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ECONOMIC IMPACT OF LEAFY SPURGE ON GRAZINGLAND AND WILDLAND IN NORTH DAKOTA

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Abstract. *A variety of undesirable plants pose problems for managers of grazingland and/or wildland because they reduce the land's usefulness for livestock grazing or are detrimental to its other functions, such as wildlife habitat or watershed protection. The purpose of this study was to assess the direct and secondary economic impacts of leafy spurge infestations in North Dakota. This involved estimating the extent of leafy spurge infestations on grazingland and wildland, estimating the effects of the infestation on the outputs of both types of land, estimating the direct economic effects of these changes in outputs, and using input-output analysis to estimate the secondary economic effects accruing to other sectors of the state economy.*

Introduction

A variety of undesirable plants, especially invasive, exotic species, pose problems for managers of grazingland and/or wildland because they reduce the land's usefulness for livestock grazing or are detrimental to its other functions (e.g., wildlife habitat, watershed). Leafy spurge, a perennial weed, is widely established in the Great Plains (Fig. 1). Within North Dakota, the most affected state, over 1.1 million acres were estimated to be infested in 1990 (North Dakota Department of Agriculture 1991). A variety of chemical control alternatives have been employed to control leafy spurge (Chow 1984; Lym and Messersmith 1986; Swenson and Lym 1992), and biocontrol technologies are now a primary focus of research (Messersmith and Lym 1990). To evaluate the economic feasibility of either available chemical controls or future biocontrols, however, requires a better understanding of the economic effects of weed infestations. Such information also may be useful for allocating resources to develop or refine new control technologies.

Economic effects of undesirable range plants include direct effects, such as those experienced by landowners and ranchers, plus secondary effects on

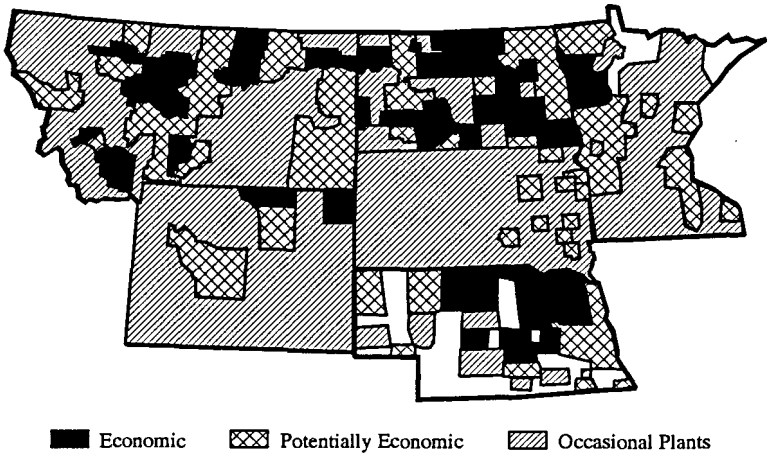

Figure 1. Leafy spurge infestation in the Great Plains.

other sectors of the rural economy. A change in an area's resource base or agricultural production practices can affect both agribusiness firms and local trade and service sectors (Leistritz and Murdock 1981; Leistritz and Ekstrom 1986). Decisions regarding public sector support for research to develop better control methods and/or public sector cost sharing for treatment efforts should take into account such secondary effects.

The purpose of this study was to estimate the direct and secondary economic impacts of leafy spurge infestations in North Dakota. This involved estimating the extent of leafy spurge infestations on grazingland and wildland, estimating the effects of the infestation on the outputs of both types of land, estimating the direct economic effects of these changes in outputs, and an estimation of the secondary economic effects accruing to other sectors of the state economy that result from the direct effects.

Procedures

Estimating the economic impact of weed infestations requires consideration of both biological and economic parameters. A bioeconomic model for estimating the impacts of leafy spurge infestations was developed (Fig. 2). Implementing the model required data from a number of sources. Secondary

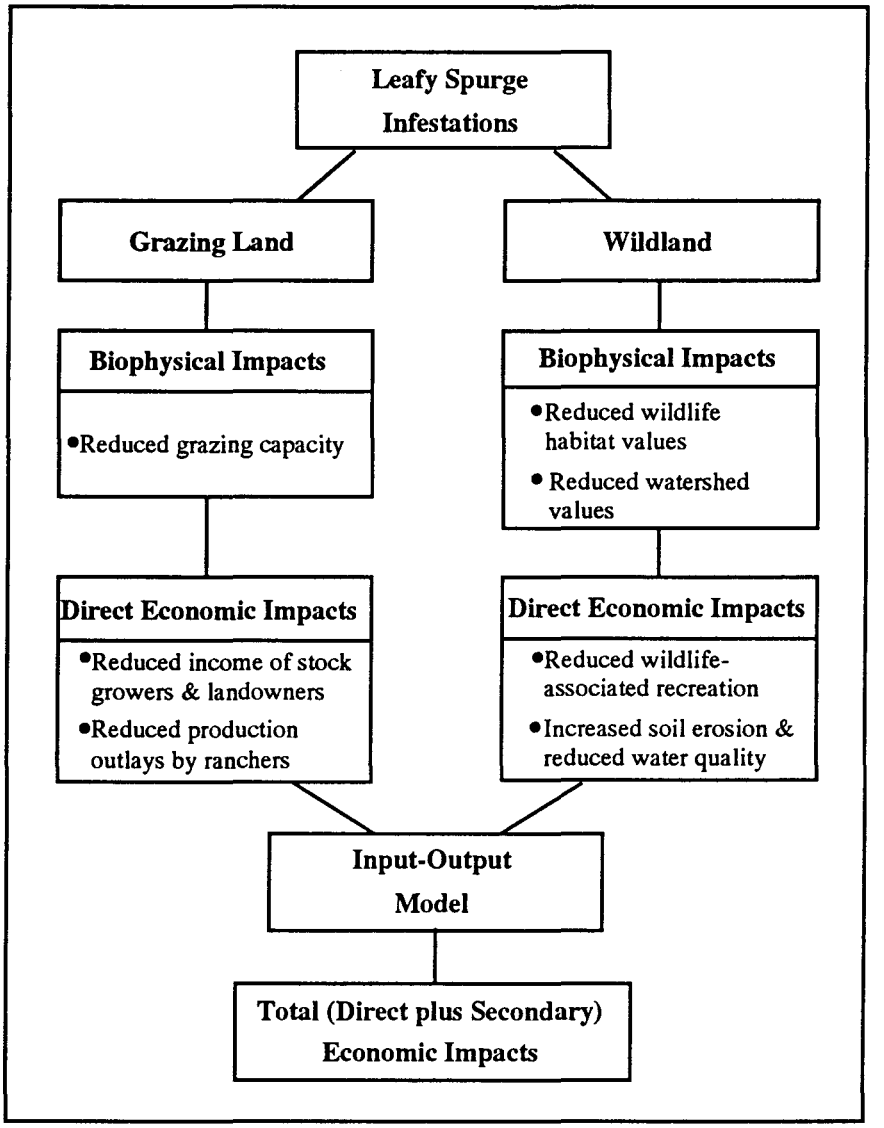

Figure 2. A bioeconomic model of leafy spurge infestation.

data sources were used to estimate the acreage of grazingland and wildland in the state (U.S. Bureau of the Census 1989; U.S. Soil Conservation Service 1987, 1991). An estimate of the total acreage affected by leafy spurge in each North Dakota county was obtained from the state Department of Agriculture. The proportions of the leafy spurge infested acres occurring on grazingland and on wildland were obtained from a survey of county weed board representatives (Wallace 1992). Leafy spurge infestation rates provided the basis for estimating the biophysical impacts of the weed on the outputs of the two types of land. The estimated changes in outputs were, in turn, the basis for estimating the direct economic impacts. The secondary impacts of leafy spurge infestations on the state economy were then estimated using input-output analysis (Coon et al. 1985; Coon et al. 1990).

The bioeconomic model serves several purposes. First, it provides a reasonable first approximation of the magnitude of the economic impact. Second, it identifies those areas where more research is needed. Several crucial assumptions were made, however, and an impact estimate could not have been made without those assumptions. Finally, it encourages scientists to either refute or validate the assumptions with sound scientific evidence.

Wildland

Wildland is broadly defined as land *not* used for industrial, urban, or agricultural purposes and includes forests, range, recreation areas, and wilderness (Randall and Peterson 1984). Leafy spurge is frequently observed in wildland habitats such as ungrazed grassland, rocky forestland, railway embankments, road and drainage ditches, public parks and wildlife areas, and riverbanks. The acreage of wildland in North Dakota was estimated by subtracting from the estimated total land area of the state the acreage of cropland, grassland, rangeland and pasture, urban and built-up land, and water. Wildland was estimated at about 4.9 million acres, approximately 10% of the total acres in North Dakota. Based on a 1991 survey of county weed board representatives, it was estimated that there were about 468,000 acres of leafy spurge on North Dakota wildland (Wallace 1992).

Wildland can be either publicly or privately owned and provides a variety of goods and services, including such non-market goods as recreation, wildlife production and habitat, erosion control, and watershed benefits (Randall and Peterson 1984). Wildlife-associated recreation and soil and water conservation were identified as the primary wildland benefits that were likely to be affected by leafy spurge infestations in North Dakota.

Grazingland

Grazingland is defined here as all lands used for grazing of domestic livestock, without reference to land tenure, other land uses, management, or treatment practices. North Dakota grazingland was estimated to total about 10,075,000 acres in 1991.

Results

The results of the analysis are presented in the sections that follow. These sections deal with impacts of leafy spurge infestations on grazingland and wildland, respectively.

Impacts on Grazingland

A critical step in estimating the economic impact of any weed is to estimate the amount of lost forage or crop yield reduction due to the infestation. Forage production of grazing land is usually measured by the number of animals the land can safely support (i.e., its carrying capacity or maximum stocking rate). Carrying capacity is the highest sustainable stocking rate possible without incurring damage to vegetation or related resources.

Carrying capacity is generally expressed as the number of animal unit months (AUMs) a tract can provide. For private grazinglands, the carrying capacity was estimated based on standards from the Soil Conservation Service of the U.S. Department of Agriculture. AUMs of grazing capacity available from state and federal lands were obtained from recent records of the responsible agencies. North Dakota grazinglands were estimated to total about 10,075,000 acres with a carrying capacity of about 5,250,000 AUMs (Bangsund and Leistritz 1991).

The value of grazing was estimated using cash rental rates for grazing land. Average per acre cash rental rates were obtained from the Economic Research Service (ERS) of the U.S. Department of Agriculture (ERS 1991). A five-year (1986-1990) average cash rental rate for grazingland was calculated for each county, adjusted for inflation to reflect 1990 price levels, and converted to a rental rate per AUM using the carrying capacity estimates discussed earlier. The average estimated value per AUM for North Dakota was $15.90. This value was used as the estimate of the reduction in stockgrowers' net incomes resulting from reduced carrying capacity.

A carrying capacity reduction model (CCRM), developed by Thompson (1990), was used to estimate the lost forage from leafy spurge infestations. Leafy spurge reduces carrying capacity for cattle by (1) inhibiting normal herbage production from direct competition of the spurge plant and (2) reducing available herbage since cattle totally or partially avoid range sites infested with leafy spurge (this effect is accentuated during spring grazing).

The CCRM estimates the potential AUM reduction for cattle only. Although sheep and goats will graze leafy spurge, their numbers in the state are expected to remain very low relative to cattle. The relationship between lost grazing capacity and amount of leafy spurge infestation is approximated by the linear function:

$$RCC = CC * [1 - (1.25 * PI / 100)]$$

where RCC = reduced carrying capacity (AUMs/acre)
CC = normal carrying capacity (AUMs/acre)
PI = level of infestation expressed as a percent of land area covered by leafy spurge

A 40% leafy spurge infestation would reduce carrying capacity by 50% from a practical range management position (Fig. 3).

Leafy spurge infestations on grazinglands could also affect wildlife habitat and soil erosion. However, the direction of change is highly uncertain and the magnitude is highly speculative, so these impacts were not included for grazingland.

The economic impacts of leafy spurge to ranchers and landowners included reduced income from reductions in grazing capacity, foregone livestock sales (resulting from lost grazing capacity), and reduced grazing land values from leafy spurge infestations. The CCRM was used with the estimated leafy spurge infestation rates to estimate the number of lost AUMs. The value of lost grazing capacity was estimated by applying the value per AUM to the number of lost AUMs. Of the 1.1 million acres infested with leafy spurge in North Dakota in 1990, about 632,000 acres were estimated to be grazingland. An estimated 583,000 AUMs were estimated to be lost as a result of the leafy spurge infestation, resulting in an estimated reduction in ranchers' and landowners' incomes of about $8.7 million.

The value of lost livestock sales was derived from the number of lost AUMs. In 1990, the grazing capacity lost to leafy spurge infestations in North Dakota would have supported a herd of about 63,100 cows, which would be

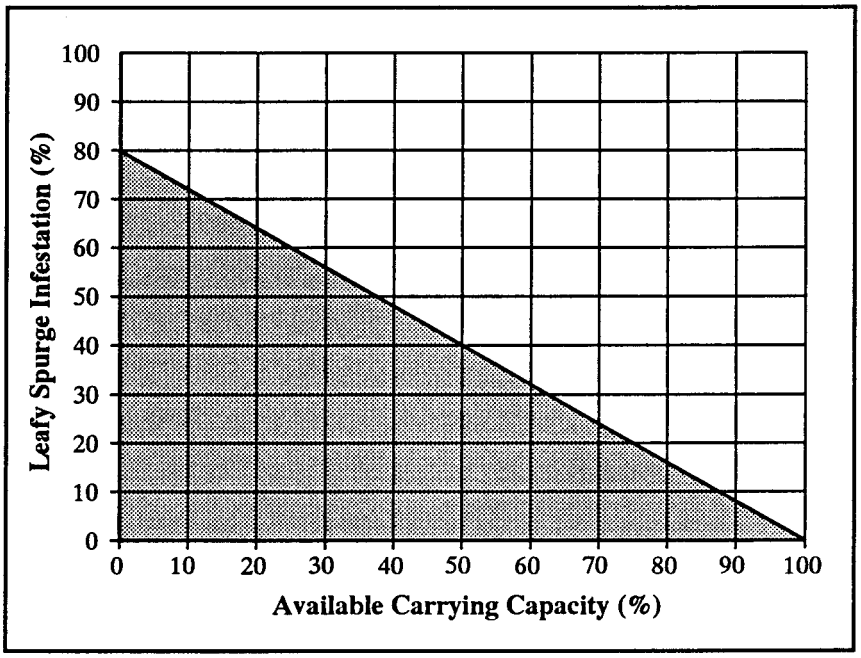

Figure 3. Reduced carrying capacity for cattle associated with various levels of leafy spurge infestation.

expected to generate about $28.2 million in livestock sales and $14.5 million in production expenditures annually.

Leafy spurge infestations reduce the productivity of grazing lands, which leads to lower land values in the absence of alternative uses. Potential decreases in land values from leafy spurge infestations were estimated assuming all other determinants of land values remained unchanged. Potential decreases in land values that could be expected from current levels of leafy spurge infestations were estimated using a value-to-rent ratio (1986 to 1990) for private grazingland. Grazingland values in North Dakota were estimated to be reduced by $123.4 million.

The direct impact of leafy spurge infestations on grazingland to the state economy can be summed from (1) the reduced income to ranchers and landowners ($8.7 million) and (2) decreases in production outlays associated with ranchers' herd reductions ($14.5 million).

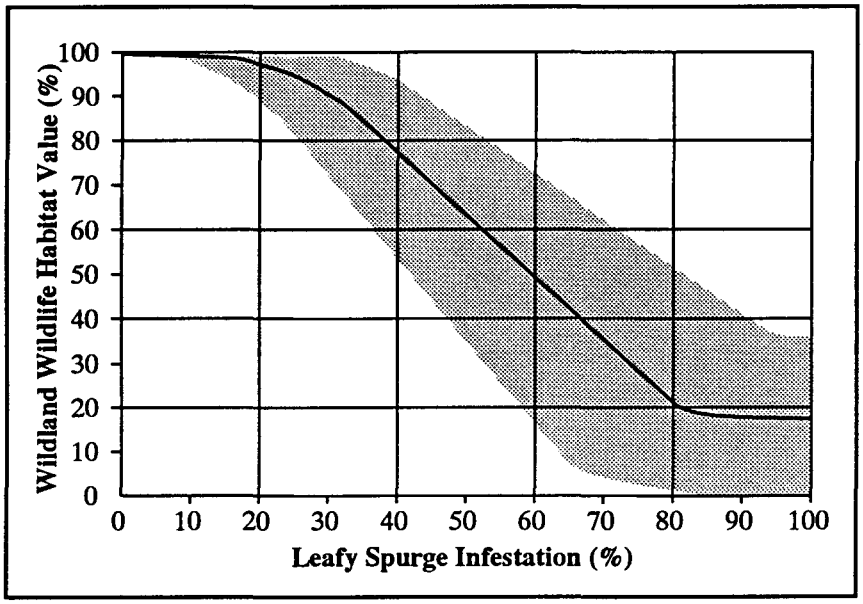

Figure 4. Estimates of reduced wildland wildlife habitat value caused by various leafy spurge infestation rates. (Shading along the function indicates there is uncertainty associated with the assumed relationship.

The secondary impacts of leafy spurge infestations on grazingland were estimated using the North Dakota Input-Output Model (Coon et al. 1985). Direct impacts of $23.2 million annually from leafy spurge infestations on grazingland generated about $53.1 million in secondary impacts to the state's economy. Total direct plus secondary impacts were about $76.3 million or about $131 per lost AUM.

Impacts on Wildland

The effects of leafy spurge infestations on wildland outputs (benefits) result from the plant's ability to literally choke out other existing vegetation (Watson 1985; Messersmith et al. 1985; Belcher and Wilson 1989). Leafy

spurge patch expansion leads to a decline in native prairie plants, and the reduction in plant diversity can substantially reduce a site's value as wildlife habitat (only an assumption at this point) and may lead to increased water runoff and soil erosion (circumstantial evidence exists to support this assumption, e.g., see Ribaudo 1989). An impact function was estimated to describe the relationship between leafy spurge and wildland habitat value (Fig. 4). Because of a lack of natural science research outlining the specific effects of leafy spurge on wildland wildlife habitat value, the function was based on the expert opinion of a few selected wildlife managers and plant ecologists together with published data reporting the shortcomings of monocultures as wildlife habitat. The estimates of reduced wildland wildlife habitat value from leafy spurge infestations were used to estimate the economic impact of leafy spurge on wildlife-associated recreation.

As leafy spurge displaces native and existing vegetation, changing the character and composition of wildland vegetative cover, runoff and soil erosion may be affected. Both on-site and off-site soil erosion damages may result. On-site soil erosion damages consist primarily of losses in soil productivity from loss of soil structure and plant nutrients. Off-site erosion damages are experienced through degradation of surface water by runoff carrying sediment, nutrients, and pesticides (Ribaudo 1986 and 1989; Rodgers et al. 1990). While some research has documented the effect of other invasive weed species on surface runoff and sediment yield (Lacey et al. 1989), an extensive literature search revealed no studies addressing the effects of leafy spurge on these wildland outputs. As a result, the authors engaged in reasoning by analogy, based on the soil and water conservation effects of enrolling highly erodible cropland in the Conservation Reserve Program (CRP).

Enrollment of cropland in the CRP has led to increased off-site water quality benefits because shifting land with less diverse vegetative cover (monoculture cropland) to more diverse cover (grassland and trees) reduces runoff and soil erosion (Ribaudo 1989). Conversely, as leafy spurge infestation on wildland increases, moving the vegetative cover toward a monoculture, runoff and soil erosion may increase, resulting in reduced off-site water quality benefits. For the purpose of this study, wildland is assumed to provide soil and water conservation benefits comparable to those offered by CRP acres, and a 100% leafy spurge infestation is assumed to reduce wildland off-site water conservation benefits by one-fourth (no data available, only an assumption at this point) (Fig. 5).

Direct economic impacts from changes in wildlife-associated recreation are the changes in wildlife-associated recreationist expenditures that impact

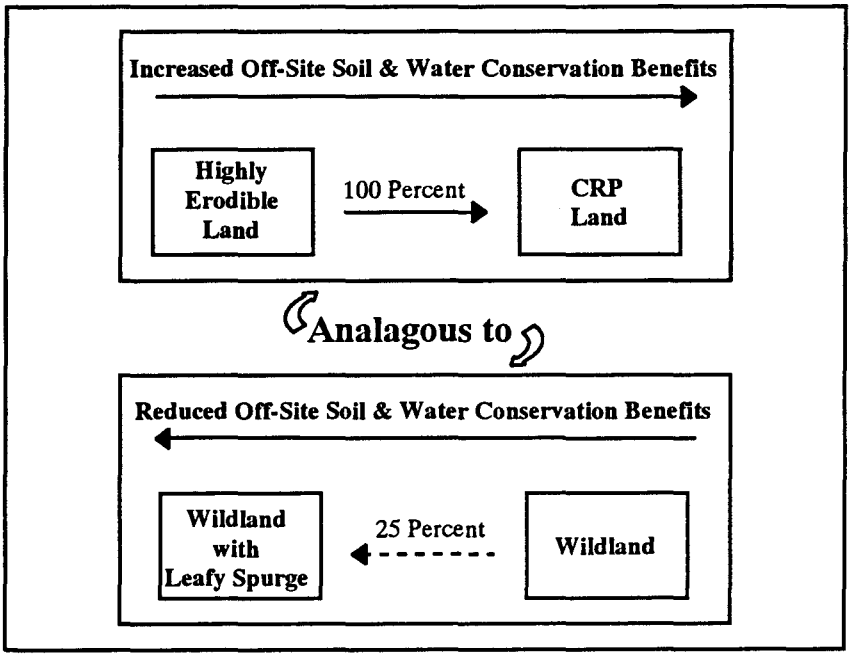

Figure 5. Conceptual relationship of highly erodible land/conservation reserve program and wildland/wildland with leafy spurge.

local suppliers of related goods and services. The reduction in expenditures from leafy spurge infestation can be expressed as

$$R = (E \times C)(H \times W)(S)$$

where R = change in wildlife-associated recreation expenditures due to leafy spurge infestation on wildland
E = total wildlife-associated recreation expenditures
C = species/land use coefficient
H = percentage reduction in wildlife habitat value
W = percentage of leafy spurge infested wildland
S = percentage of expenditures lost to state economy

Total North Dakota wildlife-related recreation expenditures (consumptive and nonconsumptive) were estimated at over $219 million in 1990 (E = $219 million) (Wallace 1992). The 468,000 acres of leafy spurge on wildland are assumed to be 100 percent infested, thus reducing wildlife habitat value by 80%. The species/land use coefficient (C) represents the relative importance of different land uses in supporting current wildlife populations. The species/land use coefficient for wildland is estimated to be 0.4 or 40% (Wallace 1992). If wildlife-associated recreation opportunities within the state decrease, some funds previously spent on wildlife-associated recreation will be reallocated to other in-state recreational activities, but some may be spent in other states (S) and thus represent a loss to the state economy. A recent study reports that 42% of North Dakota outdoor recreationists would pursue their favorite recreation activity out of state if it was not available in North Dakota (Baltezore and Leitch 1992). When these factors are combined in the equation, the direct economic impact of reduced wildlife-associated recreation due to the current leafy spurge infestation on wildland is estimated to be about $2.9 million.

Direct economic impacts from changes in wildland soil and water conservation benefits are changes in user expenditures to mitigate damages from runoff and soil erosion. For example, water is generally treated before household or commercial use. Changes in treatment costs represent the benefits (costs) of increased (decreased) water quality. The erosion control benefits of CRP land had been estimated to be $5.87 per acre for the Northern Plains region (Ribaudo 1989). Applying the assumed 25% reduction in wildland erosion control benefits due to leafy spurge infestation to the $5.87 per acre value gives an estimate of $1.47 per acre for this component of the direct economic impact. Multiplying the $1.47 per acre reduction in wildlands soil and water conservation benefits by the 468,000 acres of wildland infested with leafy spurge results in nearly $0.7 million in impacts of decreased water quality statewide.

As discussed with respect to grazingland impacts, the secondary economic impacts of leafy spurge infestations on wildland were estimated using an input-output model. The specific model used in this phase of the research had been modified to incorporate a recreation and tourism sector (Coon et al. 1990). The direct impacts of leafy spurge on wildland were estimated to total $3.6 million ($2.9 million from reduced wildlife associated recreation and $0.7 million from reduced soil and water conservation). When these impacts were applied to the input-output model, they generated secondary impacts of about $7.4 million. The total impact of leafy spurge infestations on wildland was estimated to be about $11 million, or about $23.54 per infested acre (Wallace et al. 1992).

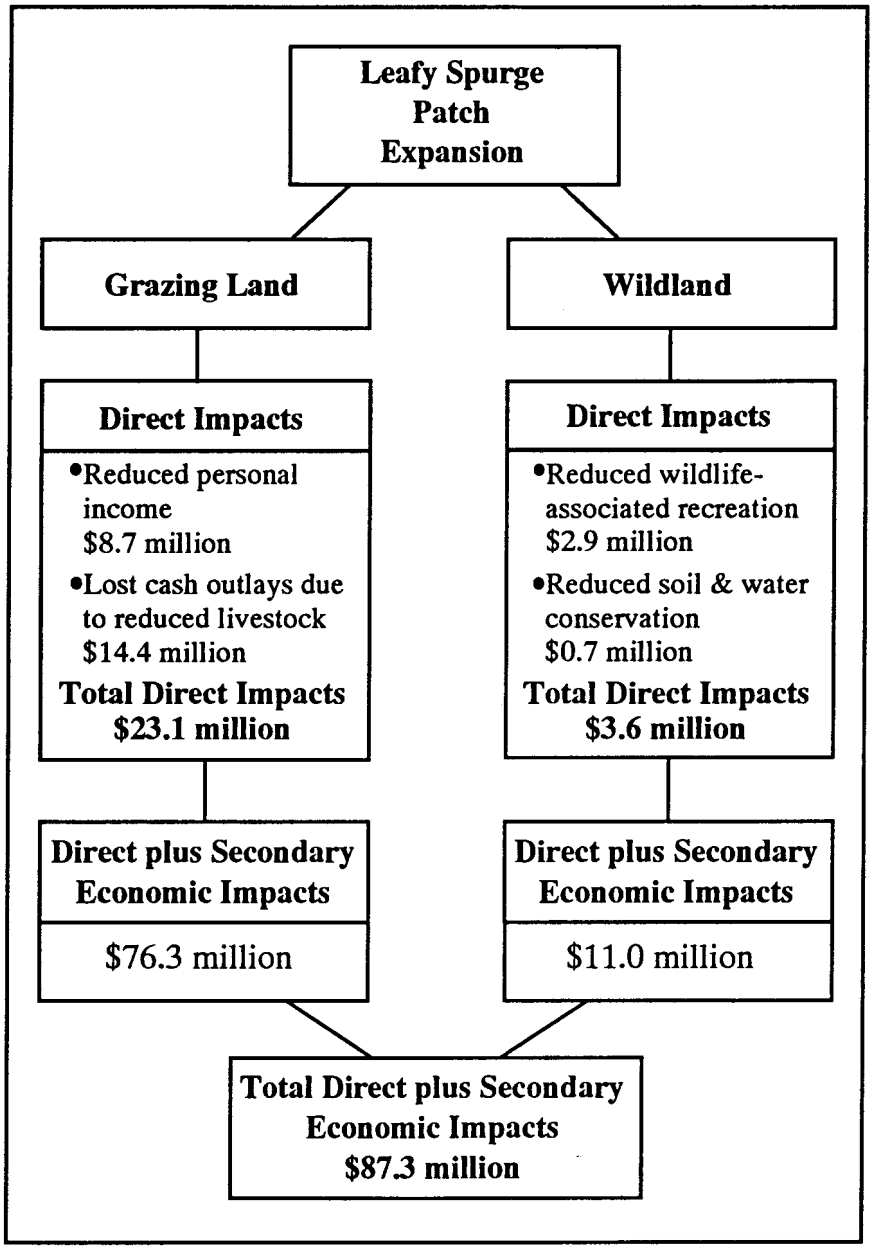

Figure 6. Bioeconomic impact assessment of leafy spurge in North Dakota.

The economic impacts (direct plus secondary) of leafy spurge infestations on grazingland and wildland in North Dakota were estimated to total $87.3 million (Fig. 6). Estimates of the direct and total impacts by economic sector demonstrate the pervasiveness of the effects of leafy spurge infestation. While the bulk of impacts occurs in the *household* sector, *retail trade* sector, and the *agricultural-crops* sector, all sectors except the *petroleum exploration and extraction* and *petroleum refining* sectors are affected. The impacts occurring in the *household* sector alone represent $28.7 million, or about $26 per acre infested. The current level of leafy spurge infestation also leads to a reduction in employment of more than 1000 jobs (Table 1).

In the analysis presented here, the impacts of leafy spurge on grazingland and wildland have been treated as being additive and mutually exclusive. This is admittedly a simplification, and one that, because of the multiple uses and products obtained from both grazingland and wildland, may lead to some understatement or overstatement of impacts. For example, leafy spurge infestations on grazingland may reduce the wildlife habitat or watershed values obtained from these lands. These effects were not included in the estimates presented here, however, because of uncertainty regarding the interaction of grazing, leafy spurge infestations, and other land values/products. For example, leafy spurge patches reduce habitat value compared to ungrazed grassland, but it is unclear how their habitat value would compare to heavily grazed rangeland. Better understanding of these interactions could improve the confidence in future estimates of leafy spurge impacts.

The accuracy of future estimates also could be improved through additional biological and physical science research and through more precise inventories of leafy spurge infestations. Specific needs include

1. More precise description of the physical relationships between leafy spurge infestations and wildlife populations.
2. Examination of the relationship of leafy spurge infestations to runoff and soil erosion.
3. More detailed estimates of the state's leafy spurge infestation by the land use/cover on which the infestation occurs (e.g., grazingland, road ditches) and land ownership (e.g., private, state, federal).

Whatever the actual amount of economic impacts resulting from the current level of leafy spurge infestation, policy makers should be aware that these impacts are substantial and are almost certain to increase substantially in the near future. Since 1962, the reported acreage of leafy spurge in North Dakota

TABLE 1

DIRECT AND TOTAL ECONOMIC IMPACTS OF LEAFY SPURGE INFESTATION ON NORTH DAKOTA GRAZINGLAND AND WILDLAND BY ECONOMIC SECTOR AND LAND TYPE

Impacts by Sector	Land Type Grazingland	Wildland	Total
	----------$000----------		
Direct Impacts:			
Ag livestock	903	--	903
Ag crops	8,244	200	8,444
Transportation	410	--	410
Communications and public untilities	442	--	410
Retail trade	2,445	--	2,445
Finance, insurance, and real estate	2,024	--	2,024
Households	8,723	--	8,723
Government	--	481	481
Electricity generation	--	7	7
Tourism and recreation	--	2,953	2,953
Total Direct Impacts	23,191	3,641	26,832
Total (Direct Plus Secondary) Impacts:			
Agriculture—livestock	2,694	240	2,934
Agriculture—crops	9,757	785	10,542
Nonmetal mining	135	13	148
Construction	1,790	178	1,968
Transportation	657	40	697
Communication and public utilities	2,610	274	2,884
Agricultural processing and miscellaneous manufacturing	2,485	1,522	4,007
Retail trade	18,735	1,430	20,165
Finance, insurance, and real estate	5,540	345	5,885
Business and personal service	1,379	177	1,556
Professional and social services	1,728	154	1,882
Households	26,528	2,184	28,712
Government	2,283	714	2,997
Coal mining	--	1	1
Electricity generation	--	7	7
Petroleum exploration and extraction	--	0	0
Petroleum refining	--	0	0
Recreation and tourism	--	2,953	2,953
Total Impacts	76,321	11,017	87,338
Secondary Employment	819	187	1,006

has been approximately doubling every 10 years, and recent estimates indicate that the acreage would be expected to increase by 37% over the next 5 years, in the absence of more effective control measures (Bangsund and Leistritz 1991). Leafy spurge has been reported in 26 states and 4 Canadian provinces, so the problem is not unique to North Dakota or even the Great Plains states.

Conclusions and Implications

Invasive weeds constitute a major problem for both public and private land managers and for policymakers. Weed infestations can have detrimental effects on a number of the outputs from grazingland or wildland. Decisions regarding resource allocation, either to use existing techniques to achieve weed control or to develop improved control technologies for future use, require an understanding of the economic effects of these undesirable plants. In this study, estimates were developed of the direct and secondary economic impacts of leafy spurge infestations on grazingland and wildland in North Dakota. The results indicate this weed has substantial economic impacts and that there is a potential for large increases in these impacts in the near future unless more effective control can be achieved. The study results indicate that, although pasture weeds are commonly regarded as a problem that affects only livestock producers, leafy spurge infestations result in direct effects to other groups as well (e.g., recreationists, water users). Further, the findings indicate that the secondary effects of leafy spurge infestations are substantial for many sectors of the state economy. Implementing more effective control of the weed should be an issue of concern to state policymakers generally, rather than just to those representing the livestock industry.

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