

***Euphorbia esula*: Perceptions by ranchers and land managers¹**

RANDALL S. SELL, DEAN A. BANGSUND and F. LARRY LEISTRITZ

Department of Agricultural Economics, North Dakota State University, Fargo ND 58105.

Abstract:

Euphorbia esula is an exotic perennial weed that is estimated to infest 650,000 ha in North and South Dakota, Montana, and Wyoming. The estimated annual economic effect of *E. esula* infestations in the four-state area is about \$130 million. We present the results of a survey of ranchers, local decision makers, and public land managers of grazing and nongrazing property from a five-county area in North and South Dakota, Montana, and Wyoming. A total of 565 ranchers, local decision makers, and public land managers were surveyed, which resulted in 267 completed questionnaires. The main objective of the survey was to evaluate respondent's perspectives of managerial, institutional, and social factors that may affect the rate and extent of implementation of various *E. esula* control strategies. The reasons for not using the various *E. esula* controls generally fell into environmental, financial, and educational categories. In many cases, little can be done to remove environmental constraints; however, financial constraints may be addressed through cost-share programs either offered locally or through state agencies. The other main reason for not using some controls was a lack of knowledge to work with various controls (e.g., grazing and biological controls). These obstacles could be addressed with workshops, demonstrations, or educational bulletins. These educational tools could be provided by universities or governmental agencies, as respondents indicated this was their choice for information dissemination. Disagreements among the survey groups were not substantial, and many share similar concerns in controlling the weed.

Nomenclature:

Leafy spurge, *Euphorbia esula* L. EPHES.

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Keywords:

Euphorbia esula, leafy spurge, EPHES, weed management, rancher opinion, public land manager opinion.

Euphorbia esula is an exotic, noxious, perennial weed that is widely established in the northern plains. It is estimated to infest 650,000 ha in a four-state region including North and South Dakota, Montana, and Wyoming. North Dakota, the most infested state, has nearly 6% of its untilled land infested (Leitch *et al.* 1994). The estimated annual economic impact from *E. esula* infestations in the four-state area is about \$130 million (Bangsund *et al.* 1993; Leitch *et al.* 1994). Until recently, *E. esula* infestations in the upper Midwest had been doubling every 10 years (Bangsund and Leistriz 1997). It is clear that *E. esula* can create serious economic losses for landowners and ranchers and pose management problems for both public and private land managers.

Euphorbia esula has unique physiological characteristics that make it difficult to control; it can rejuvenate itself from extensive root reserves and sustain itself against repeated control measures. Although current herbicides are incapable of eradicating established infestations, expansion can be controlled with a combination of biological and chemical technologies (Messersmith 1989; Lym and Messersmith 1994; Lym and Zollinger 1995; Lym *et al.* 1997). Eradication of the plant is possible using mechanical tillage; however, this method is restricted to tillable land. It has become evident that prevention of initial infestations and controlling the expansion of existing patches is critical to slow the advance of this formidable weed.

Cost effective control of *E. esula* on rangeland (public and private), wild lands, and other public lands (roadways, historic sites) requires a combination of chemical and biological control techniques in an integrated pest management system. In 1997, a major integrated pest management research and demonstration project (TEAM Leafy Spurge) was initiated to develop and integrate sustainable *E. esula* management methods and to transfer to land managers economically and ecologically proven technologies to manage *E. esula*. We present the results of a survey of ranchers, local decision makers, and public land managers of grazing and nongrazing property. The main objective of the survey was to evaluate managerial, institutional, and social factors that may affect the rate and extent of implementation of various control strategies based on respondents' perspectives.

Although this research focused on impediments to the implementation of *E. esula* control options, it is reasonable to assume that evaluation of impediments to control of other types of invasive species (plant and animal) may be evaluated using this format. This survey effort helped determine the baseline use and understanding of *E. esula* control options. The same type of survey will be administered at the end of the TEAM Leafy Spurge project to evaluate the effect of the project. The layout of this questionnaire was as follows: (1) respondents' perceptions of the weed problem in their area as it relates to other problems, (2) respondents' perceptions of the weed problems on land they manage (or land they represent either directly or indirectly in the case of local decision makers), (3) respondents' use of various control options in the past, present, and expectations for the future, (4) respondents' perceptions of the effectiveness and economics of the control

options, (5) reasons for respondents not using control options, (6) questions regarding where respondents get weed management information and in what form they prefer the information, and (7) solicitation of respondents' opinions (agreement or disagreement) to a series of statements relating to various aspects of *E. esula* control.

Methods

This study focused on a five-county area in North Dakota (Billings and Golden Valley Counties), Montana (Carter County), South Dakota (Harding County), and Wyoming (Crook County) (Figure 1). These five counties were selected for in-depth surveys because they included the demonstration plots of the TEAM Leafy Spurge project. There were 459 ranchers, 56 local decision makers, 29 public land managers of grazing land, and 21 public land managers of nongrazing land surveyed. The strategy of the survey was to survey identifiable local decision makers and public land managers who were involved in land management or represented those involved in land management in the study area. A list of ranchers whose mailing address was in the study area was obtained from Intertec Publishing (personal communication). This list represented about 31% of farmers and ranchers in the study area (Bureau of Census 1994). The goal in selecting the group of local decision makers was to solicit perspectives and opinions of individuals who were in a position to make or influence decisions about or relating to control of *E. esula* and other weeds. The survey pool of local decision makers included state legislators, county agents, county commissioners, county weed board members, and township board members. Local decision makers were included in the potential survey pool if part of their district was within or included the five-county study area.

The survey of public land managers of grazing land included those agencies that managed public grazing land in or adjacent to the five-county study area. These agencies or departments included the U.S. Department of the Interior and the Bureau of Land Management (USDI-BLM), U.S. Forest Service (USFS), North Dakota Department of Corrections, U.S. Bureau of Indian Affairs, and State Land Departments in Montana, North Dakota, South Dakota, and Wyoming. The survey of public land managers of nongrazing land included Theodore Roosevelt National Park, Devils Tower National Monument, U.S. Department of the Interior-Bureau of Reclamation, U.S. Department of the Interior-Fish and Wildlife Service (USDI-FWS), Game and Fish Management Departments, and Departments of Transportation in Montana, North Dakota, South Dakota, and Wyoming.

The individuals in each group were mailed the first questionnaire and cover letter between January and March 1998; a follow-up questionnaire and a cover letter were mailed to nonrespondents. Response rates for local decision makers and ranchers were 68% and 41%, respectively. After the second mailing, public land managers of grazing and nongrazing land nonrespondents were contacted by telephone to confirm they had received the questionnaire and to solicit their cooperation in the survey. The follow-up phone call was done with public land managers because relatively few public land managers make decisions that affect extensive areas of grazing and other public lands. Final response rates for the public land managers of grazing and nongrazing land were 83% and 86%, respectively.

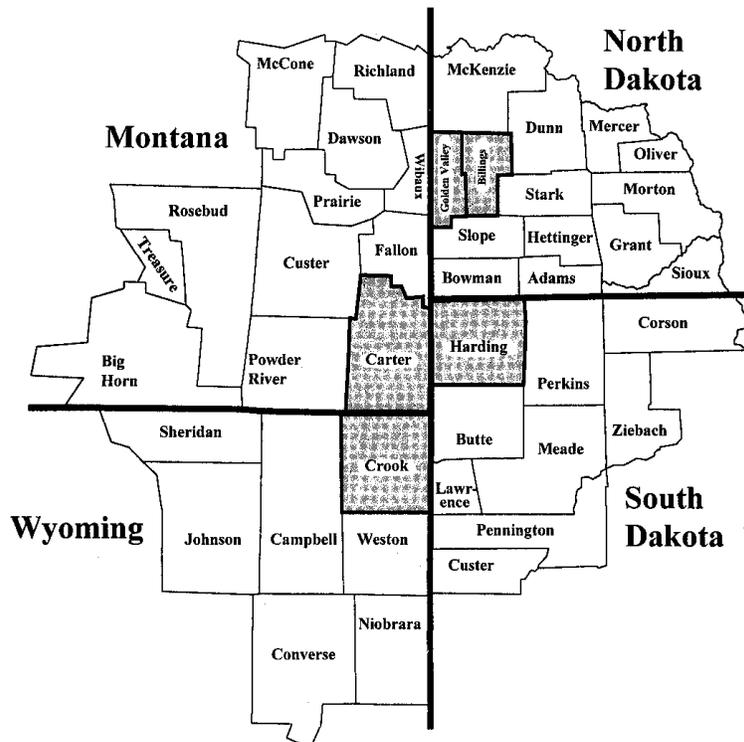


Figure 1. Study counties for perceptions of *Euphorbia esula* by ranchers, local decision makers, and public land managers, 1998.

Focus group meetings were held with ranchers, local decision makers, and public land managers from the study area to attempt to understand the issues surrounding weed management in general and *E. esula* specifically. In general, these meetings were specific to the type of group focused on (i.e., only ranchers invited to ranchers’ focus group meetings, or only public land managers at public land managers’ focus group meetings). This was done to help ensure active, constructive dialog within group meetings. A draft of questions that dealt with the issues surrounding weed management were developed from the focus group meetings.

The focus group meetings were instrumental in helping to develop the terminology and subsequent wording of the questions that would be readily understood by the respondents. For example, one method of controlling *E. esula* is biological control. This could entail use of insects or grazing animals. However, the ranchers and public land managers suggested that biological control refer only to use of insects and use of grazing animals (sheep or goats) be identified as a separate control method. Following development of the initial questionnaire, specialists in weed, animal, and range sciences were consulted to further refine the questions.

Slight variations in questions between the groups were necessary. Some questions that dealt with specific aspects of public land management would not apply to ranchers and therefore were not included in the rancher survey. Wherever possible, likert scale answers were sought to enable the relative degree of agreement with various issues to be developed. An example of a likert scale question is outlined in Table 1.

Table 1. Sample of a Likert scale question.

	Strongly disagree	Some-what disagree	Neither agree nor disagree	Some-what agree	Strongly agree	Don't know
Rangeland weeds represent a problem to all ranchers	1	2	3	4	5	0

An average score of ranchers of more than 4 (not including the “don’t know” category) would mean that, on average, ranchers responded that rangeland weeds were a problem for all ranchers.

Results

Characteristics of respondents

Nearly 70% of public managers of grazing land were from the USDI-BLM and USFS, and about 70% of public managers of nongrazing land were from the USDI-FWS, State Game and Fish Departments, and National Park Service (Table 2). The average age of ranchers and public land managers was 53 and 42 years, respectively. Slightly less than 50% of the ranchers and local decision makers had college degrees; about 90% of public managers of grazing and nongrazing land had college degrees. The average amount of land managed by public managers of grazing and nongrazing land was 525,000 and 34,000 ha, respectively. Over 90% of public managers of grazing land reported managing more than 20,000 ha. While only 56% of ranchers reported having *E. esula*, more than 90% of public managers of nongrazing land reported having *E. esula*, and 100% of public managers of grazing land had *E. esula*. The highest infestation rate was 13% of land managed by public managers of nongrazing land.

Problems faced by land managers

Respondents were asked to rate several grazing and weed management issues as major problems, minor problems, or not a problem. Public managers of nongrazing land were not asked these questions, which primarily dealt with livestock grazing issues, because they would not likely have a reason to follow the issues associated with the grazing of livestock. Exempting the “other” category, a greater share of the local decision makers than the other groups believed that livestock prices (87%) were a major problem, which was also the ranchers’ leading major problem category (Table 3). For public managers of grazing land, excluding the “other” category, the most frequently indicated major problem was noxious or invasive weeds. Public managers of grazing land and local decision makers were more likely than ranchers to respond that noxious or invasive weeds were a major problem.

Table 2. Characteristics of respondents to weed management survey, 1998.

Characteristic	Unit	Value
Response rates		
Ranchers	%	40.7
<i>n</i>		(187)
Local decision makers	%	67.9
<i>n</i>		(38)
Public land managers of grazing land	%	82.8
<i>n</i>		(24)
Public land managers of nongrazing land	%	85.7
<i>n</i>		(18)
Agency represented (based on percentage of returned questionnaires)		
Public land managers of grazing land		
Bureau of Land Management	%	47.8
Forest Service	%	21.7
State Land Departments	%	8.7
Public land managers of nongrazing land		
Federal and State Game and Fish Departments	%	37.50
National Park Service	%	31.3
State Departments of Transportation	%	18.8
Average age		
Ranchers	yr	53
Local decision makers	yr	51
Public land managers of grazing land	yr	42
Public land managers of nongrazing land	yr	42
Education (percentage with college degree)		
Ranchers	%	44.7
Local decision makers	%	43.2
Public land managers of grazing land	%	95.8
Public land managers of nongrazing land	%	88.9
Average land operated or managed (per respondent)		
Ranchers	ha	2,798
<i>n</i>		(187)
Public land managers of grazing land	ha	528,909
<i>n</i>		(24)
Public land managers of nongrazing land	ha	34,375
<i>n</i>		(18)
Distribution of land area operated		
Public land managers of grazing land		
Less than 810 ha	%	8.3
810 to 20,243 ha	%	0.0
More than 20,243 ha	%	91.7
Public land managers of nongrazing land		
Less than 810 ha	%	33.3
810 to 4,048 ha	%	16.7
4,048 to 20,243 ha	%	27.8
More than 20,243 ha	%	22.2
Currently have <i>E. esula</i> on land operated or managed		
Ranchers	%	55.6
<i>n</i>		(180)
Public land managers of grazing land	%	100.0
<i>n</i>		(24)
Public land managers of nongrazing land	%	93.8
<i>n</i>		(16)
Percentage of average land area infested with <i>E. esula</i> ^a		
Ranchers	%	3.9
<i>n</i>		(83)
Public land managers of grazing land	%	1.5
<i>n</i>		(17)
Public land managers of nongrazing land	%	13.0
<i>n</i>		(10)

^aAverage infestation for those respondents who reported the amount of *E. esula* on land operated or managed (i.e., some respondents reported currently having *E. esula* but did not give the size of infestation).

When asked to indicate which of the issues listed was the single most important, livestock prices were again indicated as the most important problem by each group (33%). Although less than 10% of all ranchers indicated that noxious and invasive weeds were the most important problem, more than one-fourth of public managers of grazing land responded that noxious and invasive weeds were the most important problem. Sixty-seven percent of ranchers and 81% of local decision makers indicated that livestock prices had become worse over the past 5 years. The majority of public managers of grazing land thought that noxious and invasive weeds had become worse. Furthermore, ranchers and local decision makers were nearly four times more likely than public managers of grazing land to believe that regulations affecting use of public land had become more of a problem in the past 5 years.

Table 3. Problems faced by ranchers and land managers in the past 5 years, 1998.

Problems and issues	Ranchers	Local decision makers	Public land managers of grazing land
	indicated a major problem		
Livestock prices**	78.7	86.5	45.0
Adverse weather conditions*	62.5	51.4	34.8
Cost of feed and supplies**	52.8	62.2	17.7
Noxious or invasive weeds*	30.8	58.3	47.8
Predators	36.3	46.0	19.1
Regulations affecting use of public lands*	34.1	47.2	4.8
Availability of grazing land	26.3	34.3	9.5
Use of CRP for haying and grazing	13.6	8.6	14.3
	indicated most important problem		
Livestock prices	32.0	37.9	30.4
Adverse weather conditions	24.4	24.1	13.0
Noxious or invasive weeds	8.1	10.3	26.1
Regulations affecting use of public lands	8.1	10.3	8.7
Cost of feed and supplies	9.9	3.5	0.0
Availability of grazing land	7.6	3.5	13.0
Predators	5.8	6.9	0.0
Use of CRP for haying and grazing	1.2	0.0	0.0
	indicated problem became worse in past 5 years		
Livestock prices*	67.0	81.1	40.0
Cost of feed and supplies*	64.8	81.1	38.9
Regulations affecting use of public lands**	53.7	58.8	13.6
Noxious or invasive weeds	42.0	66.7	72.7
Predators*	46.6	44.4	5.3
Availability of grazing land	35.8	22.9	16.7
Adverse weather conditions	26.1	8.3	11.8
Use of CRP for haying and grazing	9.8	6.3	6.7

*Statistically different at $P \leq 0.05$ among all groups of respondents for each individual problem (chi-square test statistic).

**Statistically different at $P \leq 0.01$ among all groups of respondents for each individual problem (chi-square test statistic).

Weed species and management problems

Weeds other than *E. esula* pose problems to ranchers and public land managers. Some of those weeds specifically listed in the questionnaire included: *Convolvulus arvensis* L. (field bindweed), *Cirsium* spp. (thistles), *Bromus* spp. (annual brome grasses), *Artemesia* spp. (sagebrush), *Centaurea* spp. (knapweeds), *Opuntia polycantha* Haw. (prickly pear), and *Artemesia absinthium* L. (absinth wormwood). Across all groups, the weed most often mentioned as a problem by the respondents was *E. esula* (58%), followed by *Cirsium* spp. (27%) and *C. arvensis* (22%) (Table 4). However, local decision makers and public land managers of grazing land and nongrazing land were much more likely than ranchers to indicate that *E. esula* was a major problem. When asked to identify one weed that they felt posed the most serious problem, more than 60% of all respondents indicated *E. esula*, followed by *Cirsium* spp. (11%). Local decision makers were most likely to list *E. esula* as their most important problem weed. However, since the sponsor of the questionnaire (TEAM Leafy Spurge) was mentioned in the cover letter, the respondents may have been more likely to focus on *E. esula* in responding to this question.

Table 4. Weeds posing greatest problems to land managers, 1998.

Weeds	Ranchers	Local decision makers	Public land managers	
			Grazing land	Non-Grazing land
	% indicated a major problem			
<i>Euphorbia esula</i> **				
<i>Cirsium</i> spp. (thistles)	49.4	86.8	63.6	75.0
<i>Convolvulus arvensis</i> (field bindweed)	25.3	37.8	15.0	33.3
<i>Bromus</i> spp. (annual brome grasses)	25.0	19.4	11.1	6.7
<i>Artemesia</i> spp. (sagebrush)**	13.3	15.2	30.0	38.5
<i>Centaurea/Acroptulun</i> spp. (knapweed)	8.1	11.1	10.0	7.7
<i>Opuntia polycantha</i> (prickly pear)	6.3	5.9	9.5	33.3
<i>Artemesia absinthium</i> (absinth wormwood)	5.2	3.1	10.5	0.0
	0.0	4.6	5.9	0.0
	% indicated most - important problem**			
<i>Euphorbia esula</i> **				
<i>Cirsium</i> spp. (thistles)	56.8	90.9	73.9	62.5
<i>Bromus</i> spp. (annual brome grasses)	11.2	3.0	13.0	18.8
<i>Artemesia</i> spp. (sagebrush)	8.3	3.0	8.7	6.3
<i>Convolvulus arvensis</i> (field bindweed)	7.1	0.0	0.0	0.0
<i>Centaurea/Acroptulun</i> spp. (knapweed)	4.7	0.0	0.0	0.0
<i>Opuntia polycantha</i> (prickly pear)	1.8	0.0	4.4	12.5
<i>Artemesia absinthium</i> (absinth wormwood)	0.6	3.0	0.0	0.0
	0.0	0.0	0.0	0.0

**Statistically different at $P \leq 0.01$ among all groups of respondents for each type of weed considered a major problem (chi-square test statistic). Statistical testing for the weed considered to be the most important problem was tested simultaneously (chi-square test statistic).

Opinions varied on how invasive weeds spread in the study area. The public managers of grazing land (48%) and public managers of nongrazing land (56%) were more likely than ranchers (29%) and local decision makers (24%) to indicate that invasive weeds spread from human action (Table 5). Public managers of grazing and nongrazing land were three to four times more likely than ranchers and local decision makers to respond that lack of competition from native plants was an important reason for *E. esula* infestations.

Table 5. Percentage of respondents indicating the manner in which *Euphorbia esula* infestations expanded, 1998.

Methods of spreading	Ranchers	Local decision makers	Public land managers	
			Grazing land	Nongrazing land
	———— % indicated two most important problems ————			
Infestation spread from adjoining land	63.3	60.5	40.9	68.8
Not recognized as a problem or threat until it's too late	41.7	50.0	47.8	25.0
Spread by human action (e.g., vehicle, contaminated hay)*	28.9	23.7	47.8	56.3
Lack of cost-effective controls	29.1	34.2	38.1	25.0
Overgrazing of rangeland	7.8	5.3	4.6	0.0
Lack of competition from native plants or grasses*	4.5	5.3	18.2	18.8

*Statistically different at $P \leq 0.05$ among all groups of respondents for each method of spreading (chi-square test statistic).

When respondents were asked to indicate how serious they felt weed problems were on their ranch or in their area, ranchers were the least likely to believe that weeds were a major problem (18%) (Table 6). More than 65% of local decision makers thought that weeds in their area were a major problem followed by 44% of public managers of nongrazing land who indicated weeds were a major problem.

Table 6. Respondents' perceptions of the seriousness of the weed problem on their ranch or in their area, 1998^a.

Perception of weed problem	Ranchers	Local decision makers	Public land managers	
			Grazing land	Nongrazing land
	———— % ————			
Not a problem	16.8	2.6	0.0	0.0
Minor problem	65.7	31.6	68.2	56.3
Major problem	17.5	65.8	31.8	43.8

^aRespondents were asked about the weed problem in general to help evaluate the relationship of *Euphorbia esula* to their perceptions of the general weed problem.

Table 7. Respondents' opinions and perceptions about weed management, *Euphorbia esula* infestations, and methods of *E. esula* control, 1998.

Statement	Ranchers	Local decision makers	Public land managers	
			Grazing land	Non-grazing land
	average score ^a			
I am concerned about controlling weeds in rangeland	4.8 a ^b	NA ^c	4.7 a	4.9 a
State and federal government agencies are not doing enough to control problem weeds on public grazing land	4.5 a	4.3 a	3.5 b	2.7 c
<i>E. esula</i> is a long-term management problem	4.6 a	4.7 a	4.8 a	4.8 a
Biological agents released to control <i>E. esula</i> are safe for crops and native plants	4.2 a	4.3 a	4.6 a	4.5 a
The expected payoff from biological control of leafy spurge justifies investment of public funds to develop the process	4.2 a	4.4 a	4.6 a	4.2 a
Rangeland weeds represent a problem to all ranchers	4.4 a	4.3 a	3.7 a	2.1 b
<i>E. esula</i> negatively affects various agency's ability to effectively manage their land	NA	4.2 a	4.0 a,b	3.4 b
There needs to be more research on controlling weeds in rangeland	4.0 a	4.0 a	3.3 a,b	3.6 b
Herbicides, if used properly, are not harmful to the environment	4.0 a,b	4.2 a	3.4 b	2.8 c
Governments should help pay part of the cost to control <i>E. esula</i> , even if it means an increase in taxes	3.5 a	3.7 a	3.7 a	3.3 a
Restrictions affecting the use of herbicides on rangeland are too strict	3.6 a	3.3 a	2.6 b	3.6 a
State and federal government agencies are not doing enough to help control problem weeds on private grazing land	3.7 a	3.7 a	3.3 a	2.1 b
Weed problems in rangeland are generally the result of poor range management	3.2 a	3.4 a	3.0 a	3.4 a
Local governments are not effective in controlling problem weeds	3.4 a	2.8 a	3.3 a	3.0 a
<i>E. esula</i> can be controlled but it is just too costly	3.2 a	3.0 a	2.8 a	2.6 a
It seldom makes economic sense to control weeds on other public land	NA	NA	4.3 a	2.6 b
Biological control will eventually eliminate the <i>E. esula</i> problem	2.8 a	2.9 a	2.8 a	2.8 a
It doesn't pay to control weeds on my land when my neighbor doesn't control his weeds	2.7 a	NA	2.6 a	4.1 b
<i>E. esula</i> is virtually impossible to control with current control methods and techniques	2.7 a	2.4 a	2.4 a	2.6 a
It seldom makes economic sense to control weeds on rangeland	1.9 a	1.4 a	1.7 a	1.6 a
Weeds infestations have no effect on the market (sale) value of rangeland	1.7 a,b	1.4 c	2.0 b	3.1 a
Public land managers are doing a good job of controlling weeds on public land	1.7 b	1.9 b	2.8 a	1.6 b

^aBased on a score of 1 to 5, where 1 is strongly disagree and 5 is strongly agree.

^bThose groups of respondents with different letters following their average score are statistically different at $P \leq 0.05$ (t test).

^cNA, not applicable; the question was not posed to that survey group.

Respondents were asked their opinion regarding a variety of statements about weed management, public land management, effectiveness of land management by government agencies, and *E. esula* management options. Several statements elicited significantly different responses between groups. The statement with which respondents overall most strongly agreed (average score closest to 5, strongly agree) was “I am concerned about controlling weeds in rangeland” (Table 7).

A difference in opinion was noted with the statement, “State and federal government agencies are not doing enough to control problem weeds on public grazing land.” Ranchers and local decision makers indicated strong agreement with the statement (average scores were 4.5 and 4.3, respectively), while public managers of grazing land (average score 3.5) were nearly neutral, and public managers of nongrazing land (average score 2.7) tended to disagree with the statement. A difference of opinion also existed regarding the effect of herbicides on the environment. Ranchers, local decision makers, and public managers of grazing land indicated that herbicides, when used properly, were not harmful to the environment, while public managers of nongrazing land (average score 2.8) disagreed. The statement that showed the greatest difference of opinion between ranchers, local decision makers, and public managers of grazing land versus public managers of nongrazing land was “rangeland weeds represent a problem to all ranchers.” Ranchers, local decision makers, and public managers of grazing land agreed with the statement (average scores were 4.4, 4.3, and 3.7, respectively), while public managers of nongrazing land disagreed (average score 2.1). Alternatively, ranchers, local decision makers, and public managers of grazing land disagreed with the statement “weed infestations have no effect on the market value of rangeland,” whereas public managers of nongrazing land were neutral. All groups except public managers of grazing land agreed with the statement “restrictions affecting the use of herbicides on rangeland are too strict.” Only public managers of nongrazing land thought state and federal government agencies are doing enough to help control problem weeds on private grazing land.

Respondents were asked to indicate their perceptions of effectiveness and economics of four methods of controlling *E. esula*. The methods included herbicides, biological control-insects and pathogens, grazing-sheep or goats, and tillage or mechanical control. Less than 50% of all groups thought that spraying with herbicides was very effective; however, more than 60% of all groups thought it pays to spray *E. esula* with herbicides (Table 8). While more than 50% of respondents did not indicate herbicides are very effective at controlling *E. esula*, herbicide use was perceived as being better than no control. The public managers of nongrazing land had the greatest share of respondents who indicated that biological control was very effective (62%) and also indicated that biological control pays (92%). Less than one-third of all groups thought grazing with sheep or goats was a very effective control. Most ranchers thought spraying with herbicides offered a very effective and most likely to pay type of control. Most local decision makers also thought that spraying was a very effective control, but the greatest share of local decision makers believed that biological control would be most likely to pay. Most public managers of grazing land thought grazing with sheep or goats would be a very effective and most economical type of control.

Table 8. Respondents' belief in most effective and economical methods to control *Euphorbia esula*, 1998.

Control methods	Public land managers			
	Ranchers	Local decision makers	Grazing land	Non-grazing land
% indicated very effective				
Effectiveness of these practices in controlling <i>E. esula</i>				
Spraying with herbicide	27.3	31.4	27.3	43.8
Biological control with insects or pathogens*	20.3	22.9	19.1	61.5
Grazing with sheep or goats	23.9	30.3	33.3	14.3
Tillage or reseeding	5.6	4.0	12.5	0.0
% indicating it pays				
Economical to use these practices in controlling <i>E. esula</i>				
Spraying with herbicide	70.1	60.5	68.2	82.4
Biological control with insects or pathogens	65.9	61.1	80.0	92.3
Grazing with sheep or goats	56.0	54.6	85.7	46.2
Tillage or reseeding**	19.8	4.4	58.3	14.3

*Statistically different at $P \leq 0.05$ among all groups of respondents for each control method (chi-square test statistic).

**Statistically different at $P \leq 0.01$ among all groups of respondents for each control method (chi-square test statistic).

Ranchers and public managers of grazing and nongrazing land were asked whether they used several preventive measures to thwart establishment or expansion of *E. esula* on their property. More than 95% of ranchers and 100% of public managers of nongrazing land routinely checked their land for invading plants (Table 9). Over 80% of respondents spot sprayed near fringe or boundary areas. Ranchers were more likely to keep machinery and trucks clean and insist that local governments control *E. esula* in roadways and ditches than either public land manager group. A greater percentage of both groups of public land managers had used biological control in the past and expected to use it as a control method in the future than ranchers. Public managers of grazing land were about twice as likely to have used sheep and goats as a control in the past and expect to use in the future than either ranchers or public managers of nongrazing land.

Respondents were asked to indicate the reasons for not using the various control methods. More than 60% of all respondents indicated that environmental restrictions were the main reason for not using herbicides (Table 10). However, 78% of local decision makers indicated infestations were too large as the most common reason for not using herbicides. Public managers of grazing land also mentioned factors related to a lack of funding (71%) and infestations were too large (71%) as reasons for not using herbicides. Not having sufficient time, money, or equipment was not as much of a problem for herbicide application by public managers of nongrazing land as the other groups. However, along with environmental restrictions (83%), the second most common reason reported by public managers of nongrazing land for not applying herbicides was damage to nontarget species (64%). The most common reasons for not using biological agents were limited access to agents and because they took too long to work. An important reason to more than 50% of the local decision makers was that they did not know how to use biological agents properly. Nearly 75% of all respondents indicated that lacking the right

equipment was the most important reason for not using sheep and goats, although the second most frequent reason was a lack of expertise with sheep or goats (40%). About 42% of public managers of nongrazing land indicated that they could not consider grazing sheep or goats (some agencies may be prevented because of policy or agency rules, e.g., Theodore Roosevelt National Park), and others may be prevented by logistics (e.g., Departments of Transportation) as a control alternative; also, 43% indicated that sheep and goats were not effective in controlling *E. esula*. The most common reason for not using tillage or other mechanical controls (i.e., tillage, planting competing grasses, mowing) across all groups was that infested land was not suitable for tillage (86%).

Table 9. Respondents use of preventative practices and control measures in past and future, 1998.

Preventative practice and control measures	Ranchers	Public land managers	
		Grazing land	Nongrazing land
———— % indicated using the following practices ————			
Preventative practice			
Purchase only weed-free hay	71.3	66.7	NA
Keep machinery and trucks clean*	79.7	50.0	69.2
Aggressively destroy weeds when found	91.0	76.2	92.9
Spot spraying near fringe or boundary areas	82.3	87.0	92.9
Routinely check range for invading plants**	96.9	66.7	100.0
Insist that local governments control <i>Euphorbia esula</i> in roadways and ditches**	72.1	31.6	38.5
———— % indicated using the following controls ————			
Control measures			
Herbicides	97.2	100.0	100.0
Biological control*	54.0	95.2	77.8
Sheep or goats**	30.2	83.3	40.0
Tillage or reseeding with competing grasses	15.3	10.5	12.5
———— % expecting to use in the future ————			
Herbicides	100.0	93.8	100.0
Biological control*	54.2	93.3	71.4
Sheep or goats**	26.1	71.4	37.5
Tillage or reseeding with competing grasses	16.7	13.3	25.0

*Statistically different at $P \leq 0.05$ among all groups of respondents for each control method (chi-square test statistic).

**Statistically different at $P \leq 0.01$ among all groups of respondents for each control method (chi-square test statistic).

Table 10. Based upon what respondents experienced, believed, or had been told their indication of why the following controls are not used on *Euphorbia esula*, 1998.

Reasons for not using controls	Ranchers — % indicated reason —	Local deci- sion makers	Public land managers	
			Grazing land — for not using —	Non- grazing land
Herbicide treatments				
Environmental restrictions or concerns prevent me from applying herbicides (such as, spraying near water, trees, sensitive crops, etc.)	61.7	66.7	85.7	82.8
Lack funding to efficiently manage leafy spurge infestations*	NA ^a	63.9	71.4	27.3
Area of infestations are so large that the cost of using herbicides would be prohibitively expensive*	51.8	77.8	71.4	45.5
<i>E. esula</i> infestations are inaccessible to sprayers	41.8	47.2	66.7	54.6
Herbicides are not economical**	45.4	41.7	57.1	0.0
Damage to nontarget species	NA	30.6	42.9	63.6
Do not have the time to treat the <i>E. esula</i> infestations	29.8	38.9	28.3	9.1
Herbicides are ineffective in controlling <i>E. esula</i>	24.8	27.8	38.1	36.4
Lack the equipment or expertise to apply herbicides	18.4	25.0	28.6	18.2
Cost-share programs for herbicides are no longer available or have been reduced	33.3	NA	NA	NA
Biological controls				
Limited access to biological agents (cannot collect sufficient numbers of the agents)	45.1	60.0	41.2	33.3
Biological agents take too long to work	47.8	46.7	52.9	11.1
Do not know how to properly use the agents	30.1	53.3	29.4	22.2
Do not know how to obtain or where to obtain the insects	34.5	36.7	23.5	0.0
Do not have the time to work with biological agents	23.9	20.0	29.4	22.2
Biological agents will not likely work on my <i>E. esula</i> infestations	18.6	16.7	5.9	0.0
Afraid the agents will spread or attack other plants	16.8	6.7	0.0	0.0
Biological agents are not economical	10.6	3.3	0.0	22.2
Biological agents will eventually spread to my <i>E. esula</i> without my help	7.1	3.3	0.0	22.2
Sheep or goats				
Grazing cannot be or has never been considered	NA	NA	NA	41.7
Do not have the right equipment (fences, water, shelter) for sheep and goats**	71.3	83.3	76.2	14.3
Do not have the expertise or knowledge to work with sheep and goats	41.0	41.7	47.6	0.0
Sheep and goats are too time consuming to use	39.3	33.3	33.3	14.3
Sheep and goats will negatively affect nontarget species	NA	25.0	19.1	28.6
Sheep and goats are too costly to manage or are not economical to use	23.0	11.1	38.1	14.3
Sheep and goats are ineffective in controlling <i>E. esula</i>	25.4	13.9	4.8	42.9
Departmental or agency policy prevents using sheep or goats	NA	11.1	9.5	28.6
Other control methods				
Land is not suitable for tillage (inaccessible, incompatible terrain, light soil, too rocky, etc)	84.7	97.2	81.0	73.3
These methods are ineffective	36.0	36.1	14.3	13.3
Damage to nontarget species	NA	19.4	38.1	46.7
Lack the proper equipment**	24.0	44.4	52.4	20.0
Departmental or agency policy prevents using these alternative methods	NA	30.6	19.1	40.0
Do not have enough time to work with those methods	26.7	25.0	47.6	33.3
Do not know how to use these methods	21.3	25.0	14.3	20.0

*NA, not applicable; the survey group was not asked that question.

*Statistically different at $P \leq 0.05$ among all groups of respondents for each reason (chi-square test statistic).

**Statistically different at $P \leq 0.01$ among all groups of respondents for each reason (chi-square test statistic).

The Extension Service and county weed boards were major sources of weed management information for all respondents. More than 50% of all respondents indicated that they frequently use the Extension Service and county weed boards to obtain information about weed management on grazing or hay land (40% indicated the Extension Service was the most important source followed by 30% for county weed boards; Table 11). However, the most important source of information on weed management for the public managers of grazing land was evenly divided among county weed boards, government agencies, and professional meetings (22% each).

Table 11. Sources of weed management information most often used by respondents, 1998.

Sources of weed management information	Ranchers	Local decision makers	Public land managers	
			Grazing land	Non-grazing land
	% indicated used frequently			
Extension Service, county agent, or universities	47.2	71.2	45.8	77.8
County weed board or officers	45.9	62.2	54.2	61.1
Professional meetings or associations	NA ^a	23.5	63.6	47.1
Farm, ranch, or trade magazines ^{**}	25.9	24.2	0.0	13.3
Private companies and consultants [*]	13.9	25.0	9.5	26.7
Government agencies ^{**}	11.7	6.3	53.3	42.9
Grazing associations	12.6	21.2	5.3	7.1
Public land managers (BLM, Forest Service) ^{**}	4.0	6.1	50.0	52.9
Internet or on-line computer services/DTN ^{**}	4.1	0.0	5.0	18.8
	% indicated most important source			
Extension Service, county agent, or universities	37.7	62.9	17.4	56.3
County weed board or officers	31.2	31.4	21.7	18.8
Other ranchers	11.2	NA	NA	NA
Private companies or consultants	6.5	2.9	4.4	0.0
Government agencies	2.4	0.0	21.7	18.8
Farm, ranch, or trade magazines	5.3	0.0	0.0	0.0
Professional meetings and associations	0.0	2.9	21.7	6.3
Grazing associations	3.5	0.0	0.0	0.0

^aNA, not applicable; the survey group was not asked that question.

^{*}Statistically different at $P \leq 0.05$ among all groups of respondents for each information source (chi-square test statistic).

^{**}Statistically different at $P \leq 0.01$ among all groups of respondents for each information source (chi-square test statistic).

Discussion and conclusions

Euphorbia esula is a problem for ranchers, local decision makers, and public land managers of grazing land and nongrazing land in the five-county study area, as evidenced by more than 60% who said it was their most important weed problem. The public land managers of grazing land had *E. esula* on about 1.5% of land operated, while the public land managers of nongrazing land had *E. esula* on about 13% of land operated. Noxious or invasive weeds were noted as the most important problem for approximately one-quarter of the public land managers of grazing land. Ranchers, local decision makers, and

public land managers of grazing land thought that livestock prices were the most important problem currently facing ranchers in their area.

Ranchers and public land managers indicated concern about controlling weeds in rangeland and that *E. esula* was a long-term management problem; however, the public land managers of nongrazing land did not agree with the ranchers, local decision makers, and public land managers of grazing land that rangeland weeds represented a problem to all ranchers. The public land managers of nongrazing land also believed that even properly used herbicides are harmful to the environment, and they believed that state and federal governments were doing enough to control problem weeds on private and public grazing land. None of the respondent groups thought that public land managers were doing a good job controlling problem weeds.

The public managers of grazing land are more likely than the other groups to have tried both biological control and grazing of sheep and goats in the past and are more interested in trying to use biological control and grazing of sheep and goats as a potential *E. esula* control method in the future. Although the practice of using repeated tillage has been successful in the eradication of *E. esula*, it is unlikely to be useful to most of the respondent groups because of the type of land *E. esula* infests. Although less than 50% of all respondents believe that herbicides are effective, more than 60% believe using herbicides pays to control *E. esula*.

Fewer public managers of grazing land expect to use herbicides, biological control, and grazing of sheep or goats in the future to control *E. esula* than are currently using these practices. Also, fewer public managers of nongrazing land expect to use biological control and grazing of sheep and goats in the future than are currently using these control methods. The most often mentioned reason for not using herbicides by both groups of public land managers was environmental restrictions. Inadequate funding and large infestations were common problems listed by the public managers of grazing land but were seldom indicated as problems for the public managers of nongrazing land. The most frequently indicated impediment for using biological control by public managers of grazing land was that the biological agents take too long to work, while the biggest problem for local decision makers and public managers of nongrazing land was limited access to biological agents. The public managers of nongrazing land were least likely to use the strategy of grazing sheep or goats primarily because of policy or logistical reasons, and they did not believe grazing was an effective control method. The main reason that ranchers, local decision makers, and public managers of grazing land did not use grazing as a control mechanism was that they lacked the equipment to include sheep or goats in their grazing operations.

Overall, this survey has revealed that a vast majority of respondents were concerned about controlling weeds on rangeland and that *E. esula* is viewed as a long-term management problem. The local decision makers were most likely to believe that the weed problem in their area was a major problem and that *E. esula* was the most important weed. The public managers of nongrazing land on average had a greater share of their operating area infested with *E. esula* and were more likely to believe that biological control was effective and economical. However, environmental restrictions and damage to nontarget species was indicated as an impediment to herbicide treatments by more than two-thirds of the public managers of nongrazing land.

Euphorbia esula control is costly and difficult, and none of the currently available control techniques offer land managers a panacea. However, some methods may offer economical *E. esula* control; yet these methods are often not used. We have learned that in many cases, a simple lack of knowledge is preventing land managers and ranchers from using methods that may best help them. Both private and public land managers perceive that they lack the knowledge needed to adopt various treatment programs. Education and awareness of biological control options would facilitate more adoption of biological agents to control *E. esula*. Likewise, assistance in obtaining equipment and knowledge of sheep and goat management might allow more managers to use sheep or goats to curb further *E. esula* expansion. A comparison of ranchers to the other groups indicates that financial constraints on weed control are prevalent in both private and public land management. Other control methods, which are effective but capital intensive, may not be used because of the financial constraints external to *E. esula* management.

The reasons for not using the various *E. esula* controls generally fell into environmental, financial, and educational categories. In many cases, little can be done to remove environmental constraints; however, financial constraints may be addressed through cost-share programs either offered locally or through state agencies. The other main reason for not using some controls was a lack of knowledge to work with various controls (e.g., grazing and biological controls). These obstacles could be addressed with workshops, demonstrations, or educational bulletins. These educational tools could be provided by universities or governmental agencies, as respondents indicated this was their choice for information dissemination.

Disagreements among the survey groups were not substantial, and many share similar concerns in controlling the weed. Although cooperation among private and public managers was not specifically addressed in this study, all survey groups recognized the threat *E. esula* presents and most agree on the causes of spread. Facilitating cooperative efforts between managers of adjoining lands and pooling resources could perhaps reverse many of the hardships created by *E. esula*. Although the focus of this study was *E. esula*, it is reasonable to assume that knowledge about land owners' and land managers' perceptions of this noxious weed would be useful in developing management plans for other weeds in similar situations. Also, impediments preventing the transfer of knowledge about *E. esula* control would be similar to many other weed management problems facing landowners currently and in the future.

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