Reprinted from: Leafy Spurge, Monograph series of the Weed Science Society of America. ed. Alan K. Watson, 1985. Chapter I (3):1-6.

Published by: Weed Science Society of America. http://www.wssa.net/

Introduction - The leafy spurge problem

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I. The plant

Leafy spurge is a herbaceous deep-rooted perennial weed of the Euphorbiaceae family that reproduces from seed and from numerous vegetative buds on the extensive, persistent vertical and horizontal root system. Structural characters of this weed are highly variable and considerable confusion over its classification has resulted. In North America, leafy spurge has commonly been referred to as *Euphorbia esula* L., but many synonyms and taxonomic revisions have been proposed (4, 10, 13, 21, see chapter 3). The weed is native to Eurasia and has been introduced into North America on various occasions from different sources (see Chapter 2).

Stems of leafy spurge are erect, tough and woody from 30 cm to 1 m in height with non-flowering axillary branches common. The flowers of leafy spurge are reduced and are borne in a flower-like inflorescence called a cyathium. The cyathium is a cup-shaped structure containing one pistillate flower with 11 to 20 staminate flowers. The margin of the cyathium usually bears four two-horned nectariferous glands. Flowers are cross pollinated by insects and are rarely self-pollinated. On leafy spurge the cyathea are borne terminally in an umbel-like "inflorescence." Numerous axillary cyathea are present on most flowering stems. The yellowish-green inflorescences appear in the spring, form early to late May, and generally continue to midsummer. From 12 to 150 seeds are produced per flowering stem. The leaves of leafy spurge are highly variable in shape, ranging from broadly linear-lanceolate to ovate. Margins are usually entire or slightly sinuate, with

leaves alternate except for the whorl of leaves subtending the terminal inflorescences. The seeds of leafy spurge vary in color from yellow to brown with a mottled or flecked appearance. They are smooth, globose-ovoid, ranging in size from 2.0 to 2.5 mm long and 1.3 to 1.5 mm wide with a characteristic yellow caruncle at one end. The underground portion of leafy spurge is impressive with an extensive system of roots and associated vegetative buds. All plant parts contain latex. The morphology and anatomy and the biology of leafy spurge are discussed in Chapters 4 and 5.

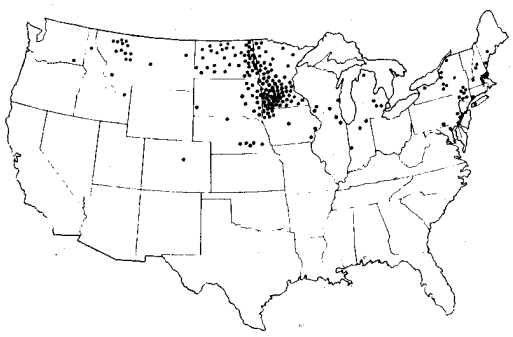

Figure 1. Distribution of leafy spurge in the United States in 1933 [from Hanson and Rudd (15)]

II. Distribution

The first record of leafy spurge in North America was from Newbury, MA, in 1827 (6). By 1933 Hanson and Rudd (15) reported leafy spurge to be most prevalent in North Dakota and Minnesota and could also be found in Maine, New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, Maryland, Michigan, Illinois, Wisconsin, Iowa, South Dakota, Nebraska, Colorado, Montana, Idaho and Washington (Figure 1). Leafy spurge continued a westward migration and in 1979 was a major economic concern in the northwestern and north-central states of the United States and in the adjacent prairie provinces of Canada (Figure 2). Leafy spurge is found in every province of Canada except Newfoundland (25).

Dunn (12) conducted a survey of the 48 contiguous states and his data, converted to percentage, are presented in Table 1. This information illustrates the relative problem of leafy spurge in the various states. The proportion of counties with infestations of more than 200 hectares demonstrates the seriousness of the problem in some states, whereas other states have relatively small infestations that could easily be eradicated. In spite of its early introduction into Massachusetts, leafy spurge has not become a major pest in the northeastern United States or in adjacent eastern Canada. Numerous infestations occur in these regions but, in the most part, they are relatively small, localized infestations. It is interesting that in one of the early leafy spurge problem states, Minnesota, most infested counties (58%) have infestations of less than 10 ha. The reasons for the apparent lack of spread in this state may give insight to understanding the dynamics of this species and

possible improved control strategies. Presently, leafy spurge is a major problem in Colorado, Idaho, Minnesota, Montana, Nebraska, North Dakota, Oregon, South Dakota, Wisconsin and Wyoming. In a 1982 survey of North Dakota, perhaps the state with the greatest spurge problem, over 349,000 hectares were infested with leafy spurge (20). This value represents about 2% of the total hectarage, 6% of the untilled land, and approximately 6.6% of farmland likely to be infested with leafy spurge in North Dakota (20). The area infested with leafy spurge in North Dakota doubled during the period from 1973 to 1982, and unless adequate management programs are implemented in the near future the area infested will continue to increase.

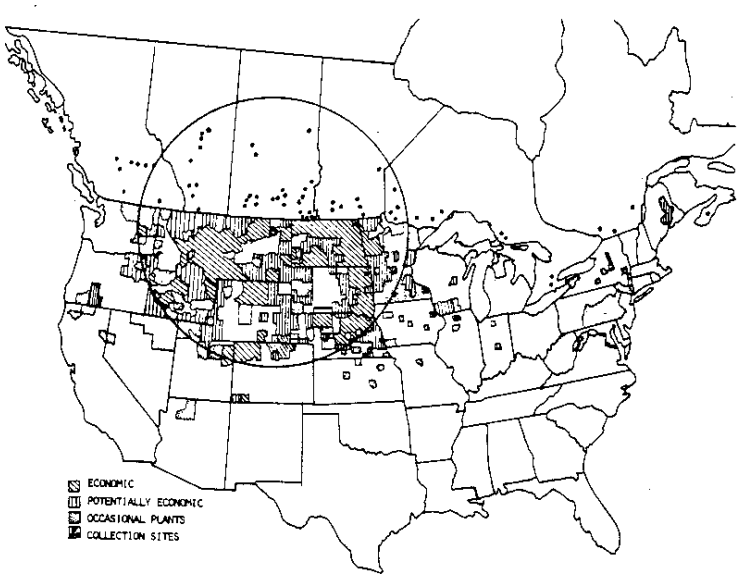

Figure 2. Distribution of leafy spurge in the United States and Canada in 1979 [from Noble *et al*. (23)]

Leafy spurge is primarily found in untilled, noncropland habitats, such as abandoned cropland, pastures, rangeland, woodland, roadsides and waste areas. The broad tolerance range of leafy spurge is exemplified by its wide distribution in North America, but it is most aggressive and competitive in semiarid habitats where interference from associated species is generally less intense (26). Spurge infestations occur in light sandy soils to heavy clay soils but generally do best in coarse-textured soils (26).

III. Spread

Leafy spurge is an aggressive perennial that spreads by seed and by its vigorous root system. Natural seed dispersal occurs when the mature capsule dehisces, propelling the seeds up to 4.6 m from the parent plant (7). Animals, birds, insects and water are natural agents of dispersal for spurge seeds (5,26) and man, through seed contamination of grain, forage seed and hay, is an effective dispersal agent (5). Seed and root fragments of leafy spurge are often transported by vehicles and farm machinery. It is difficult to measure the

long distance dispersal of such a weed species, but Thomas and Bowes (28) found the seed rain largest near the center of a patch, with substantial reduction near the edge of the patch, and less than 10% of the seeds dispersed beyond the edge of the patch.

Table 1. Distribution and levels of infestation of leafy spurge in the 48 contiguous states of the United States, 1975 (data from Dunn (12)).

	Number of counties infested	Proportion (% total) of infested counties with different infestation levels		
		200ha	10 to 200ha	10ha
Arizona	1	0	0	100
California	2	0	0	100
Colorado	8	75	25	0
Connecticut	8	100	0	0
Delaware	2	0	50	50
Idaho	28	18	43	39
Illinois	4	0	0	100
Iowa	11	0	0	100
Kansas	4	0	0	100
Maine	2	0	100	0
Massachusetts	5	100	0	0
Michigan	11	0	0	100
Minnesota	80	6	36	58
Missouri	1	0	0	100
Montana	54	52	35	13
Nebraska	54	41	39	20
Nevada	3	0	0	100
New Hampshire	4	0	0	100
New Mexico	1	0	0	100
New York	12	0	0	100
North Dakota	52	79	19	2
Oregon	6	0	83	17
Pennsylvania	27	0	0	100
South Dakota	47	51	34	15
Utah	10	10	60	30
Vermont	2	0	0	100
Washington	6	17	17	66
West Virginia	2	0	0	100
Wisconsin	8	12	63	25
Wyoming	21	38	52	10
Totals	476	33	29	38

In noncultivated habitats spurge patches increase in radius by approximately 0.3 to 0.9 m per year, with a median of 0.612 m (26). Spread is potentially much greater in cultivated habitats because of reduced interference from associated species, increased bud production and movement of root fragments (15,26). Natural spread within nondisturbed habitats is easy to measure and for leafy spurge is relatively slow (15).

Natural dispersal cannot account for the doubling of the infestation in North Dakota from 1973 to 1982 (20), and the difference must be related to the influence of man and his activities.

Auld *et al*. (3) and Auld and Coote (2) have discussed the importance of the spread of weeds, the factors involved and the need for improved monitoring of weed distribution in the development of weed control programs. By using the values reported in the literature for seed dispersal (4.6m) and vegetative spread (0.612m), the rate of increase and the size of infestations can be easily calculated for different-sized infestations (Table 2). It is apparent from these values that small infestations will increase in size at a more rapid rate than larger infestations. Therefore, containment and possible eradication of small infestations should be a major component of an integrated management program for the control of leafy spurge.

Table 2. Predicted increases in leafy spurge infestations after one, five and 10 years.

Size of initial infestation[a]	Vegetative spread[b]			Seed dispersal[c]		
	1 yr	5 yr	10 yr	1 yr	5 yr	10 yr
(ha)	[ha (% increase)]					
0.5	0.52 (3.09)	0.58 (2.91)	0.67 (2.71)	0.62 (24.4)	1.24(16.4)	2.32(11.6)
1.0	1.02 (2.18)	1.11 (2.09)	1.23 (1.99)	1.17 (17.0)	1.99(12.7)	3.30(9.63)
10	10.07 (0.69)	10.35 (0.68)	10.70 (0.67)	10.52 (5.22)	12.74(4.73)	15.82(4.23)
100	100.22 (0.22)	101.09 (0.22)	102.18 (0.22)	101.64 (1.64)	108.32(l.59)	116.97(l.53)
500	500.49 (0.10)	502.43 (0.10)	504.86 (0.10)	503.65 (0.73)	518.40(0.72)	537.13(0.71)
1000	1000.69 (0.07)	1003.43 (0.07)	1006.87 (0.07)	1005.16 (0.52)	1025.95(0.51)	1052.23(0.51)

[a]Based on the assumption that the patches of leafy spurge are circular and remain so during their increase.
[b]Increase in radius of 0.612 in per year [from Selleck *et al*.(26)].
[c]Seeds propelled up to 4.6 m from parent plant [from Bowes and Thomas (7)].

IV. Economic impact

Beneficial. The latex, which is present throughout the plant, has been suggested as a possible rubber and energy source (8), and extracts of leafy spurge have been shown to stimulate hair growth on rabbits (25). The chemistry of the latex is not well known and should be of interest to phytochemists. However, these and other possible uses of leafy spurge in no way reduce the importance of this species as a noxious weed, nor should unknown future use of leafy spurge discourage control measures.

Detrimental. Leafy spurge is an aggressive perennial weed, which, after establishment, tends to displace all other vegetation in pasture and rangeland habitats and to establish essentially single species stands. Yield reductions of associated desirable forage species have been reported from 10 to 100% (11,24). Some of the competitive ability of leafy spurge may be associated with allelopathy (27).

Spurge is generally avoided by grazing animals, but if spurge is ingested it is known to cause scours and weakness, which may result in death of the animals (18,22). Sheep are less affected by the toxic principle in leafy spurge and do graze young spurge plants. Because of this ability to graze spurge closely, sheep have been used in management programs for spurge control (16).

The latex in leafy spurge is a skin irritant that can cause severe dermatitis in humans (17,29) and in grazing animals (18). There appear to be many toxic principles in the spurge latex, and the latex has been demonstrated to contain cocarcinogenic factors (29).

Costs. Estimates of pest losses in terms of actual dollar values are difficult to obtain, often suspect, and open to variable interpretation. If one recognizes these limitations, the following quotations illustrate the seriousness of the leafy spurge problem (in economic terms) in North America:

"…private landowners in Montana are spending more than 2½ million dollars per year in an attempt to control leafy spurge." (24)

"A number of ranchers in the Judith Basin have weed control expenses that amount to more than their land payment each year." (24)

"…a conservative 1978 economic impact in the United States of 10.5 million…" (23).

A recent comprehensive evaluation of the economic impact of leafy spurge was reported by Messersmith and Lym (20) for North Dakota (Table 3). The combination of losses of hay production and beef cattle production, plus the costs of herbicides, herbicide applications and expenditures by government agencies, amounted to a total annual loss of 12.9 million dollars in just one state, North Dakota.

Table 3. Summary of economic losses from leafy spurge in North Dakota, 1982.

1.	Loss of hay production	$ 963,775
2.	Loss of beef cattle production	6,007,976
3.	Cost of herbicides	4,022,630
4.	Cost of herbicide application	475,590
5.	Expenditures by state and county governments	1,444,290
	Total	$12,914,261

Source: Messersmith and Lym (20).

The detrimental impact of leafy spurge in North America is not restricted solely to agricultural losses, but major socioeconomic concerns have also been raised. In many areas where leafy spurge is a problem special legislation has been passed to make it illegal to

sell hay contaminated with leafy spurge and to allow government authorities to enforce control of leafy spurge infestations (2,14,24). Not only are these laws difficult to enforce, they often lead to disagreements amongst neighbors, biased enforcement and perhaps inappropriate, costly herbicide applications over large areas.

The herbicide picloram (4-amino-3,5,6-trichloropicolinic acid) is very effective for the control of leafy spurge (see Chapter 7), but extensive use has caused some environmental concerns. This herbicide is relatively non-toxic to most nontarget organisms, but it is very phytotoxic in small quantities to most broadleaf species. Picloram is relatively soluble in water, and is not readily degraded. As a result, if picloram is inappropriately applied it often persists in the environment and causes dieback of desirable tree, shrub, and forb species and contamination of groundwater.

Leafy spurge can be controlled effectively by the combination of timely cultivation, cropping with competitive crops and appropriate herbicide applications (see Chapter 6), resulting in spurge not being a major problem in cultivated land. However, most infestations of leafy spurge occur on terrain unsuitable for cultivation, and many of these areas cannot be traversed by conventional spray equipment. These large areas of spurge infestation and the spurge plant itself make it a prime target for biological control. Advancement in the biological control of this weed has been made, but significantly more research and time are required before biological control of leafy spurge can be realized (see Chapter 8).

Leafy spurge is of major concern in much of the United States and Canada; as MacIntyre (19) stated "…we are in a war, and we're losing. It's a vegetative war and the enemy is a weed called leafy spurge." Many articles, both scientific and popular, have been written on the plant, its biology and its control. Despite the active efforts to suppress leafy spurge, infestations continue to spread, and the magnitude of the problem continues to increase. Public officials are becoming more aware of the problem and increased funding has been directed toward leafy spurge control. In reference to the Wyoming Leafy Spurge Control Act of 1978, Alley's (1) comment "…it is a shame this same foresight

> was not prevalent some 20 years ago, whereby the infestations could have been isolated, controlled or even eradicated when the acreage infested was only a fraction of what it now is"

illustrates the seriousness of the problem and reinforces the need for rapid and appropriate action to prevent further spread of this weed and to develop appropriate control strategies to reduce spurge infestations, in North America.

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