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Assessment of the Extent and Success of Leafy Spurge Biological Control Agents

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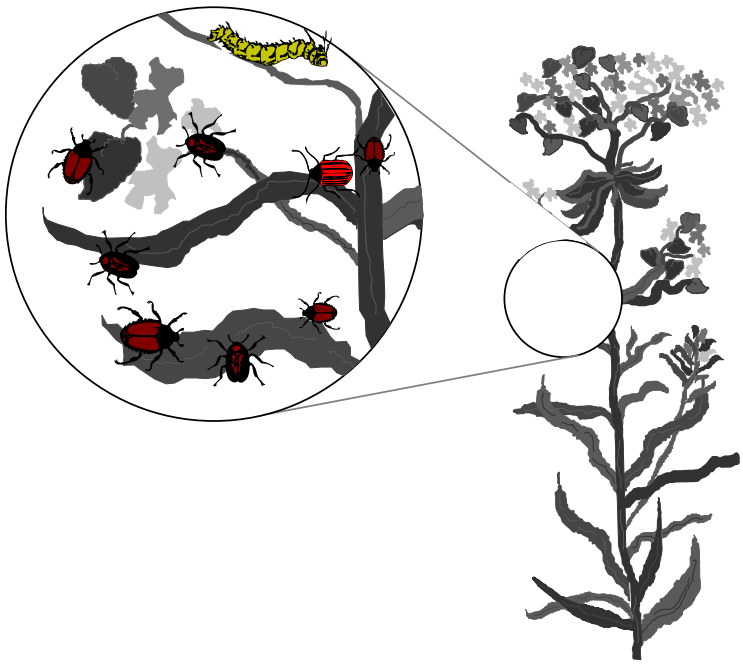

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Abstract

Leafy spurge is an exotic, noxious, perennial weed which is widely established in the north central United States and is an especially serious problem in the northern Great Plains. In 1997, the Agricultural Research Service and the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture (USDA), initiated a major Integrated Pest Management (IPM) research and demonstration project, TEAM Leafy Spurge (TLS), to develop and demonstrate ecologically based IPM strategies that can produce effective, affordable leafy spurge control. A key component of the project was to expand the use of biological control (biocontrol) agents, specifically flea beetles. To assess the level of insect establishment and the level of current and perceived future control of leafy spurge, a mail survey was conducted of 468 individuals who obtained biocontrol agents (insects) at TLS-sponsored events, as well as County Weed Boards in North Dakota, South Dakota, Montana, and Wyoming. Respondents reported basic information about the number and characteristics of release sites, characteristics of leafy spurge stands, as well as the level of control to date and perceived level of eventual control. Substantial numbers of landowners and County Weed Boards have utilized biocontrol agents as part of their leafy spurge control efforts, as well as collected flea beetles from release sites for redistribution. Respondents indicated biocontrol efforts are affecting at least some level of control and, in some cases, reported substantial reductions in spurge stands.

Key Words: leafy spurge, biological control, *Apthona lacertosa/czwalinae*, flea beetle, noxious weeds, weed management

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Introduction

Leafy spurge (*Euphorbia esula* L.), a noxious perennial weed native to Europe and Asia, has become widely established in North America and is now reported in 35 states and all but one Canadian province (Anderson et al. 2001). The weed has become a serious problem for ranchers and public land managers in the northern Great Plains states of Montana, North Dakota, South Dakota, and Wyoming, where an estimated 1.6 million acres (657,000 ha) are infested, resulting in an annual economic loss of $130 million (Leitch et al. 1996). Leafy spurge has proven particularly difficult to control on untilled land because of its ability to spread rapidly, displace native vegetation, and sustain itself despite repeated chemical treatments. While extensive research has been devoted to developing more efficacious herbicide treatments, analyses to date indicate that chemicals offer at best only short term control (Bangsund et al. 1996, Anderson et al. 2001). Cost of repeated herbicide treatments also limits their use and are most applicable to small infestations (Sell et al. 1999, Hodur et al. 2002). As a result, alternative control methods have generated substantial interest.

The principal alternatives to herbicide treatment are biological control (biocontrol) with insects and/or grazing with sheep or goats. Although sheep grazing in a mixed species grazing program has promise as a long-term management strategy, labor and financial constraints may inhibit widespread adoption of this practice. Further, sheep grazing is most economically attractive in situations where extensive leafy spurge infestations are combined with high flock proficiency (e.g., high lambing rates) (Bangsund et al. 2001). While sheep and goat grazing has not been widely adopted as a leafy spurge control alternative, biocontrol has been increasingly viewed as a promising approach (Hodur et al. 2002, Bangsund et al. 1999).

Biocontrol research efforts began in the 1960s. Based on observations that a variety of natural enemies appeared to keep the plant's density below the economic threshold in its native habitats in Europe and Asia, leafy spurge was identified as a candidate for biocontrol (Carlson and Littlefield 1983). The biocontrol program required importing natural enemies of leafy spurge from Europe, testing their host specificity, checking them for pathogens, and subsequently reproducing them for release in North America. By the mid-1980s, several *Apthona* flea beetle species had been identified as having potential as biocontrol agents. The first of these, *Apthona flava*, was initially released in 1985, followed by *A. nigriscutis* in 1989 and *A. lacertosa* in 1993 (Anderson et al. 2001). Since the mid-1990s, efforts to collect biocontrol agents from the initial release sites and transplant them to other locations have intensified. Numerous local and state government entities, federal and state land management agencies, and individual landowners have been involved in these efforts (Hansen et al. 1997).

To facilitate biocontrol efforts, in 1997 the Agricultural Research Service and the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture (USDA) initiated a major Integrated Pest Management (IPM) research and demonstration project, TEAM Leafy Spurge (TLS). The project's mission was to develop, integrate, and communicate ecological,

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economical, and sustainable leafy spurge management techniques to land managers. The TEAM Leafy Spurge project focused on a multi-county area in southwestern North Dakota, southeastern Montana, northeastern Wyoming, and northwestern South Dakota. Examples of TLS project activities include coordination of a wide range of research activities, 8 demonstration sites in 3 states, presentations at numerous state and local meetings, creation of a variety of educational publications, and several field days during which *Apthona* flea beetles were distributed to interested land managers and weed control officials.

While Apthona flea beetles have been shown to be effective in controlling leafy spurge under specific conditions, no assessment of the extent or effectiveness of leafy spurge biocontrol efforts across the Northern Plains region has been completed to date. To assess the effectiveness of biocontrol agents, this study consisted of two distinct phases. First, mail surveys were conducted of land managers who received *Apthona* beetles at TEAM Leafy Spurge field days and of all County Weed Boards in the four-state TEAM Leafy Spurge study area. Both Weed Board and landowner surveys elicited information about the respondents' use of biocontrol, including the number of sites where insects had been released, dates when releases were made, attributes of the release sites, evidence of leafy spurge stand reduction, and plans for future leafy spurge control efforts. The mail survey also queried respondents about their willingness to assist with the second phase of the study. Respondents were asked if they would assist a field team that would be visiting biocontrol release sites across the region to assess the degree of flea beetle establishment and the extent of leafy spurge control. Additionally, the respondents were asked if they could identify release sites with either GPS (global positioning system) coordinates or township, range, and section coordinates, and if they could characterize the release sites. The field assessment team used the release site information provided by the respondents in the questionnaire to identify sites for field analysis. This report summarizes the findings of the surveys of landowners, land managers, and County Weed Boards. Findings of the field assessment portion of the study are summarized in Samuel et al. (2004).

Methods

Surveys were mailed to all County Weed Boards in the four-state TLS study area (North Dakota, South Dakota, Wyoming, and Montana) and to land owners/land managers who had received *Apthona* flea beetles at TEAM Leafy Spurge field days. Surveys were mailed to 199 County Weed Boards and 468 landowner/land managers in April 2002. After a second mailing, a total of 144 County Weed Board questionnaires were received for a response rate of 72.4 percent. The landowner group returned 217 usable questionnaires for a response rate of 46.9 percent. Duplicate mailings or questionnaires returned "undeliverable" were not included in the effective response rate nor were thirty-nine individuals in the landowner/land managers study group (17.9 percent) that indicated they had not obtained/released flea beetles. Results of the 2002 survey of County Weed Boards were also compared to the results of a survey of County Weed Boards done by Bangsund et al. (1997).

Fishers's Exact test (Le 1948) was used to test for differences in perceptions between the two study groups. The test was used to compare responses of unordered questions related to leafy spurge control methods and respondents' perceptions regarding flea beetles' potential for future control of leafy spurge. All comparisons were made between study groups at a 95 percent confidence level.

Results

Characteristics of Landowner Respondents

Most landowner respondents were North Dakota residents (60 percent), likely because two major TEAM Leafy Spurge events were held in North Dakota. Most respondents (nearly two-thirds) were either full or part-time farmers or ranchers while most respondents' occupation in the County Weed Board survey was 'government/public sector.' Response rates for the County Weed Boards were very high. Response rates for Montana, North Dakota, and Wyoming Weed Boards were 80 percent, 85 percent, and 87 percent, respectively (Table 1).

The amount of land owned or operated by landowners varied, with 36 percent reporting less than 1,500 acres, while 13 percent reported over 10,000 acres. Gross farm/ranch income also varied substantially, with 51 percent reporting less than $50,000 in gross farm income, while 13 percent had gross farm incomes greater than $200,000. About 63 percent of respondents reported that more than half their gross farm income was from livestock grazing (data not shown). Average age of respondents was nearly the same for the two study groups, 52 years for the landowners and 50 years for the County Weed Board group (Table 1).

County Weed Infestations and Biological Control Implementation

County Weed Board representatives were asked to estimate the number of acres of leafy spurge in their county, as well as to what degree biocontrol had been implemented. The Weed Boards reported, on average, 10,192 acres of leafy spurge in their county (Table 2). Three percent of County Weed Boards reported no leafy spurge, while 28 percent reported 10,000 or more acres of leafy spurge in their county. Total acres of leafy spurge reported by the 144 County Weed Boards that responded to the survey was nearly 1.4 million acres. Respondents were also asked to rate on a scale of 1 to 5, where 1 is not at all and 5 is very extensively, how extensively flea beetles had been implemented in their county. Responses again varied as 11 percent of County Weed Boards had not implemented biocontrols, while 12 percent had implemented biocontrols very extensively (Table 2). Closer examination revealed a relationship between the extent of leafy spurge infestations and the extent of biocontrol implementation. Among counties reporting less than 500 acres of leafy spurge, 34 percent of County Weed Boards indicated biocontrol had not been implemented at all, and 35 percent reported very little implementation. For counties with 5,000 acres or more of leafy spurge, 44 percent of County Weed Boards reported biocontrol activities had been utilized extensively or very extensively (Appendix Table A-1).

Table 1. Respondent Demographics, Landowners and County Weed Boards, 2002

Item	County Weed Boards	Landowners
State of Residence	----------percent----------	
Montana	14.2	18.9
North Dakota	29.3	60.6
South Dakota	24.3	12.0
Wyoming	14.3	8.6
(n)	(140)	(176)
Occupation		
Farming/ranching, full-time	5.0	47.1
Farming/ranching, part-time	12.1	17.4
Government/public sector	59.3	6.4
Retired	7.1	18.6
Other	16.5	10.5
(n)	(140)	(172)
Education		
Did not complete high school	3.6	9.4
High school graduate	30.4	39.4
Vocational/Technical	18.8	16.5
Bachelor's degree	37.7	25.3
Graduate degree	9.4	9.4
(n)	(138)	(170)
Average Age	50.0	52.0
(n)	(138)	(170)
Acres Farmed/Ranched		
less than 1,500 acres	n/a	36.2
1,500 - 2,500 acres	n/a	19.0
2,501 - 5,000 acres	n/a	14.7
5,001 - 10,000 acres	n/a	16.6
more than 10,000 acres	n/a	13.5
(n)		(163)
Gross Farm Income, 2001		
less than $50,000	n/a	51.1
$50,000 - 100,000	n/a	15.1
$100,001 - 200,000	n/a	20.8
more than $200,000	n/a	13.0
(n)	--	(139)
Response Rate by State		
Montana	80.3	n/a
North Dakota	85.4	n/a
South Dakota	50.7	n/a
Wyoming	86.9	n/a
(n)	(144)	(--)

Table 2. Evaluation of Leafy Spurge Infestations and Biological Control, County Weed Boards, 2002

Item	Percent
Acres of Leafy Spurge:	
zero	2.9
1 - 100	13.9
101 - 500	7.3
501 - 2,000	20.4
2,001 - 5,000	13.1
5,001 - 10,000	14.6
> 10,000	27.7
(n)	(137)
Average Acreage of Leafy Spurge per County	10,192
(n)	(137)
Total Acres of Leafy Spurge Reported	1.4 million
(n)	(137)
Extent of Flea Beetle Implementation:	
Not at all	11.1
Very little	21.5
Somewhat	34.8
Extensively	20.7
Very extensively	11.9
Average Score[1]	3.01
(n)	(135)

[1]Based on a scale of 1 to 5 where 1 is not at all and 5 is very extensively.

The number of release sites per county and per landowner also varied. A release site was defined as any single area of one acre or less that received beetles. The County Weed Boards reported *apthona* flea beetles had been released at 9,534 release sites in the last 4 years for an average of 84 release sites per county (Table 3). The average, however, does not reveal the large range in the number of release sites. Fifteen percent of County Weed Boards reported no release sites in the last four years, while almost 11 percent had 151 or more release sites (Table 3). In addition, County Weed Boards reported that ranchers and other landowners had made a total of over 19,000 *Apthona* releases in their counties over the past 4 years, an average of 175 known releases by landowners in the county. County Weed Boards' reports of landowner releases in their county also varied as 20 percent of Weed Boards indicated no landowner releases in the last 4 years, and 19 percent of County Weed Boards indicated over 151 landowner releases over the same period.

Distribution of the number of landowner releases on their own land was not as extreme as the distribution of the number of releases made by County Weed Boards. A majority of landowner respondents (58.8 percent) reported fewer than 10 release sites on their own land, while only 2 percent had 151 or more release sites on their own land. In each study group, a few observations with very large numbers of release sites distorted the averages. Accordingly, the mode number of release sites may better describe the more typical number of releases for each study group. The most frequent number of release sites for each group was much smaller than the average, 10 for County Weed Boards and 4 for the landowner group (Table 3).

Table 3. Number of *Apthona* Release Sites in the Last Four Years, Landowners and County Weed Boards, 2002

	County Weed Boards		Landowners
Item	Weed Board Release Sites	Landowner Release Sites	Release Sites on Own Land
Number of Sites	----------percent----------		----------
zero	15.0	19.6	0.0
1 - 10	31.9	23.1	57.6
11 - 25	16.8	11.6	23.3
26 - 50	12.4	10.7	10.5
51 - 150	13.3	15.2	6.4
151 or more	10.6	18.8	2.3
(n)	(133)	(112)	(172)
Average Number of Release Sites	84	175	59
(n)	(113)	(112)	(172)
Total Number of Release Sites Reported	9,534	19,580	10,227
(n)	(113)	(112)	(172)
Mode Number of Release Sites	10	100	4
(n)	(113)	(112)	(172)
Sources of Flea Beetles[1]			---percent---
TLS Field Days	n/a	n/a	62.0
County Weed Board	n/a	n/a	52.0
County Extension Agent	n/a	n/a	25.7
Sites on own land	n/a	n/a	28.5
Sites on someone else's land	n/a	n/a	33.5
State Dept. of Ag.	n/a	n/a	7.8
Other	n/a	n/a	8.4
(n)			(179)

[1]Does not sum to 100 percent due to multiple responses.

The study groups reported a combined total of 39,341 flea beetle release sites in the four-state study area, a considerable increase over the number of release sites reported by Bangsund et al. (1997). County Weed Boards surveyed in 1997 by Bangsund et al. reported a total of 11,665 release sites. While some double counting may have occurred in the 2002 survey, the effect of any double counting was likely inconsequential. Most landowners reported 10 or fewer release sites with a mode of 4. Even if the mode number of release sites for all landowner releases was double counted, the estimate of total release sites would be over estimated by only 688 sites or 1.7 percent of the total reported sites.

Landowners most frequently acquired *Apthona* flea beetles at TEAM Leafy Spurge Field Days (62 percent) (Table 3). Most releases were made in the month of June with far fewer respondents indicating releases in July or August. Sixty percent of respondents indicated releasing flea beetles in June of 2000 (Table 4).

Table 4. Month and Year of Flea Beetle Releases, Landowners, 2002

Year	June	July	August
	----------percent[1]----------		
1998	42.8	22.0	1.7
1999	54.3	31.2	2.3
2000	60.1	30.6	2.9
2001	45.7	28.9	5.2
(n)	----------(173)----------		

[1]Does not sum to 100 percent due to multiple responses.

Release Site Attributes

Landowners and County Weed Boards reported site attributes on over 8,000 release sites (Table 5). Rangeland was the most common land use. Ninety-one percent of landowner release sites and 81 percent of County Weed Board release sites were made on rangeland. Riparian areas were a very distant second (6 percent and 10 percent, respectively). Most often, releases were made on sunny, well-drained sites (61 percent of landowner sites and 66 percent of Weed Board sites) with loamy soil (37 percent of landowner sites and 56 percent of County Weed Board sites). Shaded sites accounted for only 23 percent of landowner releases and 21 percent of County Weed Board releases. Poorly drained sites accounted for 24 percent of landowner releases and 20 percent of County Weed Board releases (Table 5).

Both groups most often made releases in heavy stands (more than 100 plants/square yard) of leafy spurge – 61 percent for landowners and 44 percent for County Weed Boards, but the two groups targeted different sized infestations. Landowners most often released flea beetles in leafy spurge infestations of 1 acre or less (48 percent), while County Weed Boards more frequently targeted leafy spurge patches of more than 10 acres (45 percent). Black flea beetles (*A. lacertosa/czswalinae*) were more frequently released by both landowners and County Weed Boards, and the bulk of releases by both groups consisted of less than 3,000 insects (Table 5). However, a few respondents (less than 1 percent) reported very large releases of more than 50,000 insects.

Table 5. Release Site Attributes, Landowners and County Weed Boards, 2002

Site Attribute	Land-owners	County Weed Boards	Land-owners	County Weed Boards	Land-owners	County Weed Boards
	percent of		average number		mode number	
Land Use	-------release sites--------		-------of release sites-------		------of release sites-------	
Rangeland	90.7	81.1	58	76	1	8
Riparian area	5.7	10.2	17	20	10	1
Hayland	1.4	3.3	7	8	1	1
Conservation Reserve Program	1.1	1.8	6	8	2	3
Fence line	0.9	2.0	5	8	2	2
Road ditch	0.2	1.6	3	8	1	1
(n)	(8,365)	(8,602)	(35)	(38)	(35)	(38)
Soil Type						
Loamy	36.8	55.6	37	97	3	10
Sandy	31.7	28.5	25	55	1	10
Clay	31.4	15.8	46	34	1	10
(n)	(6,300)	(13,389)	(62)	(69)	(62)	(69)
Drainage / Topography						
Sunny sites, well-drained	61.2	66.2	64	102	2	10
Sunny sites, poorly drained	15.5	13.7	30	33	1	5
Shaded sites, well-drained	15.1	14.5	17	28	2	1
Shaded sites, poorly drained	8.2	6.1	29	21	1	5
(n)	(8,951)	(13.496)	(59)	(62)	(62)	(62)
Stand Density						
Light (< 25 plants/sq. yard)	10.6	15.7	19	42	2	2
Moderate (25-100 plants/sq. yard)	28.6	39.9	33	66	2	20
Heavy (>100 plants/sq. yard)	60.8	44.4	106	102	5	5
(n)	(9,039)	(13,425)	(60)	(63)	(63)	(63)
Spurge Height						
Short (< 2 feet)	55.9	34.1	89	76	4	4
Medium (2 - 3 feet)	35.6	53.7	45	103	5	5
Tall (> 3 feet)	8.5	12.2	28	54	5	2
(n)	(8,940)	(13,374)	(51)	(53)	(53)	(53)
Infestation Area						
less than 1 acre	47.6	27.6	93	78	1	20
1 - 10 acres	19.2	27.8	33	51	1	1
more than10 acres	33.2	44.6	101	80	1	10
(n)	(8,213)	(10,965)	(39)	(53)	(53)	(53)
Flea Beetle Type						
Black (*A. lacertosa/czswalinae*)	57.9	36.4	77	68	10	10
Brown (*A. nigriscutis*)	21.2	33.3	33	95	2	3
Mixed (Black and Brown)	20.9	30.4	23	66	2	10
(n)	(9,848)	(13,791)	(76)	(62)	(62)	(62)
Number of Sites						
less than 3,000 flea beetles	81.3	66.0	86	132	4	10
3,000 - 9,999 flea beetles	15.1	24.7	20	45	4	5
10,000 - 50,000 flea beetles	3.0	9.1	9	35	3	1
more than 50,000 flea beetles	0.6	0.9	6	13	1	10
(n)	(9,608)	(13,582)	(51)	(59)	(59)	(59)

The large difference between the average and the mode in nearly every category of release site attributes illustrates how a few observations with very large numbers of release sites or number of insects released distorts the averages considerably. For example, County Weed Boards averaged 78 releases on leafy spurge infestations of less than 1 acre. The mode for the number of releases on leafy spurge infestations of less than one acre was one.

Collection and Redistribution

Most of the landowners (87 percent) and County Weed Boards (82 percent) had monitored sites where flea beetles had been released (Table 6). Landowners reported monitoring over 5,000 sites and County Weed Boards reported monitoring over 3,000 sites. On average, landowners monitored 40 release sites, while County Weed Boards monitored 42 sites. Of the monitored sites, moderate or substantial reductions in the leafy spurge stand were reported on 67 percent of landowner sites and 63 percent of County Weed Board sites. In addition to monitoring the release sites, more than 61 percent of County Weed Board representatives indicated they had collected flea beetles for redistribution on over 600 sites, an average of 12 sites per county (Table 6). Forty-four percent of landowners indicated they had collected flea beetles for redistribution on over 400 sites, an average of 7 sites per landowner (Table 6). Respondents who had not previously collected flea beetles generally intended to do so in the future. Of those who had not previously collected flea beetles for redistribution, 75 percent of landowners and 73 percent of County Weed Board representatives indicated plans to collect and release insects in the future (Table 6).

County Weed Boards were questioned about whether they held field days or similar events to distribute flea beetles to landowners. One-half of the County Weed Boards reported an average of 5 field days or similar events. Most Weed Boards (67 percent) held between 1 and 4 events since 1999 (Table 7). Almost all (98 percent) (data not shown) of the Weed Boards that had previously held field days plan to hold more of these events in the future, and a majority of respondents in both study groups that had not previously collected insects for further distribution plan to do so in the future (Table 6). Two-thirds of respondents in both groups indicated biocontrol efforts had met their expectations, and even those respondents that indicated biocontrol had not met their expectations plan to release flea beetles again in the future (84 percent of landowners and 94 percent of County Weed Boards) (Table 6).

Future Control

In an attempt to gauge respondents' expectations, both landowners and County Weed Board representatives were asked what percentage of leafy spurge stands on their land or land in their county they believed would eventually be controlled with flea beetles (Table 8). Both groups were generally optimistic, however, landowners were somewhat more optimistic than the County Weed Board representatives. One-third of the landowners believed that more than 75 percent of the leafy spurge on their land would eventually be controlled by flea beetles, compared to only 4 percent of County Weed Board representatives, a statistically significant difference. Alternately, County Weed Boards more frequently perceived future levels of control to be smaller. Thirty-two percent of County Weed Boards perceived future control levels to be between 26 and 50 percent compared to 15 percent of landowners, also a statistically significant difference. This would suggest a more tempered optimism on the part of the County Weed Boards.

Table 6. Distribution of Release Sites, Number of Release Sites Used for Collection, and Extent of Control, Landowners and County Weed Boards, 2002

Item	Landowners	County Weed Boards
	----------percent of respondents----------	
Respondents that Monitored Sites	87.3	82.3
(n)	(173)	(113)
	----------number----------	
Total Number of Sites Monitored	5,653	3,447
(n)	(141)	(81)
Average Number of Sites Monitored	40	42
(n)	(141)	(81)
Distribution of Monitored Sites	----------percent of respondents----------	
less than 5	41.1	29.6
5 to 15	36.2	30.9
16 to 30	9.9	19.7
31 to75	7.8	7.4
more than 75	4.9	12.4
(n)	(141)	(81)
Extent of Stand Reduction on Monitored Sites	----------percent of sites----------	
No evidence	9.6	20.1
Small reduction	23.6	16.6
Moderate reduction	36.2	23.6
Substantial reduction	30.6	39.7
(n)	(857)	(5,665)
	----------percent of respondents----------	
Collected Flea Beetles from Release Sites	44.0	61.3
(n)	(150)	(93)
	----------number ----------	
Total Number of Collection Sites	477	682
(n)	(64)	(56)
Mean Number of Collection Sites	7.1	12.2
(n)	(67)	(56)
Distribution of Collection Sites	----------percent of respondents----------	
less than 5 sites	75.0	64.3
6 to 15 sites	14.1	16.1
more than 15 sites	10.9	10.7
(n)	(64)	(56)
Respondents That Have Not Collected Beetles from Release Sites but Plan to in the Future	75.3	72.7
(n)	(75)	(33)
Biocontrol Has Met Expectations	70.1	67.6
(n)	(164)	(105)
Biocontrol Has Not Met Expectations, but Plan Future Releases	84.1	93.7
(n)	(43)	(114)

Table 7. Number of Field Days Held in the Past 4 Years, County Weed Boards, 2002

Number of Events	Percent
1 to 4	44.0
3 to 4	32.0
5 to 7	10.0
8 to 15	8.0
more than 15	6.0
(n)	(50)

Table 8. Respondents' Perceptions of Percentage of Leafy Spurge that Will Eventually be Controlled by Flea Beetles, Landowners and County Weed Boards, 2002

Amount Controlled	Landowners	County Weed Boards
	----------percent----------	
zero	4.2	1.8
1 - 10	12.5*	22.5*
11 - 25	12.5	19.8
26 - 50	14.9*	32.4*
51 - 75	23.2	19.8
more than 75	32.7*	3.6*
(n)	(168)	(111)

*Significantly different between study groups, Fisher's Exact @ P>.05.

Identifying and Characterizing Release Sites

In addition to assessing the extent of biocontrol implementation in the region, the surveys were also designed to identify release sites for a more detailed, on-site assessment by a field team. Both landowners and County Weed Board representatives were asked whether they would be able to assist a field team by identifying release sites and characterizing pre-release conditions. Seventy percent of respondents in both study groups indicated they were willing to assist the field team. On average, landowners could identify and characterize 10 sites, while County Weed Board representatives could identify and characterize 14 sites (Table 9). Respondents were also asked whether GPS coordinates were available for any of their sites; 44 percent of County Weed Board representatives and 9 percent of landowners had GPS coordinates available for some of their sites. Additionally, 89 percent of the County Weed Boards had Township, Range, and Section coordinates for over 1,000 release sites (Table 9). The surveys provided a substantial data base for the field team's on-site assessment efforts. (For a discussion of methods used and results obtained in the field assessment, see Samuel et al. 2003.)

Table 9. Number and Percentage of Respondents that can Identify and Characterize Release Sites, Landowners and County Weed Boards, 2002

Item	Landowners	Weed Boards
	----percent of respondents----	
Respondents Can Identify and Characterize Sites	59.0	60.0
	--------number of sites---------	
Total Number of Sites	1,022	900
(n)	(105)	(65)
Average Number of Identifiable Sites:	9.7	13.8*
(n)	(105)	(65)
Distribution of Identifiable Sites:	---------percent of sites--------	
1 to 5	47.6	47.7
6-15	36.2	36.9
16-30	13.3	10.8
more than 30	2.8	4.6
(n)	(105)	(65)
	----percent of respondents----	
Respondents with GPS Coordinates for Sites	9.1	43.8
(n)	(132)	(73)
	---------number of sites--------	
Total Number of Sites with GPS Coordinates	111	1,506
(n)	(9)	(28)
Average Number of Sites with GPS Coordinates	12.3	53.8
(n)	(9)	(28)
Distribution of Sites with GPS Coordinates	----------percent of sites--------	
1 to 5	55.6	39.3
6 to 15	0.0	35.7
16 to 30	44.4	10.7
over 30	0.0	14.3
(n)	(9)	(28)
	-----percent of respondents----	
Respondents with Township, Range, and Section Coordinates	n/a	88.6
(n)	--	(70)
	------------number -------------	
Total Number of Sites with Township, Range, and Section Coordinates	n/a	1067
(n)	--	(49)
Average Number of Sites with Township, Range, and Section Coordinates	n/a	21.8**
(n)		(49)
Distribution of Sites with Township, Range, and Section Coordinates	---------percent of sites--------	
1 to 5	n/a	32.6
6 to 15	n/a	40.8
16 to 30	n/a	14.3
over 30	n/a	12.2
(n)	--	(49)

*Mode = 5. Average is distorted as a few respondents have many sites, raising the average value.
**Mode = 2. Average is distorted as a few respondents have many sites, raising the average value.

Use of Other Control Practices

In addition to respondents' use of biocontrol agents, respondents were questioned about their current and future use of other control practices. Respondents most frequently use herbicides to combat leafy spurge. Almost 84 percent of landowners and 98 percent of County Weed Board representatives used herbicides to control leafy spurge (Table 10), while 24 percent of landowners and 31 percent of County Weed Boards reported grazing with sheep and/or goats. Both groups utilized tillage and reseeding with competing grasses less frequently than other controls (Table 10).

Respondents generally plan to continue to use the control practices currently in use and relatively few plan to adopt a weed control practice not currently in use. For example, 96 percent of landowners and 100 percent of County Weed Boards currently using herbicides expect to continue using herbicides (Table 10). Similarly, 68 percent of landowners and 81 percent of Weed Boards currently grazing sheep/goats expect to continue sheep/goat grazing. Alternately, only 23 percent of landowners not currently using herbicides plan to adopt the practice in the future, 6 percent plan to begin grazing sheep/goats in the future, and 8 percent plan to till and/or reseed in the future (Table 10). County Weed Board responses were similar.

Table 10. Use of Selected Practices to Control Leafy Spurge, Landowners and County Weed Boards, 2002

	Landowners			County Weed Boards		
Item	Herbicides	Grazing Sheep/ Goats	Tillage/ Reseeding	Herbicides	Grazing Sheep/ Goats	Tillage/ Reseeding
	----------percentage---------			----------percentage---------		
Currently Using Control Practice	83.9	24.5	15.1	98.5	31.0	22.7
(n)	(174)	(155)	(146)	(135)	(126)	(128)
Expect to Continue Using Control Practice	96.4	67.6	61.1	100.0	80.6	84.0
(n)	(137)	(37)	(18)	(129)	(36)	(25)
If Not Currently Using Control Practice, Plan to Adopt Control Practice in the Future	23.1	6.4	7.9	0.0	9.8	17.2
(n)	(13)	(63)	(63)	(0)	(51)	(64)

Evaluation of Control Practices

Both landowners and County Weed Board representatives rated biocontrol and IPM systems favorably. Forty-one percent of landowners rated IPM as very effective in controlling leafy spurge and 35 percent rated biocontrol as very effective, while only 16 percent rated herbicides as very effective (Table 11). County Weed Board representatives rated IPM and herbicides as very effective more frequently than landowners, but rated biocontrol as very effective less frequently than landowners (Table 11, Appendix Table A-2). The differences in perception between the study groups on whether a particular control method was very effective were statistically different for herbicides and IMP (Table 11).

Landowner and County Weed Board perspectives on whether or not a practice pays are similar with respect to biocontrols, but statistically different with respect to other leafy spurge control methods. Approximately two-thirds of respondents in each group indicated biocontrol "pays," but the similarities between the two groups regarding whether a control practice "pays" end there. Seventy-three percent of County Weed Board representatives indicated herbicide use "pays" compared to 47 percent of landowners, and 67 percent of County Weed Board representatives felt IPM systems pay compared to 44 percent of landowners, both statistically different. Differences were statistically different between the two groups regarding grazing with sheep or goats and tillage and reseeding as well (Table 11, Appendix Table A-3).

Table 11. Evaluation of Effectiveness of Leafy Spurge Control Practices, Landowners and County Weed Boards, 2002

	Landowners		County Weed Boards	
Item	Very Effective	Pays	Very Effective	Pays
	----------percent----------		----------percent----------	
Spraying Herbicides	16.0*	35.3**	46.6*	73.0**
(n)	(169)	(167)	(133)	(137)
Biological Control with Insects	34.7	63.9	24.4	66.9
(n)	(167)	(166)	(127)	(133)
Grazing with Sheep or Goats	12.6	21.6**	15.5	34.6**
(n)	(135)	(134)	(116)	(127)
Tillage and Reseeding	3.1	6.3**	4.4	18.7**
(n)	(130)	(128)	(114)	(123)
Integrated Pest Management (IPM) using Two or More Practices	41.1*	43.6**	53.8*	67.4**
(n)	(141)	(133)	(119)	(129)

*Significantly different between study groups for individual control methods @ P > .05 (Fisher's Exact test).

**Significantly different between study groups @ P > .05 (Fisher's Exact test).

Issues and Attitudes

Respondents were also asked whether they agreed or disagreed with a number of general statements related to leafy spurge and control of leafy spurge with biocontrol agents (Table 12). Sixty-six percent of landowners and 74 percent of County Weed Boards disagreed with the statement that leafy spurge is impossible to control with current methods and techniques, suggesting respondents have a fairly optimistic outlook regarding leafy spurge control. Respondents' attitudes in both groups were very consistent on the subject of controlling leafy spurge over the long term. Ninety percent of County Weed Boards and 92 percent of landowners agreed that leafy spurge is a long-term management problem. The two groups varied slightly in their perceptions of biocontrols' potential to eliminate leafy spurge. County Weed Boards were slightly less optimistic regarding biocontrols' potential to eliminate leafy spurge. Thirty-nine percent of landowners agreed with the statement that biocontrol will eventually eliminate the leafy spurge problem, while only 22 percent of County Weed Boards agreed with the statement (Table 12).

Respondents were also asked to rate how problematic various weeds were in their local area – a major problem, a minor problem, or not a problem. Leafy spurge was identified by a majority of the respondents in both study groups as a major problem (77 percent of County Weed Boards and 84 percent of landowners). Thistles were also a frequent concern as 72 percent of County Weed Boards and 58 percent of landowners indicated thistles were a minor problem. Half of the respondents in both groups indicated field bindweed was a minor problem as well (Appendix Table A-4).

Key Findings

A substantial number of County Weed Boards (89 percent) have utilized biocontrol agents as part of their leafy spurge control efforts. In contrast, only 61 percent of County Weed Boards in the same four-state area utilized biocontrol agents in 1997 (Bangsund et al. 1997). County Weed Boards reported over 29,000 biocontrol release sites and landowners reported over 10,000 biocontrol release sites. Even with the potential for some double counting of release sites in the two estimates, compared to the number of release sites (11,665) reported in Bangsund et al. (1997), the number of release sites in the region has increased substantially in the last four years.

While most landowners and County Weed Boards had less than 25 release sites, a few respondents in both groups reported more than 1,000 release sites, with a strong relationship between acres of leafy spurge and the degree to which flea beetles had been utilized. Because of a few respondents with large numbers of release sites, the average number of release sites was pulled upward. Some of the statistics describing the number of release sites and site characteristics can be misleading, specifically the mean. Because of a few observations with very large numbers, the average was often distorted. Distribution and mode in some instances provides a more accurate assessment.

Table 12. Issues and Attitudes, Landowners and County Weed Boards, 2002

	Landowners							Weed Boards						
Item	Average Score	Strongly Agree	Somewhat Agree	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree	Don't Know	Average Score	Strongly Agree	Somewhat Agree	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree	Don't Know
Leafy spurge is impossible to control with current methods and techniques.	2.2	4.7	18.3	8.9	30.8	35.5	1.8	2.1	4.4	13.8	7.3	37.0	37.7	0.0
(n)	(166)			(173)				(138)			(138)			
Leafy spurge can be controlled but it is too costly.	3.1	19.3	30.4	11.1	21.6	16.4	1.2	2.8	10.2	32.9	5.1	28.5	22.7	0.7
(n)	(169)			(171)				(136)						
Leafy spurge is a long-term management problem.	4.7	85.0	7.5	1.7	0.6	4.6	0.6	4.6	85.6	4.3	1.4	0.0	3.6	0.0
(n)	(172)			(173)				(139)			(119)			
Biological control has been successful in my area.	3.7	22.1	40.7	9.9	12.8	5.8	8.7	3.6	16.8	40.2	11.0	15.3	4.4	12.4
(n)	(157)			(172)				(120)			(137)			
Biological control will eventually eliminate the leafy spurge problem.	3.0	12.1	26.6	16.2	16.8	17.3	11.0	2.3	2.9	19.0	14.6	27.0	19.9	6.6
(n)	(154)			(173)				(128)			(137)			
Biological control will never be successful in my area.	1.9	4.1	3.5	15.0	32.4	38.7	6.4	2.2	3.7	8.8	20.6	28.7	29.4	8.8
(n)	(162)			(173)				(124)			(136)			

[1]Average score based on a scale of 1 to 5 where 1 is strongly disagree and 5 is strongly agree.

Flea beetle releases were most commonly made on sunny, well drained, rangeland sites. Most releases consisted of less than 3,000 beetles per site, and *A. lacertosa/czwalinae* were released most frequently. Respondents reported that in most cases the insects were affecting at least a small reduction in leafy spurge stands. Roughly one-third of respondents in both groups reported flea beetles had substantially reduced leafy spurge stands.

Respondents were very willing to assist a field assessment team. A large majority of respondents in both study groups indicated they would be willing to assist a field assessment team by identifying and characterizing biocontrol release sites. Both study groups were able to provide information on a substantial number of biocontrol release sites. Landowners and County Weed Boards indicated they would be able to provide GPS coordinates on over 1,000 sites, and County Weed Boards indicated Township, Range, and Section coordinates were available for another 1,000 sites. Sell et al. (2000) reported weed and land use inventory systems represented an opportunity for improved leafy spurge control management, specifically that "weed and land use inventory systems at all levels of weed control management (ranchers, local Weed Boards, regional public land management offices) were woefully inadequate." Land owners and land managers' willingness and ability to identify and monitor release sites may represent the beginning of a long-term trend toward better weed and land use inventory systems.

Substantial numbers of County Weed Boards and landowners indicated they had collected flea beetles from a release site for redistribution. The study groups reported a combined total of over 1,000 collection sites with County Weed Boards reporting over 600 collection sites. Bangsund et al. (1997) once again offers a useful comparison. County Weed Boards in the 1997 survey reported a total of 460 release sites in the four-state study area (Bangsund et al. 1997).

In addition to biocontrol methods, respondents in both survey groups also used other control methods to control leafy spurge. Herbicide use was predominate with far fewer respondents utilizing sheep and goat grazing and tillage and reseeding. Respondents appear to be satisfied with their current control methods as most that are currently using a control practice plan to continue to use the method and relatively few that are not currently using a control practice plan to implement one in the future.

Conclusions

The level of implementation of biocontrol agents varied widely. Most respondents utilized biocontrol on a relatively small scale with a few release sites, and a few respondents utilized biocontrol agents on a very large scale with many release sites and many insects released. Respondents indicated biocontrol efforts effected at least some level of control, and one-third of respondents reported substantial reductions in spurge stands. Use of biocontrol agents appears to be growing, as evidenced by the increase in the number of release sites reported by County Weed Boards in 2002 compared to Bangsund et al. (1997). While it is difficult to generalize because of the wide range of insect utilization by individual respondents, it would appear that landowners and land managers are integrating biocontrol agents into their leafy spurge control strategy. While varying levels of stand reductions were reported, two-thirds of both study groups reported moderate or substantial reductions on monitored sites. While both groups accurately view leafy spurge control as a long-term management issue, both groups appear to be guardedly positive about biocontrol agents' potential as an effective leafy spurge control method.

References

Anderson, G. L., E. S. Delfosse, N. R. Spencer, C. W. Prosser, and R. D. Richard. 2001. "Biologically-based integrated pest management of leafy spurge: An emerging success story." In Proceedings, *X International Biological Control Symposium*, Bozeman, MT, July 4-9, 2000, http://www.team.ars.usda.gov/teampub/andersonpaper.html.

Bangsund, D. A., F. L. Leistritz, and J. A. Leitch. 1997. *Predicting Future Economic Impacts of Biological Control of Leafy Spurge in the Upper Midwest*. Agribusiness & Applied Economics Report No. 382, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Bangsund, D. A., F. L. Leistritz, and J. A. Leitch. 1999. "Assessing Economic Impacts of Biological Control of Weeds: The Case of Leafy Spurge in the Northern Great Plains of the United States." *Journal of Environmental Management* 56: 35-43.

Bangsund, D. A., J. A. Leitch, and F. L. Leistritz. 1996. "Economics of Herbicide Control of Leafy Spurge (*Euphorbia esula* L.)." *Journal of Agriculture and Resource Economics* 21 (2): 381-395.

Bangsund, D. A., D. J. Nudell, R. S. Sell, and F. L. Leistritz. 2001. "Economic Analysis of Using Sheep to Control Leafy Spurge." *Journal of Range Management* 54(4): 322-329.

Carlson, R. B., and L. J. Littlefield. 1983. "The Potential for Biological Control of Leafy Spurge." *North Dakota Farm Resources* 40(5): 14-16.

Hansen, R. W., R. D. Richard, P. E. Parker, and L. E. Wendel. 1997. "Distribution of Biological Control Agents of Leafy Spurge (*Euphorbia esula* L) in the United States: 1988-1996." *Biological Control* 10:129-142.

Hodur, N. M., F. L. Leistritz, and D. A. Bangsund. 2002. "Perceptions of Leafy Spurge and Evaluation of the TEAM Leafy Spurge Project by Public Land Managers, Local Decision Makers, and Ranch Operators." Agribusiness & Applied Economic Report. No. 499. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Le, Chap T. 1948. *Applied Categorical Data Analysis*. New York, NY: John Wiley & Sons.

Leitch, J. A., F. L. Leistritz, and D. A. Bangsund. 1996. "Economic Effects of Leafy Spurge in the Upper Great Plains: Methods, Models, and Results." *Impact Assessment* 14(4): 419-433.

Samuel, Luke W., Donald R. Kirby, G. L. Anderson, and Jack E. Norland. 2004. Effects of Biological Control on Leafy Spurge (*Euphorbia esula*)-infested Rangeland. *Journal of Range Management* (forthcoming 2004).

Sell, R. S., D. A. Bangsund, and F. L. Leistritz. 1999. *"Euphorbia esula*: Perceptions of Ranchers and Land Managers." *Weed Science* 47: 740-749.

Sell, R. S., D. A. Bangsund, and F. L. Leistritz. 2000. "Impediments to Controlling Leafy Spurge in the Northern Great Plains." Agribusiness & Applied Economics Miscellaneous Report No. 185. Department of Agribusiness and Applied Economics, North Dakota State University, Fargo.

Appendix A

Appendix Tables

Appendix Table A-1. Extent of Utilization of Flea Beetles for Leafy Spurge Control by Acres of Leafy Spurge in the County, County Weed Boards, 2002

Acres of Leafy Spurge	Not at All	Very Little	Somewhat	Extensively	Very Extensively
	----------	----------	----------percent----------	----------	----------
1 to 500	34.6	34.6	15.4	15.4	0.0
(n)			(26)		
501 to 1,500	9.1	18.2	59.1	13.6	0.0
(n)			(22)		
1,501 to 3,000	33.3	22.2	22.2	22.2	0.0
(n)			(9)		
3,001 to 5,000	7.1	15.4	23.1	23.1	30.2
(n)			(13)		
more than 5,000	0.0	17.5	38.6	22.8	21.1
(n)			(57)		

Appendix Table A-2. Perceptions on the Effectiveness of Various Weed Control Practices, Landowners and County Weed Boards, 2002

	Landowners					County Weed Boards				
Item	Average Score[1]	Not Effective	Somewhat Effective	Very Effective	Don't Know	Average Score[1]	Not Effective	Somewhat Effective	Very Effective	Don't Know
		percent					percent			
Spray with herbicides	2.1	8.3	75.2	16.0	0.6	2.5	0.0	53.4	46.6	0.0
(n)	(168)		(169)			(133)		(133)		
Biological control with insects	2.3	8.4	47.9	34.7	9.0	2.1	7.8	58.3	24.4	9.5
(n)	(152)		(167)			(115)		(127)		
Graze sheep or goats	2.1	6.7	25.2	12.6	55.6	2.1	8.6	34.5	15.5	41.4
(n)	(60)		(135)			(68)		(116)		
Till and/or reseed with competing grasses	1.8	10.0	11.5	3.1	75.4	1.8	10.5	23.7	4.4	61.4
(n)	(32)		(130)			(44)		(114)		
Integrated pest management (IPM) with two or more controls	2.6	0.0	31.2	41.1	27.7	2.6	0.8	27.7	53.8	17.6
(n)	(102)		(141)			(98)		(119)		

[1]Average score based on scale of 1 to 3 where 1 is not effective and 3 is very effective.

Appendix Table A-3. Perceptions on Whether it Pays to Use Various Weed Control Practices, Landowners and County Weed Boards, 2002

	Landowners					County Weed Boards				
Item	Average Score[1]	Yes, it Pays	Pays Marginally	Does not Pay	Don't Know	Average Score[1]	Yes, it Pays	Pays Marginally	Does Not Pay	Don't Know
		percent					percent			
Spray with herbicides	1.7	35.3	50.3	10.8	3.6	1.3	73.0	25.6	1.5	0.0
(n)	(161)		(167)			(137)		(137)		
Biological control with insects	1.3	63.9	21.7	4.2	10.2	1.3	66.9	22.6	1.5	9.0
(n)	(149)					(121)		(133)		
Graze sheep or goats	1.7	21.6	17.2	9.0	52.2	1.6	34.6	26.8	5.5	33.1
(n)	(64)		(134)			(85)		(127)		
Till and/or reseed with competing grasses	2.1	6.2	8.6	10.2	75.0	1.7	18.7	20.3	7.3	53.7
(n)	(32)		(128)			(57)		(123)		
Integrated pest management (IPM) with two or more controls	1.4	43.6	24.8	1.5	30.1	1.2	67.4	14.7	0.8	17.1
(n)	(93)		(85)			(107)		(129)		

[1]Average score based on scale of 1 to 3 where 1 pays and 3 does not pay.

Appendix Table A-4. Perceptions of How Problematic Various Weeds are in Respondents' Local Area, Ranchers and County Weed Boards, 2002

	Landowners					County Weed Boards				
Item	Average Score[1]	Not a Problem	Minor Problem	Major Problem	Don't Know	Average Score[1]	Not a Problem	Minor Problem	Major Problem	Don't Know
	----------percent----------					----------percent----------				
Annual brome grasses	1.4	51.8	29.0	4.3	14.8	1.7	41.3	39.9	13.8	5.1
(n)	(138)			(138)		(131)			(138)	
Knapweeds	1.5	45.4	30.9	3.6	20.0	1.9	30.2	41.7	25.9	2.2
(n)	(132)			(139)		(136)			(139)	
Leafy spurge	2.8	0.0	15.0	84.4	0.6	2.7	1.4	21.6	77.0	0.0
(n)	(172)			(139)		(139)			(139)	
Prickly pear	1.5	45.3	32.1	2.5	20.1	1.5	53.6	29.0	7.3	10.1
(n)	(127)			(138)		(124)			(138)	
Sagebrush	1.5	50.6	37.8	6.7	4.9	1.7	35.5	44.9	10.9	8.7
(n)	(156)			(138)		(126)			(138)	
Thistles	2.1	15.3	58.2	21.1	2.4	2.7	0.7	26.6	71.9	0.7
(n)	(166)			(139)		(138)			(139)	
Wormwood (absinth)	1.6	32.9	29.8	6.2	31.1	1.9	27.5	45.7	18.8	8.0
(n)	(111)			(138)		(127)			(138)	
Field bindweed	1.9	20.5	53.0	14.5	12.0	2.1	17.2	55.4	25.9	1.4
(n)	(146)			(139)		(137)			(139)	
Others[2]	2.4	0.0	60.0	40.0	0.0	2.7	0.0	32.4	67.6	0.0
(n)	(15)			(37)		(37)			(109)	

[1] Average score is based on scale of 1 to 3 where 1 is not a problem and 3 is a major problem.

[2] Other: Canada thistle, Milkweed, Houndstongue, Mullein, Dalmation toadflax, Russian knapweed, Purple loostrife, Yellow toadflax, Downy brome, Common burdock, Hoary cress, Henbane, Whitetop, St. Johnswort, Wild licorice, Russian thistle, Greasewood, Cheatgrass, Creeping jenny.

Appendix B

Landowner / Land Manager Survey

CONFIDENTIAL

Landowner/Land Manager Survey

Please answer the following questions about leafy spurge biological control agents (flea beetles) and the characteristics of flea beetle release sites.

1. During the past four years (1998-2001), have you obtained *Aphthona* flea beetles to release on land you own or manage?

Yes **No**

(If No, please stop and return the questionnaire in the enclosed postage-paid envelope.)

2. In which of the following months and years did you release flea beetles? (*check all that apply*)

	1998	1999	2000	2001
June				
July				
August				

3. From what source(s) did you obtain your flea beetles? (Please check all that apply.)

_____ TEAM Leafy Spurge field days (Spurgefest 1999, 2001, etc.)
_____ County Agents
_____ County Weed Boards
_____ State Department of Agriculture
_____ Collection sites on my own land
_____ Collection sites on someone else's land
_____ Other (*please specify*) _____
_____

There are several techniques for releasing flea beetles in leafy spurge infestations. Depending on the technique, the definition of a "release site" varies. In order to make accurate comparisons, ***for purposes of this survey, a release site is any single area of one acre or less that has received beetles.*** For example, several containers of insects released within a one-acre area would be considered *one* release site. However, several containers of insects released at different locations over an entire field or pasture would be considered *several* release sites. Please use this criteria when determining how many release sites are in your county.

4. On approximately how many sites have *Aphthona* flea beetles been released on your land in the past four years? _____ Sites

5. How many release sites on your land fall into the following categories.
(Please indicate the number of sites that fit each description.)

A. Soil Type

_____ Sandy soils _____ Loamy Soils _____ Clay Soils

B. Drainage and/or Topography

_____ Sunny sites on well-drained side slopes, flat areas, or open range

_____ Sunny sites near drainage areas on poorly drained soils near standing or running water

_____ Shaded or semi-shaded sites (near trees, shrubs, or brush) on well to moderately drained side slopes or flat areas

_____ Shaded or semi-shaded sites near drainage areas on poorly drained soils near standing or running water

C. Spurge Density (thickness of the leafy spurge stand)

_____ Light stand (less than 25 leafy spurge plants per square yard)

_____ Moderate stand (about 25 to 100 leafy spurge plants per square yard)

_____ Heavy stand (over 100 plants per square yard)

D. Spurge Height

_____ Short (most leafy spurge plants less than 2 feet tall)

_____ Medium (most leafy spurge plants between 2 to 3 feet tall)

_____ Tall (most leafy spurge plants over 3 feet tall)

E. Overall Size of Leafy Spurge Infestation

_____ One acre or less _____ 1 - 10 acres _____ 10 acres or more

F. At how many sites were the following *Aphthona* species released?

_____ black flea beetles (*A*. lacertosa/czwalinae)

_____ brown flea beetles (*A*. nigriscutis)

_____ Mixed (both black and brown flea beetles)

G. How many release sites would have received the following numbers of beetles?

_____ At least one container or about 3,000 beetles

_____ Several containers or somewhere between 3,000 and 10,000 beetles

_____ Many containers or somewhere between 10,000 and 50,000 beetles

_____ More than 50,000 beetles

6. Have you monitored any of the release sites to determine if the flea beetles have established and if they can be harvested? *(Please circle either yes or no.)*

Yes	**No**
IF YES,	**IF NO**,
How many sites have you monitored? _____	Do you plan to monitor the sites in the future? **Yes** **No**
Of the sites you have monitored, are the flea beetles reducing the stand of leafy spurge? _____ No evidence of stand reduction _____ Small reduction (less than 10 square yards of stand reduction) _____ Moderate reduction (more than 10 square yards, but less than an acre of stand reduction) _____ Substantial reduction (more than an acre of stand reduction)	**If no**, why not: _____ time/budget constraints _____ control method is not effective _____ no longer have access to the land _____ did not record the location of the release site(s) _____other (_____)
Of the sites you have monitored, have you attempted to collect beetles from any of your release sites for further distribution? **Yes** **No**	**Please go to Question 7.**
If yes, on how many sites have flea beetles been harvested for redistribution? _____sites	**If no,** do you plan to collect beetles from your release sites for further distribution **in the future?** (*circle one)* **Yes** **No**

7. Have biocontrol efforts using flea beetles met your expectations? *(Please circle either yes or no.)*	
Yes	**No**
If Yes, go to Question 8.	**If no,** do you plan to make additional releases in the future even though control efforts have failed or have not met your expectations. **Yes** **No**

8. What percentage of the leafy spurge infestation on your land or land you manage do you believe will *eventually* be controlled with flea beetles?	
_____ zero	_____ 26 to 50 percent
_____ 1 to 10 percent	_____ 51 to 75 percent
_____ 11 to 25 percent	_____ over 75 percent

Site Characteristics

TEAM Leafy Spurge will have field assessment teams working during the summers of 2002 and 2003. This group will be visiting sites across the region to assess to what degree flea beetles have established and the level of leafy spurge control as a result of the flea beetles.

9. Would you be willing to assist the field team by identifying release sites on the land you own or manage and characterizing pre-release conditions (spurge density, spurge height, size of infestation) at those sites? *(Please circle either yes or no.)*	
YES	**NO**
If Yes, who should we contact:	**If No, go to Question 12, page 6.**
Name:	
Telephone Number:	
If Yes, how many sites would you be able to identify and characterize? _____Sites	

10. For field assessment purposes, can you provide the County, Township, Range, and Section for any of the sites you have monitored and are those sites accessable by vehicle or moderate hike? *(Even if you do not have all of the information, please provide as much as possible*.)

YES	**NO**
	If No, please go to Question 11, page 5

Site #1	Site #2	Site #3
County _____	County _____	County _____
Township _____	Township _____	Township _____
Range _____	Range _____	Range _____
Section _____	Section _____	Section _____
Accessible by vehicle or short hike **Yes** **No**	Accessible by vehicle or short hike **Yes** **No**	Accessible by vehicle or short hike **Yes** **No**

Site #4	Site #5	Site #6
County _____	County _____	County _____
Township _____	Township _____	Township _____
Range _____	Range _____	Range _____
Section _____	Section _____	Section _____
Accessible by vehicle or short hike **Yes** **No**	Accessible by vehicle or short hike **Yes** **No**	Accessible by vehicle or short hike **Yes** **No**

11. Do you have GPS (Global Positioning System) coordinates for any of the sites?

YES **NO**

If yes, for how many sites? _____sites

12. How many of your release sites were made on the following types of land?			
Rangeland	_____	Road ditch	_____
Hayland	_____	Fenceline	_____
Conservation Reserve Program	_____	Riparian Area	_____

General Issues and Attitudes

Please answer the following questions about current and future weed control practices and your opinions on general weed management issues.

13. Are you ***currently using*** any of the following in addition to insects to control leafy spurge on your land: *(Please circle either yes or no for each control practice.)*

A. HERBICIDES			
Yes		**No**	
If yes, do you plan to continue to use herbicides?	Yes No	**If no**, do you plan to use herbicides in the future?	Yes No
B. GRAZING WITH SHEEP OR GOATS			
Yes		**No**	
If yes, do you plan to continue to graze sheep or goats in the future?	Yes No	**If no**, do you plan to graze sheep or goats in the future?	Yes No
C. TILLAGE AND/OR RESEEDING WITH COMPETING GRASSES			
Yes		No	
If yes, do you plan to continue tilling and reseeding?	Yes No	**If no**, do you plan to till or reseed in the future?	Yes No

14. How would you rate the effectiveness of the following leafy spurge control practices? *(Please circle the appropriate number.)*

	Not Effective	Somewhat Effective	Very Effective	Don't Know
a.. spray with herbicides	1	2	3	4
b. biological control with insects	1	2	3	4
c. graze animals such as sheep or goats	1	2	3	4
d. till and/or reseed with competing grasses	1	2	3	4
e. integrated pest management (IPM) using two or more control methods	1	2	3	4
f. other controls *(please specify)*_____	1	2	3	4

15. Do you think it pays to use the following leafy spurge control practices? *(Please circle the appropriate number.)*

	Yes, it pays	Pays Marginally	Does Not Pay	Don't know
a. spray with herbicides	1	2	3	4
b. biological control with insects	1	2	3	4
c. graze animals such as sheep or goats	1	2	3	4
d. till and/or reseed with competing grasses	1	2	3	4
e. integrated pest management (IPM) using two or more control methods	1	2	3	4
f. Other controls *(please specify)*_____	1	2	3	4

16. Please indicate whether you agree or disagree with the following statements. (*Please circle the appropriate number for each statement.)*

	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree	Don't Know
Leafy spurge is impossible to control with current methods and techniques.	1	2	3	4	5	0
Leafy spurge can be controlled but it is too costly.	1	2	3	4	5	0
Leafy spurge is a long-term management problem.	1	2	3	4	5	0
Biological control has been successful in controlling leafy spurge in my area.	1	2	3	4	5	0
Biological control will eventually eliminate the leafy spurge problem.	1	2	3	4	5	0
Biological control with flea beetles will never be successful in my area.	1	2	3	4	5	0

17. Please rate how problematic the following rangeland weeds are in your area. (*Please circle the appropriate number for each weed.)*

	Not a problem	Minor Problem	Major Problem	Don't know
a. Annual brome grasses	1	2	3	4
b. Knapweeds	1	2	3	4
c. Leafy spurge	1	2	3	4
d. Prickly pear	1	2	3	4

17. Please rate how problematic the following rangeland weeds are in your area. (*Please circle the appropriate number for each weed.)*				
	Not a problem	Minor Problem	Major Problem	Don't know
e. Sagebrush	1	2	3	4
f. Thistles	1	2	3	4
g. Wormwood (absinth)	1	2	3	4
h. Field bindweed	1	2	3	4
i. Others *(please specify)*_____	1	2	3	4

18. Which weed *listed in Question 17* poses the most serious problem for grazing operations in your area? *(Please **circle** the appropriate letter.)*

19. Overall, how serious are the weed problems on rangeland and other untilled land in your area? *(Please circle one)*		
not a problem	minor problem	major problem

Respondent Characteristics

Following are a few general question about you. Responses to these questions help compare attitudes and perceptions based on respondent characteristics. ***Please be assured that your responses will be kept strictly confidential.***

20. How many acres do you farm and or ranch?

_____ less than 1,500 acres
_____ 1,500 - 2,500 acres
_____ 2,500 - 5,000 acres
_____ 5,000 - 7,500 acres
_____ 7,500 - 10,000 acres
_____ 10,000 - 12,500 acres
_____ 12,500 - 15,000 acres
_____ over 15,000 acres

21. In what county and state do you live?_____County_____State

22. What is your age?_____Years

23. Which of the following categories best describes the highest level of education you have completed?

a. _____ Did not complete high school
b. _____ High school graduate
c. _____ Vocational/Technical or 2-year college degree
d. _____ Bachelor's Degree (4-year college program)
e. _____ Graduate School (Masters and/or Doctorate Degree)

24. Which of the following categories best describes your current occupation?

a. _____ Full-time farming/ranching
b. _____ Part-time farming/ranching with off-farm employment
c. _____ Agricultural services/supply
d. _____ Professional/small business/business management
e. _____ Government/public service
f. _____ Retired
g. _____ Tradesman/equipment operator
h. _____ Other_____(*please specify)*

25. Which of the following categories best describes your gross farm income in 2001 (excluding hunting and oil/gas lease income)?

a. _____ Less than 50,000
b. _____ $50,001 - $100,000
c. _____ $100,001 - $150,000
d. _____ $150,001 - $200,000
e. _____$200,001 - $250,000
f. _____$250,001 - $300,000
g. _____$300,001 - $350,000
i. _____ over $350,000

26. Approximately what percentage of your gross farm income in 2001 came from grazing livestock?

_____percent

27. Which of the following categories best describes your net household income in 2001 (gross cash farm income, plus income from other sources, less gross cash farm expenses)?

    a. _____ $0 - $10,000

    b. _____ $10,001 - $25,000

    c. _____ $25,001 - $50,000

    d. _____ $50,001 - $100,000

    e. _____ over $100,001

28. Approximately what percentage of your net household income in 2001 came from off-farm employment?

    _____percent

Please include any other comments you would like to make about the establishment or effectiveness of leafy spurge biocontrol agents on your land. _____

_____

_____

_____

_____

_____

For a copy of the study results, please provide your name and mailing address below or you may contact the Department of Agribusiness and Applied Economics at North Dakota State University in Fargo, ND. Phone 701-231-7357, Fax 701-231-7400 or E-mail: nhodur@ndsuext.nodak.edu or visit our departmental listing of research reports on the world wide web at http://agecon.lib.umn.edu/ndsu.html

Thank you for completing this questionnaire. Your cooperation is sincerely appreciated.

Please return this questionnaire in the enclosed postpaid envelope.

Appendix C

County Weed Board Survey

CONFIDENTIAL

County Weed Board Survey

Please answer the following questions about leafy spurge infestations in your county, the use of leafy spurge biological control agents (flea beetles), and the characteristics of flea beetle release sites.

1. What is your best estimate of the number of acres of leafy spurge in your county?

_____ acres

(If there is no leafy spurge in your county, please stop and return the questionnaire in the enclosed postage paid envelope.)

2. How extensively has biological control using *Aphthona* flea beetles been implemented in your county? *(Please circle the number which most closely describes your activity.)*

1	2	3	4	5
Not at all				Very Extensively

***If flea beetles have not been used for leafy spurge control in your county*,** does the County Weed Board plan to release flea beetles in the future*? (Please circle one)*

Yes **No**

If No, go to question 11, page 6.

Release Site Characteristics

There are several techniques for releasing flea beetles in leafy spurge infestations. Depending on the technique, the definition of a "release site" varies. In order to make accurate comparisons, ***for purposes of this survey, a release site is any single area of one acre or less that has received beetles.*** For example, several containers of beetles released within a one-acre area would be considered *one* release site. However, several containers of insects released at different locations over an entire field or pasture would be considered *several* release sites. Please use this criteria when determining how many release sites are in your county.

3. On approximately how many sites have *Aphthona* beetles been released in your county in the past four years (1998-2001)?

County weed board release sites ____ (your best estimate)
Rancher/landowner release sites ____ (your best estimate)
Other (*please specify*_____*)* ____ (your best estimate)

4. Approximately how many of the County Weed Board's release sites fall into the following categories:
(Please indicate the number of sites that fit each description.)

A. Soil Type

_____ Sandy soils _____ Loamy soils _____Clay soils

B. Drainage and/or Topography

_____ Sunny sites on well-drained side slopes, flat areas, or open range

_____ Sunny sites near drainage areas on poorly drained soils near standing or running water

_____ Shaded or semi-shaded sites (near trees, shrubs, or brush) on well to moderately drained side slopes or flat areas

_____ Shaded or semi-shaded sites near drainage areas on poorly drained soils near standing or running water

C. Spurge Density (thickness of the stand of leafy spurge)

_____ Light stand (less than 25 leafy spurge plants per square yard)

_____ Moderate stand (about 25 to 100 leafy spurge plants per square yard)

_____ Heavy stand (over 100 plants per square yard)

D. Spurge Height

_____ Short (most leafy spurge plants less than 2 feet tall)

_____ Medium (most leafy spurge plants between 2 to 3 feet tall)

_____ Tall (most leafy spurge plants over 3 feet tall)

E. Overall Size of Leafy Spurge Infestation

_____ One acre or less _____ 1-10 acres _____ 10 acres or more

F. At how many sites were the following *Aphthona* species released?

_____ black flea beetles (*A*. lacertosa/czwalinae)

_____ brown flea beetles (*A*. nigriscutis)

_____ Mixed (both black and brown flea beetles)

G. How many release sites received the following numbers of beetles?

_____ At least one container or about 3,000 beetles

_____ Several containers or somewhere between 3,000 and 10,000 beetles

_____ Many containers or somewhere between 10,000 and 50,000 beetles

_____ More than 50,000 beetles

5. Have you or other members of the County Weed Board monitored any of the release sites where the county weed board has released flea beetles to determine if the flea beetles have established and if they can be harvested? *(Please circle either yes or no)*

Yes		**No**
IF YES,		**IF NO**,
How many sites have been monitored? _____		Do you plan to monitor the sites in the future? **Yes No**
On how many of the monitored sites are the beetles reducing the stand of leafy spurge?		**If no,** why not: *(please check all that apply)*
_____ No evidence of reduction		_____ time/budget constraints
_____ Small reduction (less than 10 square yards of stand reduction)		_____ control method is not effective
_____ Moderate reduction (more than 10 square yards, but less than an acre of stand reduction)		_____ no longer have access to the land
_____ Substantial reduction (more than an acre of stand reduction)		_____ did not record the location(s) of the release site(s)
Of the monitored sites, have you or other members of the County Weed Board collected beetles for further distribution? *(Please circle one)* **Yes No**		_____ other _____ *(please specify)*
If yes, on how many sites have flea beetles been harvested for redistribution? _____sites	**If no**, do you or other members of the County Weed Board plan to collect flea beetles from the release sites for distribution ***in the future*****?** *(circle one)* **Yes No**	**Please go to Question 6.**

6. Have biocontrol efforts using flea beetles met your Weed Board's expectations? *(Please circle either yes or no.)*

Yes	**No**
If Yes, go to Question 7.	**If no,** does the County Weed Board plan to make additional releases in the future even though control efforts have failed or have not met your expectations. **Yes** **No**

7. What percentage of the county's leafy spurge infestation do you or other members of the County Weed Board believe will eventually be controlled with flea beetles?

_____ zero	_____ 26 to 50 percent
_____ 1 to 10 percent	_____ 51 to 75 percent
_____ 11 to 25 percent	_____ over 75 percent

8. Has your County Weed Board held leafy spurge field days or similar events where landowners are given insects for release or are able to sweep insects to take home?

YES	**NO**
If yes, how many events have been held since 1999 _____ Do you plan to hold more events in the future? **Yes** **No**	**If No, please go to question 9.**

Biological Control Field Assessment

TEAM Leafy Spurge will have a field assessment team working during the summers of 2002 and 2003. This group will visit sites across the region to assess to what degree flea beetles have established and the degree of leafy spurge control achieved.

9. Would you or another member of the County Weed Board be willing to assist the field team by identifying County Weed Board release sites and characterizing pre-release conditions (spurge density, spurge height, size of infestation) at those sites? (*Please circle either yes or no.*)

YES	**NO**
If Yes, who should we contact: Name: Telephone Number:	**If No**, go to Question 10, page 6
If Yes, how many sites could be identified and characterized? _____Sites	
Are GPS (Global Positioning System) coordinates available for any of the sites? **YES** **NO** If yes, on how many sites? _____Sites	
Are Township, Range, and Section coordinates available for any of the sites? **YES** **NO** If yes, on how many sites? _____Sites	
Can you provide the Township, Range, and Section coordinates on two sites that you or some other member of the County Weed Board have monitored and that are accessible by vehicle? *(Please provide as much information as possible.)* **YES** **NO**	
If No, please go to Question 10	

Site #1	Site #2
County _____	County _____
Township _____	Township _____
Range _____	Range _____
Section _____	Section _____

10. How many of the County Weed Board's release sites were made on the following types of land?	
Rangeland _____	Road ditch _____
Hayland _____	Fenceline _____
Conservation Reserve Program _____	Riparian Area _____

General Issues and Attitudes

Please answer the following questions about current and future weed control practices and the County Weed Board's opinions on general weed management issues.

11. Is the County Weed Board currently using any of the following to control leafy spurge in your county: *(Please circle either yes or no for each control practice)*			
A. HERBICIDES			
Yes		**No**	
If yes, do you plan to continue to use herbicides?	Yes No	**If no**, do you plan to use herbicides in the future?	Yes No
B. GRAZING WITH SHEEP OR GOATS			
Yes		**No**	
If yes, do you plan to continue to graze sheep or goats?	Yes No	**If no**, do you plan to graze sheep or goats in the future?	Yes No
C. TILLAGE AND/OR RESEEDING WITH COMPETING GRASSES			
Yes		**No**	
If yes, do you plan to continue tilling and reseeding?	Yes No	**If no**, do you plan to till or reseed in the future?	Yes No

12. How would you rate the effectiveness of each the following leafy spurge control practices? *(Please circle the appropriate number for each control practice.)*				
	Not Effective	Somewhat Effective	Very Effective	Don't Know
a. spray with herbicides	1	2	3	4
b. biological control with insects	1	2	3	4
c. graze animals such as sheep or goats	1	2	3	4
d. till and/or reseed with competing grasses	1	2	3	4
e. integrated pest management (IPM) using two or more control methods	1	2	3	4
f. other controls *(please specify)*_____	1	2	3	4

13. Do you think it pays to use the following leafy spurge control practices? *(Please circle the appropriate number for each control practice.)*				
	Yes, it pays	Pays Marginally	Does Not Pay	Don't know
a. spray with herbicides	1	2	3	4
b. biological control with insects	1	2	3	4
c. graze animals such as sheep or goats	1	2	3	4
d. till and/or reseed with competing grasses	1	2	3	4
e. integrated pest management (IPM) using two or more control methods	1	2	3	4
f. other controls (*please specify)* _____	1	2	3	4

14. Please indicate whether you agree or disagree with the following statements. (*Please circle the appropriate number.)*						
	Strongly Disagree	Somewhat Disagree	Neither Agree or Disagree	Somewhat Agree	Strongly Agree	Don't Know
Leafy spurge is impossible to control with current methods and techniques.	1	2	3	4	5	0
Leafy spurge can be controlled but it is too costly.	1	2	3	4	5	0
Leafy spurge is a long-term management problem.	1	2	3	4	5	0
Biological control has been successful in controlling leafy spurge in my area.	1	2	3	4	5	0
Biological control will eventually eliminate the leafy spurge problem.	1	2	3	4	5	0
Biological control with flea beetles will never be successful in my area.	1	2	3	4	5	0

15. Please rate how problematic the following rangeland weeds are in your area. (*Please circle the appropriate number.)*

	Not a problem	Minor Problem	Major Problem	Don't know
a. Annual brome grasses	1	2	3	4
b. Knapweeds	1	2	3	4
c. Leafy spurge	1	2	3	4
d. Prickly pear	1	2	3	4
e. Sagebrush	1	2	3	4
f. Thistles	1	2	3	4
g. Wormwood (absinth)	1	2	3	4
h. Field bindweed	1	2	3	4
i. Others (*please specify*)_____	1	2	3	4

16. Which weed *listed in Question 15* poses the most serious problem for rangeland and other untilled land in your area? *(Please **circle** the appropriate letter.)*

17. Overall, how serious are the weed problems on rangeland and other untilled land in your area? *(Please circle one.)*		
not a problem	minor problem	major problem

Respondent Characteristics

Following are a few general questions about you. Responses to these questions help compare attitudes and perceptions based on respondent characteristics. ***Please be assured that your responses will be kept strictly confidential***.

18. In what county and state do you live?_____County_____State

19. What is your age?_____Years

20. Which of the following categories best describes the highest level of education you have completed?

    a. _____ Did not complete high school
    b. _____ High school graduate
    c. _____ Vocational/Technical or 2-year college degree
    d. _____ Bachelor's Degree (4-year college program)
    e. _____ Graduate School (Masters and/or Doctorate Degree)

21. Which of the following categories best describes your current occupation?

    a. _____ Full-time farming/ranching
    b. _____ Part-time farming/ranching with off-farm employment
    c. _____ Agricultural service and supply
    d. _____ Professional/small business/business management
    e. _____ Government/public service
    f. _____ Retired
    g. _____ Tradesman/equipment operator
    h. _____ Other_____(*please specify*)

Please include any other comments you would like to make about the establishment or effectiveness of leafy spurge biocontrol agents.

_____

_____

_____

_____

_____

_____

For a copy of the study results, please provide your name and mailing address below or you may contact the Department of Agribusiness and Applied Economics at North Dakota State University in Fargo, ND. Phone 701-231-7357, Fax 701-231-7400 or E-mail: nhodur@ndsuext.nodak.edu or visit our departmental listing of research reports on the world wide web at http://agecon.lib.umn.edu/ndsu.html

Thank you for completing this questionnaire. Your cooperation is sincerely appreciated.

Please return this questionnaire in the enclosed postpaid envelope.