Reprinted with permission from: Proceedings: Leafy Spurge Strategic Planning Workshop[1], Dickinson, North Dakota. March 29-30, 1994. pp. 35-41.

Sponsored by: U.S. Department of the Interior; U.S. Department of Agriculture, Forest Service; Rocky Mountain Elk Foundation; and DowElanco.

The effects of herbicide treatment on leafy spurge and non-target species

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Abstract:

The objective of this study was to evaluate the effectiveness of control of leafy spurge using an aerially applied herbicide (mixture of Tordon and 2,4-D) and examine the impact of the herbicide on non-target native species. Species composition of infested and non-infested sites were similar; however, foliar cover and aboveground biomass was substantially reduced by moderate and heavy infestations. Herbicide control has had little effect on foliar cover or biomass of the major graminoids. Forbs were impacted the most by the herbicide application which had the affect of reducing overall species richness on sprayed plots. Soil seedbank analysis indicates that herbicide control is reducing the seedbank for leafy spurge.

Introduction

Once established in an area, leafy spurge (*Euphorbia esula*) can dominate and displace some of the native constituents (Selleck *et al*. 1962, Belcher and Wilson 1989). Heavy infestations of leafy spurge threaten the structural and functional integrity of plant communities throughout the U.S. and Canada. Attempts at controlling leafy spurge with herbicides have produced mixed results. The objective of this study was to evaluate the effectiveness of control using an aerially applied herbicide (mixture of Tordon and 2,4-D) and examine the impact of the herbicide on non-target native species.

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Methods

An area near the Petrified Forest on the west side of the Little Missouri River was selected during the early part of the 1992 field season to monitor the effects of the aerially applied herbicide on targeted and non-targeted species. The site, located within the Upland Grassland Physiographic Unit, was classified as a needle-and-thread/threadleaf sedge (*Stipa comata*/*Carex filifolia*) Habitat Type (Hansen *et al*. 1984) and has about 70 acres infested with leafy spurge. Four infested and four non-infested macroplots (each macroplot is approximately 100 m^2 in size) were established in May 1992. Two of the infested macroplots and two of the non-infested macroplots were designated as control areas and were not sprayed with the herbicide. Sixteen, 20 × 50 cm quadrats were permanently established within each infested macroplot (sprayed and non-sprayed) while eight quadrats were permanently established within each non-infested macroplot (sprayed and non-sprayed). The area was aerially sprayed with a commercial herbicide mixture (Tordon and 2,4-D) during the early part of the 1993 field season.

Two quadrat manipulations were imposed on quadrats located within the infested macroplots (sprayed and nonsprayed). The manipulations included control, no manipulation, and clipped, in which all individual leafy spurge plants were clipped to ground level within the quadrat and within a 50 cm buffer zone surrounding the quadrat. The plots were initially clipped in May 1992 and then re-clipped in May 1993. The clipped treatment was designed to allow the evaluation of the effects of the herbicide on the native species with and without direct competition from leafy spurge. In May 1992, prior to quadrat manipulation, each plant species occurring in each permanent quadrat was assigned a cover class as described by Daubenmire (1959). The quadrats were also evaluated in early May 1993, prior to herbicide application, and in early August 1993, after herbicide application.

Peak aboveground biomass for the native species and for leafy spurge was harvested at ground level in August of 1991, 1992, and 1993 from 30 subjectively placed 20 × 50 cm quadrats. The 30 quadrats were subjectively placed so that a range of infestations (0% foliar cover of leafy spurge, 50% foliar cover of leafy spurge, and 100% foliar cover of leafy spurge) could be evaluated. Harvested biomass was oven dried at 105° C for approximately 24 hours or until completely dry and then weighed to the nearest hundredth of a gram. Means were analyzed using standard analysis of variance procedures and separated using Bonferroni t-tests (SAS Institute 1988).

Soil samples were collected from infested (sprayed and non-sprayed plots) and non-infested leafy spurge sites in 1992 and 1993. The samples were sifted, thoroughly mixed, and spread uniformly to a depth of 3 cm on top of 3 cm of a sterile vermiculite-peat moss mixture in a standard 20 × 20 cm seeding flat. The flats were randomized on a greenhouse bench and watered as needed from below. Leafy spurge seedlings were counted as they emerged.

Results and discussion

Overall, heavy infestations of leafy spurge has not affected species composition of the *Stipa comata*/*Carex filifolia* habitat type (Tables 1 and 2).

Table 1. Mean percent foliar cover (n=16) by species and Shannon diversity index for the non-infested (Native) and infested (Spray and Nonspray treatments) *Stipa comata*/*Carex filifolia* habitat type within the Upland Grassland Physiographic Unit for 1992 (pre-spray) and 1993 (post-spray). Plots were sprayed with a mixture of Tordon and 2,4-D in June 1993.

		Herbicide Treatment			
	Native	Spray		Nonspray	
Species	1992	1992	1993	1992	1993
Graminoids					
Agropyron smithii	4.7	0.2	0.3	0.9	0.6
Aristida longiseta	–	–	–	–	–
Bouteloua gracilis	13.5	6.4	8.1	3.4	3.6
Bromus japonicus	0.9	–	–	2.5	0.8
Calamovilfa longifolia	0.3	–	–	–	–
Carex filifolia	13.0	15.2	16.4	12.5	12.5
Carex spp.	2.2	6.1	1.9	3.4	4.3
Koeleria pyramidata	4.5	3.3	3.3	2.3	1.8
Poa pratensis	–	0.1	0.0	0.1	0.3
Sporobolus cryptandrus	–	–	–	–	–
Stipa comata	26.6	10.0	10.0	2.2	.5
S. viridula	4.8	1.1	0.0	0.1	0.1
Forbs					
Antennaria parviflora	–	–	–	–	–
Artemisia frigida	0.5	1.1	0.0	0.1	0.0
Astragalus sp.	0.1	0.9	0.0	0.0	0.9
Chrysopsis villosa	0.7	–	–	–	–
Commandra pallida	–	0.3	0.9	–	–
Euphorbia esula	–	55.8	1.2	68.4	66.1
Lactuca serriola	–	–	–	0.1	0.0
Linum rigidum	–	–	–	–	–
Lvgodesmia juncea	–	–	–	–	–
Oenothera serrulata	–	0.1	0.0	–	–
Phlox hoodii	–	–	–	–	–
Plantago purshii	0.6	–	–	–	–
Polygala alba	0.1	–	–	–	–
Potentilla sp.	–	–	–	–	–
Psoralea tenuiflora	–	0.1	0.0	–	–
Sphaeralcea coccinea	0.9	0.3	0.0	–	–
Taraxacum officinale	1.7	0.9	0.0	0.3	0.0
Tragopogon dubius	0.9	–	–	–	–
Xanthocephalum sarothrae	–	–	–	–	–
Number of Species	17	16	8	13	11
Shannon Diversity Index	1.99	1.54	1.58	1.10	1.10
Shannon Equitiability	0.70	0.56	0.76	0.43	0.46

Table 2. Mean percent foliar cover (n=16) by species and Shannon diversity index for the non-infested (Native) and infested (Spray and Nonspray treatments) *Stipa comata*/*Carex filifolia* habitat type within the Upland Grassland Physiographic Unit for 1992 (pre-spray) and 1993 (post-spray). Leafy spurge plants were clipped to ground level in May 1992 and 1993. Sprayed plots were sprayed with a mixture of Tordon and 2,4-D in June 1993.

		Clipped Plots			
	Native	Spray		Nonspray	
Species	1992	1992	1993	1992	1993
Graminoids					
Agropyron smithii	4.7	0.5	0.3	0.3	1.3
Aristida longiseta	–	–	–	0.0	0.9
Bouteloua gracilis	13.5	12.7	11.9	7.3	8.0
Bromus japonicus	0.9	–	–	1.2	0.1
Calamovilfa longifolia	0.3	–	–	–	–
Carex filifolia	13.0	11.4	14.2	8.8	10.6
Carex spp.	2.2	8.1	4.5	2.7	5.3
Koeleria pyramidata	4.5	5.3	1.3	6.3	6.4
Poa pratensis	–	–	–	0.9	0.3
Sporobolus cryptandrus	–	0.3	1.9	–	–
Stipa comata	26.6	15.1	16.1	7.8	7.3
S. viridula	4.8	0.9	0.1	1.9	1.8
Forbs					
Antennaria parviflora	–	–	–	0.0	0.3
Artemisia frigida	0.5	0.9	0.0	0.5	1.1
Astracralus sp.	0.1	–	–	0.0	0.9
Chrysopsis villosa	0.7	1.1	0.1	–	–
Commandra pallida	–	–	–	0.1	0.1
Euphorbia esula	–	53.9	0.1	59.5	27.8
Lactuca serriola	–	–	–	–	–
Linum rigidum	–	–	–	0.0	0.3
Lygodesmia juncea	–	0.3	0.0	0.9	0.0
Oenothera serrulata	–	–	–	–	–
Phlox hoodii	–	–	–	–	–
Plantago purshii	0.6	–	–	0.3	–
Polygala alba	0.1	–	–	–	–
Potentilla sp.	–	–	–	–	–
Psoralea tenuiflora	–	0.1	0.0	–	–
Sphaeralcea coccinea	0.9	–	–	–	0.3
Taraxacum officinale	1.7	–	–	0.9	0.9
Tragopogon dubius	0.9	0.3		0.3	0.3
Xanthocephalum sarothrae	–	–	–	–	–
Number of Species	17	14	10	16	19
Shannon Diversity Index	1.99	1.64	1.56	1.57	2.00
Shannon Equitiability	0.70	0.62	0.68	0.55	0.69

Foliar cover for several of the major species has, however, been reduced by the infestation. Threadleaf sedge (*Carex filifolia*) was the exception. Belcher and Wilson (1989) also reported a sedge that demonstrated no variation in frequency with an increase in leafy spurge frequency. Cover for the major graminoids was similar for the clipped and herbicide plots. Forbs were impacted the most by the herbicide application which had the effect of reducing species richness (Tables 1 and 2). Diversity, as evaluated by the Shannon-Weiner Diversity Index (Goldsmith *et al*. 1986), was similar for the sprayed plots before and after herbicide application in spite of reduced richness. This is in response to the reduction in dominance by leafy spurge by the herbicide which increased the evenness component of the diversity index. Diversity in the leafy spurge clipped plots was higher in 1993 as a function of both increased species richness and equitability (Table 2).

Native species biomass was reduced 39-77 percent by moderate infestations of leafy spurge while heavy infestations reduced biomass 78-85 percent (Table 3).

Table 3. Mean peak biomass (g/M^2, ± standard error, n=10) for all native species and leafy spurge at three levels of infestation (0% foliar cover of leafy spurge, 50% foliar cover leafy spurge, and 100% foliar cover of leafy spurge) and in response to a herbicide aerially applied in June, 1993.

	Native Biomass			Leafy Spurge Biomass	
Year	0% Foliar cover	50% Foliar Cover	100% Foliar Cover	50% Foliar Cover	100% Foliar Cover
1991	127 ± 7.0b	71 ± 9.4c	28 ± 4.5d	119 ± 8.6b	262±17.1a
1992	87 ± 11.7b	20 ± 4.4c	13 ± 2.5c	105 ± 11.4b	301 ± 22.8a
1993					
Nonspray	218 ± 15.3a	134 ± 18.6b	35 ± 9.8d	96 ± 8.3bc	214 ± 25.9a
Spray	207 ± 23.3a	—	57 ± 11.1cd	—	—

Means within a year followed by a different letter are significantly different P<0.05.

Table 4. Mean seedling emergence of leafy spurge from 20 × 20 cm seed flats from infested (1992 and 1993) and sprayed and nonsprayed (1993) plots (n=10 for 1992, n=20 for 1993).

Year	Infested	Non-infested	Sprayed	Non-sprayed
1992	30.1a	2.7b		
1993	38.0a	0.1b	24.8	13.3 NS

Means of infested and non-infested sites followed by the same letter are not significantly different P>0.05.
NS=non-significant differences (P>0.05) between sprayed and non-sprayed plots.

Similarly, Lym and Kirby (1987) found that leafy spurge reduced long-term forage production 17 to 33 percent on North Dakota rangeland that was 50 to 100% infested with leafy spurge. Leafy spurge biomass harvested from heavily infested macroplots was 106-246 percent greater than native species harvested from non-infested sites for 1991 and 1992. Total biomass was similar between heavily infested and non-infested macroplots for 1993. The herbicide treatment had no affect on native species biomass in infested or non-infested macroplots.

The number of seedlings emerging from infested sites was substantially higher than from non-infested sites for both years (Table 4). Seedling emergence was lower from sprayed sites ($P>0.05$) compared to non-sprayed sites. Because the sites were sprayed in early June, before flowering, the seedlings which emerged from soil samples collected from the sprayed sites undoubtedly represent seeds stored in the soil from previous years. A second year of soil seedbank analysis may provide an indication of the potential reduction in recruitment of leafy spurge from the seed bank.

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