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Economic impact of leafy spurge on North Dakota wildland

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Highlights:

Leafy spurge is a widely established noxious weed, which can be found in every county in North Dakota. First sighted in North Dakota in 1909, it now infests over 1 million acres. Leafy spurge acreage has doubled every 10 years for the last 30 years and likely will double again in 10 years.

A framework is developed and an initial estimate is made of the regional economic impact of leafy spurge on North Dakota wildland. Wildland is land not classified as urban or built-up, industrial, or agricultural, such as forest, range, or recreation areas and represents approximately 4,899,000 acres, or 10 percent of the state's total land area.

The biophysical impacts of leafy spurge on wildland wildlife-associated recreation, soil and water conservation, and intangible benefits resulted in direct economic impacts of $3.6 million. Using the North Dakota 18-sector Input-Output Model, regional (North Dakota) economic impacts (direct plus secondary impacts) from leafy spurge on wildlands were estimated at over $11.0 million. Total regional economic impact (direct plus secondary impacts) from the leafy spurge infestation on wildland and rangeland is estimated at $87.3 million.

These estimates of the substantial losses associated with leafy spurge infestation reinforce the need for economically feasible control methods. Without feasible control the continued expansion of leafy spurge is certain as are continued losses in personal income and business activity. Even with the high level of losses associated with the current leafy spurge infestation, it is important the cost of control (using current control methods) does not exceed the benefits of control.

Introduction

Leafy spurge is a widely established noxious weed which can be found in every North Dakota county (Lym and Messersmith 1985) and in 26 states and six Canadian provinces (Dunn 1985) Invasive characteristics make leafy spurge a particularly serious economic threat. As leafy spurge spreads, it displaces existing vegetation (Watson 1985) and is difficult to control with current technology (e.g., herbicides). First sighted in North Dakota in 1909, it infests over 1 million acres in the state (North Dakota Department of Agriculture 1989) (Appendix Table 1). The acreage of leafy spurge has doubled every 10 years for the last 30 years and likely will double again in 10 years (Thompson 1990).

Leafy spurge is a non-native, or alien, species in the United States. Once introduced, alien species can spread at alarming rates. Leafy spurge and other invaders enjoy remarkable success when introduced to ecosystems that have evolved without their presence and without the natural biocontrols that limit invaders to a specific niche in their native environment (Rendall 1990). After establishment, leafy spurge tends to displace other vegetation in pasture, rangeland, and other non-tilled land and to establish essentially single species stands (Watson 1985a), reducing the production of desirable forages (Messersmith *et al.* 1985).

Leafy spurge expansion is compounded by difficulty in control. Effective leafy spurge control must be considered a long-term management program. No single treatment will eradicate leafy spurge (Lym *et al.* 1988). Chemical control has traditionally been the most common control method on untitled land; however, high treatment costs and continued concern over the safety of chemicals have prompted research into alternative control methods. Biological control, the use of one organism to control another, has been gaining support as a potential control alternative (Carlson and Mundal 1990).

The continued expansion of leafy spurge and its ability to withstand eradication has resulted in direct economic losses for the agricultural sector in North Dakota, South Dakota, Montana, and Wyoming (Bangsund and Leistritz 1991). The economic impact of leafy spurge on grazing land is substantial. In North Dakota, rancher incomes and production outlays associated with ranchers' herds were reduced by $23.1 million and total business activity was reduced by $76.3 million in 1990 (Bangsund and Leistritz 1991). Reductions in rancher incomes and production outlays in Montana, South Dakota, and Wyoming were $5.7 million, $3.8 million, and $778,000, respectively. Reductions in total business activity for Montana, South Dakota, and Wyoming were $18.7 million, $12.6 million, and $2.3 million, respectively (Bangsund and Leistritz 1991).

Pasture and rangeland are not the only types of land leafy spurge affects (Wallace 1991). Leafy spurge also infests other non-tilled land, such as road ditches, recreation areas, and wildlife production areas. This other non-tilled land (wildland) provides direct and indirect social and economic benefits to society. Leafy spurge can cause similarly adverse economic impacts, as on pasture and rangeland, to occur as a result of infestations on wildland.

Objectives

The objective of this study was to outline a procedure to estimate, and to make an initial estimate of, the economic impact of leafy spurge on North Dakota wildland. Specific tasks included:

1 Estimating acres of wildland and acres of wildland infested with leafy spurge in North Dakota,
2. Identifying and quantifying the outputs/benefits of North Dakota wildland,
3. Estimating the physical impacts of leafy spurge on the outputs of North Dakota wildland,
4. Estimating the economic impact of leafy spurge on infested wildland on the regional (North Dakota) economy, and
5. Identifying gaps in natural and physical science research that describe the physical relationships between leafy spurge and wildland outputs.

The purpose of this study is two-fold: first to illustrate the potential economic damages of exotic flora and second to illustrate the problems encountered in applied economics research when gaps in physical and natural science research exist.

Procedures

The acreage of wildland was estimated using existing published data. Acres of wildland infested with leafy spurge were estimated based on a survey of county weed board representatives (Wallace 1991). A literature review identified three main categories of wildland benefits: 1) wildlife-associated recreation, 2) soil and water conservation, and 3) intangibles (Wallace 1991). These benefit categories serve as a conservative proxy for all wildland benefits.

The biophysical impacts of leafy spurge on wildland were estimated from published literature and input from wildlife and soil science specialists. The value of wildlife-associated benefits was based on wildlife-associated recreationist expenditures and changes in water users' expenditures to mitigate off-site water quality damages. Intangible benefits were qualitatively assessed.

The biophysical impacts of leafy spurge on wildland were applied to the estimated value of wildlife-associated benefits and soil and water conservation benefits to estimate direct economic impacts. The impact of leafy spurge on the regional economy (direct plus secondary impacts) was estimated using the North Dakota 18-sector Input-Output Model (Coon *et al.* 1990). Physical and natural science research critical to this analysis were found to be lacking as work progressed on the first four objectives.

Wildland definition

Wildland can be broadly defined as land not used for industrial, urban, or agricultural purposes and includes forests, recreation areas, and wilderness (Randall and Peterson 1984). Selleck *et al.* (1962) observed leafy spurge in wildland habitats such as ungrazed

grassland, rocky forest land, railway embankments, road and drainage ditches, and riverbanks. Since the literature did not contain any published estimate of wildland area in North Dakota, using this or any other definition, wildland area was estimated by excluding land use/cover categories that were not wildland. Acreage of cropland, grassland, rangeland, and pastureland (assumed agricultural), urban and built-up (assumed urban and industrial), and water were subtracted from the estimated total land area of North Dakota. Wildland was estimated at 4,899,000 acres, approximately 10 percent of the total acres in North Dakota (Table 1).

Table 1. Estimated wildland acreage in North Dakota, 1987.

Land Use/Cover	Acres
Total area North Dakota:	45,245,000
Less:	
Cropland	28,063,000
Pastureland & rangeland	11,139,000
Urban and built-up land	207,000
Census water[a]	937,000
Total	**4,899,000**

Source: U.S. Soil Conservation Service, 1991. National Resources Inventory 1987 - North Dakota. U.S. Department of Agriculture, Washington, D.C.

[a]U.S. Soil Conservation Service, 1988. Basic Statistics 1982 National Resources Inventory. Soil Conservation Statistical Bulletin No. 765. U.S. Department of Agriculture, Washington, D.C.

Data from a survey of county weed board representatives were used to estimate acreage of leafy spurge on wildland (Wallace 1991). Respondents estimated acreage of leafy spurge on seven land use/cover categories: private range and private other (e.g., shelterbelts, section lines, rights-of-way), public rangeland, road ditches, recreation areas, wildlife production areas, and military/other. Categories classified as agricultural, industrial, and urban and built-up were not included in the estimate. Based on survey results, there are approximately 468,000 acres of leafy spurge on North Dakota wildland, approximately 10 percent of the 4.9 million acres of wildland (Table 2).

Table 2. Estimated leafy spurge acreage on North Dakota wildland, 1991.

Land Use/Cover	Acres
Private other[a]	247,623
Road ditches	124,006
Recreation areas	17,738
Wildlife production areas	51,508
Military & other	27,121
Total	**467,996**

Source: Wallace (1991).

[a]Shelterbelts, section lines, rights-of-way.

Wildland benefits

Wildland can be either publicly or privately owned and provides a variety of goods and services, such as forest products and mineral resources. Non-market goods such as recreation, wildlife production and habitat, erosion control, and watershed benefits are also products of wildland that provide society with benefits (Randall and Peterson 1984). Wildlife-associated recreation, soil and water conservation, and intangibles are identified as wildland benefits.

Wildlife-assiociated recreation

Wildlife habitat is an important output of North Dakota wildland. Wildland outputs (e.g., wildlife) in combination with other inputs can form recreation experiences. The state's economy is impacted by the expenditures of individuals pursuing wildlife-associated recreation, such as the purchase of special equipment, gasoline, food, lodging, and other services. Wildlife-associated recreation consists of hunting, fishing, and nonconsumptive activities (e.g., wildlife photography) (U.S. Fish and Wildlife Service 1989). Only hunting and nonconsumptive expenditures were estimated, as fishing is not a relevant recreational activity on wildland. Total North Dakota wildlife-associated recreation expenditures (consumptive and nonconsumptive) were estimated at over $219 million in 1990 (Table 3).

Table 3. Wildlife-associated recreation expenditures and participants in North Dakota, 1990.

Recreation Category	Expenditures[a]	Participants
	-- $1,000 --	
Consumptive wildlife-ssociated recreation		
Resident[b]	196,006	210,220[e]
Nonresident[c]	4,269	8,223[f]
Total	200,275	218,443
Nonconsumptive wildlife-associated recreation[d]		
Resident	4,811	81,500
Nonresident	14,616	68,700
Total	19,427	150,200
Total wildlife-associated recreation	**219,702**	**368,643**

[a]U.S. Department of Labor. 1991. All numbers are inflated to 1990 real dollars using Implicit Price Deflator for the Gross National Product.

[b]James F. Baltezore and Jay A. Leitch. 1988. Extent and Impact of Resident Hunter and Angler Expenditures in North Dakota in 1986. Agricultural Economics Report No. 236, Agricultural Experiment Station, North Dakota State University, Fargo.

[c]Randall S. Anderson and Jay A. Leitch. 1984. Characteristics and Expenditures of Nonresident Sportsmen in North Dakota in 1983. Agricultural Economics Miscellaneous Report No. 77, Agricultural Experiment Station, North Dakota State University, Fargo.

[d]U.S. Fish and Wildlife Service. 1989. 1985 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. U.S. Department of the Interior, Washington, D.C.

[e]Active hunters

[f]Licenses issued

Soil and water conservation

Alteration of the use or condition of water resources can lead to output, and subsequently value, changes. Changes in water resource values can be expressed as changes in water user production costs or changes in expenditures to prevent or counteract damage from pollutants (Ribaudo 1989). Ribaudo (1989) estimated the water quality benefits from placing highly erodible cropland into trees or grassland through the Conservation Reserve Program (CRP). Runoff and soil erosion are reduced when tilled cropland is converted to permanent cover, such as trees or grass, thus reducing off-site water quality damages. Benefits are equal to the reduction in expenditures formerly necessary to mitigate damages from nonpoint source pollution (Ribaudo 1986).

Present value of the off-site benefits of placing highly erodible cropland in CRP for the Northern Plains (North Dakota, South Dakota, Nebraska, and Kansas) was estimated at over $248 million or $47.60 per acre (Ribaudo 1989). Discounting the stream of benefits at 4 percent (the discount rate used by Ribaudo 1989) over the 10-year CRP contract period results in annual benefits of $5.87 per acre (Wallace 1991). Assuming wildland and CRP have analogous soil and water conservation benefit[1], the results of the Ribaudo (1989) study can be used to estimate pre-leafy spurge wildland off-site water conservation benefits. By multiplying benefits per acre ($5.87) by acres of wildland (4,899,000), wildland soil and water conservation benefits are estimated at $28,757,130.

Intangibles

Existence and option values are non-market benefits of wildlands. Existence value is based on the utility an individual derives from simply "knowing" a resource exists, without ever intending to actually use the resource. Option value is similar to existence value but includes the possibility of future use.

Intangible benefits, such as existence and option values, are non-market benefits that accrue to individuals as increased or reduced consumers' surplus and, as such, do not impact the regional economy (Wallace 1991). Although intangibles are recognized as wildland benefits that accrue to individuals, intangible benefits have neither direct nor indirect monetary impact on the regional economy and, as such, were not included in the analysis of the economic impact of leafy spurge on wildland.

Biophysical impacts

The ability of leafy spurge to literally choke out other existing vegetation has been documented (Watson 1985, Belcher and Wilson 1989, Messersmith *et al.* 1985). Leafy spurge is clearly related to a decline in native prairie plants and alone can have a negative effect on prairie vegetation, posing a considerable threat to native and existing wildland vegetation (Belcher and Wilson 1989). A substantial change in plant diversity due to leafy

[1]This assumption bridges one of the physical science gaps. There doesn't appear to be any information on which to base this or any alternate assumption, yet this assumption seems to be a "reasonable" starting point.

spurge may not provide the necessary cover or forage to support existing indigenous wildlife populations and may negatively impact wildland soil and water conservation.

Wildlife-associated recreation

The ability of leafy spurge to change a diverse plant community to a monoculture is a threat to wildlife habitat. The U.S. Department of Agriculture (1989) reports floral monocultures reduce the interspersion of cover types, which in turn reduces habitat. Assuming a change in plant biodiversity would affect wildlife carrying capacity, an impact function was posited to describe the relationship between leafy spurge and wildland habitat value (Figure 1). Due to the lack of natural science research on the effects of leafy spurge on wildland wildlife habitat value, this first estimate of the relationship between leafy spurge and wildland wildlife habitat value[2] is based on the expert opinion of a few selected wildlife managers and plant ecologists and published data reporting the shortcomings of monocultures as wildlife habitat. Estimates of reduced wildland wildlife habitat value from leafy spurge infestations will be used to estimate the economic impact of leafy spurge on wildland wildlife-associated recreation.

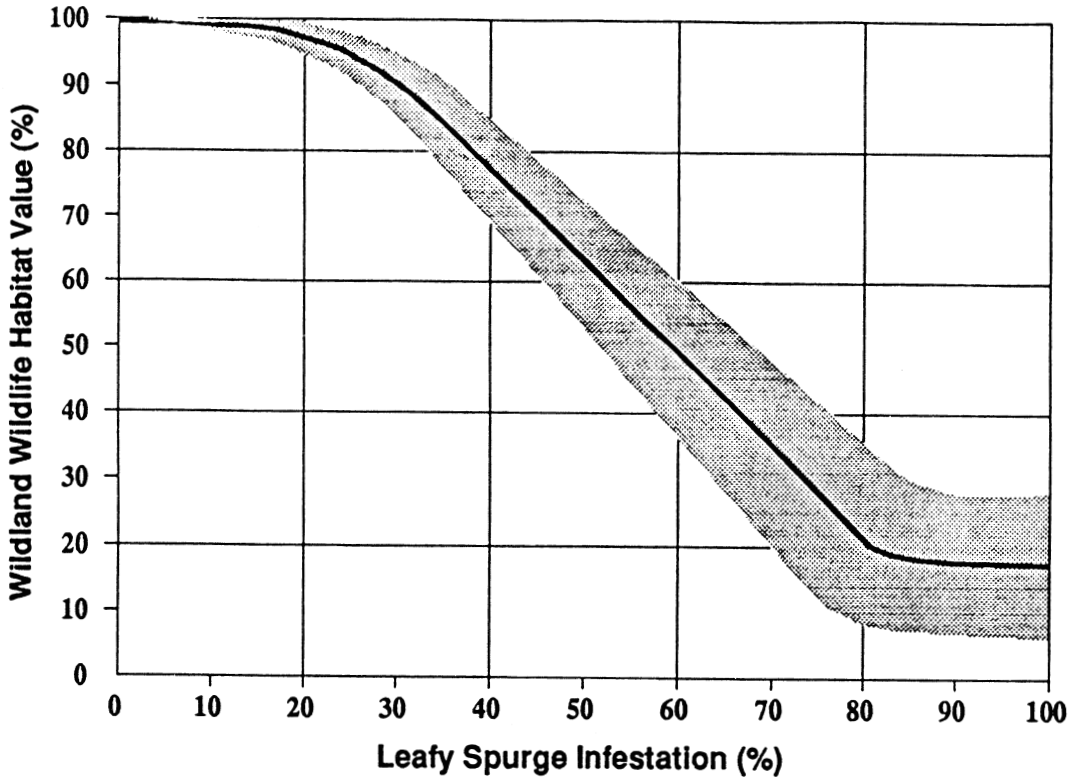

Figure 1. Estimates of reduced wildland wildlife habitat value caused by various leafy spurge infestation rates*

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

[2]The relationship depicted in Figure 1 is another major natural science data gap. The function depicted seemed "reasonable" to the authors.

Soil and water conservation

As leafy spurge displaces native and existing vegetation, it changes the character and composition of wildland vegetative cover, an important factor influencing runoff and soil erosion. A change in vegetative cover due to leafy spurge may affect soil erosion, thereby altering wildland soil and water conservation benefits. 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 (Rodgers *et al.* 1990, Ribaudo 1986 and 1989). Examples of off-site soil erosion damage are increased flood damages, damage to aquatic ecosystems, reduced water-based recreation opportunities, increased municipal and industrial water treatment costs, accelerated loss of water storage capacity, and aggradation and siltation of navigation and water conveyance channels (U.S. Environmental Protection Agency 1984, Ribaudo 1986 and 1989).

Enrollment of highly erodible cropland in the Conservation Reserve Program (CRP) has led to increased off-site water quality benefits (Ribaudo 1989). Removing highly erodible cropland from production has taken land with less diverse vegetative cover (monoculture cropland) and made it more diverse (trees and grassland). This more favorable vegetative mix for preventing runoff and soil erosion results in increased off-site water quality benefits.

A converse situation is possible with leafy spurge infestation on wildland. As the vegetative cover changes from more diverse to less diverse, moving toward a monoculture, runoff and soil erosion may increase, resulting in reduced off-site water quality benefits. A definitive estimate of increased runoff and soil erosion due to leafy spurge is not practical at this time due to the lack of physical science research describing the relationships among runoff, soil erosion, and leafy spurge. However, assuming 1) wildland without leafy spurge provides on- and off-site soil and water conservation benefits analogous to CRP acres, and 2) wildland with leafy spurge provides fewer on- and off-site soil and water conservation benefits than wildland without leafy spurge, a percentage reduction can be a proxy for possible reductions in soil and water conservation benefits due to leafy spurge infestation. For the purpose of this study, a 100 percent leafy spurge infestation is assumed to reduce wildland off-site water conservation benefits by one-fourth[3] (Figure 2).

Direct economic impacts

Economic impacts are increases or decreases in economic activity due to the expansion or shrinkage of a particular firm, industry, or sector in the area economy (Coon *et al.* 1985). This study estimates the direct economic impacts that affect local suppliers and producers of wildland-related goods and services. 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. Direct economic

[3]There is no available theoretical or empirical research to suggest what the increases in soil erosion and the degradation in water quality might be. This is another physical science data gap that exists. The conclusions of this study are not highly sensitive to 50 percent changes in the assumed 25 percent reduction.

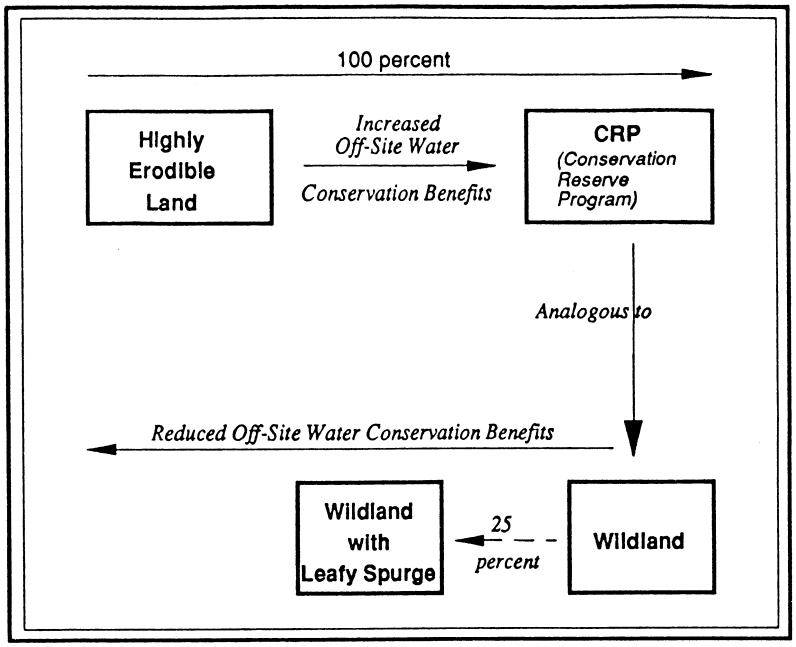

Figure 2. Conceptual relationship of highly erodible land, Conservation Reserve Program (CRP), and wildland.

impacts from changes in wildland soil and water conservation benefits are changes in user expenditures to mitigate damages from runoff and soil erosion.

Wildlife-associated recreation

The reduction in expenditures from the 468,000-acre wildland 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

Assessing the impact of this infestation begins by referring to the estimated relationship of leafy spurge and wildland wildlife habitat value. The 468,000 acres of leafy spurge on wildland are assumed to be 100 percent infested, thus reducing wildland wildlife habitat value (H) by 80 percent (see Figure 1). An 80 percent reduction on 10 percent of all wildland (W) is equal to an 8 percent overall reduction in wildlife habitat value from leafy spurge.

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 .40, or 40 percent (Wallace 1991). The species/land use coefficient multiplied by total wildlife-associated expenditures results in an estimate of the portion of wildlife-associated expenditures attributable to wildland. Multiplying the reduction in wildland wildlife habitat value (H x W) by wildland wildlife-associated recreation expenditures (E x C) estimates the reduction in wildlife-associated recreation expenditures from leafy spurge infestation on wildland.

Some expenditures previously spent on wildlife-associated recreation will be reallocated to other in-state recreational activities. Other expenditures previously spent in-state will be spent in other states (S), thus representing a loss to the state economy. Baltezore and Leitch (1992) reported 42 percent of recreationists would pursue their favorite recreation activity out of state if it was not available in North Dakota. Direct economic impact (reduced expenditures) of reduced wildlife-associated recreation due to the current leafy spurge infestation on wildland is estimated to be approximately $2.9 million.

$$R = (\$219{,}702{,}000 \times .40)\ (.80 \times .10)\ (.42)$$

$$R = \$2{,}953{,}795$$

Soil and water conservation

Direct economic impacts to soil and water conservation are defined as changes in defensive expenditures to prevent or counteract damage from pollutants. For example, water for municipal and industrial use is generally treated before household or commercial use. Changes in treatment costs represent the benefits (costs) of increased (decreased) water quality. Increased (decreased) water quality represents direct economic benefits (damages) to water users.

Applying the assumed 25 percent reduction in wildland soil and water conservation (erosion control) benefits due to the leafy spurge infestation to the $5.87 per acre off-site water conservation benefits of CRP land estimates the reduction in wildland soil and water conservation benefits at $1.47 (.25 x $5.87). 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 damages due to decreased water quality from leafy spurge on wildland.

Secondary economic impacts

Secondary, or regional, economic impacts are the resultant changes in business activity in other economic sectors of the North Dakota economy due to an initial change in business activity in one or more sectors. The North Dakota 18-sector Input-Output Model traces linkages among business sectors and calculates additions or reductions (secondary economic impacts) in total business activity, as well as estimating the number of jobs gained or lost. Total regional (North Dakota) economic impact of reduced wildlife-associated recreation and reduced soil and water conservation benefits due to the current leafy spurge infestation is the sum of direct and secondary economic impacts.

Reduced Wildlife-associated Recreation

Tourism and Recreation is the economic sector directly impacted by reduced wildlife-associated recreation. Expenditure categories in the Tourism and Recreation sector include auto transportation (e.g., gasoline service stations), lodging (e.g., hotels), food service (e.g. restaurants), entertainment/recreation (e.g., theaters), and general retail trade (Coon *et al.* 1985). The estimated $2.9 million reduction in expenditures (direct impact) reduced total business activity (direct and secondary economic impacts) by over $9.7 million. Personal income (gross business volume of the Household sector) was reduced by over $1.9 million (Table 4). The reduction in total business activity due to reduced wildlife-associated recreation is enough to support 138 jobs.

Table 4. Direct and secondary economic impacts due to the leafy spurge infestation on North Dakota wildland, by business sector and benefit category, 1991.

Business sector	Wildlife-associated recreation	Soil & water conservation	Totals
	---------- dollars ----------		
Direct Impacts			
Tourism and recreation	2,953,000	0	2,953,000
Government	0	481,000	481,000
Agriculture - crops	0	200,000	200,000
Electricity generation	0	7,000	7,000
Reduction in Expenditures	**2,953,000**	**688,000**	**3,641,000**
Secondary (includes direct) Impacts			
Agriculture - livestock	225,000	16,000	240,000
Agriculture - crops	566,000	219,000	785,000
Nonmetal mining	12,000	1,000	13,000
Construction	162,000	16,000	178,000
Transportation	38,000	2,000	40,000
Communication and public utilities	257,000	17,000	274,000
Agricultural processing and miscellaneous manufacturing	1,489,000	33,000	1,522,000
Retail trade	1,226,000	164,000	1,430,000
Finance, insurance, and real estate	311,000	34,000	345,000
Business and personal service	163,000	14,000	177,000
Professional and social services	141,000	13,000	154,000
Households	1,988,000	196,000	2,184,000
Government	214,000	500,000	714,000
Coal mining	0	1,000	1,000
Electricity generation	0	7,000	7,000
Petroleum exploration and extraction	0	0	0
Petroleum refining	0	0	0
Recreation and tourism	2,953,000	0	2,953,000
Reduction in Total Business Activity (Direct and Secondary Impacts)	**9,745,000**	**1,233,000**	**11,017,000**

Soil and water conservation

Changes in soil and water conservation benefits directly impact three economic sectors, Government, Agriculture-Crops, and Electricity Generation. The three sectors had $0.5 million, $0.2 million, and $7,000 in reduced benefits (increased expenditures), respectively, totaling $0.7 million (Wallace 1991). The estimated $0.7 million in direct economic impacts reduced total business activity (direct and secondary impacts) by nearly $1.2 million. The Government sector (executive, legislative, judicial, administrative, and regulatory activities for federal, state, local, and international governments [Coon *et al*. 1985]) had a reduction in total business sector expenditures of over $0.5 million. Agriculture-Crops (crops production) and Households (personal income) had reductions in total business sector expenditures of $0.2 million (Table 4). The reduction in total business activity due to reduced wildland soil and water conservation benefits is enough to support 45 jobs.

Total impact

Direct economic impacts in the Recreation and Tourism sector ($2.9 million), the Government sector ($0.5 million), the Agriculture-Crops sector ($0.2 million), and the Electricity Generation sector ($7,000) reduced total business activity (direct and secondary economic impacts) by over $11.0 million. The Recreation and Tourism sector experienced the largest reduction in sector expenditures with over $2.9 million in reduced business sector expenditures. The reduction in total business activity due to leafy spurge on wildland would support 187 jobs. Reductions in personal income (Household sector) were estimated at over $2.1 million (Table 4).

Conclusions

This study was a first attempt to estimate regional economic impacts of leafy spurge on wildland in North Dakota. The present leafy spurge infestation on North Dakota wildland has direct economic impact of over $3.6 million. Total foregone business activity (direct plus secondary impacts) is estimated to be $11.0 million, enough to support 187 jobs. Further research is needed to refine the impact assessment. Additional natural and physical science research, more specific land use/cover inventories, and improved leafy spurge inventories would help to narrow the confidence intervals in these initial damage estimates.

Specific inventory data needs include:

- expanding the annual estimation of leafy spurge infestation per county to include the land use/cover on which the infestation occurs (e.g., rangeland or road ditches), and
- identifying ownership of spurge-infested land (e.g., public or private, federal or state).

Biophysical research needs include:

- a more precise description of the physical relationship between leafy spurge, wildland, and wildlife populations, and
- physical research to describe the impact of leafy spurge on run-off and soil erosion.

This information would help to more confidently assess the impacts of leafy spurge on different types of land and to identify who leafy spurge impacts (i.e., resource owner, resource user, regional economy, or society) and estimate to what degree.

Considering the historic and potential future expansion and the economic damages due to leafy spurge in North Dakota, continued research to refine the estimate of the biophysical and economic impacts of leafy spurge on wildland is warranted. Reliable methods are available to refine the estimate of economic impacts of leafy spurge on wildland, provided the physical relationship between leafy spurge and wildland outputs can be adequately addressed.

The results of this first estimate of the economic impacts of leafy spurge on wildland are, of course, sensitive to the many assumptions made in the study. As the biophysical relationships of leafy spurge and wildland are refined, enhanced data can be applied to the framework for estimating economic impacts developed in this study.

Implications

The economic impact of leafy spurge has been addressed in two separate studies. This study assessed the impact of leafy spurge on wildland and a companion study assessed the impact of leafy spurge on range and pastureland (Thompson *et al.* 1990). Conceptually, the land uses addressed in these two studies are mutually exclusive and the results additive to estimate the economic impact of leafy spurge on the North Dakota economy. However, there is potential for overlap. Thompson *et al.* (1990) assumed all leafy spurge infestations were on grazing or pastureland. This overestimates the acreage of leafy spurge on grazing land as some of the leafy spurge assumed to be on range and pasture is actually on wildland.

In the interim, Bangsund and Leistritz (1991) updated the initial estimate of the economic impacts of leafy spurge on range and pastureland by correcting for the initial overestimate of acres of leafy spurge on range and pastureland and by using current leafy spurge acreage estimates. While Bangsund and Leistritz (1991) corrected for a potential overestimate in rangeland benefits in Thompson *et al.* (1990), potentials for both over- and underestimates in rangeland and wildland impacts remain.

Potential overestimates include the inclusion of all federal land in the wildland estimate. Some federal land is leased for agricultural purposes, e.g., grazing for cattle production. An argument could be made that federal land leased for agricultural purposes should be classified as agricultural land and thus excluded from the wildland estimate. Under the assumption federal land leased for grazing is not wildland, the inclusion of all federal land in the wildland estimate may overestimate the economic impact of leafy spurge on wildland. The inclusion of federal land in the wildland study may also overestimate the economic impact of leafy spurge on the North Dakota economy, as federal land leased for grazing was included in both the rangeland and wildland study.

Potential underestimates include the exclusion of wildlife-associated benefits from the rangeland assessment. Rangeland does provides wildlife habitat, but the relative importance of rangeland wildlife habitat as well as the impact of leafy spurge on rangeland wildlife habitat are unknown. This represents yet another gap in natural science data.

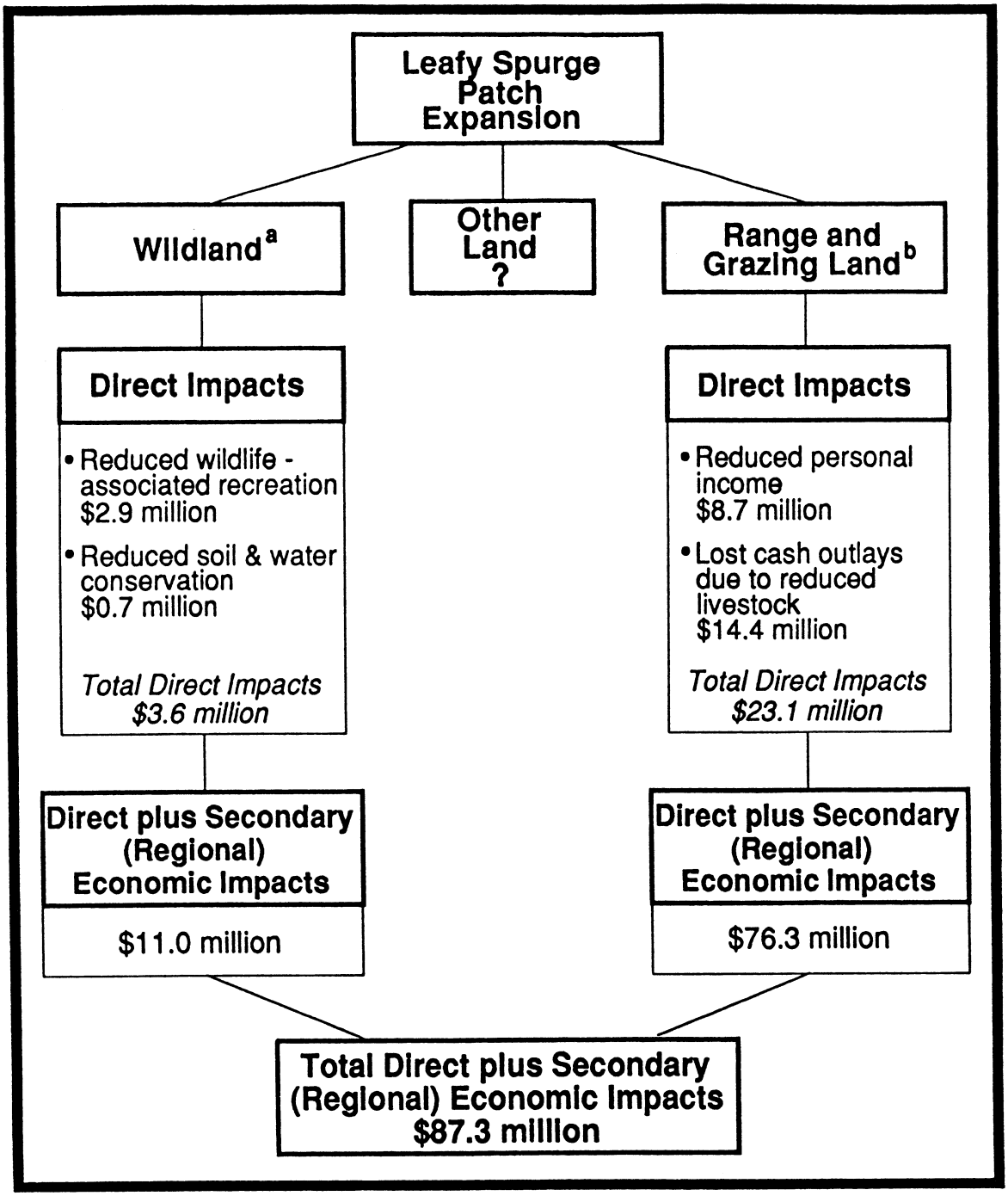

Figure 3. Bioeconomic impact assessment of leafy spurge in North Dakota.

[a] Nancy M. Wallace. 1991. Economic Impact of Leafy Spurge on North Dakota Wildland. Unpublished M.S. Thesis, Department of Agricultural Economics, North Dakota State University, Fargo.

[b] Dean A. Bangsund and F. Larry Leistritz. 1991. Economic Impact of Leafy Spurge on Grazing Land in the Northern Great Plains. Agricultural Economics Report No. 275-S, Agricultural Experiment Station, North Dakota State University, Fargo.

Potential unidentified impacts include soil and water conservation impacts of leafy spurge on rangeland. Leafy spurge may provide greater soil and water conservation benefits than heavily grazed rangeland, thus providing a benefit, or it may represent a reduction in benefits as on wildland. Excluding the impact of leafy spurge on rangeland soil and water conservation benefits is indeterminate and may represent either an underestimate or overestimate of the economic impact of leafy spurge in North Dakota.

Without feasible control, the continued expansion of leafy spurge is certain, as are continued reductions in personal income and business activity. Currently the damage estimate for both rangeland and wildland is $26.7 million in direct impacts and $87.3 million in regional economic impacts (direct plus secondary impacts) (Figure 3). These first approximations suggest that leafy spurge is a major problem in North Dakota. Substantial losses associated with the leafy spurge infestation reinforce the need for continued research aimed at developing efficient, economical control methods. Considering the historic and potential future expansion of leafy spurge, further economic losses associated with continued expansion are likely and will intensify the need for cost effective control methods. However, until a feasible solution is found, even with the high level of losses associated with the current leafy spurge infestation, it is important that the cost of control (using current control methods) does not exceed the benefit of control.

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Appendix

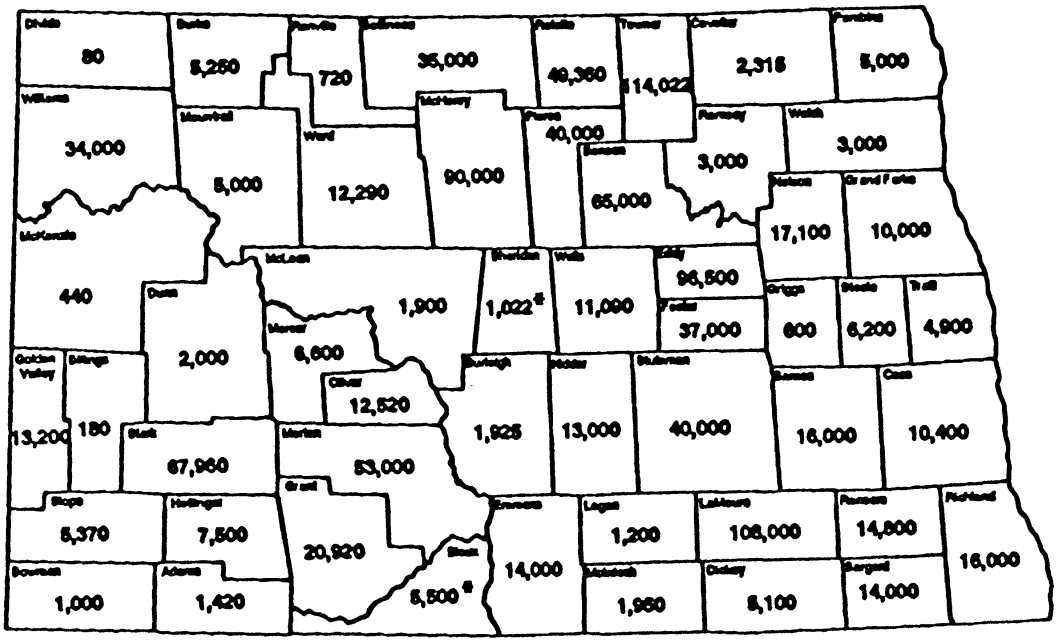
Appendix Table 1. Leafy spurge infestation by North Dakota County, 1989.

County	Acres	County	Acres
Adams	1,420	Mercer	6,600
Barnes	16,000	Morton	53,000
Benson	65,000	Mountrail	5,000
Billings	180	Nelson	17,100
Bottineau	35,000	Oliver	12,520
Bowman	1,000	Pembina	5,000
Burke	5,250	Pierce	40,000
Burleigh	1,925	Ramsey	3,000
Cass	10,400	Ransom	14,800
Cavalier	2,315	Renville	720
Dickey	5,100	Richland	16,000[a]
Divide	80	Rollette	49,360
Dunn	2,000	Sargent	14,000
Eddy	96,500	Sheridan	1,022[b]
Emmons	14,000	Sioux	5,500[b]
Foster	37,000	Slope	5,370
Golden Valley	13,200	Stark	67,960
Grand Forks	10,000	Steele	6,200
Grant	20,920	Stutsman	40,000
Griggs	600	Towner	114,022
Hettinger	7,500	Traill	4,900
Kidder	13,000	Walsh	3,000
LaMoure	108,000	Ward	12,250
Logan	1,200	Wells	11,090
McHenry	90,000	Williams	34,000
McIntosh	1,950		
McLean	1,900	**Total**	**1,103,854**

Source: North Dakota Department of Agriculture. 1989. Unpublished data of the Leafy Spurge County Statistical Summary. Bismarck.

[a]1988 estimate

[b]1990 preliminary estimate



Estimated acres of leafy spurge by county, 1989

*** Indicates 1990 preliminary estimates of acreage.**

Source: North Dakota Department of Agriculture. 1989. Unpublished data of the Leafy Spurge County Statistical Summary. Bismarck.