3	5	-	-	-	-	-	-
3	6	5	4	4	1	-	-	-	-
4	1	5	3	3	3	1	1	-	-
5	3	3	4	8	11	14	14	15	15
Total	16	16	16	15	15	15	15	15	15
Black Birch									
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	6	-	4	-	-	-	1	-	-
4	7	6	-	7	3	-	7	-	-
5	1	8	10	7	11	14	7	15	15
Total	14	14	14	14	14	14	15	15	15

1988 Basal Bark Study
Experiment I

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 Rite Way 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 75° F and 52° F respectively. The air and soil temperature on 3/17/88 was 61° F and 54° 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 using the same procedure and equipment as experiment 1 of 1987. Each stem was rated on a scale of (0-5) with (0) indicating no treatment effects and (5) indicating no visible living tissue

RESULTS AND DISCUSSION

Boxelder was completely controlled by all treatments except Chopper in 1988 and no recovery was apparent in 1989 (Table 12). The degree of injury increased for stems treated with Chopper in 1989.

Garlon at 20% in mineral oil was the only treatment to provide total control of ailanthus in 1988 and no recovery was evident in 1989. No other treatment provided total control of ailanthus in 1989. The degree of injury slightly decreased however for Garlon at 5% in mineral oil in 1989 when compared to 1988. The degree of injury increased for all other treatments in 1989 when compared to 1988.

Black locust in either diesel fuel or mineral oil provided good, but not total control. Chopper provided poor control of locust. 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 12: Injury to stems of black locust, boxelder maple, and tree of heaven. Each stem was rated on a 0 to 5 scale with a '0' indicating no treatment effect and a '5' indicating no visible living tissue. Stems of boxelder and black locust were treated on April 4, 1988 and tree of heaven was treated on March 17, 1988. Rating dates appear at the top of each column. 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 used for each treatment.

Control Rating	Garlon 5% Diesel Fuel		Garlon 5% Mineral Oil		Garlon 20% Diesel Fuel		Garlon 20% Mineral Oil		Access 5% Diesel		Access 20% Diesel Oil		Chopper 6.25% Diesel Fuel	
0-5	---------- number of stems ----------													
Box Elder														
	8/88	10/89	8/88	10/89	8/88	10/89	8/88	10/89	8/88	10/89	8/88	10/89	8/88	10/89
0	-	-	-	-	-	-	-	-	-	-	-	-	1	-
1	-	-	-	-	-	-	-	-	-	-	-	-	3	-
2	-	-	-	-	-	-	-	-	-	-	-	-	5	-
3	-	-	-	-	-	-	-	-	-	-	-	-	6	5
4	-	-	-	-	-	-	-	-	-	-	-	-	13	8
5	39	39	34	34	31	31	33	33	36	36	30	30	11	26
Total	39	39	34	34	31	31	33	33	36	36	30	30	39	39
Ailanthus														
	8/88	10/89	8/88	10/89	8/88	10/89	8/88	10/89	8/88	10/89	8/88	10/89	8/88	10/89
0	-	-	-	-	-	-	-	-	-	-	-	-	6	-
1	1	-	-	-	-	-	-	-	-	-	-	-	8	-
2	6	-	-	-	-	-	-	-	-	-	-	-	5	1
3	3	5	-	-	3	-	-	-	1	-	-	-	7	1
4	4	8	1	3	5	4	-	-	14	4	4	3	12	8
5	10	11	34	32	34	38	40	40	17	18	28	29	4	32
Total	24	24	35	35	42	42	40	40	22	22	32	32	42	42
Black Locust														
	9/89	10/89	9/89	10/89	9/89	10/89	9/89	10/89	9/89	10/89	9/89	10/89	9/89	10/89
0	1	1	-	-	-	-	-	-	-	-	-	-	-	3
1	-	1	-	-	-	1	-	1	-	-	-	-	7	2
2	-	1	-	1	-	-	-	1	-	-	-	-	1	2
3	3	1	1	1	1	-	2	-	1	1	-	-	-	-
4	-	-	1	-	-	-	-	-	6	1	-	-	-	1
5	16	15	8	8	19	19	9	9	-	5	9	9	1	1
Total	19	19	10	10	20	20	11	11	7	7	9	9	9	9

1988 Basal Bark Study

Experiment II

INTRODUCTION

In late 1987, reports described adequate control of several species of brush using the basic basal technique except the treatment was applied at a height of four feet on the stem rather than at the base of the stem. The advantages of this variation include much easier and quicker treatment because the applicator would not be concerned with clearing vegetation from the base of the stem, treatment could still be performed when the ground is snow covered, and bark tissues tend to be thinner at that height when compared to the base of the stem. This experiment was performed to compare a treatment band at four feet on the stem with a conventional application to the base of the stem.

OBJECTIVE

To compare a conventional basal bark application to the base of the stem to a treatment band at four feet on the stem on box elder maple, tree of heaven (ailanthus), black locust, and black birch.

MATERIALS AND METHODS

Garlon 4 was diluted in diesel fuel and applied at 5 and 20% in late March 1988 to stems of box elder maple, tree of heaven (ailanthus), black locust, and black birch. Treatments were applied to either the base of the stem or to a height of approximately four feet. The treatment width for the base application was 12-16", which is the conventional method. The band width for the four foot was targeted to be as close to the 12-16" band as possible. However, treatments tended to run down the stem after application and the effective band could have been larger than 12-16", particularly on birch, which has a shiny, oily bark surface.

Each stem was rated on 9/9/88 and 10/9/89 on a scale of (0-5) with (0) indicating no treatment effects and (5) indicating no visible living tissue. Only the 10/9/89 data is presented. The stems treated with the base treatment only received one rating for the whole plant. Those stems treated at four feet received two ratings; one describing conditions above the treatment band, and another describing conditions below the treatment band. Those stems with a "5" rating above the band and a "0" rating below the band indicates that the treatment had no effect on existing stems or resprouts in that region. A stem with a rating of "5" above and below the treatment band indicates the whole stem was controlled.

RESULTS AND DISCUSSION

The total number of stems occurring each rating category for all species is presented in Table 13. All species resprouted except black birch. Black birch produced some adventitious buds, and a few small sprouts below the treated area the first season, but none of them were present on 10/9/89. Box elder was the most prolific resprouter producing an intense flush of growth along the length of the stem below the treatment. Many stems of black locust had established stems below the treated area and these produced intense growth during both seasons after treatment.

Boxelder was easily controlled by 5 and 20% Garlon when treated at the base. At 5% treated at four feet, over half of the stems survived and resprouted vigorously. At 20% treated at four feet, control was somewhat better, but 14 out of 34 resprouted.

The best treatment for controlling ailanthus was Garlon 20% treated at the base. The control achieved with the 5% base treatment was not adequate. Roughly half of the stems treated at four foot with either rate resprouted below the treatment band.

Black locust was controlled reasonably well with either rate of Garlon when treated at the base. However, there was prolific growth from existing stems below the four foot treatment area at both rates.

Black birch did not produce many resprouts and the four foot treatments were the most effective on this species. Garlon at 5% provided moderate control of birch at either treatment. Garlon at 20% applied at the base controlled all treated stems on 10/9/89. The four foot treatment controlled 25 of the 29 stems treated.

CONCLUSION

Black birch was the only species that was adequately controlled by the four foot treatments. All others were able to grow well from existing stems or adventitious buds. This may suggest Garlon only moves upward in the plant or is moved downward in a sublethal dose when applied to the bark in this manner.

Table 13: Injury to stems of boxelder maple, tree of heaven (ailanthus), black locust, and black birch treated with basal bark applications at the stem base or at a height of 4 ft. Each stem was rated on a 0 to 5 scale, with a '0' indicating no treatment effect and a '5' indicating no visible living tissue. Treatments were applied in late March, and rated on October 9, 1989. All treatments were diluted in diesel fuel.

Control Rating	Garlon 4@5% Treated at Base Above Trt.	Garlon 4@5% Treated at 4 foot Above Trt.	Garlon 4@5% Treated at 4 foot Below Trt.	Garlon 4@20% Treated at Base Above Trt.	Garlon 4@20% Treated at 4 foot Above Trt.	Garlon 4@20% Treated at 4 foot Below Trt.
0-5	number of stems					
Box Elder						
0	-	-	22	-	-	14
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	39	31	9	31	34	20
Total		39	31	31	31	34
24						
Ailanthus						
0	-	-	17	-	-	20
1	-	-	-	-	-	-
2	-	2	-	-	-	-
3	5	-	-	-	-	-
4	8	-	-	4	-	-
5	11	32	17	38	40	20
Total	24	34	34	42	40	40
Black Locust						
0	1	-	13	-	-	15
1	1	-	1	1	-	1
2	1	-	1	-	-	-
3	1	-	-	-	-	-
4	-	-	-	-	-	-
5	15	19	4	19	16	-
Total	19	19	19	20	16	16
Black Birch						
0	-	-	-	-	-	-
1	-	-	-	-	-	-
2	-	1	-	-	-	-
3	5	5	-	-	-	-
4	9	12	-	-	4	-
5	20	16	34*	22	25	29*
Total	34	34	34	22	29	29

* No sprouting was evident on birch, while all other species resprouted below the four foot treatment band.

1989 Basal Bark Study
Experiment I

OBJECTIVE

To determine the efficacy of five diluents in combination with 20% Garlon 4 in controlling ash and birch.

MATERIALS AND METHODS

Garlon 4 at 20% was mixed with five diluents and applied at 1.0 ml/inch and 2.0 ml/inch circumference to stems of ash and birch. Twenty stems of both species were used for each treatment. The diluents were Arborchem Basal Oil, N.G. Gilbert Rite Way Mineral Oil, a soybean oil (Helena Soy-Dex), a paraffin based oil (Helena Penetrator Plus), and diesel fuel. 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 in early April, 1989. Each stem was rated for control on September 28, 1989 on a rating scale was from 0-5, with a (0) being no treatment effect and (5) indicating no visible living tissue.

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 1990 season.

Diesel fuel, Basal Oil, mineral oil, and Penetrator Plus at either rate all provided good control of ash on September 28, 1989. The Soy-Dex did not provide adequate control of ash at this rating date.

The high and low rate with mineral oil and the high rate with diesel fuel provided a "5" rating in over 50% of the treated stems of birch. No other treatments provided this degree of injury. Based on the previous experiments, the true expression of control in birch will not be known until at least the 1990 season.

Table 14: Injury to stems of green ash and black birch treated with measured amounts of solution containing 20% Garlon 4 diluted in either diesel fuel, Basal Oil, mineral oil, Soy-Dex, or Penetrator Plus. Each stem was rated on a 0 to 5 scale with a '0' indicating no treatment effect and a '5' indicating no visible living tissue. Treatments were applied in early April 1989and rated in September 1989.

	Garlon 4 20% Diesel Fuel		Garlon 4 20% Basal Oil		Garlon 4 20% Mineral Oil		Garlon 4 20% Soy-Dex		Garlon 4 20% Penetrator Plus	
Control Rating	1 ml/ inch	2 ml/ inch	1 ml/ inch	2 ml/ inch	1 ml/ inch	2 ml/ inch	1 ml/ inch	2 ml/ inch	1 ml/ inch	2 ml/ inch
0-5	----------	----------	----------	----------	number of stems	----------	----------	----------	----------	----------
Green Ash										
0	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	1	2	-	-
2	-	-	-	-	-	-	1	1	1	-
3	-	-	-	-	1	-	3	1	-	1
4	-	-	-	-	1	-	7	6	1	1
5	20	20	20	20	18	20	8	10	18	18
Total	20	20	20	20	20	20	20	20	20	20
Black Birch										
0	-	-	1	-	-	-	1	-	-	-
1	-	-	4	-	-	-	5	2	3	-
2	2	-	3	3	-	-	9	5	5	2
3	5	-	5	8	5	3	4	5	4	7
4	7	8	4	5	3	4	1	2	4	5
5	6	12	3	4	12	13	-	6	4	6
Total	20	20	20	20	20	20	20	20	20	20

TOTAL VEGETATION CONTROL STUDIES

The 1989 total vegetation control research consisted of the following four studies:

- Preemergence applications to a guiderail site
- Postemergence applications to a guiderail site.
- Comparison of preemergence materials for giant foxtail control.
- Comparison of 'burn-down' materials for postemergence applications.

Table 1 lists all the herbicides used in the above studies.

TABLE 1: Product name, formulation, active ingredient, and manufacturer of herbicides used for total vegetation control research in 1989.

Product	Formulation	Active Ingredient	Manufacturer
Arsenal	2 S	imazapyr	American Cyanamid
Diquat H/A	2 S	diquat	Valent
Hyvar X	80 DF	bromacil	DuPont
Ignite	1.67 S	glufosinate	American Hoechst
Karmex	80 DF	diuron	DuPont
Krovar I	80 DF	bromacil plus diuron	DuPont
Lorox	50 DF	linuron	DuPont
Oust	75 DF	sulfometuron methyl	DuPont
Prozine	70 DF	atrazine plus pendimethalin	American Cyanamid
Ronstar	50 WP	oxadiazon	Rhone Poulenc
Ronstar	2 EC	oxadiazon	Rhone Poulenc
Roundup	4 S	glyphosate	Monsanto
Spike	80 WP	tebuthiuron	DowElanco
Stomp	4 EC	pendimethalin	American Cyanamid
Surflan	4 AS	oryzalin	DowElanco
Velpar	2 S	hexazinone	DuPont

Preemergence Applications to Guiderails

OBJECTIVE

To evaluate the efficacy and duration of control provided by several herbicide combinations applied prior to emergence of annual weeds on highway guiderail sites.

MATERIALS AND METHODS

The experimental site was a cable-and-post guiderail along SR 0220 near Unionville, in Centre County. The treatments were applied April 18, 1989, using a CO_2 pressurized backpack sprayer delivering the equivalent of 27 GPA at 25 psi with two OC-04 nozzles. One nozzle was angled forward, the other rearward, to provide coverage around the guiderail posts. Each plot was 25 feet long and three feet wide, with two feet in front, and one foot behind the guiderail treated. The plots were arranged in a randomized complete block experimental design with four replications. Weed species present at the time of treatment included broadleaf dock, plantains, wild parsnip, goldenrod, red clover, wild carrot, bull thistle, common evening primrose, wild garlic, Kentucky bluegrass, and tall fescue. Visual ratings of percent vegetative cover were taken August 15 and October 30, 1989, 17 and 28 weeks after treatment (WAT), respectively.

The treatments were centered around six soil applied herbicides providing broad spectrum control , and three herbicides for residual preemergence control of annual weeds. The treatment combinations and results are listed in Table 2. Rates were based on consideration of labeling, current PennDOT use rates, and results of 1988 research. Karmex, Hyvar X, Krovar I, and Spike were evaluated alone, while Arsenal and Oust were evaluated alone and in combination with either Prozine, Surflan, or Stomp.

TABLE 2: Percent weed cover ratings for bare ground treatments applied April 18, 1989. Each value is the mean of four replications.

Treatment	Application Rate	Application Rate	Weed Cover 17 WAT	Weed Cover 28 WAT
	(product/acre)	(lb ai/acre)	(%)	(%)
1. Arsenal	3 pts	0.75	46	46
2. Arsenal + Prozine	3 pts + 11.5 lb	0.75 + 8	11	18
3. Arsenal + Surflan	3 pts + 3 qts	0.75 + 3	37	28
4. Arsenal + Stomp	3 pts + 4 qts	0.75 + 4	39	46
5. Oust	4 oz	0.19	28	28
6. Oust + Prozine	4 oz + 11.5 lb	0.19 + 8	13	19
7. Oust + Surflan	4 oz + 3 qts	0.19 + 3	38	38
8. Oust + Stomp	4 oz + 4 qts	0.19 + 4	30	30
9. Karmex	16 lb	12.8	11	20
10. Hyvar X	5 lb	4	11	10
11. Krovar I	10 lb	8	13	19
12. Spike 80W	4 lb	3.2	9	20
13. Untreated Check	- - -	- - -	90	91
LSD (P=0.05)			20	22

RESULTS

The untreated check was rated at 90 and 91 percent cover, 17 and 28 WAT. All treatments provided control significantly better than the check at both rating dates, and there was little change in the ratings for each treatment between rating dates, indicating that all treatments maintained their residual activity for at least 28 weeks. Differences between treatments may have been due more to initial activity, rather than residual properties.

At 17 WAT, Arsenal plus Prozine provided significantly better control than Arsenal alone, or Arsenal plus either Surflan or Stomp. The atrazine component of Prozine apparently enhanced the control of existing vegetation. At 28 weeks, Arsenal plus Prozine again provided significantly better control than Arsenal alone or Arsenal plus Stomp.

The performance trends observed with the Arsenal combinations were also apparent in the Oust combinations. Oust plus Prozine plots had less weed cover than Oust alone or in combination with Surflan or Stomp at both rating dates.

The applications of Hyvar X and Krovar I included equal amounts of bromacil. Though Krovar I also included diuron, its performance was rated slightly less than Hyvar X. Under the conditions of this study, the addition of diuron to bromacil in Krovar I did not enhance performance compared to bromacil alone in Hyvar X.

Karmex and Spike provided control similar to Hyvar X and Krovar I.

CONCLUSION

In plots treated with six of the twelve herbicide combinations, weed cover was 20 percent or less at the end of the season. These six treatments were Arsenal plus Prozine, Oust plus Prozine, Karmex, Hyvar X, Krovar I, and Spike. Arsenal and Oust when applied alone or with either Surflan or Stomp were not as effective as when combined with Prozine. The atrazine in Prozine apparently enhanced the control of the existing vegetation, and supplemented the preemergence activity of the pendimethalin in Prozine.

Postemergence Applications to Guiderails

OBJECTIVE

To evaluate efficacy of herbicide combinations applied to burn down emerged annual weeds and to determine the length of control when provided along highway guiderails.

MATERIALS AND METHODS

The site and application equipment used for this study was the same as that used in the preemergence study. Ten herbicide combinations and an untreated check were applied May 22, 1989. Six bare-ground herbicides, Arsenal, Oust, Karmex, Krovar I, Hyvar X, and Spike, were applied at the same rates as the preemergence study. Arsenal and Oust were also applied in combination with either Roundup or Diquat, to evaluate the effects of adding foliarly active herbicides to bare ground herbicides. A surfactant, CideKick II, was added to all treatments at 0.25% (v/v). Observations of percent weed cover were taken August 15 and October 30, 12 and 23 WAT, respectively. Treatment combinations and results are listed in Table 3.

TABLE 3: Weed cover ratings for bare ground treatments applied May 22, 1989. Each value is the mean of four replications.

Treatment	Application Rate	Application Rate	Weed Cover 12 WAT	Weed Cover 23 WAT
	(product/acre)	(lb ai/acre)	(%)	(%)
1. Arsenal	3 pts	0.75	27	41
2. Arsenal + Roundup	3 pts + 1 qt	0.75 + 1	22	30
3. Arsenal + Diquat	3 pts + 1 qt	0.75 + 0.5	29	36
4. Oust	4 oz	0.19	28	41
5. Oust + Roundup	4 oz + 1 qt	0.19 + 1	13	29
6. Oust + Diquat	4 oz + 1 qt	0.19 + 0.5	8	15
7. Karmex	16 lb	12.8	7	16
8. Hyvar X	5 lb	4	44	35
9. Krovar I	10 lb	8	14	10
10. Spike 80W	4 lb	3.2	31	39
11. Untreated Check	- - -	- - -	81	84
LSD (P=0.05)			22	24

RESULTS

The untreated check was rated at 81 and 84 percent cover 12 and 23 WAT. All treatment combinations provided control significantly better than the check.

All Arsenal treatment combinations had 30 percent or greater weed cover when rated 23 WAT. The performance of Arsenal was not significantly enhanced by the addition of Roundup or Diquat.

When Roundup or Diquat was added to Oust, an increase in control was observed, particularly at 23 WAT. Oust plus Diquat was rated at 15 percent cover, which was significantly better than Oust alone, rated at 41 percent weed cover. Oust plus Roundup was rated at 29 percent cover 23 WAT, which was not significantly different from either Oust alone or with Diquat.

Although the rate of bromacil applied in Krovar I and Hyvar X treatments was equal, Krovar I performed significantly better than Hyvar X, indicating the addition of diuron to bromacil enhances postemergence performance.

The performance of Karmex was similar to Krovar I. Spike and Hyvar X provided similar control, but both provided less control than Karmex or Krovar I.

CONCLUSION

When applied alone, neither Arsenal nor Oust provided adequate control of existing weeds or long term control. The addition of Roundup or Diquat did not greatly improve the performance of Arsenal, but the addition of Diquat did significantly improve the performance of Oust. Bromacil alone was not as effective applied postemergence compared to preemergence, but Krovar I, with bromacil and diuron, performed well pre- and postemergence. Diuron alone, Karmex, also performed well pre- and postemergence. Spike, like Hyvar X, was less effective applied postemergence compared to preemergence.

Comparison of Preemergence Herbicides for Giant Foxtail Control

OBJECTIVE

To evaluate preemergence herbicides for their ability to provide season long control of giant foxtail, a common species along guiderail areas treated with bare ground herbicide combinations.

MATERIALS AND METHODS

Twelve treatments were applied to an agricultural site with a heavy infestation of giant foxtail. The site had been fallow in 1988, and was used for no-till corn weed control research in 1987. The area had not been tilled for nearly twenty years. Up to one inch of plant stubble covered the soil surface. Treatments were applied May 23, 1989, using a CO_2 pressurized hand-boom sprayer, delivering the equivalent of 34 GPA at 25 psi with Spraying Systems 6504 flat fan nozzles. Plots were 6 by 25 feet, and arranged in a randomized complete block design with three replications.. Some giant foxtail had already emerged, and was up to the two leaf stage. Diquat and surfactant were added to all treatments to kill the existing foxtail. The herbicides included in the study were Prozine, Surflan, Stomp, Karmex, two formulations of Ronstar, Lorox, and Diquat alone. Data for giant foxtail cover was collected July 19 and October 16, 8 and 21 WAT. Treatment combinations and results are listed in Table 4.

TABLE 4: Giant foxtail cover ratings for treatments applied May 23, 1989. Each value is the mean of three replications.

Treatments	Application Rate	Application Rate	Foxtail Cover 8 WAT	21 WAT
	(product/acre)	(lb ai/acre)	(%)	(%)
1. Prozine + Diquat	11.5 lb + 1 qt	8 + 0.5	8	45
2. Surflan + Diquat	3 qt + 1 qt	3 + 0.5	57	55
3. Surflan + Diquat	4 qt + 1 qt	4 + 0.5	30	48
4. Stomp + Diquat	3 qt + 1 qt	3 + 0.5	30	55
5. Stomp + Diquat	4 qt + 1 qt	4 + 0.5	33	78
6. Karmex + Diquat	8 lb + 1 qt	6.4 + 0.5	6	18
7. Karmex + Diquat	16 lb + 1 qt	12.8 + 0.5	0	3
8. Ronstar 50W + Diquat	4 lb + 1 qt	2 + 0.5	13	50
9. Ronstar 2E + Diquat	4 qt + 1 qt	2 + 0.5	15	55
10. Lorox 50DF + Diquat	2 lb + 1 qt	1 + 0.5	82	87
11. Diquat	1 qt	0.5	82	87
12. Untreated Check	---	---	83	92
LSD (P=0.05)			22	37

RESULTS

The untreated check was rated at 83 and 92 percent giant foxtail cover 8 and 21 WAT. Lorox and Diquat alone were essentially indistinguishable from the check.

The two rates of Karmex provided the best control, both initially and at 21 WAT. At 21 WAT, control provided by the high rate was significantly better than all treatments except the low rate of Karmex.

Prozine provided good control at the 8 WAT rating, but by 21 WAT, giant foxtail covered 45 percent of the plots. Surflan did not provide adequate control at either rate of application. The results from Stomp were similar to those of Surflan, with slightly more cover 21 WAT.

There was no performance difference between the two formulations of Ronstar. Both performed well 8 WAT, but by 21 WAT control was similar to Surflan and Stomp.

CONCLUSION

The limited control provided by Surflan and Stomp is thought to be due to the timing of the applications and the condition of the soil surface. Since giant foxtail was already germinating, it is reasonable to assume that plants were present as germinated seeds and seedlings that had not yet broken the soil surface. These plants would not be affected by the Diquat that was added to all treatments. Surflan and Stomp have very low solubilities, and may not have been able to reach the germination zone in time to prevent already germinated plants from developing normally. The plant residue on the surface would further increase the amount of time, or rainfall, necessary to carry Surflan and Stomp to the seedbed.

Like Stomp, Prozine contains pendimethalin, and was applied at a rate of pendimethalin equal to the high rate of Stomp. The performance difference between these two products 8 WAT was probably due to the atrazine in Prozine. Atrazine is more soluble than pendimethalin, and is translocated once taken up by roots.

Ronstar has a very low solubility like Surflan and Stomp, but provided better early control than these two herbicides. Ronstar forms a barrier at the soil surface and burns seedlings as they emerge, so Ronstar is essentially 'in place' when it is applied, whereas Surflan and Stomp must be moved into the upper layer of the soil, before germination, to be active.

Karmex has a higher solubility than Surflan or Stomp, and it is effectively translocated after root uptake. Plants that were not controlled by Diquat would be controlled once the Karmex was taken up by the roots. This wider spectrum of activity, in conjunction with the rates used and stable characteristics of the site contributed to the superior performance of Karmex in this study.

This study should be repeated with an earlier application time to appraise preemergence activity. Ideally the study should be conducted on both an agricultural and a guiderail site. Using an agricultural site provides a better opportunity to evaluate these materials under conditions of consistent foxtail density. The disadvantage of the agricultural area is that the site is not subjected to the water flow conditions of guiderail sites, nor are the soil conditions the same. By combining the information from a site with consistent, high foxtail pressure and a guiderail site with high variabilities in water flow, surface characteristics, and foxtail density, a reasonable estimate of the giant foxtail control provided by these materials under guiderail conditions can be made.

Comparison of Burndown Materials for Postemergence Applications

OBJECTIVE

To compare foliar active herbicides for their ability to control existing vegetation as part of a bare ground herbicide application.

MATERIALS AND METHODS

The site used was an agricultural area with a dense stand of giant foxtail. Other species present included common lambsquarters and prickly lettuce. The treatments were applied August 3, 1989, using a CO_2 pressurized hand held plot sprayer, using Spraying Systems 8004 flat fan nozzle at 24 psi, delivering a spray volume of 26 GPA. Each plot was 6 by 25 feet, replicated three times in a randomized complete block design. When the treatments were applied the giant foxtail was 12 to 18 inches tall, and no seedheads had emerged. The temperature was 90° F, and the relative humidity was approximately 90 percent. The site received rainfall seven hours after treatment. The plots were rated for percent burndown August 11 and August 28, 1 and 4 WAT.

The treatments and results are listed in Table 5. Six herbicides that have non-crop labels, or are near registration for non-crop use were evaluated. They were Diquat, Ignite, Karmex, Lorox, Roundup, and Velpar. A non-ionic surfactant, CideKick II, was included at 0.25% (v/v) with all treatments except Ignite, which had surfactant premixed.

TABLE 5: Percent burndown for treatments applied August 3, 1989. Each value is the mean of three replications.

			Weed Burndown	
Treatment	Application Rate	Application Rate	1 WAT	4 WAT
	(product/acre)	(lb ai/acre)	(%)	(%)
1. Roundup	1 qt	1.0	95	100
2. Diquat	1 pt	0.25	70	60
3. Diquat	1 qt	0.5	78	70
4. Lorox	2 lbs	1.0	0	8
5. Ignite	5 pts	1.0	87	100
6. Karmex	4 lbs	3.2	0	20
7. Karmex	8 lbs	6.4	0	63
8. Velpar	3 pts	0.75	0	17
LSD (P=0.05)			2	8

RESULTS AND CONCLUSION

Treatment effects from Roundup, Ignite, and Diquat were evident 1 WAT. By 4 WAT, the control provided by Roundup and Ignite was 100 percent, while control by Diquat had decreased. Since Diquat is strictly a contact material, any growing points that were not contacted continued to grow. Karmex, Lorox, and Velpar showed no effects at 1 WAT. Karmex was rated at 63 and 20 percent burndown for the high and low rates at 4 WAT, Lorox was rated at 8 percent burndown, and Velpar was rated at 17 percent burndown.

The results of this study demonstrated distinct differences between the materials tested. A roadside setting will have different soil and water flow characteristics and a greater variety of species than were evaluated in this test. However, this study does give an indication of relative performance under a standard test condition. Also, the burndown component of a mix is not the sole control agent. Most bare ground herbicides will control plants through root uptake if a burndown herbicide does not provide complete control. There will be situations where a burndown material is not appropriate, such as woody vine control with a foliar herbicide such as Arsenal. A quick acting burndown herbicide will interfere with the activity of the vine control material, and result in poor control. Consider the target species and the activity of the bare ground herbicides when choosing a burndown herbicide.

WILDFLOWER SPECIES EVALUATION

INTRODUCTION

The use of wildflowers for roadside plantings has been receiving great attention throughout the country in recent years. Pennsylvania roadside managers have been interested in initiating a wildflower program, but had concerns about selecting species to include in a seed mixture. The ideal mixture will be one that would flower most of the season, be persistent year after year, and compete well with weeds. A species selection study began in 1988 to evaluate several annual and perennial plants. The species involved in this initial study were selected by Pure Seed Testing Inc. of Oregon as part of a national wildflower evaluation. All species were planted in individual plots and evaluated for two seasons on their flowering, weed competition, and cover potential.

Based on these evaluations, the successful species will be candidates for mixes to be utilized on Pennsylvania's roadsides. A wildflower was considered successful if it vegetatively covered at least 60% of the plot area and its flower production covered at least 30% of the plot area. If a plant were being evaluated for use by itself, 60% coverage may not be adequate. However, the mix will be a combination of several plants and 60% coverage is thought to be sufficient.

OBJECTIVES

Evaluate wildflower species for their suitability as roadside vegetation, based on ability to establish and persist while providing an aesthetic attraction for the motorist.

MATERIALS AND METHODS

Twenty-four annuals and twenty-six perennial wildflower species were planted on April 24, 1988 in individual 5 by 5 foot plots and replicated three times. Species and planting rates are listed in Table 1. The planting site is located near State College, PA and had previously been an alfalfa field. The site was prepared by eliminating the alfalfa with an application of Roundup (glyphosate) and 2,4-D on April 10, 1988. A PTO driven verticut unit from an Olathe overseeder was used to slit the soil approximately 0.5 inch deep on 3 inch centers. The seed for each plot was suspended in 100 grams of Milorganite and shaken on the plot using a one quart mason jar with a perforated lid. A wind screen was placed around the plot during seeding. The study site was not irrigated or fertilized during the growing season. In late October 1988, each plot was mowed and the clippings were left in the plot.

Each plot was rated for percent of the plot area covered by the wildflower species, percent weed cover, and percent of the plot covered by blossoms. Only percent cover and percent bloom will be discussed in this report. By the end of the 1988 season, the area of the plot not covered by the wildflowers was covered with weed growth. Ratings in 1988 were taken on June 13, June 27, July 12, August 9, and September 28. This report includes the 1989 ratings of May 29, June 22, July 4, and July 18. Based on this study, the wildflower species rated as successful will be incorporated into several different mixes to be utilized on Pennsylvania's roadsides. A wildflower was considered successful if it vegetatively covered at least 60% of the plot area and its flower production covered at least 30% of the plot area.

RESULTS

In general, the annual species established and produced cover sooner than the perennial species at the early rating periods in 1988. Twenty of the twenty four annual species produced more than 60% vegetative cover in 1988 (Figure 1). These twenty species were grouped based on general growth patterns. The first group produced a flush of growth by June 5, and coverage remained stable throughout the season. Some examples of species in this group were garland chrysanthemum, tall plains coreopsis, and California poppy. A second group displayed a decline in cover after the initial flush of growth, and by the end of the season were typically invaded by weed growth. Examples of these species were farewell-to-spring, clarkia, and spurred snapdragon. A third group displayed a relatively slow establishment rate, yet coverage increased steadily throughout the season. Examples of species in this group are lemon mint, scarlet flax, and cosmos.

TABLE 1: Common name, scientific name, and seeding rate in pounds per acre for the annual wildflower species planted in 1988.

Common Name	Scientific Name	Seeding Rate (lbs/acre)
Pimpernel	Anagallis arvensis	24
Dwarf Cornflower	Centaurea cyanus dwarf.	20
Garland Chrysanthemum	Chrysanthemum coronarium	76
Farewell to Spring	Clarkia amoena	21
Clarkia	Clarkia unguiculata	20
Tall Plains Coreopsis	Coreopsis tinctoria	20
Cosmos	Cosmos bipinnatus	19
Rocket Larkspur	Delphinium ajacis	20
African Daisy	Dimorphotheca aurantiaca	41
California Poppy	Eschscholzia californica	20
Indian Blanket	Gaillardia pulchella	22
Globe Gilia	Gilia capitata	19
Baby's Breath	Gypsophila elegans	20
Tidy Tips	Layia platyglosa	20
Mountain Phlox	Linanthus grandiflorus	24
Spurred Snapdragon	Linaria maroccana	20
Scarlet Flax	Linum grandiflorum rubrum	50
Sweet Alyssum	Lobularia maritima	32
Blue Bells	Mertensia virginica	19
Lemon Mint	Monarda citriodora	31
Baby Blue Eyes	Nemophila menziesii	22
Corn Poppy	Papaver rhoeas	20
Scabiosa	Scabiosa stellata	40
Catchfly	Silene armeria	20

TABLE 2: Common name, scientific name, and seeding rate in pounds per acre for the perennial wildflower species planted in 1988.

Common Name	Scientific Name	Seeding Rate (lbs/acre)
White Yarrow	Achillea millefolium	20
Red Yarrow	Achillea millefolium rubrum	20
Chamomile	Anthemis tinctoria	39
Dwarf Columbine	Aquilegia vulgaris	25
Snow in Summer	Cerastium biebersteinii	20
Siberian Wallflower	Cheiranthus allionii	19
English Wallflower	Cheiranthus cheiri	22
Lance-Leaved Coreopsis	Coreopsis lanceolata	23
Sweet William	Dianthus barbatus	19
Maiden Pinks	Dianthus deltoides	19
Purple Coneflower	Echinacea purpurea	51
Blanketflower	Gaillardia aristata	21
Dames Rocket	Hesperis matronalis	20
Standing Cypress	Ipomopsis rubra	20
Blue Flax	Linum perenne lewisii	20
Forget-me-not	Myosotis sylvatica	23
Evening Primrose	Oenothera lanarkiana	19
Missouri Primrose	Oenothera missouriensis	20
Rocky Mountain. Penstemon	Penstemon strictus	20
Prairie Coneflower	Ratibida columnifera	42
Black-Eyed Susan	Rudbeckia hirta	19
Small Burnet	Sanguisorba minor	20
Creeping Zinnia	Sanvitalia procumbens	21
Soapwort	Saponaria ocymoides	19
Wild Thyme	Thymus serpyllum	19
Johnny Jump Up	Viola cornuta	21

included blanketflower, English wallflower, standing cypress, Siberian wallflower, and small burnet. Although sweet William and purple coneflower did not perform well in 1988, they have been successful in 1989.

The eleven species that provided over 60% coverage in 1989 also provided impressive flowers during the 1989 ratings (Figure 8). Blue flax flowered the earliest and was already past its peak before the first rating date on May 29. Dames rocket had started flowering approximately a week prior to May 29 and was at its peak at that date. Chamomile, sweet William, lance leaf coreopsis, and both yarrows were producing blooms on June 22 and were at peak production on July 4. On July 18, black-eyed Susan, prairie coneflower, and purple coneflower were the most impressive.

Information will be collected from this study throughout the 1989 growing season. This information will be used to develop wildflower mixes for Pennsylvania's roadsides. Roadside managers can use this information to select wildflower species with the coverage potential, flowering time, and flowering duration desired.

TABLE 3: Rainfall accumulation (inches) for the growing season in 1988 and 1989.

Month	1988	1989
April	1.50	0.70
May	4.20	6.15
June	0.92	8.80
July	3.35	5.47
August	5.88	0.55
September	2.97	3.17
October	1.27	3.50
Growing Season Total	20.09	28.34
Deviation From Average (24.20)	- 4.11	4.14

All of the annual species bloomed during the season (Figure 2). The bloom production was diverse and occurred throughout the season. Some species such as baby's breath and clarkia displayed profuse flower production for a short period of time. Others such as Indian blanket and catchfly flowered steadily throughout the season.

The growth and flowering of the perennials was slower than the annuals. Fourteen out of the twenty six species planted produced more than 60% coverage during 1988 (Figure 3). Coverage generally increased at a steady rate throughout the season with most species rated at peak cover on the last rating date.

Ten perennials produced flowers during 1988 (Figure 4). Of these, only Siberian wallflower, black-eyed Susan, and blanketflower produced impressive displays. All other perennial species produced mostly vegetative growth.

Although ratings are not complete for the 1989 season, data through July 18 shows overall wildflower performance is different from that observed in 1988. In 1989, few annuals displayed acceptable performance, while the activity of several perennials was impressive. Although twenty annual species were successful in 1988, only seven of these reseeded successfully enough to produce more than 60% coverage in 1989 (Figures 5 & 6). The greatest percent coverage was achieved by rocket larkspur, tall plains coreopsis, and dwarf cornflower. These three species also had the best flower production. The other annuals that reseeded successfully were globe gilia, sweet alyssum, California poppy, and catchfly.

In 1989, eleven perennial species produced more than 60% coverage (Figure 7). Although fourteen species were successful in 1988, only nine of these performed well in 1989 and included blue flax, dames rocket, chamomile, red yarrow, white yarrow, prairie coneflower, lance leaved coreopsis, black-eyed Susan, and evening primrose. The five species that did not perform well

Figure 1: Percent vegetative cover provided by annual wildflower species in 1988.

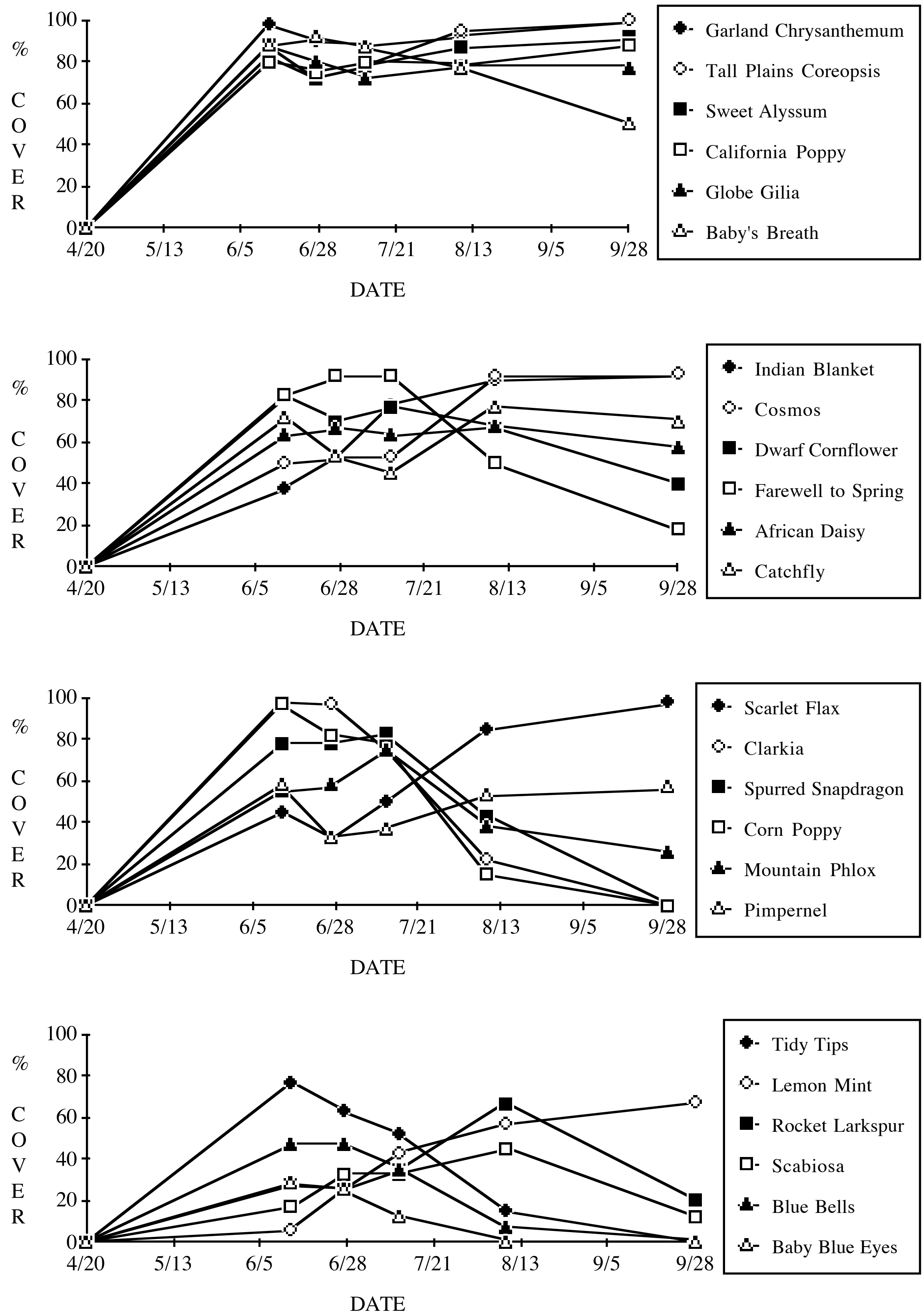


Figure 2: Percent blossom cover provided by annual wildflower species in 1988.

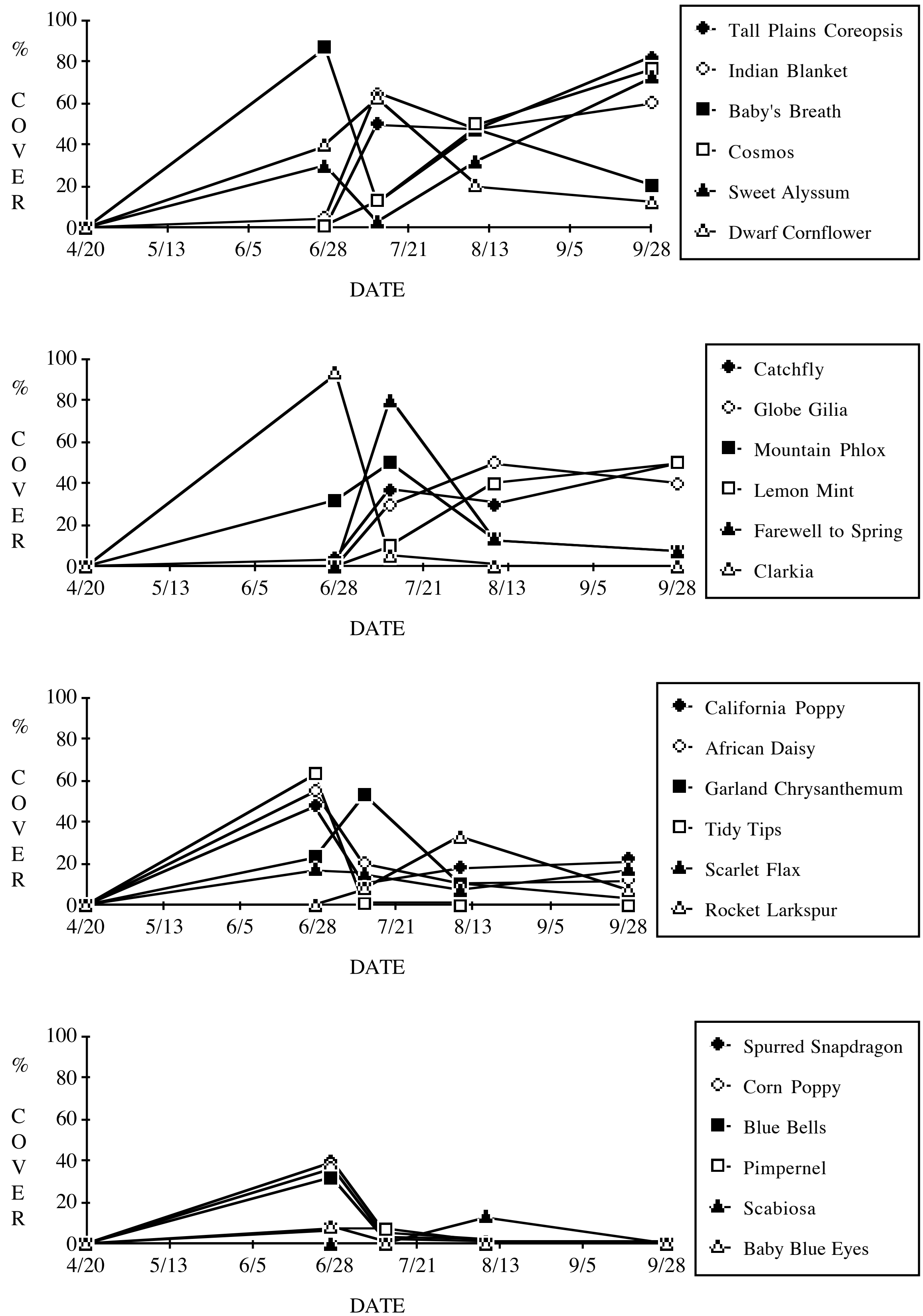


Figure 3: Percent vegetative cover provided by perennial wildflower species in 1988.

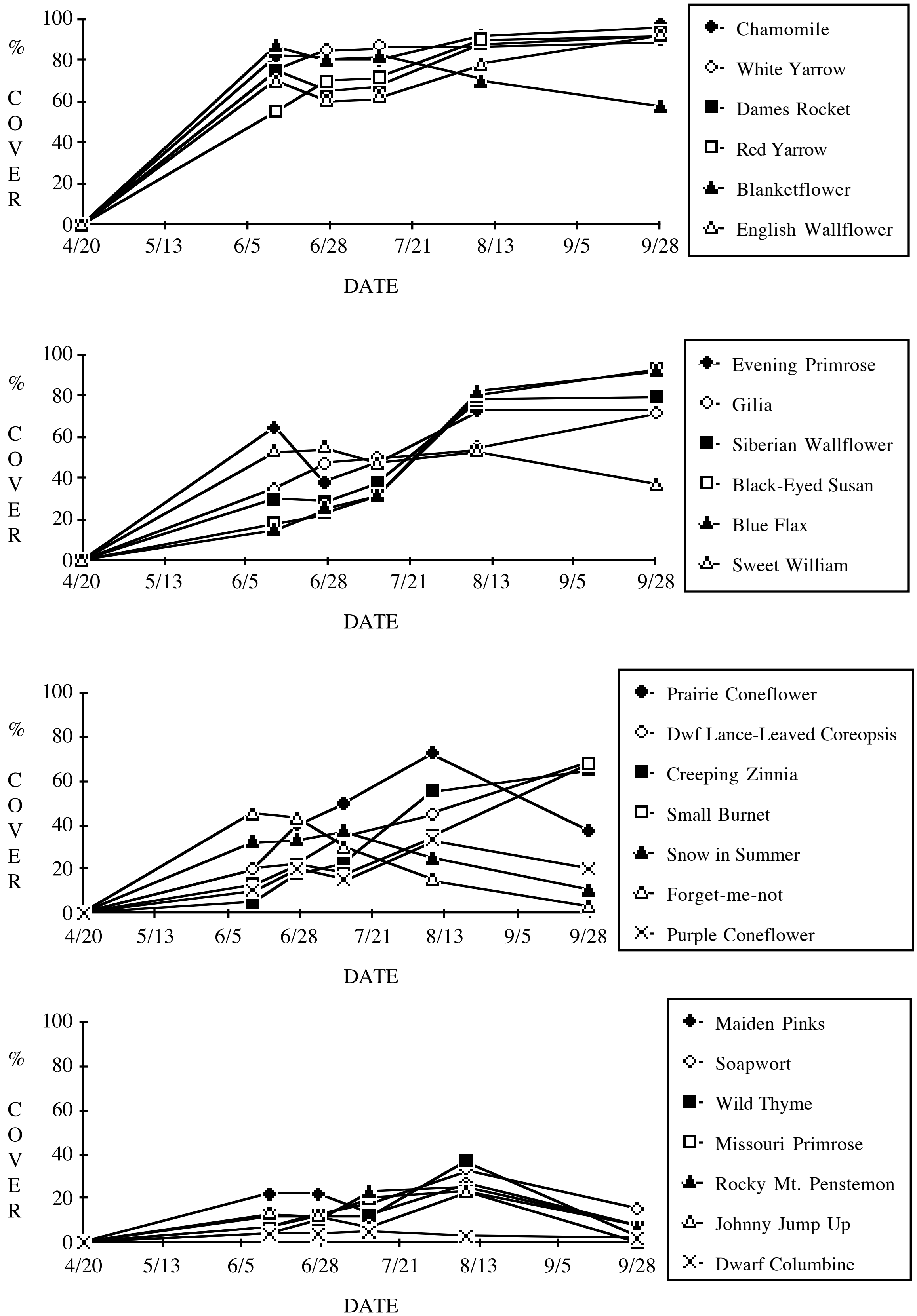
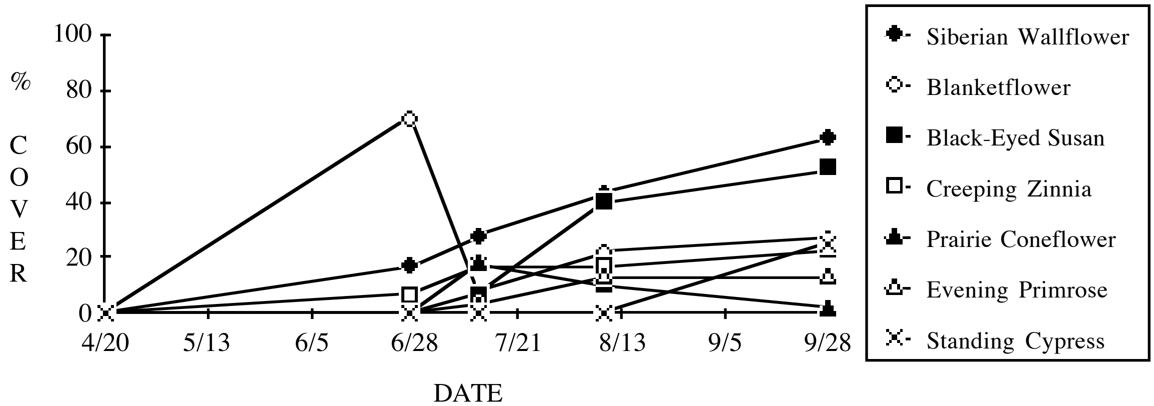


Figure 4: Percent blossom cover provided by perennial wildflower species in 1988.



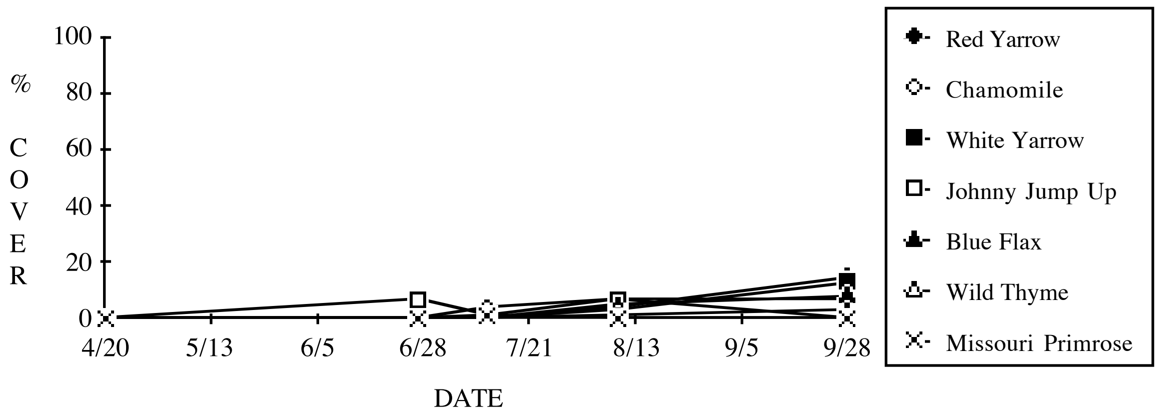


Figure 5: Percent vegetative cover provided by annual wildflower species in 1989.

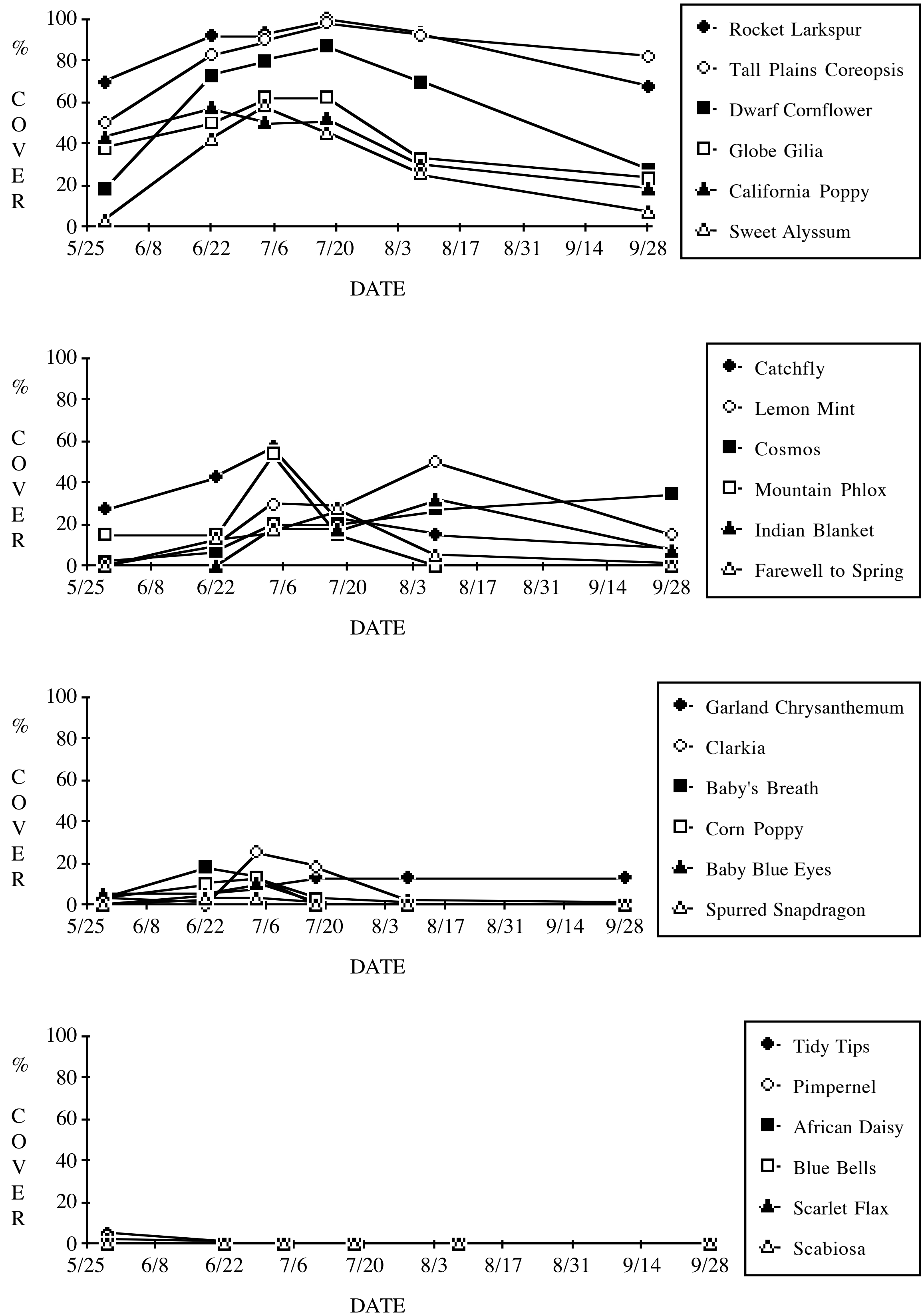


Figure 6: Percent blossom cover provided by annual wildflower species in 1989.

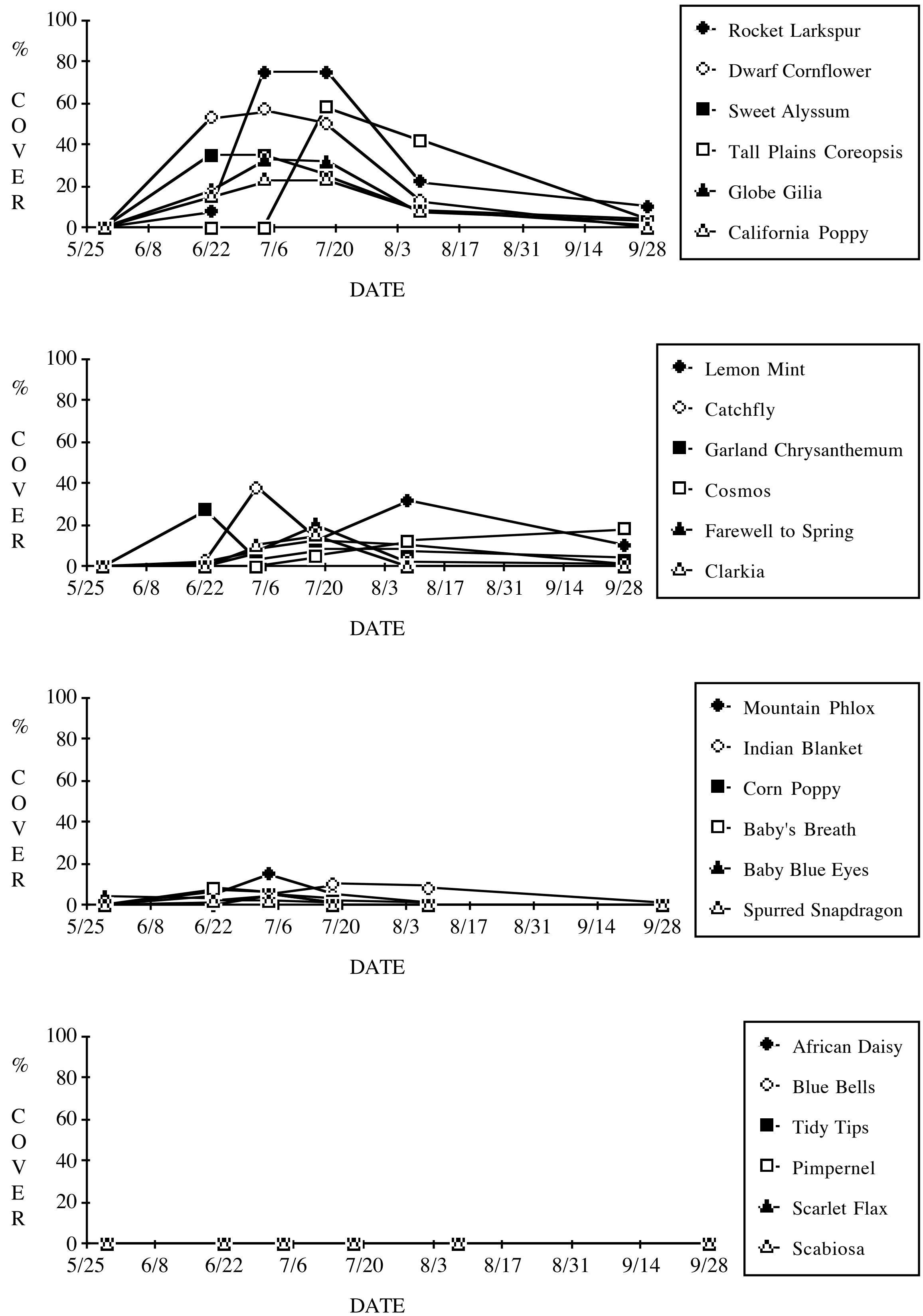


Figure 7: Percent vegetative cover provided by perennial wildflower species in 1989.

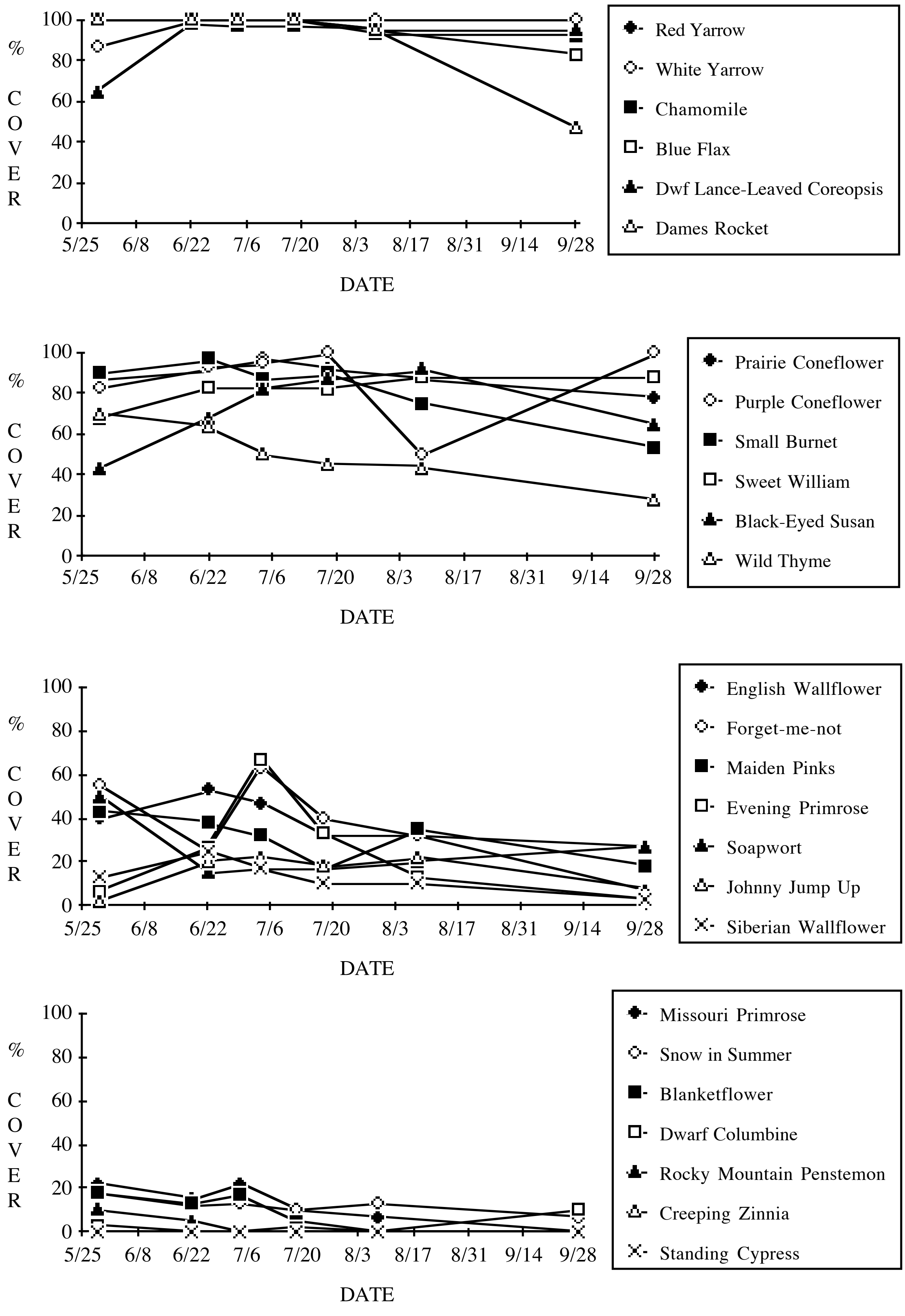
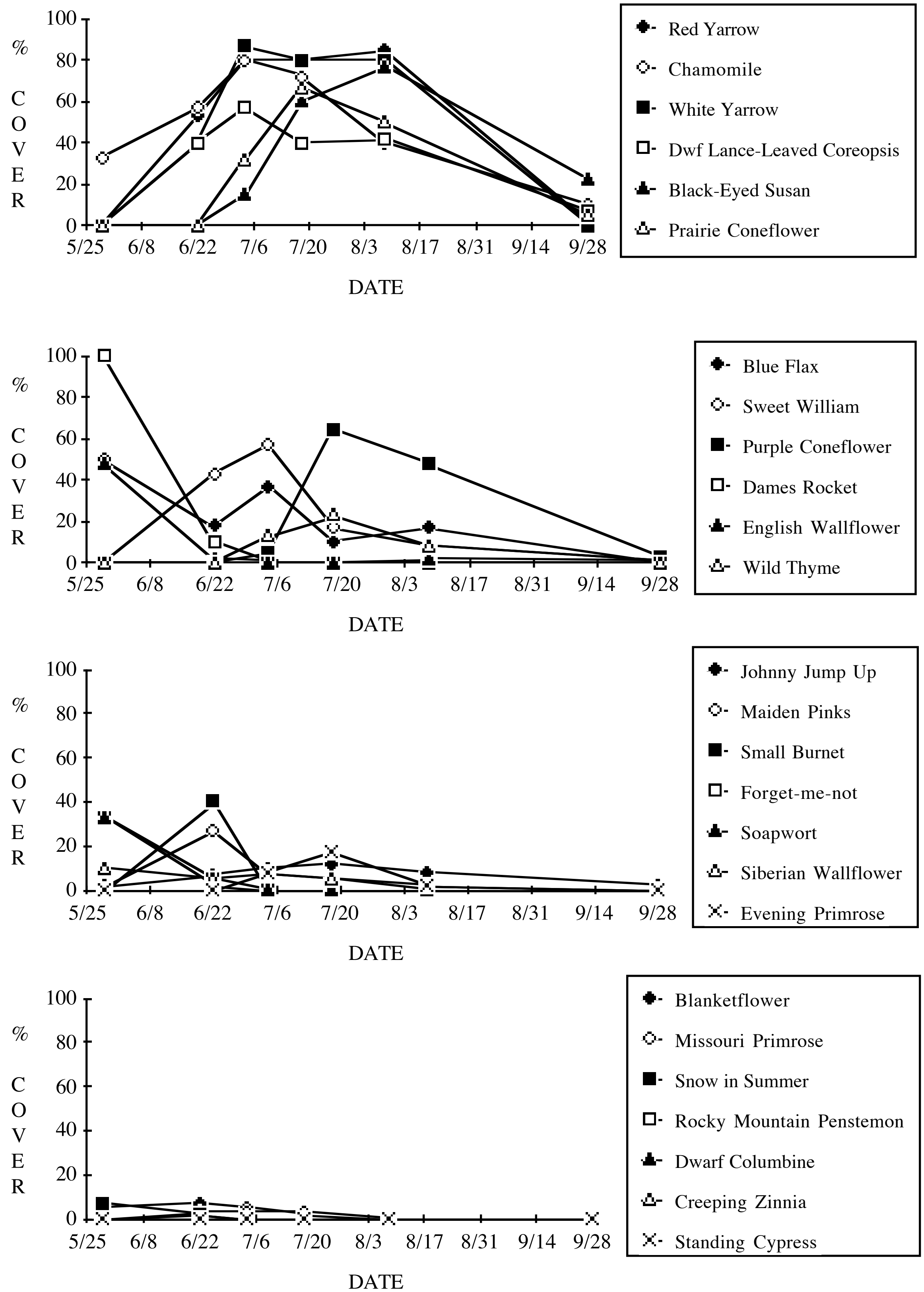


Figure 8: Percent blossom cover for perennial wildflower species in 1989.



PLANT GROWTH REGULATOR STUDIES

The 1989 research evaluating plant growth regulator (PGR) applications to turf consisted of three studies:

- A screening study evaluating new PGR combinations.
- A study to determine the effects of time of application on the efficacy of Embark, Escort, and their combination.
- PGR's applied to 'Kentucky-31' and a turf-type tall fescue blend to determine response differences associated with tall fescue variety.

Table 1 lists all of the PGR materials used in the above studies.

TABLE 1: Product name, formulation, active ingredient, and manufacturer of herbicides used for plant growth regulator research in 1989.

Product	Formulation	Active Ingredient	Manufacturer
Banvel	4S	dicamba	Sandoz
Classic	25 DF	chlorimuron ethyl	DuPont
Embark	2S	mefluidide	PBI/Gordon
Escort	60 DF	metsulfuron methyl	DuPont
Event	1.46 S	imazethapyr and imazapyr	American Cyanamid
Harmony	75 DF	DPX-M6316[1]	DuPont
Telar	75 DF	chlorsulfuron	DuPont

1 Formerly known as thiameturon

PGR Screening Study

OBJECTIVE

Compare pre-mow applications of previously evaluated, and new PGR materials for tall fescue seedhead suppression, turf injury, and broadleaf weed control on roadside turf.

MATERIALS AND METHODS

The study site was a shoulder of the Valley Vista exit ramp off the Mt. Nittany Expressway, SR 0322, near State College, Centre County. The site vegetation was a thin stand of primarily tall fescue. Other species included orchardgrass, spotted knapweed, plantains, crownvetch, Kentucky bluegrass, quackgrass, clovers, and Canada bluegrass. The treatments were applied April 25, 1989, using a utility vehicle mounted, CO_2 powered boom sprayer delivering 35 GPA at 30 psi with Spraying Systems 11004 flat fan nozzles. Each plot was 17 by 40 feet, arranged in a randomized complete block design with three replications. Visual ratings of seedhead suppression and broadleaf weed control were taken June 1, 1989. At that time, no turf injury was observed. Broadleaf weed control ratings were also taken August 28, 1989. The plots were not mowed until after the August 28 rating. The treatment combinations, application rates, and treatment costs are reported in Table 2, and results are listed in Table 3.

TABLE 2: Application rates and costs for PGR treatments applied April 25, 1989 to the Valley Vista Drive exit ramp on SR 0322, State College, Centre County.

Treatment	Application Rate (ounces/acre)	Application Rate (lb ai/acre)	Treatment Cost ($/acre)
1. Embark + Banvel + surfactant	12 + 16	0.18 + 0.5	12.67
2. Embark + Banvel + surfactant	18 + 16	0.28 + 0.5	15.39
3. Embark + Escort	8 + 0.125	0.12 + 0.005	6.60
4. Embark + Telar	8 + 0.25	0.12 + 0.012	7.37
5. Embark + Classic	8 + 0.5	0.12 + 0.023	11.62
6. Embark + Classic	8 + 1	0.12 + 0.046	19.62
7. Embark + Harmony	8 + 0.17	0.12 + 0.008	5.29
8. Embark + Harmony	8 + 0.33	0.12 + 0.016	6.96
9. Embark + Event	4 + 4	0.06 + 0.04	9.15
10. Embark + Event	8 + 4	0.12 + 0.04	10.96
11. Embark + Event + Banvel	4 + 4 + 16	0.06 + 0.04 + 0.5	15.60

RESULTS

The stand of turf at this site was quite thin, primarily due to low fertility, and as a result individual plants lacked vigor. The edge of the plot nearest the road had several inches of anti-skid material accumulation. The area is mapped as a Morrison soil, which is a sandy, acidic soil. This lack of turf vigor made PGR activity more difficult to detect, and resulted in the use of a rating scale with only four categories of seedhead suppression: 0=0 to 30% (poor), 1=30 to 70% (fair), 2=70-90% (good), and 3=>90% (excellent).

TABLE 3: PGR activity and broadleaf weed control results for treatments applied April 25, 1989 to an exit ramp shoulder. PGR activity is based primarily on seedhead suppression, as well as growth suppression. Values are the means of three replications.

Treatment[1/]	Product Application Rate	PGR[2/] Activity 6/1/89	Broadleaf[2/] Weed Control 6/1/89	Broadleaf[3/] Weed Control 8/28/89
	(ounces/acre)	(0-3)	(0-3)	(0-9)
1. Embark + Banvel	12 + 16	1.7	2.0	7.7
2. Embark + Banvel	18 + 16	2.7	3.0	8.0
3. Embark + Escort	8 + 0.12	1.7	1.7	1.7
4. Embark + Telar	8 + 0.25	1.7	1.0	0.7
5. Embark + Classic	8 + 0.5	1.0	1.0	0.7
6. Embark + Classic	8 + 1	1.0	1.0	2.3
7. Embark + Harmony	8 + 0.17	0.7	0.0	1.3
8. Embark + Harmony	8 + 0.33	1.0	0.3	0.3
9. Embark + Event	4 + 4	1.0	0.7	0.0
10. Embark + Event	8 + 4	1.3	1.0	0.0
11. Embark + Event + Banvel	4 + 4 + 16	1.3	2.0	8.3
Significance Level (P)		0.0579	0.0067	0.0001
LSD (P=0.05)		1.1	1.3	1.9

1/ Cidekick II was added to treatments 1 and 2 at 0.25% (v/v).
2/ Based on a scale of 0 to 3, 0=0-30% seedhead suppression, 1=30-70%, 2=70-90%, 3=>90% seedhead suppression.
3/ Based on a scale of 0 to 9, where 0=no weed control, and 9=complete weed control.

Embark (18 oz) plus Banvel (16 oz) provided the best tall fescue seedhead suppression, and received good and excellent ratings on June 1. Embark (12 oz) plus Banvel (16 oz), Embark plus Telar, and Embark plus Escort were rated as providing the same seedhead suppression, and received ratings from good to fair. Embark (8 oz) plus Event (4 oz) and Embark (4 oz) plus Event (4 oz) and Banvel (16 oz) received fair to good ratings. Embark (4 oz) plus Event (4 oz) without Banvel received fair ratings only. Classic or Harmony did not seem to enhance the PGR activity of Embark to the same degree as the other sulfonylurea products (Telar and Escort).

Broadleaf weed control ratings on June 1 were best for the three combinations that included Banvel at 16 oz product/acre, and the combination of Embark plus Escort. All other materials added to Embark showed little to no broadleaf weed control activity.

Only broadleaf weed control ratings taken August 28, as there were no detectable differences in turf quality between the plots. An overall rating for turf color on a 0 to 9 scale, with 0=dead turf and 9=superior turf, would have been a 2. Treatments that included Banvel received high ratings for broadleaf weed control. Plots that were not treated with Banvel showed a considerable amount of crownvetch invasion from outside the plot area.

Effects of Application Timing on Embark and Escort Combinations

OBJECTIVE

Determine if Embark and Escort have differing PGR activity levels during the spring growth phase of tall fescue, prior to seedhead production. Previous observations suggested that Embark activity decreased and Escort activity increased as tall fescue approached the boot stage.

MATERIALS AND METHODS

The study site was a median section of the SR 0322 'Mount Nittany Expressway' between the Park Avenue interchange and Fox Hollow Road overpass in Centre County. Treatments were scheduled to be applied at three or four day intervals between April 26 and May 18, 1989. Due to rain, only five applications were made, April 26, April 28, May 3, May 9, and May 19. The applications were made with a CO_2 powered hand held boom sprayer, delivering 29 GPA at 25 psi with Spraying Systems 8004 flat fan nozzles. The experimental design was a randomized complete block with a split-plot treatment arrangement, with application time as 24 by 50 ft. whole plots, and the four 6 by 50 ft. PGR treatment sub-plots randomly assigned within the application time plot. The species of interest was tall fescue, but the study area also contained quackgrass, smooth brome, Kentucky bluegrass, and redtop. Tall fescue seedhead suppression ratings were taken June 1 and July 14, and turf quality rankings for each PGR treatment within an application time plots were taken July 14. Results are reported for the treatment .

TABLE 4: Tall fescue seedhead suppression and turf quality results for four treatments averaged over five different application dates. Each value is the average of 15 replications.

Treatments	Application Rate	Application Rate	Tall Fescue Seedhead Suppression June 1	Tall Fescue Seedhead Suppression July 14	Quality[1/] Ranking
	(oz product/acre)	(lb ai/acre)	(- - - - % - - - -)		(1-4)
Embark	24 oz	0.375	58	72	2.3
Embark + surfactant	24 oz + 0.25%	0.375	66	78	1.6
Escort	1/3 oz	0.0125	39	65	3.3
Embark + Escort	8 oz + 1/8 oz	0.125 + 0.0047	44	62	2.9
Significance Level (P)			0.0001	0.2693	0.0009
LSD (P=0.05)			11	18	0.8

1 The four treatment plots within each application time whole plot were ranked 1 to 4, with 1 being the best based on seedhead suppression, color, and consistency.

TABLE 5: Tall fescue seedhead suppression for four treatments applied at five dates. Each value is the mean of 12 replications.

Application Date	Tall Fescue Seedhead Suppression June 1	Tall Fescue Seedhead Suppression July 14
	(%)	(%)
April 26	58	83
April 28	59	84
May 3	78	93
May 9	18	38
May 19	34	49
Significance Level (P)	0.0069	0.0019
LSD (P=0.05)	10	23

TABLE 6: Tall fescue seedhead suppression and turf quality rankings for four treatment combinations applied at five dates. Each value is the mean of three replications.

Application Date	Application Treatments	Application Rate	Application Rate	Tall Fescue Seedhead Suppression June 1	Tall Fescue Seedhead Suppression July 14	Quality[1/] Ranking
		(oz product/acre)	(lb ai/acre)	(- - - - % - - - -)		(1-4)
4/26	Embark	24 oz	0.375	70	90	2.0
4/26	Embark + surfactant	24 oz + 0.25%	0.375	92	97	1.0
4/26	Escort	1/3 oz	0.0125	33	68	3.3
4/26	Embark + Escort	8 oz + 1/8 oz	0.125 + 0.0047	37	75	3.7
4/28	Embark	24 oz	0.375	75	90	2.0
4/28	Embark + surfactant	24 oz + 0.25%	0.375	85	95	1.0
4/28	Escort	1/3 oz	0.0125	37	75	3.3
4/28	Embark + Escort	8 oz + 1/8 oz	0.125 + 0.0047	40	75	3.7
5/3	Embark	24 oz	0.375	83	93	2.3
5/3	Embark + surfactant	24 oz + 0.25%	0.375	92	96	1.3
5/3	Escort	1/3 oz	0.0125	60	90	4.0
5/3	Embark + Escort	8 oz + 1/8 oz	0.125 + 0.0047	78	92	2.3
5/9	Embark	24 oz	0.375	20	30	3.0
5/9	Embark + surfactant	24 oz + 0.25%	0.375	18	47	2.3
5/9	Escort	1/3 oz	0.0125	15	43	2.7
5/9	Embark + Escort	8 oz + 1/8 oz	0.125 + 0.0047	20	33	2.0
5/19	Embark	24 oz	0.375	27	55	2.0
5/19	Embark + surfactant	24 oz + 0.25%	0.375	30	57	2.3
5/19	Escort	1/3 oz	0.0125	43	47	3.0
5/19	Embark + Escort	8 oz + 1/8 oz	0.125 + 0.0047	37	37	2.7
Significance Level (P)				0.0065	0.9950	0.2485
LSD (P=0.05)				24	40	1.8

1 The four treatment plots within each application time whole plot were ranked 1 to 4, with 1 being the best based on seedhead suppression, color, and consistency.

RESULTS

There was no significant interaction between the effects of treatment and application time for seedhead suppression ratings and turf quality rankings July 14, and will therefore be considered for treatment and application date separately. Tall fescue seedhead suppression ratings taken June 1 did show a significant interaction between treatment and application date, and are shown in Figure 1. The source of the interaction was the improvement of the Escort treatments relative to the Embark alone treatments as the application date approached seedhead emergence. For the application dates April 26 and 28, treatments of Embark at 24 oz/acre provided significantly better seedhead suppression than the Escort treatments. For the May 3 application, Embark plus surfactant was rated significantly better than Escort alone, but the rating for Embark plus Escort was not significantly different from either Embark or Embark plus surfactant. The ratings for May 9 were 20 percent or less for all treatments. There was rainfall approximately five hours after treatment, which may have been a factor, as the Embark label recommends 8 rain-or-irrigation free hours after application. For the seedhead suppression ratings for the May 19 application, the Escort treatments were both rated higher than the Embark alone treatments. However, all ratings were less than 43 percent, and were not significantly different.

Seedhead suppression ratings for July 14, when the seedheads were completely mature and brown, were higher than ratings taken June 1. There were no significant differences due to treatment, but application time was highly significant. The applications on May 3 gave the best seedhead suppression, but were not significantly different than the ratings for the April 26 and 28 plots. These three applications, however, did provide significantly better seedhead suppression than the May 9 and 19 applications.

The turf quality rankings taken July 14 were significantly different due to treatment effects. The treatments were ranked, best to worst, Embark plus surfactant , Embark, Embark plus Escort, and Escort. The Embark plus surfactant combination was significantly better than either Escort treatment, and the Embark alone was significantly better than Escort alone. Turf quality ranking could not be compared for application timings as the treatments were ranked within each application time whole plot and hence always averaged 2.5 for each timing.

CONCLUSIONS

The results of this study indicate that Escort PGR activity increases as the seedhead emergence of tall fescue approaches. Under the conditions of this study, Escort in combination with a low rate of Embark did not perform better than a high rate of Embark alone, however, in past studies the combination of Embark and Escort performed better than Embark alone. This study confirmed previous work, which showed that timing of PGR applications greatly impacts the efficacy of the treatment. For this study, May 3 was the best application date, with the two previous applications on April 26 and 28 also proving effective.

PGR Applications to 'Kentucky 31' and Turf Type Tall Fescue

OBJECTIVE

Determine if there any response differences between 'Kentucky 31' and turf type tall fescue to PGR applications. Turf type tall fescues are being evaluated for roadside use. If there are any response differences between these tall fescue types, this would have to be accounted for when specifying PGR treatments for roadside turf.

MATERIALS AND METHODS

Seven treatments were applied to blocks of 'Kentucky 31' and 'Transition Blend', a combination of 'Cimarron', 'Bonanza', and 'Olympic' turf type tall fescues, at the Landscape Management Research Center, University Park, in Centre County. Initial applications were made May 9, 1989, but rainfall occurred almost immediately after the applications. The treatments were reapplied to adjacent areas on May 18. The areas used for the May 18 application had been mowed twice prior the application to a height of 3 inches. The treatments were applied with a CO_2 powered hand-held boom sprayer, delivering 33 GPA at 30 psi with Spraying Systems 6504 flat fan nozzles. The plots were 3 by 18 ft. and arranged in a randomized complete block with three replications. Seedhead suppression was rated for each replication relative to the untreated check on June 1 and July 3, two and five weeks after treatment (WAT). Turf color and quality ratings were also taken 5 WAT. The treatments and results are reported in Table 7.

RESULTS

The combinations of Embark, Banvel, and surfactant were the least effective treatments under the conditions of this study. These two treatments did not provide acceptable levels of seedhead suppression for either variety of tall fescue, although there was more of a response to the rate of Embark with the 'Transition Blend' tall fescue. The 'Kentucky 31' plots treated with Embark plus Banvel and surfactant received a lower color rating than the untreated check, suggesting that the treatment caused some discoloration. Turf quality ratings for 'Kentucky 31' plots treated with Embark plus Banvel and surfactant were considered unacceptable due to the amount of seedheads and discoloration. The 'Transition Blend' plots treated with Embark plus Banvel and surfactant were rated as acceptable for turf quality, even though seedhead suppression was poor, because the turf type tall fescue did not produce as many seedheads as the 'Kentucky 31' in this test, and there was no apparent discoloration from the treatment.

TABLE 7: Percent seedhead suppression, turf color and quality ratings, and plot dry weights for 'Kentucky 31' and 'Transition Blend' tall fescue stands treated May 18, 1989.

Treatment	Application Rate	Seedhead Suppression 2 WAT	Seedhead Suppression 5 WAT	Turf[1/] Color 5 WAT	Turf[1/] Quality 5 WAT
	(oz/acre)	(%)	(%)	(0-9)	(0-9)
'KENTUCKY 31' TALL FESCUE					
1. Embark	12	33	60	6.3	4.0
Banvel	16				
surfactant	0.25% (v/v)				
2. Embark	18	38	67	5.3	4.3
Banvel	16				
surfactant	0.25% (v/v)				
3. Embark	8	90	100	6.3	7.0
Escort	0.125				
4. Embark	8	90	100	7.7	7.7
Telar	0.25				
5. Embark	4	88	100	8.0	8.0
Event	4				
6. Embark	8	88	100	8.0	8.0
Event	4				
7. untreated check	- - -	0	0	7.0	3.0
Significance Level (P)		0.0001	0.0001	0.0068	0.0001
LSD (P=0.05)		23	9	1.3	0.5
'TRANSITION BLEND' TALL FESCUE					
1. Embark	12	10	17	7.0	6.0
Banvel	16				
surfactant	0.25% (v/v)				
2. Embark	18	22	37	6.7	6.0
Banvel	16				
surfactant	0.25% (v/v)				
3. Embark	8	95	100	6.3	6.7
Escort	0.125				
4. Embark	8	92	100	7.0	7.0
Telar	0.25				
5. Embark	4	92	100	7.3	7.7
Event	4				
6. Embark	8	93	100	6.7	7.3
Event	4				
7. untreated check	- - -	0	0	5.3	5.0
Significance Level (P)		0.0001	0.0001	0.0314	0.0003
LSD (P=0.05)		11	27	1.1	0.9

1/ Rated on 0 to 9 scale, with 0 = brown turf, 9 = superior color, and 6 considered the minimum for acceptability. Quality ratings incorporated color, seedhead suppression, and stand consistency.

Embark plus Escort provided excellent seedhead suppression for both rating periods. Turf color ratings for 'Kentucky 31' were lower than the check, and similar to the low rate combination of Embark plus Banvel and surfactant, suggesting some discoloration from the treatment. For 'Transition Blend' plots, Embark plus Escort was rated lowest of the applied treatments for turf color, but the rating was acceptable. Turf quality ratings for both tall fescue varieties were acceptable, due primarily to the excellent seedhead control.

The performance of Embark plus Telar, and the two Embark plus Event combinations was virtually indistinguishable, as all three combinations provided excellent seedhead suppression, and the highest color ratings for both varieties of tall fescue.

CONCLUSIONS

There were only minor differences in the response of 'Kentucky 31' and 'Transition Blend' tall fescues to the PGR's applied under the conditions of this study. Embark in combination with either Escort, Telar, or Event provided excellent seedhead suppression and maintained acceptable to good turf color. The combinations of Embark plus Banvel and surfactant caused different responses for the two stands of tall fescue. The degree of seedhead suppression was different, though unacceptable for both stands. This could be due to differing maturation for the two stands, as the amount of seedheads was greater for 'Kentucky 31' compared to 'Transition Blend'. It is highly possible that the 'Transition Blend' turf produced seedheads earlier and some were removed by the mowing operations prior to PGR application. This would explain the reduction in both the number of seedheads and the effectiveness of the Embark applications, as Embark has been demonstrated in other studies to be less effective as at the onset of seedhead emergence.

This preliminary work indicates that the same PGR treatments can be applied to both 'Kentucky 31' and the turf type tall fescues used in this study. Plants at the same growth same growth stage appear to respond similarly. However, there may be maturity differences between varieties, which would further complicate the timing constraints facing a vegetation manager specifying pre-mow PGR applications.

LOW MAINTENANCE GRASS STUDIES

Low maintenance grass studies are ongoing at three locations.

- The terminal end of the SR 0220 Tyrone Bypass, near Tyrone, Blair County.
- The interchange of SR 0283 and 0230, near Landisville, Lancaster County.
- The Landscape Management Research Center, University Park, Centre County.

OBJECTIVES

Evaluate turf species as an alternative to 'Kentucky 31' tall fescue for roadside use, using different locations and minimal site preparation. Evaluations are based on establishment success and persistence of cover under low maintenance conditions.

Tyrone and Landisville Sites

MATERIALS AND METHODS

Both of these sites were established in September, 1987. Each site was treated with Roundup, mowed about one week after treatments, scarified with a PTO powered vertical cut overseeder, and drop seeded. Although the overseeder scarified the soil less than one inch deep, much of the vegetative residue was incorporated into the soil, allowing for good seed to soil contact. Each plot was seeded at the rate of 100 lb. seed/acre. The species and combinations used are listed in Table 1. Each site was treated in 1988 with Trimec at 2 qts/acre (1.22 lb ae/acre 2,4-D, 0.65 lb ae/acre MCPP, and 0.11 lb ae/acre dicamba) for broadleaf weed control. The Tyrone site was treated June 17, and Landisville July 5. The Landisville site was mowed once in 1989, and the Tyrone site has never been mowed. Ratings for percent turf cover and percent weed cover were taken August 29, at Landisville, and September 5 at Tyrone. Because the weeds were often taller than the turf, two canopies were rated and the sum of turf and weed cover may be more than 100 percent. The 1989 results for turf cover and weed cover for Tyrone and Landisville are reported in Table 1.

RESULTS

Of the 11 combinations planted, all but turf type tall fescue and Canada bluegrass developed a vigorous stand of turf at both sites. Turf type tall fescue received the highest turf cover rating at Landisville with 97 percent, and the lowest rating at Tyrone with a 55 percent turf cover. Most of the performance difference is due to one replication, which was rated at 20 percent, while the other two were rated 85 and 60 percent. This low rating appeared to be due to conditions within the plot because the plot was largely bare of turf or weeds. Canada bluegrass was rated lowest for turf cover at Landisville with 27 percent, but was rated at 67 percent turf cover at Tyrone. At Landisville, the Canada bluegrass was very spotty and overrun with weeds. At Tyrone Canada bluegrass had a very consistent canopy. There was little variability in height, and though the turf cover was less than 70 percent, the density was very even and the weed cover ratings were very low.

TABLE 1: Turf and weed cover ratings for plots established at Landisville (LND) and Tyrone (TYR) in September 1987. Ratings were taken 8/29/89 at Landisville, and 9/5/89 at Tyrone.

Species	Turf Cover LND	Turf Cover TYR	Weed Cover LND	Weed Cover TYR
	(%)		(%)	
1. 'K-31' tall fescue	94	80	11	17
2. turf type tall fescue	97	55	5	38
3. red fescue	87	90	23	13
4. hard fescue	80	93	45	13
5. Canada bluegrass	27	67	72	7
6. perennial ryegrass	80	68	27	32
7. h.fescue/r.fescue (70/30)	93	77	10	27
8. h.fescue/t.t.t.fescue (90/10)	88	95	20	8
9. h.fescue/p.ryegrass (90/10)	93	90	23	17
10. h. f./r. f./t.t.t.f. (80/10/10)	88	93	28	9
11. t.t.t.fescue/p.ryegrass (70/30)	90	75	22	17
LSD (P=0.05)	14	27	23	21

University Park Site

MATERIALS AND METHODS

A total of sixteen treatments were seeded September 16, 1988, at the Landscape Management Research Center. Eleven single variety plots, four combination treatments, and an unseeded check were included. Site preparation methods were the same used at Tyrone and Landisville, consisting of spraying with Roundup, mowing, scarifying with an Olathe vertical cut slit seeder unit, and drop seeding. No fertilizer has been applied to this study. One half of each plot was mowed June 8, 1989, for demonstration purposes for the PennDOT-Penn State field day June 15. The entire study area was mowed July 6 at a height of 3.5 in. with a flail forage harvester, and the clippings were removed for yield measurements. A sub-sample of the forage from each plot was weighed, dried, and weighed again to determine dry matter content and determine the dry matter yield for each plot. The varieties, seeding rates, dry matter yield, and dry matter content are reported in Table 2.

TABLE 2: Forage dry matter yield and dry matter content of grasses harvested July 6, 1989. Plots were seeded September 16, 1988. Each value is the mean of three replications.

	Species	Seeding Rate	Dry Matter Forage Yield 7/6/89	Dry Matter 7/6/89
		(lbs seed/acre)	(lbs/acre)	
1.	'Kentucky 31' tall fescue	100	5,015	0.33
2.	'Transition Blend' turf type tall fescue (TTTF)	100	4,666	0.35
3.	'Ensylva' red fescue	100	3,789	0.39
4.	'Pennlawn' red fescue	100	3,931	0.36
5.	'Aurora' hard fescue	100	3,004	0.38
6.	'SR 3000' hard fescue	100	2,723	0.39
7.	Kentucky bluegrass blend	75	1,978	0.37
8.	'Reubens' Canada bluegrass	75	4,027	0.36
9.	'Overseeding Blend' perennial ryegrass	100	3,856	0.46
10.	sweet vernal grass	80	3,527	0.35
11.	'Barclay' perennial ryegrass	40	3,582	0.35
12.	'Highway Blend'	100	3,890	0.35
13.	perennial ryegrass + TTTF (30/70)	100	4,104	0.40
14.	perennial ryegrass + TTTF (50/50)	100	4,640	0.42
15.	perennial ryegrass + TTTF (70/30)	100	4,419	0.44
16.	not seeded	- - -	1,969	0.35
LSD (P=0.05)			1,114	0.04

RESULTS

All species established well and produced greater than 80 percent cover. By the July 6 harvest all species had produced seed. 'Kentucky 31' tall fescue produced the most dry matter with 5015 lbs/acre. Turf type tall fescue, the turf type tall fescue/perennial ryegrass blends, Canada bluegrass, and 'Pennlawn' red fescue produced more than 3900 lbs dry matter/acre and were not significantly different than 'Kentucky 31'. The two perennial ryegrass varieties, 'Ensylva' red fescue, and sweet vernal grass produced between 3500 and 3800 lbs dry matter/acre. 'Aurora' and 'SR 3000' hard fescue produced similar yields of 3004 and 2723 lbs dry matter/acre, respectively. The Kentucky bluegrass blend and the unseeded check produced less than 2000 lbs dry matter/acre. Plots with the 'Overseeding Blend' perennial ryegrass had the highest dry matter content, suggesting a higher seedhead/leaf ratio for the forage. The tall fescue varieties had the lowest dry matter contents, suggesting more leaf tissue compared to the other varieties.

HERBACEOUS WEED CONTROL STUDIES

There were four studies conducted evaluating different aspects of roadside herbaceous weed control.

- A comparison of three treatments and two application times for Canada thistle control in crownvetch
- A comparison of growth hormone type herbicides for broadleaf weed control.
- A screening study comparing several combinations of various herbicides for broadleaf weed control.

4. A comparison of three seeding and application dates to determine optimum conditions for seeding birdsfoot trefoil in conjunction with an Arsenal application.

Thistle Control in Crownvetch

OBJECTIVES

Evaluate three treatments and two application timings for control of Canada and plumeless thistle in crownvetch.

MATERIALS AND METHODS

The study site was the eastbound exit ramp for Park Avenue off the 'Mt. Nittany Expressway' portion of SR 0322, Centre County. Three treatments were applied at two application times. The products, rates, and application timings are listed in Table 1. The treatments were applied with a tractor mounted small plot sprayer delivering 27 GPA at 20 psi with Spraying Systems XR 80015 flat fan nozzles. Each plot was 50 feet wide and varied in length due to the width of the interchange. The plots were laid out in randomized complete block design with two replications.

On September 7, 1988, Canada thistle that had flowered was dead but there was about 6 to 8 inches of new growth from the root stocks. The second year flower stalks of plumeless thistle were also dead but new rosettes were 6 to 12 inches in diameter. On June 6, 1989, Canada and plumeless thistle were 24 to 40 inches tall and the crownvetch was 18 to 24 inches tall when treatments were applied. The June 28 treatment of Basagran was applied to crownvetch that had been burned back to 6 to 20 inches by the June 6 treatment and both Canada and plumeless thistles were now 24 to 48 inches. All Basagran and Laddok treatments included 1 qt. of crop oil concentrate per acre. Visual crownvetch, grass, and thistle percent injury ratings were made on July 3 and August 26, 1989. August ratings included an estimate of control of both the second year flower stalks and new rosettes of plumeless thistle.

TABLE 1: Herbicide application rates and date for thistle control in crownvetch.

Treatment[1]	Application Dates	Application Rate (product/acre)	Application Rate (lb ai/acre)
1. Velpar	9/7/88	2 qts	1.0
2. Velpar	6/6/89	2 qts	1.0
3. Laddok	9/7/88	5 pts	1.0 + 1.0
4. Laddok	6/6/89	5 pts	1.0 + 1.0
5. Basagran	9/7/88 + 6/6/89	1.5 + 1.5 pts	0.75 + 0.75
6. Basagran	6/6/89 + 6/28/89	1.5 + 1.5 pts	0.75 + 0.75

1 Laddok and Basagan treatments included crop oil concentrate at 1 qt/acre.

RESULTS

Crownvetch showed no injury from September applied treatments when rated the following July (Table 2). There was still evidence of injury from these same treatments when applied on June 6, four weeks before the rating. The split Basagran treatment showed the most injury since the second part of the treatment had been applied only five days earlier. By August 26, there was no longer any evidence of crownvetch injury from any of the treatments.

TABLE 2: Crownvetch injury, and Canada and plumeless thistle control ratings taken July 3 and August 26, 1989.

		CV Injury	Canada Thistle Control		Plumeless Thistle Control		
					Flower Stalk		Rosette
Treatments	Application Time	Jul 3	Jul 3	Aug 26	Jul 3	Aug 26	Aug 26
1. Velpar	9/7/88	0	50	45	98	98	0
2. Velpar	6/6/89	20	98	98	98	99	98
3. Laddok	9/7/88	0	0	0	95	100	0
4. Laddok	6/6/89	25	69	0	94	98	0
5. Basagran	9/7/88-6/6/89	5	65	0	95	95	0
6. Basagran	6/6/89-6/28/89	40	95	49	97	99	0
Significance level (P)		0.0129	0.0542	0.1485			
LSD (P = 0.05)		19	59	87			

September applied Velpar or Laddok did not provide a significant amount of Canada thistle control when rated on July 3 of the following year. If the split Basagran treatment had been rated before the second application on June 6, there would have been no evidence of control. All treatments applied on June 6 did give significant Canada thistle control of 69 to 98% but only Velpar maintained a significant control rating of 98% to August 26. Basagran split between September and June, and Laddok applied at either time did not show any evidence of Canada thistle control by the following August 26. September applied Velpar, and Basagran split between June 6 and 28, 1989 still showed 45 and 49% control respectively on August 26, but this was not significantly better than the control.

Plumeless thistle was not present in several plots so a statistical analysis could not be done. From the unanalyzed data, it would appear that all treatments, whether applied in September or June gave excellent (94 to 100%) flower stalk control when rated the following July or August. The September treatments would have controlled the rosettes and the June 6 treatments would have controlled the young flower stalks. None of the treatments except Velpar applied on June 6 apparently had enough soil residue to prevent the establishment of new rosettes from seed.

Comparison of Growth Hormone Type Herbicides

OBJECTIVE

Evaluate currently available formulations of growth hormone herbicides at equal active ingredient rates for broadleaf weed control.

TABLE 3: Rates of active ingredients for products used in the hormone-type herbicide test. All products were applied at the rate of 0.5 lb acid equivalent/acre.

	Product	Active Ingredients	Application Rate (lb ae/acre)
1.	Weedar 64	2,4-D dimethylamine	0.50
2.	Weedone LV4	2,4-D butoxyethyl ester	0.50
3.	Banvel	dicamba dimethylamine	0.50
4.	Banvel 720	dicamba dimethylamine	0.17
		2,4-D dimethylamine	0.33
5.	Trimec D	2,4-D isooctyl ester	0.31
		2,4-DP butoxyethanol ester	0.16
		dicamba	0.03
6.	Trimec Classic	2,4-D dimethylamine	0.31
		MCPP dimethylamine	0.16
		dicamba dimethylamine	0.03
7.	Garlon 3	triclopyr triethylamine	0.50
8.	Garlon 4	triclopyr butoxyethyl ester	0.50
9.	Crossbow	2,4-D butoxyethyl ester	0.33
		triclopyr butoxyethyl ester	0.17
10.	Curtail	2,4-D alkanolamine	0.42
		clopyralid	0.08
11.	Hi-Dep	2,4-D dimethylamine	0.33
		2,4-D diethanolamine	0.17

MATERIALS AND METHODS

This experiment was performed in an old hay field with a mixture of alfalfa, bluegrass, quackgrass, orchardgrass, dandelion and buckhorn plantain with some yellow foxtail and redroot pigweed appearing in late summer. All growth hormone herbicides, whether applied alone or in combination, were applied at 0.5 lb ai/A so comparisons are on an equal basis. The treatments were applied June 30, 1989, with a tractor mounted small plot sprayer delivering 12 GPA at 20 psi using Spraying Systems 8001 flat fan nozzles. The herbicides used and their active ingredients are listed in Table 3. Every treatment except Hi-Dep was applied both with and without a surfactant (Cidekick II @ 0.25% v/v) to compare the efficacy. Weed control was visually rated July 26 and September 5.

RESULTS

Weed control results are listed in Table 4. Broadleaf weed control was very good even with the relatively low rate and all treatments gave 69% or better control on July 26 and 73% or better on September 5. Statistically, there was no difference between any of the treatments at the 5% level of probability. The addition of the surfactant did not improve the activity of any of the treatments.

Postemergence Broadleaf Weed Control Screening Trial

OBJECTIVES

Evaluate established as well as new herbicide combinations for broadleaf weed control.

MATERIALS AND METHODS

This test was performed in an old hay field with a mixture of alfalfa, bluegrass, quackgrass, orchardgrass, dandelion and buckhorn plantain with some yellow foxtail and redroot pigweed appearing in late summer. The treatments were applied June 23, 1989 with a tractor mounted small plot sprayer delivering 10 GPA at 18 psi with Spraying Systems 8001 flat fan nozzles. Weed control was visually rated on July 26 and September 5, 1989. Treatment combinations and weed control ratings are reported in Table 5.

RESULTS AND DISCUSSION

Event (Pursuit + Arsenal @ 0.1 + 0.003 lb ai/A) (T3) had no effect on perennial grasses or broadleaves and at best provided marginal yellow foxtail and redroot pigweed control. Rifle , (T4,5,6) gave 58 to 84% alfalfa control one month after treatment with about the same level of perennial grass and broadleaf control. By September 5, all of these species showed signs of recovery but the alfalfa and perennial broadleaf recovery was greatest at the high rate of Rifle (T6) where perennial grass control was still 53%. Amber (T7) had no effect on perennial grasses or broadleaves. It did provide good annual broadleaf weed control.

TABLE 4: Broadleaf and grass weed control ratings on July 26 and September 5, 1989 for treatments applied June 30, 1989. Each value is the mean of three replications.

Treatment	Weed Control Ratings: Broadleaf 7/26/89	Annual Broadleaf 9/5/89	Perennial Broadleaf 9/5/89
	(%)		
1. 2,4-D amine	77	83	73
2. 2,4-D amine + surfactant[1/]	88	78	82
3. 2,4-D ester	90	99	90
4. 2,4-D ester + surfactant	89	93	87
5. Banvel	95	96	88
6. Banvel + surfactant	93	97	90
7. Banvel 720	98	100	98
8. Banvel 720 + surfactant	97	100	98
9. Trimec D	69	87	98
10. Trimec D + surfactant	81	100	99
11. Trimec Classic	82	99	97
12. Trimec Classic+ surfactant	80	100	92
13. Garlon 3	83	93	94
14. Garlon 3 + surfactant	66	86	71
15. Garlon 4	99	99	97
16. Garlon 4 + surfactant	96	100	99
17. Crossbow	95	93	95
18. Crossbow + surfactant	98	97	99
19. Curtail	97	96	96
20. Curtail + surfactant	91	93	88
21. Hi-Dep	70	88	76
Significance Level (P)	0.5181	0.3711	0.5813
LSD (P=0.05)	30	17	26

1/ Surfactant used was Cidekick II at 0.25% (v/v).

Escort , Telar, and Oust (T8,9, 12, 13) are sulfonylureas with differing levels of activity on alfalfa. Escort (T8) is extremely active on alfalfa and from other research it appears to be the same on thistle. Telar (T9) on the other hand would appear to be safe enough to use for weed control in alfalfa. Neither has much activity on perennial grasses but both are very active on annual and perennial broadleaves.

TABLE 5: Herbicide combinations and weed control ratings for applications made June 23, 1989.

	Treatment	Application Rate	Weed Control Ratings Alfalfa Jul 26	Broadleaf Jul 26	Alfalfa Sep 5	Annual B-leaf Sep 5	Perennial B-leaf Sep 5
		(lb ai/acre)	- - - - - - - - - - - - -	(%)	- - - - - - - - - - - - -		
1.	Velpar	1	1	69	4	69	48
2.	Laddok	2	3	5	25	28	3
3.	Event	0.103	1	6	26	74	15
4.	Rifle	0.0178	58	75	60	92	79
5.	Rifle	0.0357	79	78	59	53	56
6.	Rifle	0.0714	84	90	16	69	69
7.	Amber	0.023	1	30	2	86	38
8.	Escort	0.0285	100	100	98	96	94
9.	Telar	0.023	9	91	2	76	86
10.	Poast	0.1875	16	7	12	21	6
11.	Poast	0.375	19	8	4	10	4
12.	Oust	0.125	8	100	6	100	95
13.	Oust	0.25	8	100	6	99	96
14.	Garlon 4	0.5	75	50	74	61	44
15.	Garlon 4	1	100	85	99	77	81
16.	Tandem	2	1	1	2	68	8
17.	Garlon 4 + Oust	0.25 + 0.062	45	96	31	85	74
18.	Garlon 4 + Oust	0.5 + 0.062	63	100	50	95	91
19.	Garlon 4 + Oust	0.25 + 0.125	69	100	43	96	96
20.	Garlon 4 + Oust	0.5 + 0.125	70	100	54	99	96
21.	Roundup + Oust	1.5 + 0.062	15	100	5	100	95
22.	Tandem + Oust	2 + 0.062	18	100	13	88	90
23.	Tandem + Oust	2 + 0.125	3	100	2	93	97
24.	Tandem + atrazine	2 + 1	1	28	1	41	20
25.	Tandem + simazine	2 + 1	0	18	1	33	14
26.	Tandem + prometone	1 + 10	1	81	3	80	64
27.	Tandem + prometone	2 + 10	11	83	7	86	54
28.	Tandem + Poast	1 + 0.28	1	1	1	6	1
29.	Tandem + Poast	1.5 + 0.28	3	5	3	23	6
30.	Tandem + Poast	2 + 0.28	0	2	1	5	0
31.	Untreated Check	- - -	1	1	2	37	3
32.	Untreated Check	- - -	0	3	1	53	5
Significance Level (P)			0.0001	0.0001	0.0001	0.0001	0.0001
LSD (P=0.05)			31	15	31	34	19

Oust (T12,13) was active on both perennial grasses and broadleaves without injury to alfalfa. The control persisted to September and also prevented annual grasses and broadleaves from invading the plots. When used in combination with Garlon 4 (T17-20), some of the alfalfa was controlled, but control was somewhat less than when Garlon 4 was used alone. Roundup or Tandem combined with Oust (T 21-23) did not increase weed or alfalfa control, when compared with Oust (T21) applied alone. Control of all other vegetation was excellent.

Poast (T10,11) is known to have no activity on dicots and proved ineffective on alfalfa and other broadleaves. It did provide up to 74% perennial grass control on July 26 (T11), which declined to 54% control by September 5.

Garlon 4 (T14,15) was very good on alfalfa, especially at the 1 lb/A rate. Perennial broadleaf control, primarily dandelion, was marginal with 50 to 85% control one month after treatment and about the same at the end of the season. Grasses were not affected by the Garlon 4 treatment.

Tandem (T16) had no effect on alfalfa, perennial grasses or broadleaves and when compared to the untreated check it appeared to have little effect on annual grasses or broadleaves. Tandem is expected to give improved grass control when mixed with a triazine such as atrazine or simazine (T24,25). Since atrazine and simazine were not applied alone, it is not known if Tandem contributed anything to the overall weed control, and the same is true of the tank mixes with prometone (T26,27) or Poast (T28-30). None of these mixtures injured alfalfa. The perennial grass and broadleaf control was best when compared with prometone, which is labeled for total vegetation control. It wasn't as effective as Oust however as the perennial broadleaves showed signs of recovery by September 5.

Birdsfoot Trefoil Establishment with Different Seeding and Arsenal Application Dates

OBJECTIVES

Compare three birdsfoot trefoil seeding dates and three Arsenal applications at varying rates to determine the best combination for roadside establishment.

MATERIALS AND METHODS

The trial area was heavily infested with giant foxtail (95%), a few velvetleaf, and elm tree seedlings (5%). Birdsfoot trefoil was seeded with a Brillion Seeder at 4.4 lb/A on three dates (4/11, 5/18, and 6/27). Arsenal was applied as a log treatment of 16 oz, 8 oz, 4 oz, 2 oz, and 1 oz product/acre or 0.25, 0.125, 0.062, 0.031, and 0.016 lb ai/acre respectively, on the same dates. The plots were 6 by 100 ft. and arranged in a split-block design with a non-random rate component using three replications. On April 11 there was no evidence of any giant foxtail seedlings or any other green vegetation. By May 18, giant foxtail was 0-2 in. and had 0-2 leaves. On June 28 the giant foxtail was 8-12 in. tall and a small patch of Canada thistle was 18-24 in. and in bud. Giant foxtail and birdsfoot trefoil yields were measured in October by harvesting half-meter square quadrats at 25 ft. intervals within each plot to estimate Arsenal rates.

RESULTS

Arsenal rate had no significant effect on giant foxtail dry matter yields when averaged over application date and BFT seeding date (Table 6). The amount of BFT was very sparse, probably due to excessive competition from uncontrolled giant foxtail.

Birdsfoot trefoil seeding date had no effect on giant foxtail yield (Table 7). It is apparent that the earlier seeding date was best for birdsfoot trefoil establishment. Very little birdsfoot trefoil became established from the May 18 seeding and none from the June 27 seeding.

The time of Arsenal application did have an effect on the giant foxtail control (Table 8). Arsenal, at the relatively low rates applied, provided excellent control of weeds that had already emerged but did not provide much residual control in the soil. Any Arsenal applied early enough to allow giant foxtail to germinate afterwards did not maintain control for the season. Arsenal applied on June 28 controlled the giant foxtail that was present, and was late enough in the season so very little germinated after treatment, thus the plots remained weed free for the remainder of the season. This late application also allowed the most growth of birdsfoot trefoil, particularly that seeded on April 11.

CONCLUSION

It would appear that the best birdsfoot trefoil establishment came from the April 11 seeding followed by an Arsenal application on June 28 (Table 9). Perhaps seeding birdsfoot trefoil early with a low rate of Arsenal followed by a second treatment in June would have potential in light of the short residual activity of Arsenal at these rates. Higher rates are very likely not possible because of the potential for injury to the seedling birdsfoot trefoil.

TABLE 6: Effect of Arsenal rate on yield of birdsfoot trefoil and giant foxtail averaged over three seeding dates and three application dates.

Imazapyr Rate	Application Date	Seeding Date	Birdsfoot Trefoil	Giant Foxtail
(lb ai/acre)			(- - - g fresh wt./0.5 m^2	- - -)
0.016	- - -	- - -	3	472
0.031	- - -	- - -	3	457
0.062	- - -	- - -	2	422
0.125	- - -	- - -	7	330
0.25	- - -	- - -	2	559
Significance Level (P)			0.6152	0.1983
LSD (P=0.05)			8	195

TABLE 7: Effect of birdsfoot trefoil seeding date on the yield of birdsfoot trefoil and giant foxtail, averaged over Arsenal rate and application date.

Imazapyr Rate	Application Date	Seeding Date	Birdsfoot Trefoil	Giant Foxtail
(lb ai/acre)			(- - - g fresh wt./0.5 m^2 - - -)	
- - -	- - -	4/11	9	466
- - -	- - -	5/18	1	459
- - -	- - -	6/27	0	420
Significance Level (P)			0.0018	0.3259
LSD (P=0.05)			5	65

TABLE 8: Effect of Arsenal application date on yield of birdsfoot trefoil and giant foxtail averaged over Arsenal rate and seeding date.

Imazapyr Rate	Application Date	Seeding Date	Birdsfoot Trefoil	Giant Foxtail
(lb ai/acre)			(- - - g fresh wt./0.5 m^2 - - -)	
- - -	4/11	- - -	2	637
- - -	5/18	- - -	1	662
- - -	6/28	- - -	7	46
Significance Level (P)			0.0378	0.0001
LSD (P=0.05)			5	65

TABLE 9: Effect of Arsenal application date and birdsfoot trefoil seeding date on the yield of birdsfoot trefoil and giant foxtail averaged over Arsenal rates.

Imazapyr Rate	Application Date	Seeding Date	Birdsfoot Trefoil	Giant Foxtail
(lb ai/acre)			(- - - g fresh wt./0.5 m^2 - - -)	
- - -	4/11	4/11	4	635
- - -	4/11	5/18	1	630
- - -	4/11	6/27	0	647
- - -	5/18	4/11	2	726
- - -	5/18	5/18	1	709
- - -	5/18	6/27	0	550
- - -	6/28	4/11	20	36
- - -	6/28	5/18	1	38
- - -	6/28	6/27	0	63
Significance Level (P)			0.0119	0.0490
LSD (P=0.05)			9	112