An Annotated Bibliography on the Economics of Invasive Plants

by

Sarah Stutzman[a], Karen M. Jetter[b] and Karen M. Klonsky[c]

University of California
Agricultural Issues Center

April 2004

[a] Sarah Stutzman is a post-graduate researcher with the Agricultural Issues Center, University of California.
[b] Karen Jetter is an assistant research economist with the Agricultural Issues Center, University of California
[c] Karen Klonsky is a Cooperative Extension Specialist, Department of Agriculture and Resource Economics, University of California, Davis.

Bangsund, Dean A., James F. Baltezore, Jay A. Leitch, and F. Larry Leistritz. 1993. *Economic Impacts of Leafy Spurge on Wildlands in Montana, South Dakota, and Wyoming.* North Dakota State University, Agricultural Economics Station, Agricultural Economics Report no 304. 49 pages.

This report examines the economic costs of leafy spurge on wildland in Montana, South Dakota, and Wyoming. Wildland is land not used for/classified as agriculture, urban, built-up, or surface water acreage such as rivers and streams. Leafy spurge infestations reduce recreational expenditures, and soil and water conservation benefits. Recreational expenditures include all wildlife consumptive (hiking, hunting, fishing, etc.) and nonconsumptive activities (aesthetic viewing of wildland, benefits provided knowing it exists for future generations, etc.). The authors make use of existing estimates to value the soil and water conservation benefits provided by wildland acreage.

The report finds that wildlife expenditures, and soil and water conservation benefits lost to leafy spurge are $465 thousand a year in Montana, $267 thousand in South Dakota and $71 thousand in Wyoming. The total annual direct and indirect costs of leafy spurge on wildland is $1.041 million in Montana, $728 thousand in South Dakota and $176 thousand in Wyoming for total lost benefits of $1.95 million in all three states.

Bangsund, Dean A. and F. Larry Leistritz. 1991. *Economic Impact of Leaf Spurge in Montana, South Dakota, and Wyoming.* North Dakota State University, Agricultural Experimental Station, Agricultural Economics Report no. 275. 85 pages.

This report estimates the direct and indirect economic impact of leafy spurge on Montana, South Dakota, and Wyoming grazing lands. Grazing land includes private pasture, private ranchland, and federal grazing land. Economic losses attributed to leafy spurge result from reductions in carrying capacity. Carrying capacity reduction models are used to calculate the reduction in carrying capacity resulting from leafy spurge infestations. Direct economic losses are evaluated as changes in payments to land owners and decreased expenditures for livestock inputs. Lost land income is determined by multiplying lost carrying capacity by land rental rates. The decrease in livestock expenditures are extrapolated from developed livestock budgets, one for Montana and Wyoming, and another for South Dakota. The secondary effects of leafy spurge on other related business sectors are estimated using the North Dakota Input-Output model.

Leafy spurge results in direct losses of $5.7 million a year in Montana, $3.8 million for South Dakota, and $0.8 million for Wyoming. The direct and secondary effects of leafy spurge in all three states is $34 million, $13 million in Montana, $8.8 million for South Dakota and $1.8 million in Wyoming. If left untreated, by 1995 leafy spurge losses may rise to $46 million a year in Montana, South Dakota, and Wyoming.

Bangsund, Dean A., F. Larry Leistritz, and Jay A. Leitch. 1997. *Predicted Future Economic Impacts of Biological Control of Leafy Spurge in the Upper Midwest*. North

Dakota State University, Agricultural Experimental Station Agricultural Economics Report no. 382. 53 pages.

This report estimates the benefits of controlling leafy spurge in the Midwest (Montana, North Dakota, South Dakota, and Wyoming) using a biological control program. The benefits of controlling leafy spurge include increases in: grazing AUMs, wildlife recreational expenditures, and water and soil conservation. This report hypothesizes that by the year 2025, 65% of future infestations or 1.85 million acres of leafy spurge, will be 65% controlled. It assumes grazing land returns to 75% of pre-infestation productivity after treatment, and wildland to 100%.

Total annual grazing benefits are $11.5 million, recreation benefits are $2.6 million, and water and soil benefits are $0.320 million. Adding secondary impacts to these, the report arrives at an annual benefit estimate of $58 million for controlling leafy spurge in the Midwest by the year 2025.

Bangsund, Dean A., F. Larry Leistritz, and Jay A. Leitch. 1999. "Assessing Economic Impacts of Biological Control of Weeds: the Case of Leafy Spurge in Northern Great Plains of the United State." ***Journal of Environmental Management*** **56. p. 35-53.**

In this article, the direct and indirect benefits of controlling leafy spurge using a biological control program are estimated for the Great Plains region (Montana, North Dakota, South Dakota and Wyoming). Direct benefits of controlling leafy spurge include increases in livestock and wildlife carrying capacity. The indirect benefits from changes in business volume, personal income, retail sales, and other economic activity, are calculated using an input-output analysis.

Direct leafy spurge control benefits are $19.1 million a year. This is allotted as $4.98 million in improved livestock carrying capacity, $11.74 million in increased livestock production expenditures, $1.8 million in wildlife related recreational expenditures, and $0.485 million in water and soil conservation. Adding secondary benefits of $39.3 million results in leafy spurge removal benefits of $58.4 million a year in the Great Plains region by the year 2025.

Bangsund, Dean A., Jay A. Leitch and F. Larry Leistritz. 1996. ***Economic Analysis of Herbicide Control of Leafy Spurge in Rangeland.*** **North Dakota State University, Agricultural Experimental Station, Agricultural Economics Report no. 342. 44 pages.**

This report compares the net returns of leafy spurge control under three different treatment options: no treatment, perimeter treatments, and rangeland renovation. The present value of net returns is calculated for a base scenario of a one-acre leafy spurge infestation spreading at 2.00 feet per year, and for variations of the base scenario using a 4% discount rate and a twenty-year period.

Perimeter treatments result in negative net returns regardless of the weed infestation specifics. Rangeland renovation, in contrast, results in positive net returns for infestations of less than half an acre. However, only rarely does rangeland renovation of infestations of larger than fifty aces, or those with carrying capacities higher than 0.65 acres per AUM, result in positive net returns.

Bangsund, Dean A., Dan J. Nudell, Randall S. Sell, and F. Larry Leistritz. 1999. *Economic Analysis of Controlling Leafy Spurge with Sheep*. North Dakota State University, Agricultural Experimental Station, Agricultural Economics Report no. 431. 119 pages.

A benefit/cost analysis of using sheep to reduce leafy spurge in pastures is modeled in this report. The benefits of using sheep arise from their ability to maintain carrying capacity levels that would otherwise be lost due to leafy spurge infestations. The level of carrying capacity that would be lost without sheep grazing, given various leafy spurge levels, is determined using models developed by Bangsund et al (1996). Sheep are obtained either by setting up a sheep enterprise or by renting sheep on a per month basis. Sheep enterprise costs are obtained from budgets. When sheep are rented, the cost is $1to $2 per ewe per month. The base scenario used in this report is a 350-acre ranch, with 50 or 250 acres infested and grazing losses of 17%, 50%, and 100% (increasing 1.5% annually). Initial carrying capacity is 0.20 AUM per acre or 0.90 AUM per acre. The costs of building a fence to confine the sheep, the debt financing system use to obtain the sheep, the initial carrying capacity of the land, the initial infestation size and percentage infested, and sheep performance levels are varied to determine the benefits and costs for different grazing scenarios.

With a sheep enterprise and under best-case scenarios, the present value of net returns per acre ranges from $90 to $180 over a five-year period and $170 to $340 over a fifteen-year period. Under sheep performance levels significantly worse than best-case scenarios, net returns per acre range from –$50 to $80 over five years and –$85 to $80 over fifteen years. For the sheep rental scenario, there are negative net returns when evaluated over a five-year period. Over a ten-year period, the net returns to leasing sheep become positive only with high initial leafy spurge levels and rangeland carrying capacities.

Coombs, Eric M., Hans Radtke, Dennis L. Isaacson, and Stanley Snyder. 1996. "Economic and Regional Benefits from Biological Control of Tansy Ragwort, *Senecio Jacobaea*, in Oregon." In *International Symposium on Biological Control of Weeds*. VC Moran and JH Hoffmann (eds.) University of Cape Town. Stellenbosch, South Africa. p. 489-494.

This report compares ragwort induced economic losses in Oregon with the cost of a ragwort biological control program. Losses from ragwort include livestock poisonings, lost livestock forage, and money spent on ragwort control. Cattle poisonings consumed 2%-10% of herds in 1974 valued at $3.72 million. Horse poisonings cost $29 thousand in 1974. Ragwort losses in Oregon in 1974, after including lost forage and other control expenses, were approximately $5 million.

Under a joint public/private cost-sharing program, the following insects were released throughout Western Oregon: the cinnabar moth, the ragwort flea beetle and the ragwort seed fly. In 1974, contributions to fund the biological control program were $483 thousand from county, state and federal funds, and $849 thousand from private ranch owners. Using a discount rate of 7%, biological control generates a benefit/cost ratio of 15:1. With a 10% discount rate, the benefit/cost ratio becomes 13:1.

Dewit, Marcia. 2001. " Economic Impact of Invasive Weeds." In *Noxious Weeds* 4, no 1. California Interagency Noxious Weed Coordinating Committee. p. 8-11.

This article uses data from Pimentel et al, 2000, to determine the economic impact of invasive weeds in lakes and streams, agriculture, pastures, lawns, golf courses and gardens. Economic losses from weeds include reduced output and the cost of weed control. In addition, it also estimates the effect of weeds on natural services using over 1,000 estimates from published papers. Natural services are any function the ecosystem provides that generates a human benefit.

The article concludes that invasive weeds in lakes and streams, agriculture, pastures, lawns, golf courses and gardens cost the U.S. $34.1 billion a year. Natural services lost to weeds are valued at $33.3 trillion a year.

Hartmans, Martha A., Hongpei Zhang, and Ed L. Michalson. 1997. *Costs of Yellow Starthiste Management*. Agricultural Experimental Station, University of Idaho, Bulletin 793. 12 pages.

The report compares the costs and benefits of treating yellow starthistle in Idaho. The following treatment options are evaluated: no treatment, annual spraying, or a rangeland renovation program involving spraying and reseeding. Slope elevation, project time and program success rates were varied in the analysis. Depending on the slope elevation, spraying and seeding was done with a tractor, an airplane or a helicopter.

The report finds that the internal rate of return (IRR) under a rangeland renovation program is negative for the first three years of the project, regardless of application method. The IRR improves once the benefits of a rangeland renovation program are spread over the full life of the project. Using a tractor for application, the IRR with treatment ranges from 13.9% over ten years to 17.4% over twenty years. When a helicopter is used, the IRR is lower, but remains favorable at 4% over ten years and 9.4%

over twenty years. Annual spraying had a negative IRR under all conditions, and using all application methods.

Hirsch, Steven A. and Jay A. Leitch. 1996. *The Impact of Knapweed on Montana's Economy.* North Dakota State University, Agricultural Experimental Station, Agricultural Economics Report no. 355. 43 pages.

This report estimates the impact of knapweed generated economic losses in Montana. Direct losses attributed to knapweed include lost grazing potential, reduced wildlife-related recreation, higher levels of soil erosion and reduced water quality. Secondary losses arise from reduced employment, income and expenditures in related economic sectors. Annual direct losses from knapweed in Montana are $11.0 million in grazing, $1.2 million in wildlife, and $1.92 million in soil and water conservation. Adding secondary losses of $28 million results in knapweed losses of $42 million a year.

Jetter, Karen M., Joseph M. DiTomaso, Daniel J. Drake, Karen M. Klonsky, Michael J. Pitcairn, and Daniel A. Sumner. 2003. "Biological Control of Yellow Starthistle." Chapter 15 in *Exotic Pests and Diseases: Biology and Economics for Biosecurity*. Daniel A. Sumner (ed.). Iowa State University Press. Ames, Iowa. p. 225-241.

This chapter examines the costs and benefits of a ten-year public biological control program for yellow starthistle, and estimates how public biological control programs affect the incentives ranchers have to undertake private rangeland restoration programs. The benefits of a public biological control program are calculated as the increase in the land's asset value. Program costs include the net present value of public expenditures to find, test, import, and release biological control agents. The benefits of private rangeland restoration are due to increases in land values from being able to graze a greater number of animal units on a given amount of land. The costs of the private four-year restoration program include weed treatment, reseeding and lost grazing income. With no biological control, weed treatments are for yellow starthistle and all other weeds. When the public biological control program is successful, the cost to ranchers to control yellow starthistle is equal to zero, and ranchers only treat for all other weeds.

Benefits of a biological control program are estimated to range from $40 million-$1.412 billion. Using a discount rate of 7%, a public biological control program must have at least a 21% probability of success at the lower bound benefit level and a 0.60% probability of success at the upper bound benefit level for the expected benefits to equal the expected costs. The private costs of rangeland restoration are greater than the private benefits, even with a successful public biological control program, thus a policy of public subsidies may be needed to encourage ranchers to restore infested land. A successful public biological control program reduces the subsidies needed to encourage private rangeland restoration from $26-$46/acre to $4-$21/acre.

Leitch Jay A., F. Larry Leistritz, and Dean A. Bangsund. 1994. *Economic Effects of Leafy Spurge in the Upper Great Plains: Methods, Models and Results.* North Dakota State University, Agricultural Experimental Station, Agricultural economics report no. 316. 8 pages

In this report, the methods and models used in the authors' previous studies are updated to estimate costs of leafy spurge infestations in the Upper Great Plains in 1993. Both wildland and rangeland impacts due to leafy spurge infestations are calculated .

This report finds that leafy spurge removal in 1993 would generate annual benefits to the Upper Great Plains of $37.1 million in direct livestock sales, $24.3 million in direct production expenditures, and $119 million in both direct and indirect grazing. Adding wildland benefits to the sum results in total leafy spurge removal benefits of $129.5 million a year.

Pimentel David, Lori Lach, Rodolfo Zuniga, and Doug Morrison. 2000. "Environmental and Economic Costs of Non-indigenous Species in the U.S." *Bioscience* 50, no. 1. p. 53-65.

This article addresses the environmental impacts and economic costs of non-indigenous species in the U.S. This is done using previously published estimates. Damages caused by non-indigenous species are based upon total damages caused by both indigenous and non-indigenous species in the U.S., and the percentage of the total species that is non-indigenous.

The report determines that the U.S. spends $137 billion annually fighting non-indigenous species. This includes non-indigenous plants, mammals, birds, reptiles, fish arthropods, mollusks and microbes. The U.S. spends $100 million treating aquatic non-indigenous weeds and incurs $10 million in additional economic damages. The U.S. also spends $26.4 billion on agricultural weeds; $6 billion on pasture weeds, and $1.5 billion on lawn, garden and golf course weed treatment. This results in $34 billion spent or lost annually in the U.S. to non-indigenous weeds.

Rockwell, William H. 2003. *Summary of a Survey of Literature on the Economic Impact of Aquatic Weeds*. Aquatic Ecosystems Restoration Foundation Report. http://www.aquatics.org/pubs/economic_impact.pdf. Accessed 12/2/2003. 18 pages.

This report estimates the benefits and costs of treating invasive aquatic weeds in the U.S. using two different methods. The first method takes the $25 million in weed control costs in Florida and assumes that Florida accounts for between 5% and 20% of total U.S. weed control expenditures. The second method uses the current costs of treating aquatic weeds in the U.S. with chemicals only, assumes that 10%-75% of aquatic weeds are treated chemically, and that chemical treatment is 0.5 to 2 times as effective as other treatments. Using a benefit/cost ratio of 10:1, the report calculates the benefits of treating aquatic weeds in the U.S. as $10 for every $1 in control costs.

Using the first method, the benefits are $250 million for Florida. When Florida accounts for 5% of aquatic weed treatments, the benefits to the U.S. are $1.0 billion. When Florida accounts for 20%, the U.S. benefits are $10 billion. Using the second method, $150-$400 per acre is spent treating inland water surfaces for weeds with chemicals, resulting in total costs of $50-$100 million a year. Weed treatment benefits for the U.S. range from $500 million when 75% of weeds are treated chemically, and other treatments are half as effective as chemical treatment, to $1 billion when 10% of weeds are treated chemically, and other treatments are twice as effective as chemical treatment.

Smith, H. Arlen, Wayne S. Johnson, J.Scott Shonkwiler, and Sherm R. Swanson. 1999. "Implications of Variable or Constant Expansion Rates in Invasive Weed Infestations." ***Weed Science*** **47. p. 62-66.**

The article compares weed control costs using constant as opposed to variable weed patch growth rates. Using 35 weed patch size observations from different times, they specify a weed patch growth rate function. They then use estimated weed treatment costs ($90/acre for herbicide control with 75% effectiveness) and both a constant and variable weed expansion model to determine how the choice of functional form affects weed treatment cost estimates.

Costs are calculated for immediate control and delayed control assuming initial infestation rates of 10 hectares, 100 hectares and1000 hectares, and time periods from 5 years to10 years. For 10 hectare and 100 hectare infestations, the results show that costs increase when treatments are delayed, and when a variable rate expansion path is used.

Thompson, Flint, Larry Leistritz, and Jay Leitch. 1990. ***Economic Impact of Leafy Spurge in North Dakota*****. Agricultural Experimental Station, North Dakota State University. 23 pages.**

This report examines the consequences of leafy spurge on livestock income and related expenditures in North Dakota. It uses developed models to calculate leafy spurge expansion rates in North Dakota and resulting reductions in carrying capacity and estimates the value of lost carrying capacity and reductions in rancher spending due to lower carrying capacities. Secondary impacts of leafy spurge consist of indirect impacts on regional businesses from reductions in carrying capacity and rancher expenditures.

Leafy spurge infestations on North Dakota cause losses of $8.6 million a year in carrying capacity and $14.4 million a year in potential direct rancher spending. Including secondary impacts, leafy spurge results in economic losses of $75 million a year in North Dakota.

Wallace, Nancy M., Jay A. Leitch, F Larry Leistritz. 1992. *Economic Impact of Leafy Spurge on North Dakota Wildland.* Department of Agricultural Economics, North Dakota State University, Agricultural Economics Report no. 281. 23 pages.

This report examines the benefits of controlling leafy spurge on North Dakota wildland. According to this report, wildland is any land not used for industrial, urban, or agricultural purposes. Removing leafy spurge will increase wildlife- related recreational expenditures, and soil and water conservation benefits. Estimates of water and soil conservation benefits from non-infested wildland are taken from the literature on agriculture conservation preserve programs.

In 1990, $2.95 million in potential direct recreational expenditures and $0.7 million in direct water and soil conservation benefits were lost due to leafy spurge infestations. Adding secondary benefits from changes in business activity of $7.4 million, results in leafy spurge losses of $11.0 million a year in North Dakota.

Washington State Noxious Weed Control Committee. 1996. *Economic Analysis: Noxious Weed Control on State Land*. Presented to the Washington State Legislature. 37 pages.

In this report, the total potential costs of noxious weed treatment on state managed land in Washington are estimated. Weed treatment costs are based upon estimates from state agencies and vary depending on land type, infestation severity and extent, and weed treatment method. Costs are calculated for each activity in a weed treatment program: surveying, prevention, controlling new infestations, controlling established infestations, and monitoring past efforts.

Given an annual weed treatment budget of $5.375 million, the Washington State Noxious Weed Control Board determines that about $2.2 million should be spent controlling existing infestations and $12 million for surveying. Controlling new infestations should receive $875 thousand, prevention $859 thousand and monitoring $250 thousand.

Zavaleta, Erika. 2000. "The Economic Value of Controlling an Invasive Shrub." *Ambio.*29, no. 8. p. 462-467.

This article compares the economic benefits and costs of a tamarisk removal program. Economic losses from tamarisk are estimated as the lost benefits of not having approximately 1.4 billion to 3.0 billion m^3 of water a year available for household use, irrigation agriculture, hydroelectric power generation and flood control. The value of household, agricultural, hydrologic and flood losses was $280-$450 ha^{-1} a year for 22 years.

The tamarisk removal program consists of: planning, removal, revegetation, and monitoring activities. This program costs $7,400 ha^{-1} and between 470 thousand to 650 thousand hectares would be treated. With the annual benefits of tamarisk removal accruing forever, and using discount rates from 0-6%, the article estimates that it will take 17-26 years to recover all eradication costs at a 0% discount rate and 16-50 years at a discount rate of 6%.

Zavaleta, Erika. 2000. "Valuing Ecosystems Services Lost to Tamarisk Invasion in the United States." Chapter 12 in *Invasive Species in a Changing World*. H. A. Mooney, Hobbs, R.J. (eds). Island Press, Washington D.C. p. 261-300.

This chapter compares the benefits and costs of treating tamarisk infested land in the U.S. Treating tamarisk generates an extra 1.16 million to 2.41 million acre feet of water available for: household use, agriculture, hydrological power generation, flood control, river recreational activities, wildlife, and ecosystem natural services. This generates benefits of $6,300-$9,700 per acre over 55 years.

These benefits are compared with the costs of a tamarisk removal program consisting of: evaluation, plowing, hand-application of herbicide, revegetation, and monitoring. Such a program costs $3,006 per acre and 1.16 million acres of tamarisk are treated. Evaluated over a period of 55 years, and using discount rates of 0-6%, the benefit/cost ratio is 2.10-3.32 for a 0% discount rate and 1.05-1.63 for a 6% discount rate.