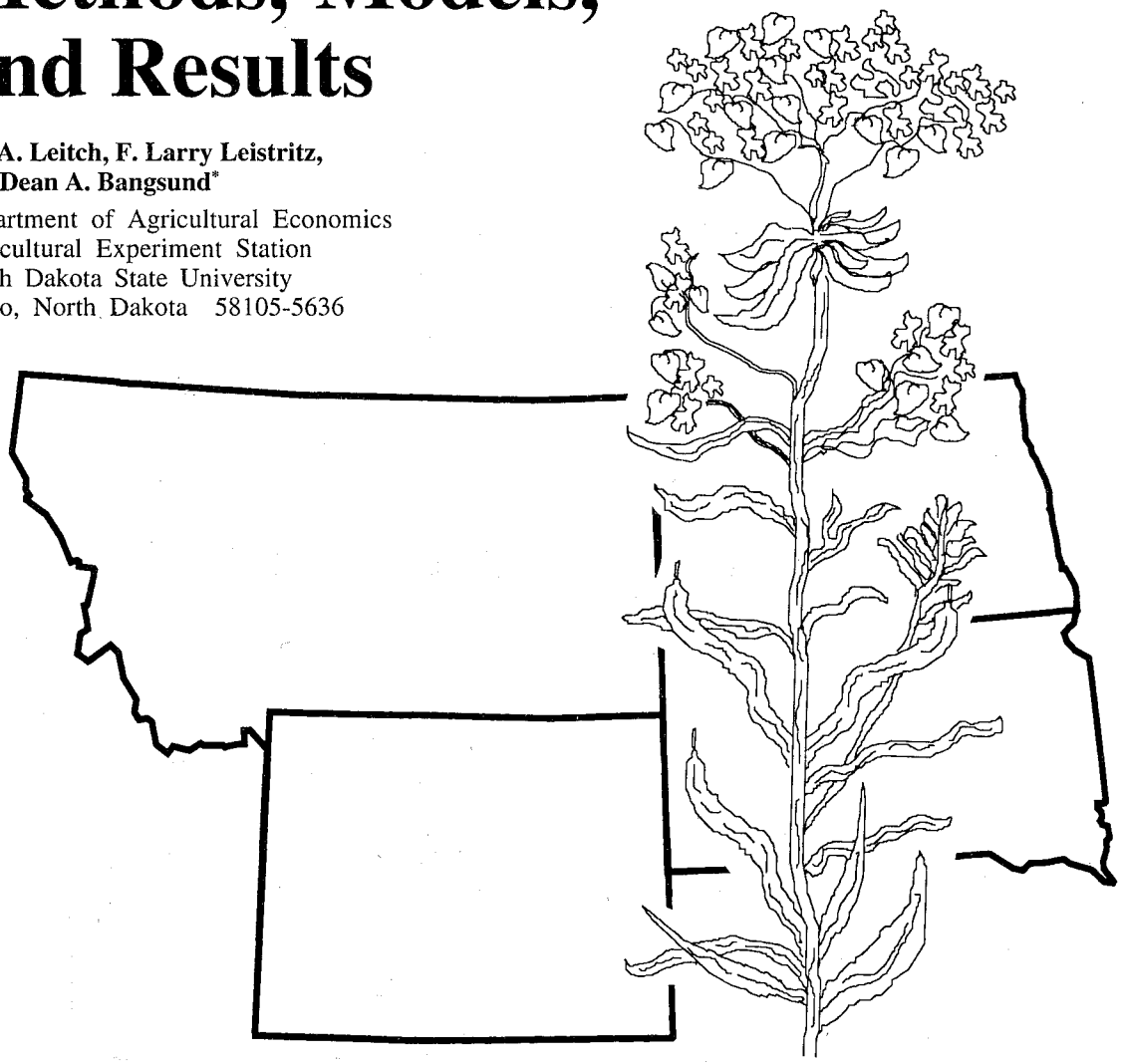
Economic Effect of Leafy Spurge in the Upper Great Plains: Methods, Models, and Results

Jay A. Leitch, F. Larry Leistritz, and Dean A. Bangsund*

Department of Agricultural Economics
Agricultural Experiment Station
North Dakota State University
Fargo, North Dakota 58105-5636



Highlights:

Research was initiated in 1989 to develop a bioeconomic model of leafy spurge in the upper Great Plains. The study resulted in two M.S. theses, several monographs, and numerous articles in periodicals and professional journals. Methods included budget analyses and regional economic analyses. Models of leafy spurge patch expansion, infestation and grazing carrying capacity, infestation and wildlife habitat, and wildlife and wildlands were developed. Leafy spurge infestation results in an estimated direct annual impact of $40.5 million in Montana, North Dakota, South Dakota, and Wyoming. Impacts in North Dakota account for nearly 67 percent of the total. Total secondary impacts could be as high as $89 million per year and represent the potential loss of 1,433 jobs. While more work could be done to refine the models, it is clear that leafy spurge control deserves attention, especially when leafy spurge acreage has been doubling about every ten years.

Leafy Spurge

Leafy spurge (*Euphorbia esula*) is a widely established weed in the north central United States and Canada. It infests about 657,435 hectares (1,624,500 acres) in the four-state region of Montana, North Dakota, South Dakota, and Wyoming. Nearly 6 percent of North Dakota's untilled land is infested.

Leafy spurge, a perennial weed native to Europe and Asia, was introduced to North America in the 19th century. It first appeared in the upper Midwest in North Dakota in 1909. Leafy spurge has become a particularly serious problem because of the speed with which it spreads and the difficulty of control. It is primarily a problem on untilled lands, such as rangeland, wildland, and idled cropland, such as CRP.

This report summarizes the methods and models of previous studies (see list of previous work) estimating the economic impact of leafy spurge on rangeland and wildland in the upper Midwest and updates the economic impacts in the upper Midwest, based on 1993 leafy spurge infestations.

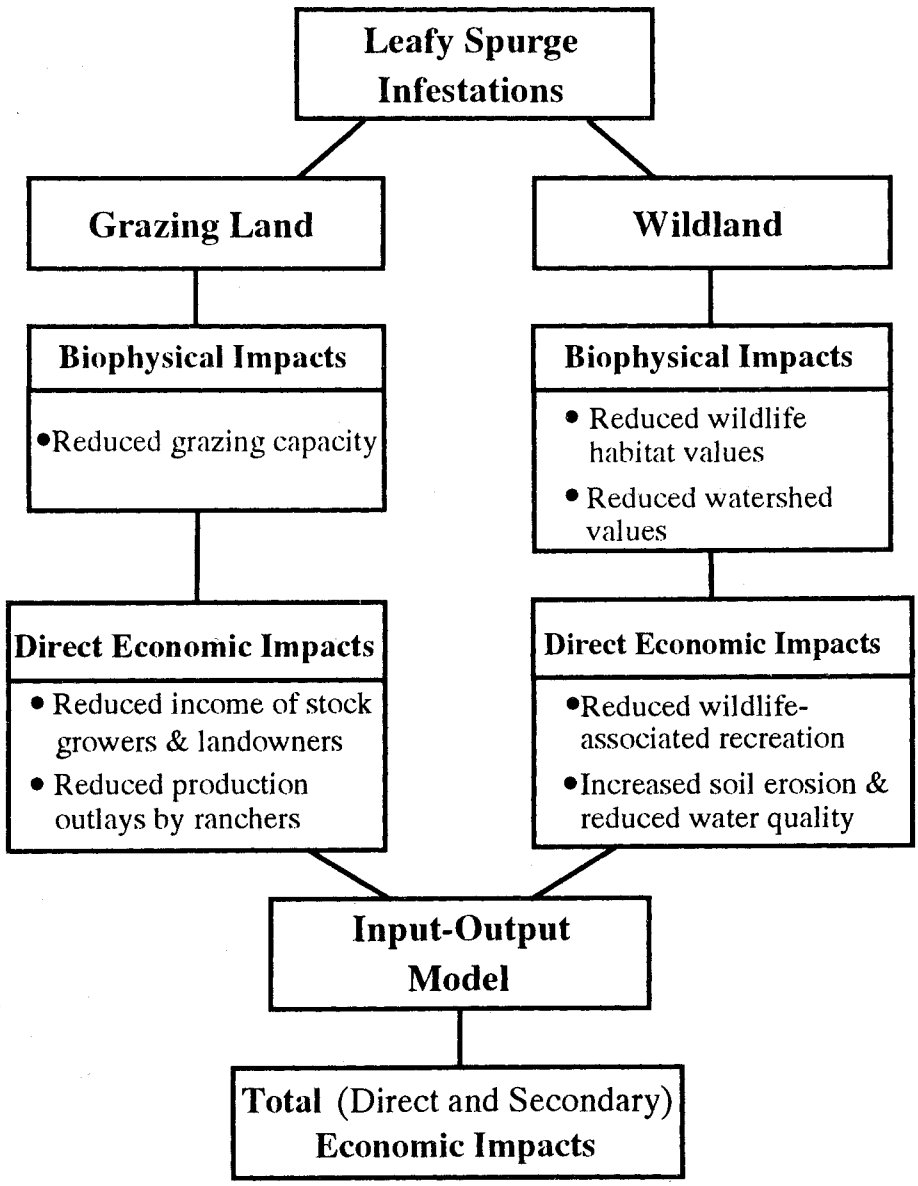


Figure 1. A Bioeconomic Model of Leafy Spurge Infestation

Methods and Models

A bioeconomic model (Figure 1) was developed to guide research efforts from the biological aspects through to the economic impacts. In the research process, a number of assumed relationships were also developed, such as the relationship between leafy spurge infestation and grazing carrying capacity.

Three steps in the evaluation process were (1) modeling patch expansion, (2) estimating rangeland impacts, and (3) estimating wildland impacts. Patch expansion was modeled using in-field observations and secondary data. Rangeland impacts were developed by assessing the effect of leafy spurge on carrying capacity and estimating the economic effects on both producers and regional economies. Producer effects were estimated using livestock operation budgets. Regional impacts were estimated by using an input-output model of the states' economies. Wildland impacts were developed by estimating the impact on outdoor recreation activity and changes in soil and water conservation benefits.

Results

Results from previous work include a leafy spurge patch expansion model, grazing land impacts, wildland impacts, and policy and research implications. The impact results are sensitive to the assumed relationships, but one of the primary results is the identification of areas requiring more biological research.

Patch Expansion

Leafy spurge patch expansion depends on a number of site-specific conditions (e.g., moisture, soil, vegetative competition, natural barriers). However, in general, the size of a leafy spurge patch can be modeled as a function of time (Figure 2). The mathematical model of leafy spurge patch expansion is

$$X = \pi * [(Y - 4) * 0.61M]^2$$
$$Z = X * (100 \text{ stems}/M^2)$$

where Y = years,
M = meters,
X = area of patch in square meters, and
Z = total stems in patch.

According to time-series inventories of leafy spurge and discussions with weed control managers, leafy spurge infestations double in area about every 10 years in the upper Midwest.

Grazing Land Impacts

Grazing land includes all lands used for grazing of domestic livestock, without reference to land tenure, other land uses, management, or treatment practices. The four-state study region has approximately 146 million acres of grazing land.

The value of grazing was estimated using cash rental rates for grazing land. A carrying capacity reduction model (CCRM) 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 grazing infested range sites.

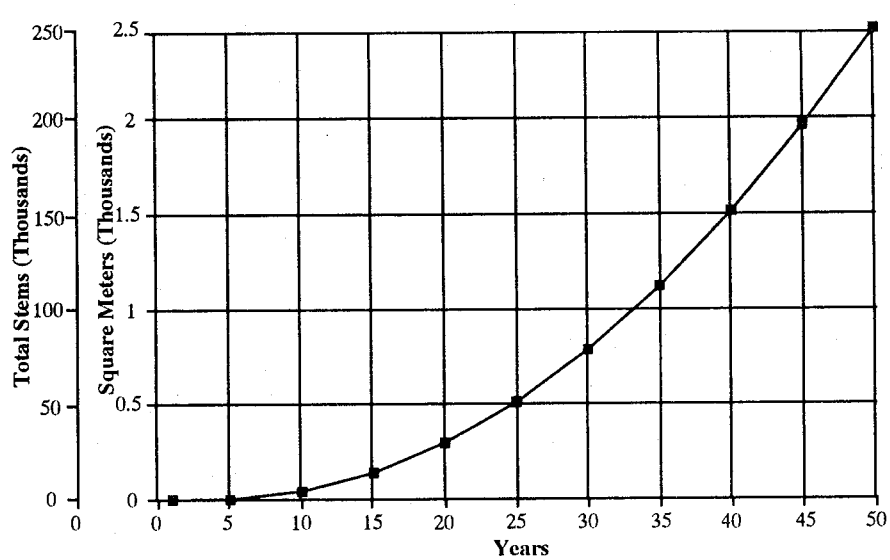


Figure 2. Leafy Spurge Patch Expansion in Area and Number of Stems

The relationship between lost grazing capacity and amount of leafy spurge infestation is approximated by a 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 (%),

and is depicted graphically (Figure 3).

The economic impacts of leafy spurge on ranchers and landowners include reduced income from reductions in grazing capacity, foregone livestock sales, and reduced grazing land values as a result of infestations. The value of lost livestock sales was derived from the number of lost animal unit months (AUMs). In 1993, the grazing capacity lost to leafy spurge infestations in the four states would have supported a herd of about 90,000 cows, which could generate about $37.1 million in annual livestock sales and $34.2 million in annual production expenditures.

Secondary impacts of leafy spurge infestations on grazing land were estimated using the North Dakota Input-Output Model. Direct impacts of $37.1 million annually from infestations on grazing land generated about $82.6 million in secondary impacts to the region's economy. Total direct and secondary impacts were about $119.7 million or about $163 per lost AUM.

Wildland Impacts

Wildland is land not classified as urban or built-up, industrial, or agricultural, such as forest, range, or recreation areas. The effects of leafy spurge infestations on wildland outputs result from the plant's ability to displace existing vegetation. Leafy spurge expansion leads to a decline in native prairie plants, and the reduction in plant diversity can substantially reduce wildlife habitat and may increase water runoff and soil erosion. An impact function was estimated to describe the relationship between leafy spurge and wildland habitat value (Figure 4).

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. Direct economic impacts from changes in wildlife-associated recreation are the changes in wildlife-associated recreationist expenditures that impact local suppliers of related goods and services. The reduction in expenditures can be expressed as

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

where R = change in wildlife-associated recreation expenditures from 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, and
S = percentage of expenditures lost to the state economy.

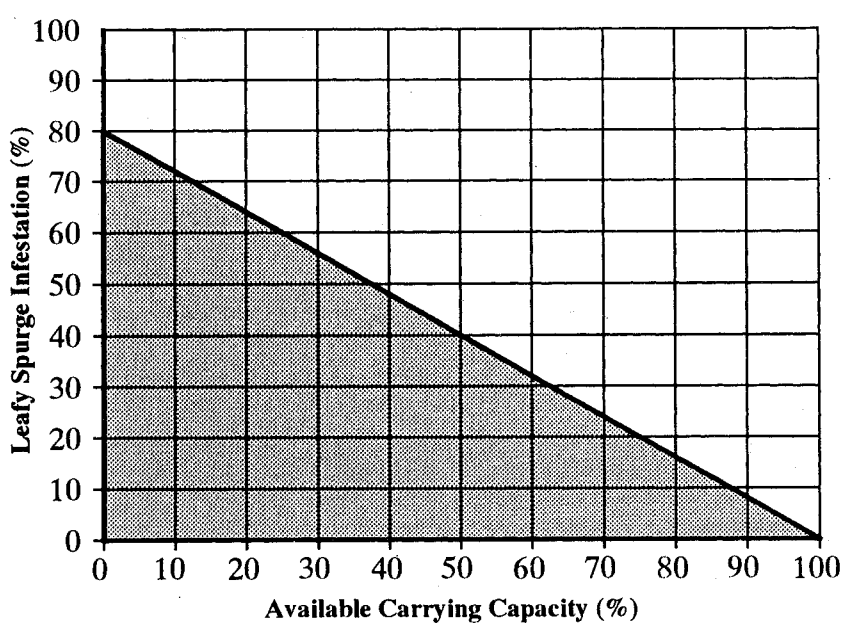


Figure 3. Reduced Carrying Capacity for Cattle Associated with Various Levels of Leafy Spurge Infestation

The species/land use coefficient represents the relative importance of different land uses in supporting current wildlife (Figure 5). The species/land use coefficient for North Dakota, for example, is 0.4 or 40 percent. In other words, the 10 percent of the state's area that is wildland supports 40 percent of the state's wildlife. The wildland coefficient for Montana is 0.69, for South Dakota is 0.48, and for Wyoming is 0.77.

The economic impacts of leafy spurge on wildland were estimated from changes in wildlife habitat and soil and water conservation benefits. Degradation of habitat was assumed to reduce wildlife-

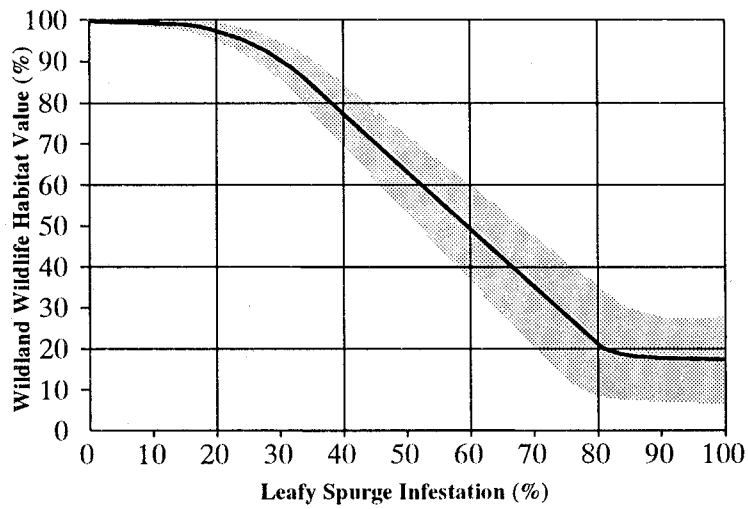


Figure 4. Estimates of Reduced Wildland Wildlife Habitat Value Caused by Various Leafy Spurge Infestation Rates*

****Shading along the function indicates uncertainty associated with the assumed relationship.***

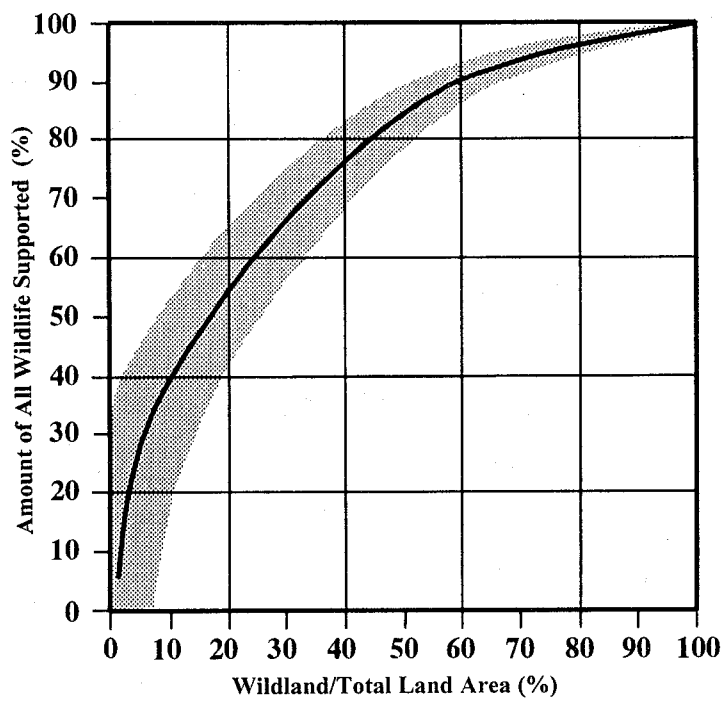


Figure 5. Relationship Between the Amount of Wildland and the Amount of Wildlife Supported by Wildland*

****Shading along the function indicates uncertainty with the assumed relationship.***

related expenditures in each of the states. Soil and water conservation benefits were derived using USDA estimates of similar benefits on CRP land. Nearly $3.4 million in direct economic impacts result from slightly less than 1 percent infestation levels of leafy spurge. Eliminating leafy spurge on wildlands could add 174 jobs and $9.8 million in business activity in the four states. An unquantified impact of leafy spurge on less intensively managed wildland is its potential role as a nursery or seed bank from which it can spread to rangeland and other areas.

Combined Impacts

Direct and secondary economic impacts of leafy spurge infestation on grazing land and wildland in the four-state area are approximately $129.5 million (Table 1, Figure 6). This amount of economic activity is sufficient to support 1,433 jobs.

TABLE 1. ANNUAL ECONOMIC IMPACTS FROM LEAFY SPURGE INFESTATIONS ON GRAZING LAND AND WILDLAND IN THE UPPER MIDWEST, 1993

Grazing Land Impacts

	Grazing Acres	Infested Acres	Infestation Rate	Lost AUMs	Value of Lost AUMs	Lost Expenses and Returns	Economic Impacts Direct	Economic Impacts Secondary	Economic Impacts Totals
	- - - 000 acres - - -		%	000s	- - - - - - - - - - - - - - dollars (000s) - - - - - - - - - - - - - -				
Montana	54,401	351.3	0.65	131.6	1,757.7	3,745.2	5,502.9	12,091	17,594
North Dakota	11,426	625.9	5.48	459.0	6,876.0	17,317.0	24,193.0	53,989	78,182
South Dakota	24,976	105.8	0.42	121.0	1,803.5	4,572.3	6,375.8	14,230	20,606
Wyoming	54,750	60.5	0.11	24.7	216.6	816.5	1,033.1	2,269	3,302
Totals	145,553	1,143.5	0.79	736.2	10,653.8	26,451.0	37,104.8	82,579	119,684

Wildland Impacts

	Wildland Acres	Infested Acres	Infestation Rate	Reductions in: Soil and Water Conservation	Reductions in: Wildlife-Recreation Expenditures	Economic Impacts Direct	Economic Impacts Secondary	Economic Impacts Totals
	- - - 000 acres - - -		%	- - - - - - - - - - - - - - - - - - dollars (000s) - - - - - - - - - - - - - - - - - -				
Montana	30,686	133.9	0.44	328.1	137.4	465.5	576	1,041
North Dakota	4,899	350.3	7.15	514.1	2,111.6	2,625.7	5,291	7,917
South Dakota	7,709	68.4	0.89	102.9	163.8	266.8	461	728
Wyoming	25,103	8.9	0.04	21.8	19.0	40.8	63	104
Totals	68,397	561.5	0.82	966.9	2,431.8	3,398.8	6,391	9,790

Combined Impacts

	Lost Secondary Jobs	Economic Impacts Direct	Economic Impacts Secondary	Economic Impacts Totals
		- - - - - - - dollars (000s) - - - - - - -		
Montana	209	5,968	12,667	18,635
North Dakota	965	26,819	59,280	86,099
South Dakota	227	6,643	14,691	21,334
Wyoming	32	1,074	2,332	3,406
Totals	1,433	40,504	88,970	129,474

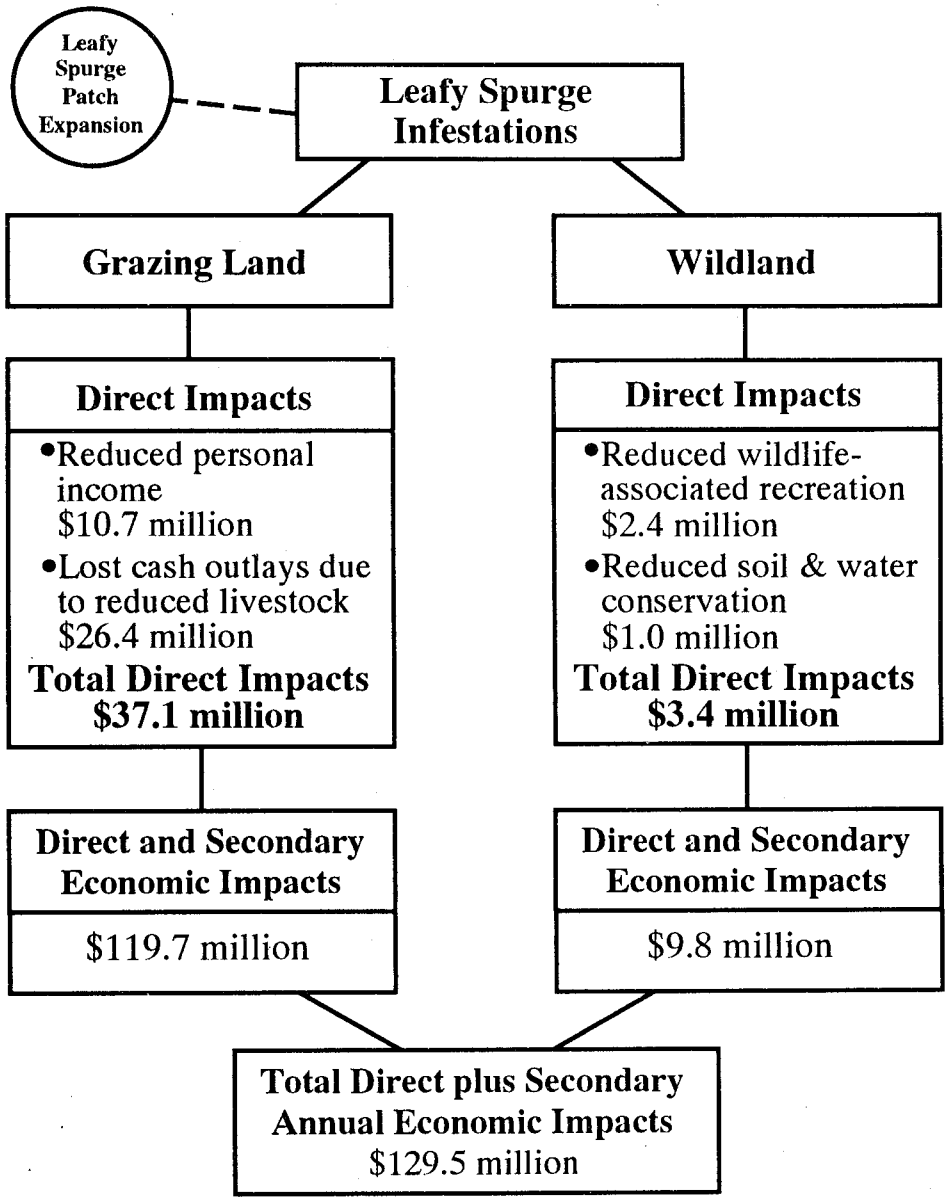


Figure 6. Bioeconomic Impact Assessment of Leafy Spurge in the Upper Midwest.

Policy and Research Implications

Implications for both policymakers and leafy spurge researchers can be drawn from this effort to estimate economic impacts of leafy spurge. Policymakers become aware of the economic implications of the current situation and of the potential for substantial additional impacts if leafy spurge remains unchecked.

Economists have methods, models, and techniques for sorting out issues and arranging information so that decision makers are better informed. However, economists depend upon researchers from many other disciplines to provide the information vital to accurately analyzing an issue. Researchers are exposed to several information shortcomings in the impact estimation process, which may encourage them to help refine the components of the bioeconomic model. Researchers also have a better idea of the importance of developing control solutions and the role they can play in understanding the benefits of control.

Previous Work

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*Leitch and Leistritz are professors and Bangsund is research associate, Department of Agricultural Economics. Coauthors of earlier works drawn upon to prepare this summary include James F. Baltezore, Rodney K. Stroh, Flint Thompson, and Nancy M. Wallace.

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