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Economic impact of leafy spurge in North Dakota

FLINT THOMPSON, F. LARRY LEISTRITZ, and JAY A. LEITCH

The authors are respectively, former graduate research assistant, professor, and associate professor, Department of Agricultural Economics, North Dakota State University, Fargo.

Highlights

Leafy spurge is a rapidly spreading noxious perennial weed that is widely established in North Dakota and throughout the Northern Great Plains. It is a particularly serious problem because of the speed with which it spreads and the difficulty of controlling it with available control mechanisms. The amount of leafy spurge infested land in North Dakota has been doubling about every ten years, currently affecting more than 1.2 million acres in the state.

A rangeland economics model was developed to estimate the economic impacts of leafy spurge infestation on both ranchers and regional economies. A leafy spurge induced carrying capacity reduction of about 580,000 AUMs, or enough for 77,000 cows, results in an annual income reduction to ranchers of nearly $9 million. In addition, another $14 million is not being spent by ranchers on input costs, which causes a reduction in activity.

The regional impacts of present levels of leafy spurge infestation estimated using the North Dakota Input-Output Model, are about $25 million in direct reductions which represents about $75 million in reduced business activity for all sectors.

These foregone rancher incomes, subsequent land value depreciation, and impacts on regional economies suggest the potential returns to leafy spurge control could be substantial. However, attention needs to be paid to the economics of control to ensure the level of control does not exceed that which is economically optimal.

Key words: Leafy spurge (*Euphorbia esula*), economics, control, regional impacts, rangeland

Leafy spurge (*Euphorbia esula*) is a widely established weed in North Dakota, infesting over 1.2 million acres or about 9.2 percent of the state's 13.1 million untitled acres in 1987 (Lym *et al.* 1988). The long-lived perennial plant, a native to Europe and Asia, was introduced to North America in 1827 and was first reported in North Dakota in 1909 (Messersmith and Lym 1983). It spreads rapidly by both seeds and rhizomes and is found primarily in untitled agricultural land (rangeland, pasture, and hayland), along highways and railroads, around lakes, and in parks.

Leafy spurge presents special problems to rangeland and pasture owners because it can reduce livestock carrying capacity by as much as 75 percent (Reilly and Kaufman 1979). Reilly and his colleagues believe that two thirds of the 75 precent reduction in carrying capacity results from a reduction in herbage production due to competition from leafy spurge, and one third can be lost because of poor utilization (cattle totally or partially avoid leafy spurge infested sites).

Leafy spurge is a particularly serious problem because of the speed with which it spreads and the difficulty of controlling it given currently available technology (i.e., herbicides). The weed's rapidity of spreading is demonstrated by the increase in acreages affected. North Dakota had an estimated 200,000 acres with leafy spurge in 1962. The acreage more than doubled to 423,425 by 1973, and doubled again to 861,823 by 1982 (Messersmith and Lym 1983). The speed with which leafy spurge is spreading is particularly alarming when the magnitude of present control efforts is considered. During the period 1985-87, North Dakota real property owners were assessed a total of about $770,000 per year for leafy spurge control, while the state legislature appropriated about another $181,000 per year. When the landowners' cost share of 20 percent is also considered, the total cost of leafy spurge control appears to have exceeded $1 million per year during this period.

Numerous studies have been conducted to test the effectiveness of various herbicides to restrict the spread of leafy spurge or, preferably, eradicate the weed (for example, see Lym and Messersmith 1985a, 1985b, 1985c, 1986). The cost effectiveness of such methods differs depending on the amount and type of herbicide applied, its effectiveness in killing leafy spurge, costs of application, and values of rangeland production; nevertheless, chemical treatments to date appear difficult for a private landowner to justify economically.

Recent research has focused on several biocontrol mechanisms because of concerns about the cost effectiveness of chemical treatments, as well as growing public interest in the possibility of adverse side-effects (Carlson and Littlefield 1983). To evaluate the economic feasibility of either presently available chemical controls or the chemical and biocontrol technologies that may be available in the future, a better understanding of the economic effects of leafy spurge infestations is required. Such information also may be useful in making decisions regarding allocation of resources to develop and refine new control technologies.

Examining the economic effects of leafy spurge dispersal requires considering not only the direct effects, such as those experienced by landowners and ranchers, but also the secondary effects on other sectors of the rural economy. A change in an area's resource base or its agricultural production practices can have substantial effects on both agribusiness firms and on local trade and service sectors (Leistritz and Ekstrom 1986). For example,

Mortensen *et al.* (1989) estimated that the retirement of 1.3 million acres of cropland in the Conservation Reserve Program in North Dakota resulted in a direct effect (through decreased expenditures for inputs) of about $35 million for the retail trade sector and about $56 million for all sectors combined. When the secondary effects of the program were included, the total impact was estimated to be $141 million. Leafy spurge infestation can cause similar economic impacts to occur.

Objectives

The purpose of this study was to develop a method to estimate the direct and secondary effects of reduced livestock carrying capacity resulting from leafy spurge infestation and to conduct a case study in North Dakota. The specific objectives were:

1. to develop a mathematical function that depicts the growth and spread of leafy spurge over time,
2. to develop a function that relates the increase in leafy spurge infestation to the decrease in livestock carrying capacity for North Dakota pasture and rangeland,
3. to estimate the economic effects of leafy spurge infestation on landowners for both reduced income derived from grazing and reduced land values,
4. to estimate the impacts of leafy spurge infestation on the regional economy, and
5. to determine areas where natural resource research could contribute substantially to improving the reliability of economic impact estimates.

Procedures

The leafy spurge growth model (objective 1) and the carrying capacity function (objective 2) were developed through an extensive literature review and consultation with agronomists and range scientists who have experience in research on leafy spurge. Estimating the effect of reduced carrying capacity on landowners' income (objective 3) required establishing a value for units of lost carrying capacity. Two approaches were used to estimate the value of lost carrying capacity (measured in animal unit months or AUMs). These were (1) an analysis of historical rental rates for pasture and (2) a ranch budget analysis. The impact of leafy spurge infestation on the regional economy (objective 4) was estimated using the North Dakota Input-Output Model (Coon *et al.* 1985). Areas where the state-of-the-science was less than desirable for confidence in the overall model (objective 5) were identified as work progressed through the first four objectives. The major steps in the analysis are summarized in Figure 1.

Leafy spurge growth model

Informed decisions regarding control of leafy spurge require practical knowledge concerning the rate at which it spreads and increases its area of coverage. Several researchers have developed diagrammatic population models for leafy spurge (for example, Bowes and Thomas 1978; Watson 1985; and Maxwell *et al.* 1988), but these models were judged to be overly complex for use by typical land managers. Stroh *et al.* (1990) developed

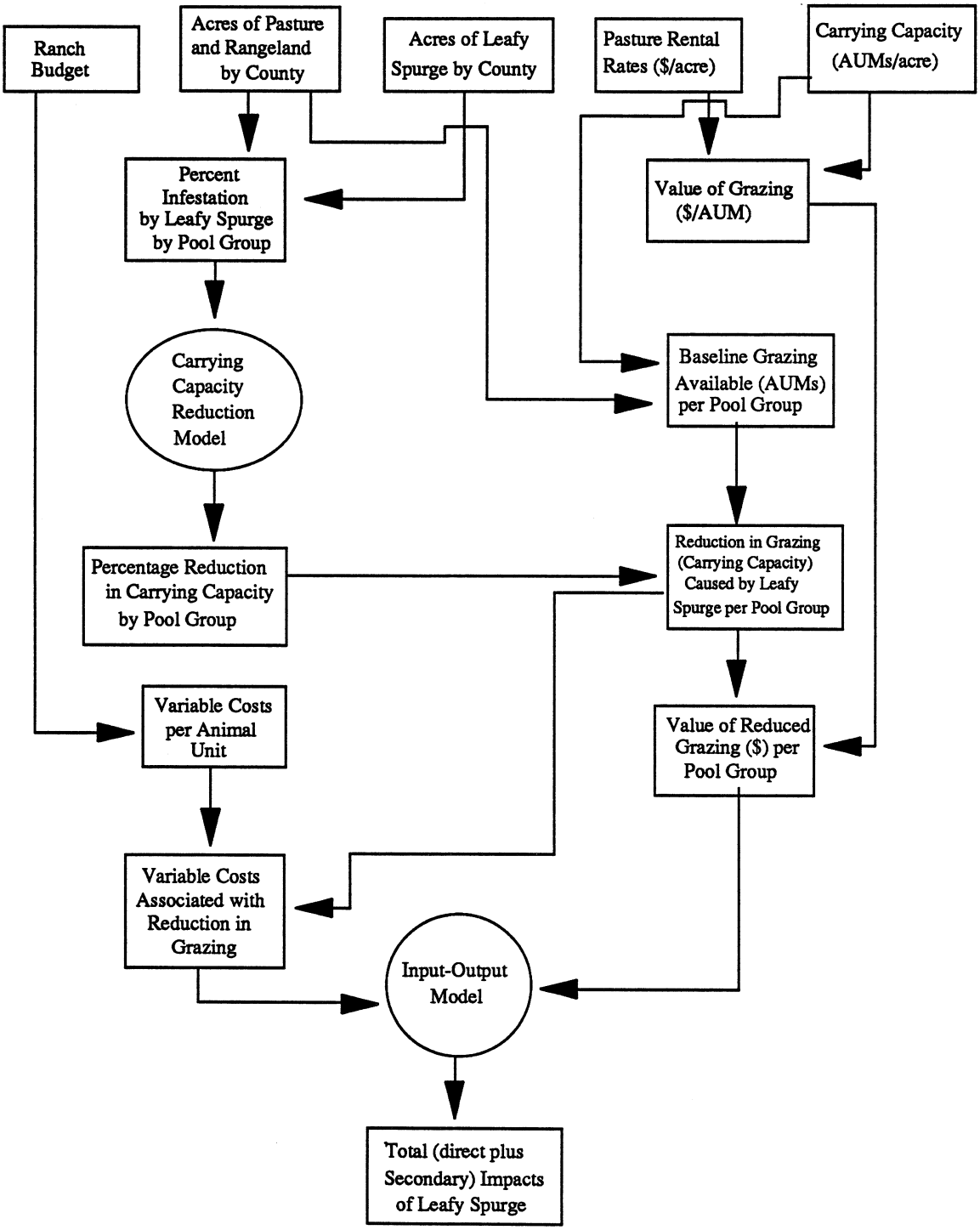

Figure 1. Process of analyzing impact of leafy spurge.

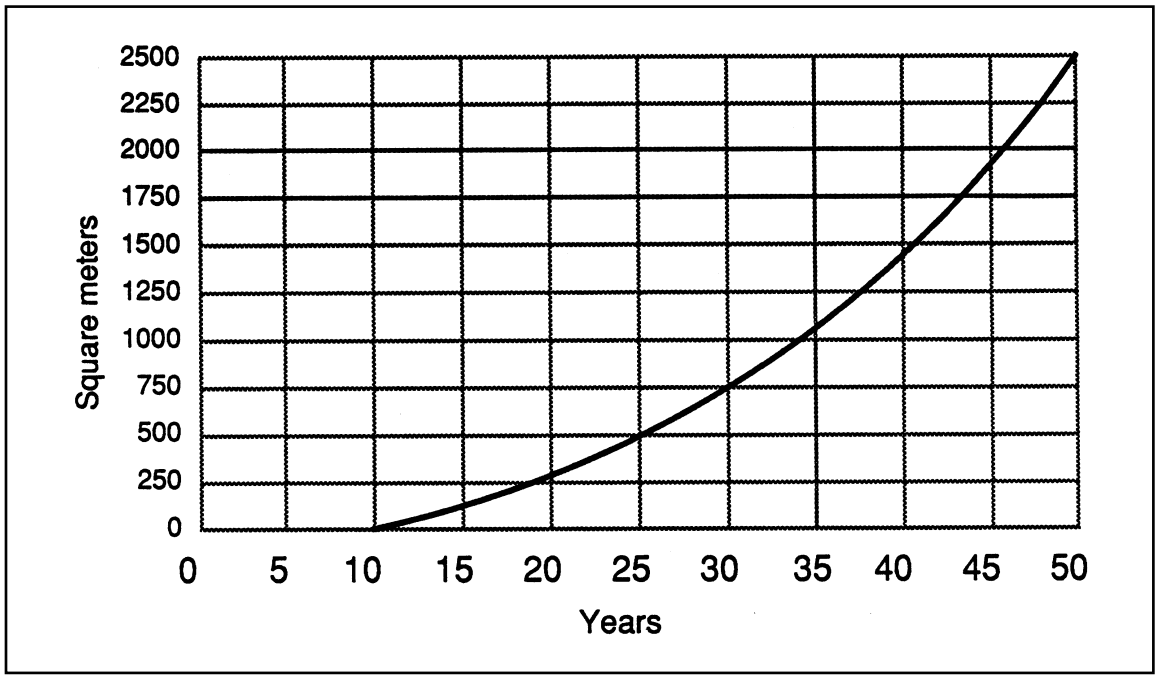

Figure 2. Leafy spurge area patch expansion.

Source: Stroh *et al.* 1990.

a simplified model for expansion of a leafy spurge patch, based on a literature review and synthesis. The model is as follows:

Radius (r) of leafy spurge patch = 2 feet (Years - 4)

Area (A) = πr^2

Total stems (S) in patch = A (10 stems per foot^2)

The (Years - 4) term is based on an estimate that about 4 years will be required before a leafy spurge seedling, growing in competition with native grassland, will start to spread vegetatively. Thereafter, the radius of the patch is estimated to increase by an average of 0.61 meter (2 feet) annually. Stem (plant) density is estimated to average 10 stems per square foot (ft^2). All these estimates were developed from recent literature describing the growth and spread of leafy spurge in the Northern Great Plains (for a more detailed discussion, see Stroh *et al.* 1990 or Thompson 1990).

The leafy spurge growth model implies that one leafy spurge plant could spread over 50 years to cover over 27,000 square feet (Figure 2). It should be noted that the model assumes uninterrupted expansion with no constraints such as coalescing patches, cropland boundaries, water bodies, or roadways to inhibit growth. At the same time, the model is conservative because it assumes that no new patches are formed by seed dispersal. Rather, the patch is assumed to expand almost entirely through lateral root spread.

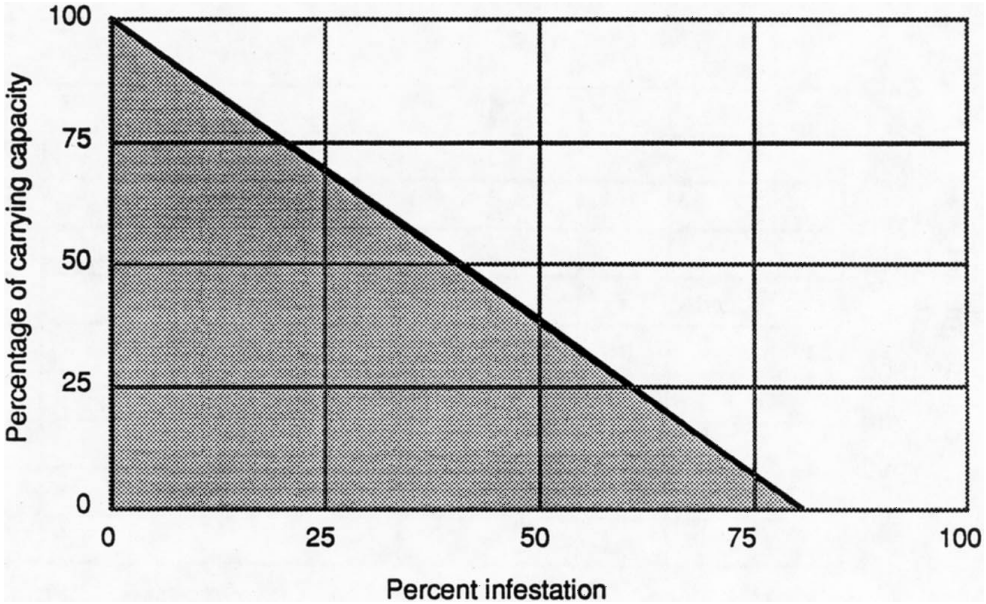

Figure 3. Estimates of reduced carrying capacity caused by various leafy spurge infestation rates.

Source: Kirby and Lym. 1989.

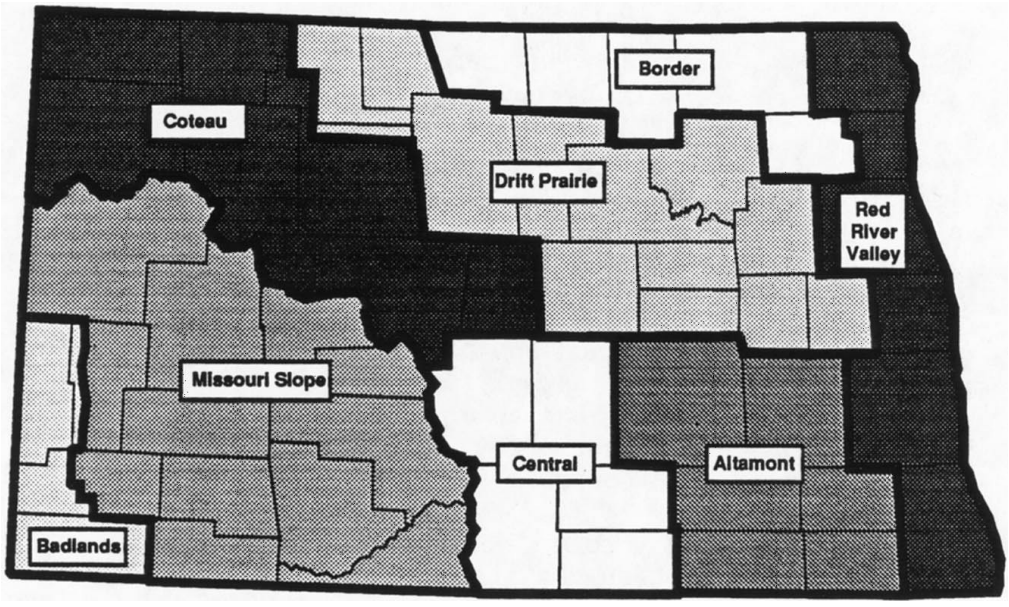

Figure 4. North Dakota vegetative zones.

Source: North Dakota Soil Conservation Service, 1974.

Carrying capacity reduction model

The model relating an increase in leafy spurge infestation to a reduction in carrying capacity also was developed through review and synthesis of recent literature (Thompson 1990). Carrying capacity is defined as the highest stocking rate that can be achieved without inducing damage to vegetation or related resources (i.e., it is the highest sustainable stocking rate). Leafy spurge infestation reduces livestock carrying capacity in two ways: (1) herbage production is reduced due to competition from leafy spurge and (2) additional useful forage can be lost because cattle totally or partially avoid leafy spurge infested sites, especially early in the grazing season. The relationship between the percentage of a pasture's land area covered by leafy spurge and the reduction in carrying capacity-appears to be best approximated by the following linear function:

C.C. 100 - 1.25 (P.I.)

where C.C. = carrying capacity

P.I. = percent infestation or the percent of land area covered by spurge

A leafy spurge infestation covering 80 percent of the total land area in a pasture would reduce the carrying capacity to zero from a practical range management standpoint (Figure 3).

Carrying capacity

Carrying capacity of rangeland and pastureland is typically specified in animal unit months (AUMs), the amount of feed required per month by one animal unit for maintenance and growth. One animal unit (AU) is a mature cow weighing approximately 1,000 pounds or her equivalent based upon an average daily forage consumption of 26 pounds of dry matter per day (Shaver 1977).

North Dakota is divided into eight vegetative zones: Altamont, Badlands, Border, Central, Coteau, Drift Prairie, Missouri Slope, and Red River Valley (Figure 4). Each vegetative zone is composed of various range sites. Range sites are particular kinds of rangeland (usually distinguished from other range sites on the basis of elevation, soil texture and depth, average annual precipitation, and topography), each with the potential to produce a specific amount and kind of forage.

The U.S. Department of Agriculture (1984) rates the carrying capacity of range sites for each of four condition classes for each vegetative zone. Range condition is a measure of the current "state of health" of range vegetation. Condition classes are based on the percentage of the present range vegetation that is climax vegetation. A climax community is the highest ecological development of a plant community capable of perpetuation under the prevailing climatic and soil conditions (Shaver 1977). Excellent condition rangeland has 76 percent or more of the climax vegetation present; good condition, 51 to 75 percent; fair condition, 26 to 50 percent; and range in poor condition, 25 percent or less. Range condition is also an indicator of forage production. The amount of palatable, high quality forage a site produces is considerably reduced as range condition goes from excellent to poor.

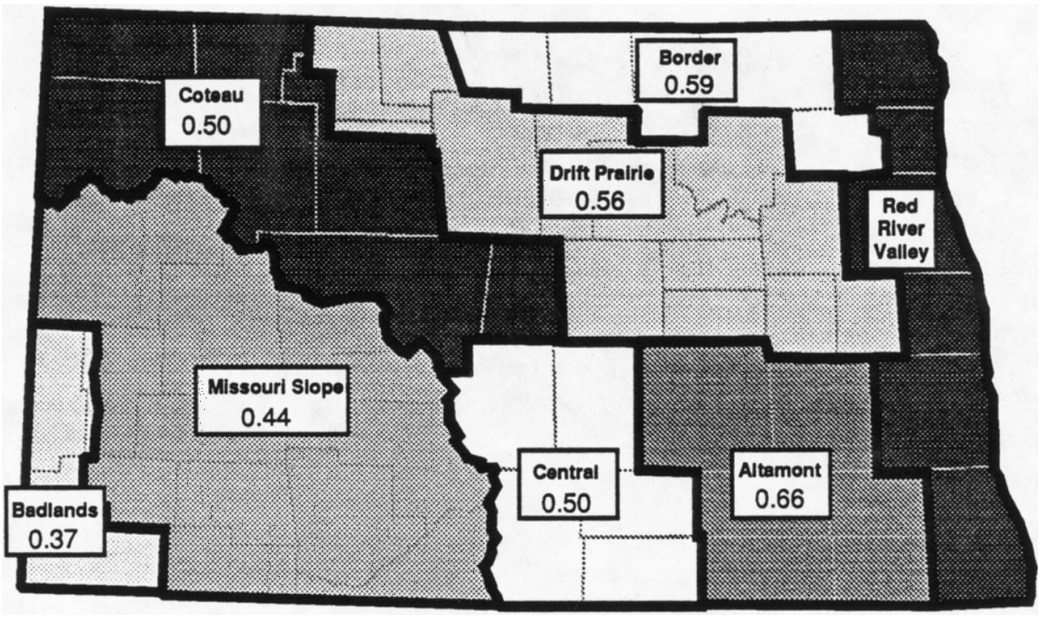

Figure 5. Rangeland baseline carrying capacities (in AUM's) by vegetative zones.

Source: North Dakota Soil Conservation Service, 1984.

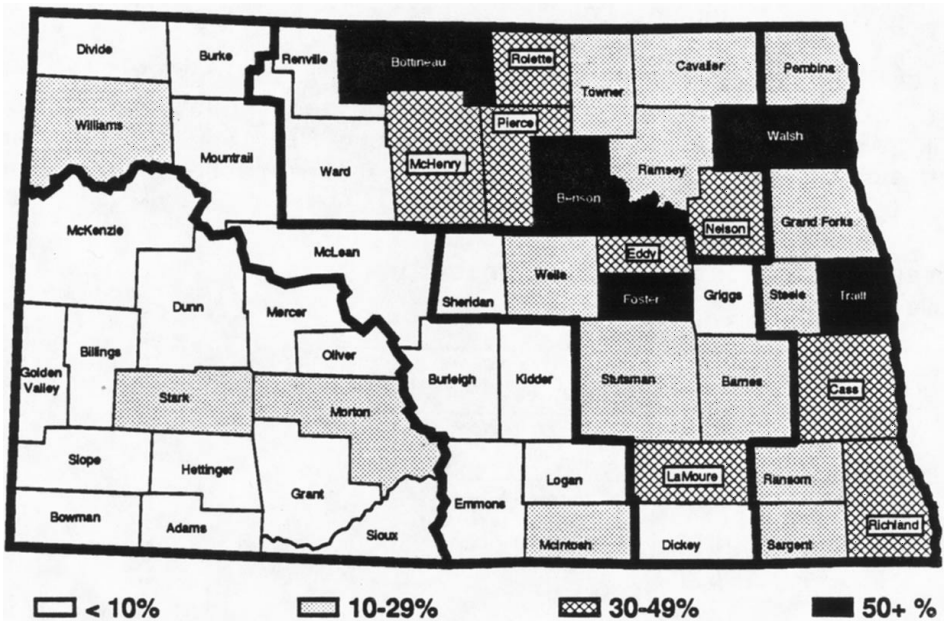

Figure 6. Percentage of pastureland and rangeland infested with leafy spurge.

Source: U.S. Bureau of the Census 1989, 1984, 1981, and North Dakota Department of Agriculture 1988.

North Dakota rangeland exhibits diversity in carrying capacity (Figure 5). The U.S. Department of Agriculture (1984) determined a baseline carrying capacity for each region (except the Red River Valley) for a clayey-silty range site with no leafy spurge infestation and with a condition intermediate between good and fair. Clayey-silty range sites are widely distributed range sites and provide an intermediate figure between high and low carrying capacity range sites. The acres needed for one animal unit vary with the carrying capacity of the rangeland and the time period grazed (Table 1). The relation in carrying capacities across North Dakota becomes apparent by comparing regions of the state. Grazing one animal unit in the Badlands region for 180 days would require about 16 acres of rangeland, compared with approximately 9 acres in the Altamont region.

Current levels of leafy spurge infestation

The North Dakota Department of Agriculture, which conducts an annual survey to estimate the amount of leafy spurge in each county, has found leafy spurge in all 53 counties in North Dakota (Figure 6). The northern and eastern counties contain the highest percentage of infested pasture and rangeland; however, very little pasture and rangeland is found in eastern counties, which may account for the high infestation percentages. Infestation rates for all North Dakota counties are presented in Appendix Table 1. Five counties have acreages of leafy spurge infestation that total more than half of their total acreage of pasture and rangeland, and one county (Foster) has leafy spurge acreage that exceeds its total pasture and rangeland acreage. This seemingly anomalous result could occur because some leafy spurge acreage is on railroad and highway right-of-ways, in parks, and on other lands that are not counted as farmland by the *Census of Agriculture.*

Table 1. Acres needed for one Animal Unit for various time periods.

Available AUMs/Acre	Days Grazed			
	120	150	180	210
	number of acres			
0.25	16.0	20.0	24.0	30.0
0.30	13.3	16.7	20.0	23.3
0.40	10.0	12.5	15.0	17.5
0.50	8.0	10.0	12.0	14.0
0.60	6.7	8.3	10.0	11.7
0.70	5.7	7.1	8.6	10.0
0.80	5.0	6.3	7.5	8.8

SOURCE: North Dakota Soil Conservation Service, 1984.

Valuation of grazing

The value of grazing capacity reduction had to be established before the economic effects of reductions in carrying capacity arising from leafy spurge infestations could be estimated. Two approaches to estimating the value of grazing were compared: (1) land rental rate and (2) ranch budgeting.

Land rental rate approach

Cash rent is used extensively in grazing land leases in North Dakota. Cash rents for grazing land are typically specified as a fixed payment per acre for the grazing season. Rental rates are analytically attractive as a measure of the value of grazing because (1) they are published annually for six of the state's farming areas and (2) under conditions of a competitive market they should closely approximate the contribution of a unit of grazing to a rancher's income. Rental rate variations among tracts or areas should reflect differences in productivity, as well as differentials in supply and demand conditions; variations over time should reflect differences in the profitability of livestock production (as well as possible changes in availability of grazing land).

Average per acre rental rates for range and pastureland for six North Dakota farming areas (Figure 7) are shown in Table 2 for the period 1984-88. Calculating all rental rates per AUM required several steps. First, rental rates reported for the six farming areas had to be related to the carrying capacities reported for the seven vegetative zones. The farming areas and vegetative zones are similar in configuration except for the Drift Prairie vegetative zone, which is divided about equally among the Northwest, Northeast Central, and Southeast Central farming areas. An average rent for these farming areas was used to approximate the rental rate for the Drift Prairie Zone. Thus, the correspondence between farming areas and vegetative zones was as follows:

Vegetative Zone	Farming Area
Altamont	Southeast central
Border	Northeast Central
Drift Prairie	Average of NW, NE Central, and SE Central
Central	Southwest Central
Coteau	Northwest
Missouri Slope	Southwest
Badlands	Southwest

After per acre rental rates for each vegetative zone had been estimated, these rates were divided by the AUMs per acre (or multiplied by the acres per AUM) to obtain the rental rate per AUM (Figure 8). The average rent per AUM ranges from $10.66 for the Coteau region to $17.95 for the Badlands.

Ranch budgeting approach

An enterprise budget was used as an alternative method of estimating the value of grazing. Leafy spurge infestation is assumed to reduce carrying capacity, which leads to a commensurate reduction in herd size. The reduction in farm income (technically, return to operator labor, management, and equity) resulting from the reduction in herd size divided by the decrease in AUMs that triggered it becomes the estimate of the value of grazing AUMs. The enterprise budget was developed by Hughes *et al.* (1989). Some key assumptions follow:

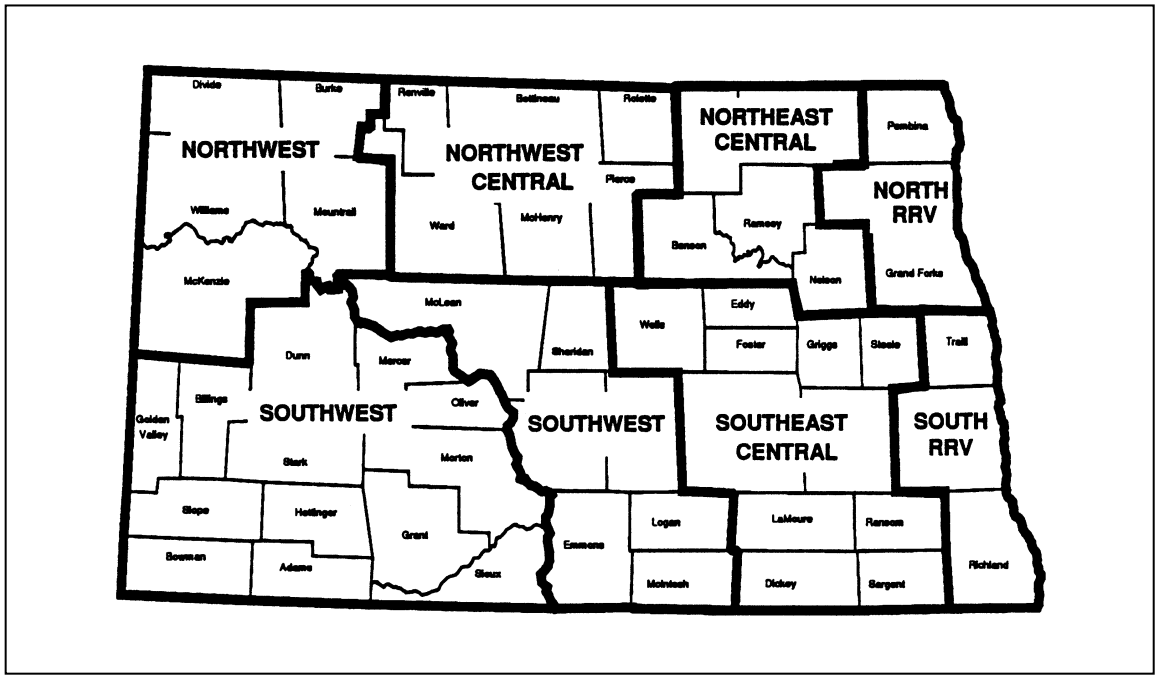

Figure 7. North Dakota farming areas.

* large-framed cows wean 550-pound steers,
* prices and costs are appropriate for the 1988-91 period,
* the calf crop is 90 percent and is sold in the fall, and
* pasture requirements are 743 AUM for cows, bulls, and replacement heifers.

When a 25-percent leafy spurge infestation was assumed, carrying capacity was reduced 31 percent (Figure 3) (to 511 AUMs), and the 100-cow herd was cut to 69 head. This herd reduction causes the return to operator labor, management, and equity to fall from $10,920 to $7,286 (Table 3). Dividing the loss of ranch income ($3,634) by the number of AUMs lost (232) gives an estimate of the value of AUMs ($15.66). If a second, higher infestation level (50 percent) is assumed, a further herd reduction is required, ranch income is further reduced, and an estimated value of $16.16 per AUM is obtained.

Table 2. Average per acre cash rents for North Dakota pastureland: 1984-88.

Farming Area	1984	1985	1986	1987	1988	5-year avg.
	dollars/acre					
Northwest	5.16	4.75	4.60	5.42	6.71	5.33
Northwest Central	8.90	7.71	6.25	6.81	7.30	7.39
Northeast Central	8.50	8.50	8.37	10.00	10.00	9.07
Southwest	7.05	7.05	6.26	6.44	6.42	6.64
Southwest Central	9.12	7.78	7.95	8.07	8.30	8.24
Southeast Central	10.92	10.28	8.63	8.69	9.11	9.53

SOURCE: Johnson 1985-89.

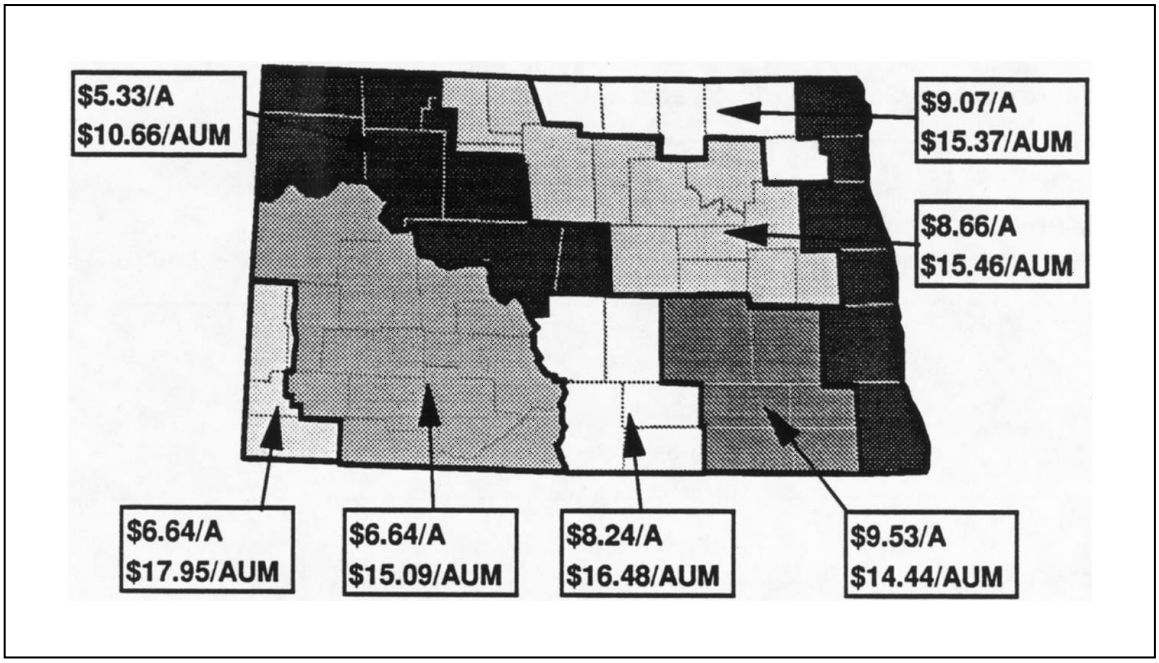

Figure 8. Estimated cash rent of rangeland in dollars per AUM at baseline carrying capacity with no leafy spurge using five-year average rents of 1984-1988.

Comparison of results of the cash rent and enterprise budgeting approaches indicates that they place similar values on grazing AUMs. The cash rent approach valued AUMs among the state's vegetative zones from $10.66 to $17.95, and the enterprise budget method provided estimates of $15.66 and $16.16. Because values from the two methods were similar and because the cash rent method was considered better able to reflect regional variations, the cash rent method was used as the basis for subsequent analysis.

Impacts on farmers and ranchers

The impacts of leafy spurge on farmers and ranchers were estimated by computing the value of grazing AUMs for each county and aggregating these values to obtain totals for the Conservation Reserve Program (CRP) pool groups (Figure 9) and for the state. Then the effect of leafy spurge infestation on land values (i.e., potential selling price) was estimated.

Table 3. Value per AUM calculated from enterprise budgets for zero, 25, and 50 percent leafy spurge infestation levels, 1989.

Infestation Level	Number of Head	Required AUMs	Returns Labor & Mgt.	Change in Income	Change in AUMs	Value Per AUM
------ % ------	- no. -	-- AUMs --	---------- dollars ----------		- AUMs -	dollars
0	100	743	10,920	-----	-----	-----
25	69	511	7,286	-3,634	-232	15.66
50	37	279	3,536	-3,750	-232	16.16

CRP pool groups

To facilitate subsequent analysis of impacts on the regional economy, county-level estimates of reduced carrying capacity and grazing value are aggregated into the regional groupings used by administrators of the Conservation Reserve Program (CRP) and termed "pool groups." This aggregation of counties was considered most appropriate because of the similarity of soil and farming conditions among counties within these groups and because the data bases associated with the North Dakota Input-Output Model had been aggregated into these county groupings (Mortensen *et al.* 1989).

Current baseline value of grazing

The current baseline value of grazing AUMs was estimated using the estimates of carrying capacity (Figure 4) and cash rent per AUM (Figure 7) in conjunction with the estimated acreages of pasture and rangeland from the *Census of Agriculture.* The baseline, although counterfactual, assumes there is no leafy spurge infestation. Because estimates of carrying capacity and rental rates were not available for counties in pool group five, cash rental rates and carrying capacities from adjacent farming areas and vegetative zones were used to estimate rental rates and production capacities for pool group five.

Pool group one has the highest total baseline value of AUMs at $38.4 million followed by pool group two at $15.6 million. The state total value is $72 million for 4.8 million AUMs (Appendix Table 2).

Impact of present infestation

The effect of leafy spurge infestation on carrying capacity was estimated for each pool group by dividing the reported acreage of leafy spurge (Appendix Table 1) by the total acreage of pasture and rangeland (Appendix Table 2) and then applying the carrying capacity model (Figure 3). The reduced AUMs were then valued based on the cash rental rates per AUM reported in Table 2. Statewide, the present leafy spurge infestation is estimated to cause a reduction of 577,000 AUMs, valued at $8.6 million to the ranch operator, other things being equal (Table 4). The loss in carrying capacity resulting from the present leafy spurge infestation is equivalent to that needed for a herd of about 77,000 cows.

Leafy spurge infestations reduce the productivity of grazing lands and will lead to decreased land values. Over the period 1984-88, grazing land rental rates have averaged $8.36 per acre, and the sale prices of such lands have averaged $133 per acre. If this value-to-rent ratio of 15.9 is applied to the estimated $8.6 million loss of value of grazing AUMs, then the estimated reduction in grazing land value is $137 million.

Impacts on the state's economy

The secondary impacts of leafy spurge infestations on the state's economy arise from two sources: (1) the reduction in income of ranch operators and land owners represented by the loss in grazing value discussed earlier and (2) decreases in production expenditures associated with ranchers' herd reductions. The decreases in production expenditures were

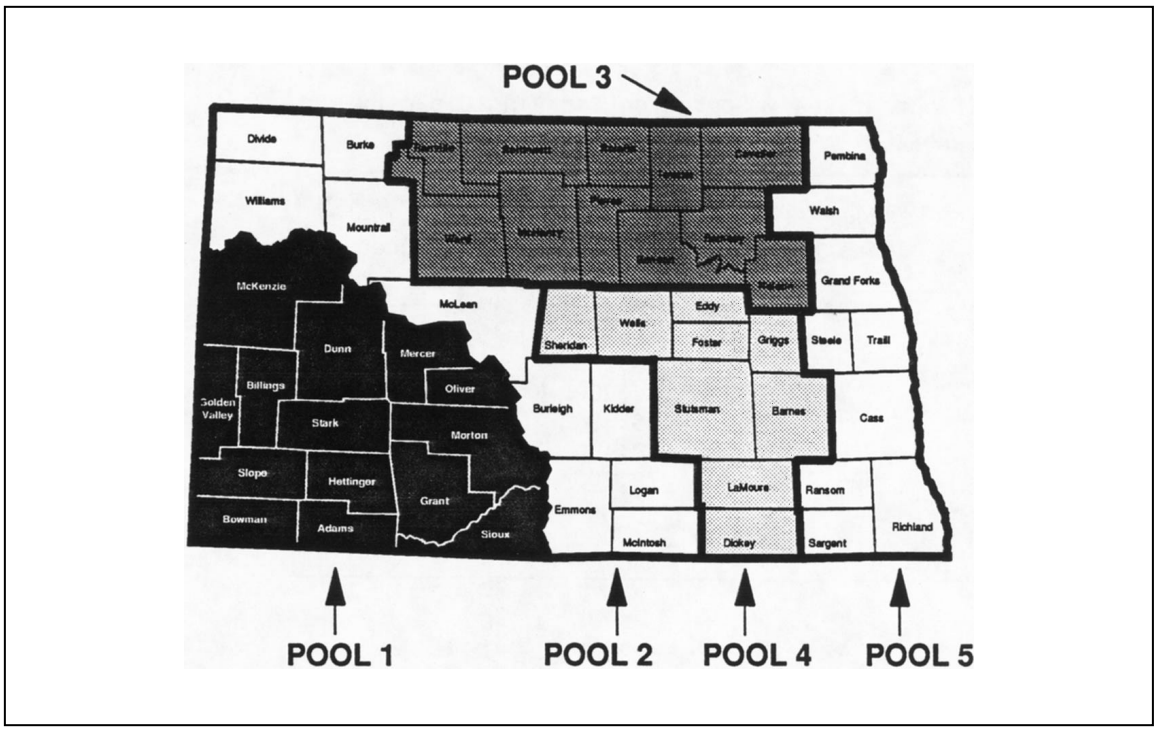

Figure 9. North Dakota CRP pool groups.

estimated using the ranch budget discussed earlier (Hughes *et al.* 1989). Statewide, the reduction in production expenses associated with decreases in carrying capacity resulting from leafy spurge infestations were estimated to total about $14.4 million. These reductions in expenditures, which are also decreases in revenues for input suppliers, together with the estimated $8.6 million in reduced income to landowners and ranchers constitute the direct impact of present levels of spurge infestation (Table 5).

The secondary and total impacts of present levels of leafy spurge infestation (Table 5) were estimated using the North Dakota Input-Output Model (Coon *et al.* 1985). The total impact of the present level of leafy spurge infestation includes a reduction in personal

Table 4. Effect of leafy spurge on carrying capacity and value of grazing by pool group, 1989.

Pool Group	Percent Infestation	Reduced AUMs	Value of Reduced AUMs
	--------- % ---------	----- AUMs -----	---------- $000 ----------
1	4.0	123,600	1,900
2	4.0	56,300	800
3	31.0	196,500	3,000
4	20.8	130,400	1,900
5	29.2	70,200	1,000
State Total	8.6	577,000	8,600

income (i.e., the household sector) of $25 to $26 million, or about $44.20 per lost AUM. Substantial impacts are also shown for the retail trade sector ($19.3 million) and the agriculture—crops sector ($10.7 million). The total reduced business activity for all sectors was $74.7 million (Figure 10). (If the initial reduction in livestock sales, about $29,751,000 is added to this figure, a total impact estimate of about $105 million is obtained.)

Conclusions and implications

Leafy spurge is definitely a problem that warrants attention, both at the farm and regional economy levels. Foregone rancher incomes of $3,600 per 100-cow ranch and land value depreciation of $137 million, coupled with $75 million in foregone business activity, suggest the potential returns to leafy spurge control could be substantial. The high levels of foregone business activity, which also represents foregone tax revenues, further suggest public resources could effectively be used to ameliorate North Dakota's leafy spurge problem; however, attention needs to be paid to the economics of control to ensure the level of control does not exceed that which is economically optimal.

Table 5. North Dakota business activity decreases associated with present leafy spurge infestation.

Sector	Baseline Business Activity (assuming no leafy spurge)	Impact of Present Leafy Spurge Infestation		
		Direct	Secondary	Total
	---------- $000 ----------			
Ag livestock	1,472	699	1,793	32,244[a]
Ag crops	3,673	9,197	1,482	10,679
Nonmetal mining	50,000	0	134	134
Construction	732	0	1,760	1,760
Transportation	92	620	244	864
Comm & pub util	662	672	2,053	2 , 725
Ag proc & misc mfg	2,146	0	2,432	2,432
Retail trade	5,341	3,265	16,035	19,300
Fin, ins, real estate	1,114	41	3,465	3,506
Bus and pers service	490	0	1,316	1,316
Prof & soc service	523	0	1,660	1,660
Households	7,981	8,749	16,819	25,568
Government	681	0	2,255	2,255
Coal mining	135	0	0	0
Elec generation	226	0	0	0
Pet exp/ext	884	0	0	0
Pet refining	121	0	0	0
TOTAL	26,321	23,243	51,448	104,443[a]

[a]Includes $29,752,000 of reduced livestock sales resulting from leafy spurge infestation. This value was not used directly in the estimation of secondary impacts but is included here for conceptual completeness.

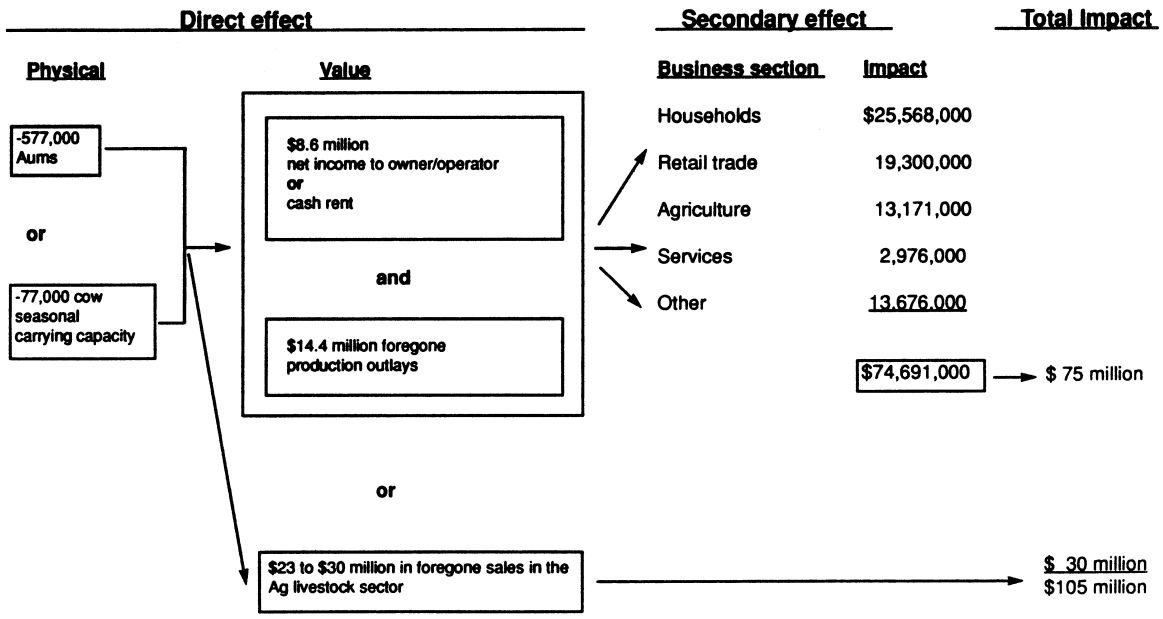

Figure 10. Economic impacts of leafy spurge infestation in North Dakota, 1989.

Research Needs

Two areas where additional research is needed to improve the economic impact model are

- the effect of seed dispersal on patch expansion, and
- the relationship between carrying capacity and infestation by geographic area.

Areas of investigation that would improve empirical estimates of the primary and secondary economic impacts are

- the site-specific effect of natural or manmade constraints to patch expansion (i.e., roadways, water bodies), and
- the refinement of the percent distribution and extent of leafy spurge infestation.

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Appendix

Appendix Table 1. Acreage of pasture and rangeland and acreage infested by leafy spurge, North Dakota, 1988.

County	Acreage of Pasture Rangeland[a]	Acreage of Leafy Spurge[b]	Percent Infestation
	---------- acres ----------		--- percent ---
Adams	221,876**	1,400	0.63
Bowman	360,814	950	0.26
Billings	664,469	160	0.02
Dunn	898,910*	1,000	0.11
Grant	482,652	19,000	3.94
Golden Valley	252,390	12,000	4.75
Hettinger	100,492	2,300	2.29
McKenzie	587,910	300	0.05
Mercer	252,703	6,600	2.61
Morton	598,474	86,500	14.45
Oliver	180,182*	13,140	7.29
Sioux	524,984**	7,500	1.43
Slope	439,037*	6,500	1.48
Stark	234,749*	67,000	28.54
Total Pool 1	5,799,642	224,350	3.87
Burke	95,994	5,250	5.47
Burleigh	346,787	1,820	0.52
Divide	116,742**	50	0.04
Emmons	263,950	13,300	5.04
Kidder	264,549*	11,000	4.16
Logan	220,189	1,200	0.54
McIntosh	139,890	18,000	12.87
McLean	193,241	1,750	0.91
Mountrail	303,208	5,000	1.65
Williams	307,572	34,000	11.05
Total Pool 2	2,252,122	91,370	4.06

Appendix Table 1. Acreage of pasture and rangeland and acreage infested by leafy spurge, North Dakota, 1988, continued.

County	Acreage of Pasture Rangeland[a]	Acreage of Leafy Spurge[b]	Percent Infestation
	---------- acres ----------		--- percent ---
Benson	110,126	57,000	51.76
Bottineau	61,480	35,000	56.93
Cavalier	16,874	2,310	13.69
McHenry	267,859	90,000	33.60
Nelson	36,920	15,600	42.25
Pierce	78,226	37,000	47.30
Ramsey	19,089	4,000	20.95
Renville	35,123	720	2.05
Rolette	64,214	19,630	30.57
Towner	20,732	5,000	24.12
Ward	189,341	12,500	6.60
Total Pool 3	899,984	278,760	30.97
Barnes	60,963	16,000	26.25
Dickey	93,880	5,000	5.33
Eddy	72,164*	30,000	41.57
Foster	33,375*	37,000	110.86
Griggs	45,721	700	1.53
LaMoure	63,348	23,000	36.31
Sheridan	121,247	375	0.31
Stutsman	241,945	38,000	15.71
Wells	72,398*	17,600	24.31
Total Pool 4	805,041	167,675	20.83
Cass	21,973	8,500	38.68
Grand Forks	29,763	7,500	25.20
Pembina	19,033	4,500	23.64
Ransom	108,123	14,800	13.69
Richland	33,796	16,000	47.34
Sargent	47,431	14,000	29.52
Steele	13,33	3,300	24.94
Traill	8,086	4,680	57.88
Walsh	24,116	16,000	66.35
Total Pool 5	305,554	89,280	29.22
TOTAL STATE	9,840,467	851,435	8.65

[a]Source: Data were obtained from the *1987 Census of Agriculture* except for data marked with * (denoting the *1982 Census of Agriculture)* and ** (denoting the *1978 Census of Agriculture)* U.S. Bureau of Census, 1989, 1984, and 1981.
[b]Source: North Dakota Department of Agriculture, 1988.

Appendix Table 2. Total value of Animal Unit months available per pool group, 1989.

County/Pool	Pasture & Rangeland[a]	Carrying Capacity[b]	Available AUMs	Cash Rent/AUM	Value of AUMs
	--- acres ---	AUM's/acre	AUMs	---------- dollars ----------	
Adams	221,876*	0.44	97,625	15.09	1,473,168
Bowman	360,814	0.37	133,501	17.95	2,396,346
Billings	664,469	0.44	292,366	15.09	4,411,808
Dunn	898,910*	0.44	395,520	15.09	5,968,403
Grant	482,652	0.44	212,367	15.09	3,204,616
Golden Valley	252,390	0.37	93,318	17.95	1,676,248
Hettinger	100,492	0.37	37,182	15.09	561,077
McKenzie	587,910	0.44	258,680	15.09	3,903,487
Mercer	252,703	0.44	111,189	15.09	1,677,847
Morton	598,474	0.44	263,329	15.09	3,973,628
Oliver	180,182*	0.44	79,280	15.09	1,196,336
Sioux	524,984**	0.44	230,993	15.09	3,485,684
Slope	439,037	0.37	162,444	17.95	2,915,864
Stark	234,749	0.44	103,290	15.09	1,558,639
Total Pool 1	5,577,766		2,471,151		38,403,153
Burke	95,994	0.50	47,997	10.66	511,648
Burleigh	346,787	0.50	173,394	16.48	2,857,525
Divide	116,742**	0.50	58,371	10.66	622,235
Emmons	263,950	0.50	131,975	16.48	2,174,948
Kidder	264,549*	0.50	132,275	16.48	2,179,884
Logan	220,189	0.50	110,095	16.48	1,814,357
McIntosh	139,890	0.50	69,945	16.48	1,152,694
McLean	193,241	0.50	96,621	10.66	1,029,975
Mountrail	303,208	0.50	151,604	10.66	1,616,099
Williams	307,572	0.50	153,786	10.66	1,639,359
Total Pool 2	2,252,122		1,126,061		15,598,722
Benson	110,126	0.56	61,671	15.46	953,427
Bottineau	61,480	0.56	34,429	15.46	532,269
Cavalier	16,874	0.59	9,956	15.37	153,018
McHenry	267,859	0.56	150,001	15.46	2,319,016
Nelson	36,920	0.56	20,675	15.46	319,639
Pierce	78,226	0.56	43,807	15.46	677,249
Ramsey	19,089	0.56	10,690	15.46	165,265
Renville	35,123	0.56	19,669	15.46	304,081
Rolette	64,214	0.59	37,886	15.37	582,312
Towner	20,732	0.59	12,232	15.37	188,004
Ward	189,341	0.56	106,031	15.46	1,639,239
Total Pool 3	899,984		507,046		7,833,519

Appendix Table 2. Total value of Animal Unit months available per pool group, 1989, continued.

County/Pool	Pasture & Rangeland[a]	Carrying Capacity[b]	Available AUMs	Cash Rent/AUM	Value of AUMs
	--- acres ---	AUM's/acre	AUMs	---------- dollars ----------	
Barnes	60,963	0.66	40,236	14.44	581,002
Dickey	93,880	0.66	61,961	14.44	894,714
Eddy	77,164*	0.56	40,412	15.46	624,767
Foster	33,375*	0.56	18,690	15.46	288,947
Griggs	45,721	0.56	25,604	15.46	395,834
LaMoure	63,348	0.66	41,810	14.44	603,732
Sheridan	121,247	0.56	67,898	15.46	1,049,708
Stutsman	241,945	0.66	159,684	14.44	2,305,833
Wells	72,398*	0.56	40,543	15.46	626,793
Total Pool 4	805,041		496,837		7,371,330
Cass	21,973	0.66	14,502	14.44	209,411
Grand Porks	29,763	0.56	16,667	15.46	257,676
Pembina	19,033	0.59	11,229	15.37	172,597
Ransom	108,123	0.66	71,361	14.44	1,030,455
Richland	33,796	0.66	22,305	14.44	322,089
Sargent	47,431	0.66	31,304	14.44	452,036
Steele	13,233	0.56	7,410	15.46	114,566
Traill	8,086*	0.56	4,528	15.46	70,005
Walsh	24,116	0.59	14,248	15.37	218,691
Total Pool 5	305,554		193,537		2,847,528
TOTAL STATE	9,840,467		4,794,632		$72,054,252

[a]Data were obtained from the *1987 Census of Agriculture,* except for data marked with * (denoting the *1982 Census of Agriculture)* and ** (denoting the *1978 Census of Agriculture)* U.S. Bureau of Census, 1988, 1984, and 1981.
[b]United States Department of Agriculture, 1984.