Predicted Future Economic Impacts of Biological Control of Leafy Spurge in the Upper Midwest*

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

Leafy spurge is an exotic, noxious perennial weed that has become widely distributed in the northern Great Plains. The annual economic losses caused by the weed have been estimated at $130 million annually in Montana, North Dakota, South Dakota, and Wyoming (Leitch et al. 1994).

For several decades, scientists have attempted to develop effective economical control methods for leafy spurge. Most control methods have lacked wide-spread adoption because they are uneconomical or have other constraints preventing their implementation. Biological control is currently viewed as a possible wide-spread, cost-effective management tool for leafy spurge.

The desire to develop biological control methods for leafy spurge in North America surfaced in the late 1970s and early 1980s. The Leafy Spurge Biological Control Program (LSBCP), started in the mid- to late-1980s, required testing and screening natural enemies of leafy spurge for release in North America. Within the last five years, the LSBCP has expanded beyond initial research and screening stages to the general collection and release of agents by local entities (Hansen et al. 1997).

The wide-spread adoption of biological control agents has prompted a closer look at the potential value of this control method. Fiscal pressure at all levels of government has focused debate over the amount of public funds that should be used to facilitate development of biological control programs for problem weeds. Economic information on the benefits of biological control of leafy spurge helps decision makers weigh the merits of developing other biological control programs.

OBJECTIVE

The purpose of the study is to estimate the expected future economic benefits of the biological control of leafy spurge in the upper Great Plains.

PROCEDURE

This study largely follows the impact assessment methods and models presented by Leitch et al. (1994). Previous economic impacts of leafy spurge have been based on reductions in grazing outputs and reductions in nonagricultural benefits of wildland. Although biological control by itself will not eradicate the weed, in successful applications of biological control, the density of leafy spurge infestations can be reduced such that the plant is no longer an economic threat.

Estimates of the future amount of leafy spurge were developed based on (1) the growth of reported leafy spurge acreage in the late 1980s and in the 1990s and (2) the

*Research funded by USDA-APHIS.

**Research scientist, professor, and professor respectively, Department of Agricultural Economics, North Dakota State University, Fargo.

amount of control activities ongoing within the individual states. The distribution of leafy spurge on rangeland and wildland was previously estimated (Bangsund et al. 1993; Wallace et al. 1992). Assuming the allocations between rangeland and wildland were valid for future expansions, estimates of future leafy spurge infestations on rangeland and wildland were estimated using past infestation percentages.

The exact role biological agents will play in controlling existing leafy spurge infestations is unknown. Based on the current understanding of the biological control process, it is impossible to precisely predict the future level of leafy spurge control with biological agents. Scientists and other individuals involved with insect dissemination, biological control research, and public land management were consulted to obtain information on the current and speculated future effectiveness of biological control of leafy spurge. A synthesis of information from those individuals provided the basis for much of the analysis in this study.

BIOLOGICAL CONTROL PROGRAM FOR LEAFY SPURGE

The Leafy Spurge Biological Control Program (LSBCP) has been implemented since 1988 by the United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS). The program was to be implemented in three phases. The goal of phase I was to establish a limited number of field insectary sites (FIS) for each agent in each state. Phase II was designed to collect agents from phase I FIS to establish additional FIS for further collection and distribution. Phase III involves collection and distribution of agents from phase I and II FIS to landowners and managers throughout leafy spurge infested regions (Hansen et al. 1997). Many areas in the country are experiencing the transition from developing insectaries to collecting and distributing agents for general release. Montana, North Dakota, and Wyoming have been in the redistribution stages of phase III for nearly two years, while South Dakota appears to have entered phase III in 1997 (Hanson 1997).

Future Biological Control of Leafy Spurge

Acreage of leafy spurge in the four-state region was projected to increase about 4.5 percent from 1996 to 2000. Although uncontrolled leafy spurge acreage was projected to peak at 1.85 million acres in 2000, acreage in South Dakota and Montana was projected to peak in 2005. Total leafy spurge infestations (controlled and uncontrolled infestations) were projected to reach 1.865 million acres. Total leafy spurge acreage after the turn of the century was forecast to decrease through 2025, when biological control was predicted to reach an equilibrium with leafy spurge infestations.

The future level of biological control, measured in terms of acreage of leafy spurge suppressed, is dependent upon a number of factors, many of which are not fully understood. Given the level of knowledge currently available on biological control of leafy spurge, most experts contacted suggested that about 60 to 70 percent of future leafy spurge infestations eventually will be controlled with biological agents. The time needed for biological agents to reach their maximum level of control fell into the range of 10 to 30 years.

Some areas in the northern Great Plains will likely experience greater control than 60 or 70 percent of existing leafy spurge infestations; however, other areas or infestations will achieve less control. Based on success to date, low- to medium-density leafy spurge stands appear best suited to

control with biological agents in the United States (McClay et al. 1995; Hansen et al. 1997). Success to date has been poor in riparian or other high moisture areas or infestations in shaded environments. It remains uncertain (1) if current biological agents, cleared for use in North America, can be adapted to be effective in those environments that currently have proven difficult to control or (2) if new biological agents can be discovered and cleared for use in North America that may prove to be better suited to those environments.

Future control with biological agents is difficult to predict since (1) the amount and type of infestations that may remain unsuitable for biological control in the future is unknown and (2) the percentage of existing infestations that are in suitable or favorable habitats for control with existing biological agents is unknown (i.e, acreage of leafy spurge considered to be low- to medium-density stands in suitable environments). Thus, 65 percent of the total future leafy spurge acreage was assumed to be controlled with biological agents by the year 2025 (Figure 1).

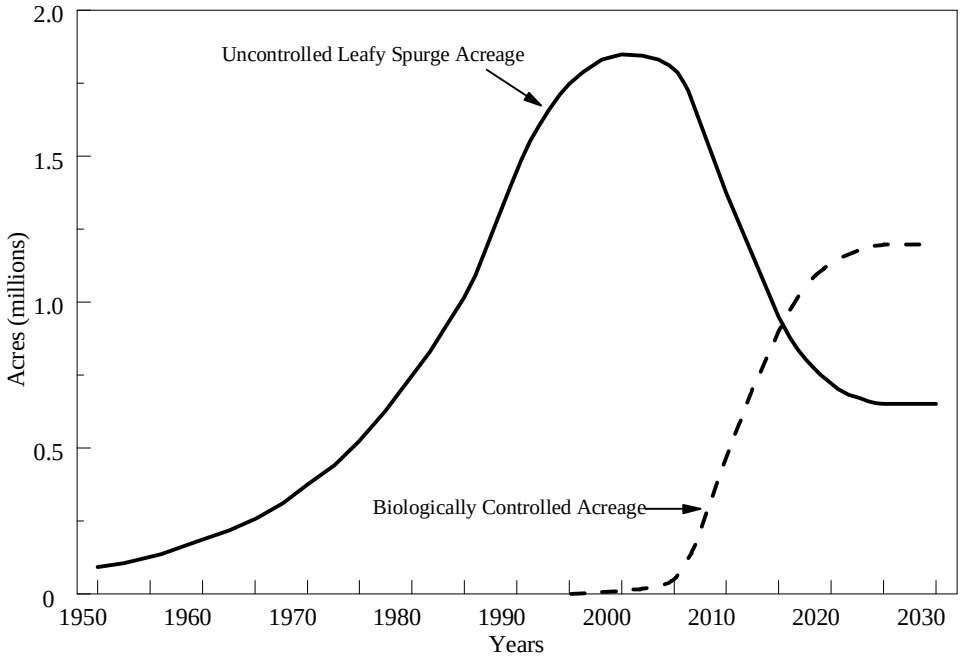

Figure 1. Postulated Future Leafy Spurge Acreage and Acreage of Leafy Spurge Controlled With Biological Agents in Montana, North Dakota, South Dakota, and Wyoming, 1997

Populations of biological control agents for leafy spurge, given proper conditions, can increase at logarithmic rates (Spencer 1994; Hansen et al. 1997). Anecdotal evidence suggests that the amount of area controlled by biological agents also is capable of increasing at logarithmic rates. Availability of biological control agents may no longer be the limiting factor in the expansion of the LSBCP in some locations. Instead, manpower, needed to collect and redistribute the agents, may be the limiting factor. It would appear unlikely that constraints on manpower could be removed to the extent that efforts to collect and redistribute agents could keep up with logarithmic increases in insect populations. However, some of the biological agents may inoculate infestations without human assistance. Mobility of biological agents in field situations is not well understood and the role of insect mobility in inoculating leafy spurge infestations has not been documented. Thus, insect population dynamics, collection and distribution efforts, and insect mobility will affect the continued growth of the LSBCP.

ECONOMIC IMPACT OF BIOLOGICAL CONTROL

Economic impacts of a project, program, or policy can be categorized into direct and secondary impacts. Direct impacts are those changes in output, employment, or income that represent the initial or direct effects of a project, program, or event. The secondary impacts (sometimes further categorized into indirect and induced effects) result from subsequent rounds of spending and respending within the economy. This process of spending and respending is sometimes termed the multiplier process, and the resultant secondary effects are sometimes referred to as multiplier effects (Leistritz and Murdock 1981).

The secondary impacts of the biological control of leafy spurge were estimated by using the North Dakota Input-Output Model (Coon et al. 1985). Input-Output (I-O) analysis is a mathematical tool that traces linkages among sectors of an economy and calculates the total business activity resulting from a direct impact in a basic sector.

Rangeland

Impacts from leafy spurge on rangeland stem from the plant's ability to reduce livestock carrying capacity. The economic benefits of biological control on rangeland were based on increases in grazing output associated with a reduction in the density of leafy spurge infestations.

Direct Impacts

Rangeland output, after the biological suppression of leafy spurge infestations, is a function of overall range health, grazing management, amount and type of forage present, density of pre-control leafy spurge infestation, and degree of leafy spurge suppression (Kirby 1997). Little scientific information exists on the amount of grazing output from rangeland after the biological suppression of leafy spurge, at least as a percentage of pre-infestation capacities. Rangeland carrying capacity, after biological control of leafy spurge, was assumed to be 75 percent of its pre-infested capacity.

Biological control was estimated to suppress 65 percent, or about 820,000 acres, of leafy spurge in rangeland in the four-state region by 2025 (Table 1). The suppression of leafy spurge was estimated to recover

320,500 AUMs annually by 2025. The annual value of recovered AUMs were estimated at nearly $5 million (1997 dollars) (Table 1).

Table 1. Future Annual Benefits of Biological Control of Leafy Spurge in Rangeland in the Upper Great Plains, 2025 (1997 dollars)

Item	Total
Acres infested	1,262,000
Acres controlled	820,000
AUMs recovered	320,500
Value of AUMs ($)	4,980,000
Increase in beef herds (number of cows)	39,400
Increase in beef herd expenditures & revenues ($)	11,470,000
Total direct impacts ($)	16,450,000

The AUMs recovered were expected to increase beef-cow herds by about 39,400 cows. The expanded beef-cow herds were expected to annually generate about $11.47 million (1997 dollars) in revenues to input suppliers and related businesses in the region (Table 1). The total annual direct economic impacts (value of recovered AUMs and increased production expenditures) from biological control of leafy spurge on grazing lands were $16.45 million (1997 dollars) (Table 1).

Secondary Impacts

Total direct impacts of $16.5 million in the four-state region would generate $36.3 million in secondary impacts to the region's economy, which included about $11.8 million of personal income (**households** sector), $11.2 million of **retail trade** activity, and $2.4 million in the **finance, insurance, and real estate** sector. Total economic impacts from biological control of leafy spurge on rangeland were estimated at $52.7 million (1997 dollars) annually by 2025. Total secondary employment in the four-state region was estimated to reach 758 jobs annually.

Wildland

Wildland provides a variety of outputs, such as grazing, forest products, and mineral resources (market goods); and recreation, wildlife production and habitat, erosion control, and watershed benefits (nonmarket goods) (Randall and Peterson 1984). The effects of leafy spurge on wildland outputs stem from the ability of the weed to choke out most native vegetation. Leafy spurge leads to a decline in plant diversity which in turn reduces wildlife habitat and increases water runoff and soil erosion.

Direct Impacts

Information on post-biological control relationships on wildlife habitat productivity and effects on soil and water conservation was unavailable. Biological control of leafy spurge is expected to reduce existing infestation densities to a level where the plant no longer has substantial effects on the land's ability to support indigenous wildlife and retain normal soil and water conservation benefits. Although this study assumed a 100 percent return of pre-infestation wildland outputs after biological control of leafy spurge, minor impacts on wildlife habitat and soil and water conservation benefits may be present. However, the effect is likely sufficiently small as to be of relatively minor economic consequence.

The total annual increase in wildlife-related expenditures in the four-state region

by the year 2025 was estimated at $1.8 million (1997 dollars). The total annual increase in soil and water conservation benefits in the four-state region was estimated at $785,000 (1997 dollars). The value of biological control of leafy spurge in wildland by 2025 was estimated at $2.6 million (1997 dollars) annually (Table 2).

Table 2. Future Annual Benefits of Biological Control of Leafy Spurge in Wildland in the Upper Great Plains, 2025 (1997 dollars)

Item	Total
Acres infested	693,500
Acres controlled	450,400
Value of increased wildlife-related expenditures ($)	1,845,000
Soil & water conservation benefits ($)	785,000
Total direct impacts ($)	2,630,500

Secondary Impacts

Total direct impacts of $2.6 million from the biological control of leafy spurge infestations on wildland in the four-state region generated $3 million in secondary economic impacts to the regional economy, which included $1.2 million of personal income (**households** sector), $0.8 million of **retail trade** activity, and $0.2 million in the **finance, insurance, and real estate** sector. The biological control of leafy spurge on wildland would create enough business activity to support 118 jobs in the four-state region in 2025.

SUMMARY

Leafy spurge was forecast to ultimately infest 1.865 million acres. Biological agents were estimated to eventually control about 1.21 million acres or about 65 percent of leafy spurge in untilled land--820,000 acres in rangeland and 392,000 acres in wildland. The net increase in rangeland output was estimated at about 320,500 AUMs valued at $5 million (1997 dollars) annually. The increase in grazing output was expected to support an increase in beef cattle operations equivalent to a 39,400 beef-cow herd. The increase in grazing activities was expected to generate $11.5 million annually in additional production expenditures to local economies. Total direct economic impacts from the biological control of leafy spurge on rangeland were estimated at $16.45 million (1997 dollars) in 2025. Secondary economic impacts were estimated to generate another $36.3 million in annual impacts. Total, direct and secondary, economic impacts from the biological control of leafy spurge on rangeland were estimated at $52.7 million (1997 dollars) annually in 2025 (Table 3).

Biological agents were estimated to ultimately control about 392,000 acres of leafy spurge on wildland. Biological control was estimated to be responsible for $1.8 million (1997 dollars) in increased wildlife-related expenditures in the four-state region in 2025. Also, an additional $785,000 in increased soil and water conservation benefits were expected to result from the biological control of leafy spurge on wildland. The $2.6 million in direct economic impacts were expected to generate another $3 million in secondary economic impacts. Total economic impacts from the biological control of leafy spurge on wildland was estimated at $5.6 million (1997 dollars) annually in 2025 (Table 3).

Biological control was speculated to ultimately control 65 percent of the 1,865,000 future acres of leafy spurge in the upper Great Plains. The 1,212,000 acres of leafy spurge on rangeland and wildland controlled by biological agents was estimated to generate an annual direct economic impact of $19.1 million (1997 dollars). Total annual secondary economic impacts were estimated at $39.3 million (1997 dollars). Total, direct and secondary, economic impacts from the biological control of leafy spurge in the Upper Midwest were estimated at $58.4 million annually (Table 3). An additional 876 secondary jobs would be supported in the four-state region as a result of biological control of leafy spurge.

Table 3. Future Annual Economic Impacts of the Biological Control of Leafy Spurge on Rangeland and Wildland in Montana, North Dakota, South Dakota, and Wyoming, 2025

	Economic Impacts		
State	Direct	Secondary	Totals
	---------- 1997 dollars (000s) ----------		
Montana	2,572	5,116	7,688
North Dakota	11,753	24,012	35,765
South Dakota	4,218	9,010	13,228
Wyoming	539	1,138	1,677
Total	19,082	39,276	58,358
Number of jobs gained			876

CONCLUSIONS

If the level of leafy spurge control postulated in this study is eventually achieved, the biological control program would enhance economic activity in the Upper Midwest. Assuming 65 percent control of the future acreage of leafy spurge, the LSBCP should provide an economic benefit of nearly $60 million (1997 dollars) annually in the Upper Midwest. Success to date indicates that the LSBCP will be an economic success regardless of the precise amount of future control. For example, if actual suppression of leafy spurge only reaches about half the level predicted in this study (37 percent instead of 65 percent of future infestations), the program would still generate $25 to $30 million (1997 dollars) in annual economic benefits (direct and secondary) in the four states. In addition to the economic benefits realized in the Upper Midwest, substantial infestations of leafy spurge can be found in other western states. Leafy spurge infestations in those states are currently being inoculated with biological control agents, and it would appear likely that those states will experience similar benefits from biological control, thereby raising the value of the LSBCP in the United States.

The results of this study are particularly sensitive to several subjective assessments of key components of the analysis. The consequence of using these assessments is that results represent at best, an educated guess of the future value of the LSBCP. Considering the rapid growth and success of the LSBCP, our “best guesses” would be less speculative in perhaps as little as five years. The assessment of the economic value of the LSBCP would benefit from incorporation of additional information as the overall understanding of the biological control process grows.

REFERENCES

Bangsund, Dean A., James F. Baltezore, Jay A. Leitch, and F. Larry Leistritz. 1993. *Economic Impact of Leafy Spurge on Wildland in Montana, South Dakota, and Wyoming*. Agricultural Economics Report No. 304. Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University, Fargo.

Coon, Randal C., F. Larry Leistritz, Thor A. Hertsgaard, and Arlen G. Leholm. 1985. *The North Dakota Input-Output Model: A Tool for Analyzing Economic Linkages*. Agricultural Economics Report No. 187, Department of Agricultural Economics, North Dakota State University, Fargo.

Hansen, Richard. 1997. Personal communication. Plant Protection and Quarantine, Animal and Plant Health Inspection Service, United States Department of Agriculture, Bozeman, MT.

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

Kirby, Donald. 1997. Personal Communication. Department of Animal and Range Sciences, North Dakota State University, Fargo.

Leistritz, F. Larry and Steve H. Murdock. 1981. *Socioeconomic Impact of Resource Development: Methods for Assessment*. Boulder, Colorado.: Westview Press.

Leitch, Jay A., F. Larry Leistritz, and Dean A. Bangsund. 1994. *Economic Effect of Leafy Spurge in the Upper Great Plains: Methods, Models, and Results*. Agricultural Economics Report No. 316. Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University, Fargo.

McClay, A. S., D. E. Cole, P. Harris, and C. J. Richardson. 1995. *Biological Control of Leafy Spurge in Alberta: Progress and Prospects*. Report AECV95-R2, Alberta Environmental Centre, Vegreville, Alberta, Canada.

Randall, Alan and George L. Peterson. 1984. "The Valuation of Wildland Benefits: An Overview." pp. 1-52 in *Valuation of Wildland Resource Benefits*, George L. Peterson and Alan Randall, eds., Boulder, CO.: Westview Press.

Spencer, Neal. 1994. "Insect Graphs and Charts." published in *Purge Spurge: Leafy Spurge Database*, Version 3. Agricultural Research Service, U.S. Department of Agriculture and Montana State University, Bozeman.

Wallace, Nancy M., Jay A. Leitch, and F. Larry Leistritz. 1992. *Economic Impact of Leafy Spurge on North Dakota Wildland*. Agricultural Economics Report No. 281. Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University, Fargo.

This report is a summary of a larger report, entitled Predicted Future Economic Impacts of Biological Control of Leafy Spurge in the Upper Midwest, Ag Econ Report No. 382, Department of Agricultural Economics, North Dakota State University, Fargo, ND 58105 (701)-231-7441, Fax (701)-231-7400, e-mail address bangsund@plains.nodak.edu. A complete documentation and presentation of results are contained in the main report.

This study was funded by the Animal and Plant Health Inspection Service through the Cooperative State Research Service of the U.S. Department of Agriculture and the North Dakota Agricultural Experiment Station.