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Economic Impacts from the Effects of Invasive Weeds on Outdoor Recreation: An Input-Output Model

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Summary: The impacts of alien, invasive weeds on the economics of outdoor recreation, and subsequent secondary impacts in other sectors of the economy, are not well understood. The data to estimate such impacts are not collected. We used an input-output analysis here to estimate the economic impacts that invasive weeds have via their effects on outdoor recreation. To reflect underlying uncertainty in the data, we develop a range of estimates using low, medium, and high scenario combinations of various parameter and variable values. In a case study of alien, invasive weeds on public lands in Nevada, we estimate economic impacts from reduced recreation expected ranging from $6 to $12 million per year. Using our most conservative findings for annual economic impacts, we predict that discounted impacts over five years would range from about $30 to $40 million, depending on actual future expansion rates of the invasive weeds.

INTRODUCTION

Smith *et al.*, 1999 demonstrated that terrestrial and aquatic, alien weeds spread

Photo by David Spencer, USDA Exotic & Invasive Weeds Research Unit, Davis, CA

Eurasian watermilfoil interferes with swimming, boating, fishing and other water-associated activities.

rapidly in riparian ecosystems. They interfere with water-based recreation, wildlife viewing, fishing, hunting, and hiking, by affecting water quality and quantity, soil quality, plant diversity, availability of forage and cover, and animal diversity and abundance, including that of fish (Olson, 1999; Madsen, 1997; Newroth, 1985).

Few estimates of overall economic impacts induced by negative effects on recreation due to weeds exist, except analyses that 1) are part of studies on reduced grazing, 2) are focused on weed species that have yielded substantial economic impacts, and 3) are helped by good maps or other data collected for other purposes (Leistritz et al., 1992; Leitch et al., 1996).

Photo by Wayne S Johnson

Perennial pepperweed replaces native riparian plant communities. This displaces large and small game dependent upon the native plants for forage and habitat.

Herein, we deal with the common problem of estimating economic impacts from alien invasive weeds for an area or community when data are scarce or of poor quality and estimates are sought by agencies, commissions, or legislatures to decide how to spend money on invasive weed detection, prevention, and control. For lack of "bottom up" data, we use aggregated state-level data in an input-output analysis using IMPLAN. This approach purposefully acknowledges and reflects uncertainty in the available data by estimating a range of potential economic impacts.

MATERIALS AND METHODS

Data: First, we used available estimates of recreation days per year in Nevada for fishing, hunting, and wildlife watching (U.S. Fish and Wildlife Service, 1996), Table 1.

Second, consumer annual expenditures on recreation in Nevada, year 2000 dollars, are given in Table 2 (U.S. Fish and Wildlife Service, 1996). These data are necessary for our "expenditure-based" approach for measuring impacts from depressed recreation.

Table 1. Recreation days per year in Nevada.[a]

Recreation activity	Recreation days/yr
Hunting	649,000
Fishing	1,976,000
Wildlife viewing	1,394,000
Totals	4,019,000

[a] U.S. Fish and Wildlife Service, 1996.

Third, to estimate infestation rates of alien invasive weeds for this study, we conducted an expert opinion survey of state and federal agency land managers. About 87 percent of Nevada is under federal agency management. The mean response for the percentage of a typical watershed infested was 47 percent. Variability among geographic and management units was significant. To reflect such variability and uncertainty in our estimation techniques, we use "lower" (35 percent) and "higher" (65 percent) estimates for the statewide mean percent infestation rates along with a "middle" estimate of about 50 percent as derived from the survey.

Table 2. Annual recreation expenditures in Nevada (millions of dollars).[a,b]

Activity	Expenditures per year			
	Trip-related	Equipment	Other items	Total
Hunting	$22.8	$74.3	$7.2	$104.2
Fishing	$81.2	$142.1	$8.5	$231.8
Wildlife viewing	$94.6	$184.6	$9.4	$288.6
Totals	$198.6	$401.0	$25.1	$624.6

[a] U. S. Fish and Wildlife Service, 1996.
[b] All values have been updated to June 2000 dollars.

Input-Output Analysis: We developed "lower," "middle" and "higher" estimates of annual economic impacts induced by lost recreation. This reflects uncertainty in the analyses, yields a "bounding exercise," and produces a likely range of potential impacts. Using a Nevada input-output model, we estimate economic losses to the state's economy. Input-output analysis estimates the direct, indirect, and induced change, or "shock," to an economy. We used IMPLAN Pro™ (Impact Analysis for PLANning model) (Anon., 1999) to estimate output and employment impacts caused by alien weed-induced reductions in recreational visitor expenditures. To do this we first developed a range of estimates of reductions in wildlife-based recreational direct expenditures using the following equation:

$$RE = (\eta)(\phi)(CE + RE) \qquad (1)$$

where:

RE = reductions in wildlife-based recreational direct expenditures
η = the rate at which wildlife recreation expenditures are reduced when land is weed infested
ϕ = the fraction of potential recreational lands currently alien weed infested
CE = Current wildlife-based recreational expenditures

Estimates were made for three values (low, middle and high) of η and ϕ, since the values of the parameters are uncertain. Baseline wildlife-related recreation expenditures (CE) are $599.6 million under each scenario and correspond to total recreation expenditures less "expenditures for other items" (approx. $625 million minus $25 million, see Table 2), which are subtracted out because they mostly leave the region. Losses in direct recreation expenditures (Row four) are calculated using equation 1 and the values in Rows one to three of Table 3:

We then estimated the portion of these losses attributable to reductions in recreation spending by out-of-state residents as in-state residents respond to infestations either by a) switching to substitute, noninfested recreation sites or b) diverting spending to other forms of entertainment expenditure within the state. We calculated that 17 percent of the total recreation days in Nevada are by out-of-state visitors. We apply this percentage to the calculated losses in total direct expenditures (Row four) to derive the estimated nonresident direct expenditure losses (Row five). The reductions in nonresident direct expenditures were then broken down specifically into retail trade and service sector purchases at 67 percent

Photo by Wayne S Johnson

Dense stands of saltcedar on the Muddy River preclude all recreational uses of the river. Excess water is lost from the watershed into the air as saltcedar transpires more water than native plants.

and 33 percent, respectively (Table 4). We used this ratio from the Great Plains (Bangsund et al., 1999), because we lacked primary wildlife-associated recreation expenditure data specific to Nevada. Allocating expenditures between these two sectors estimates the regional economic impacts of how the monies from purchases flow throughout the economy and affect regional employment and income. Finally, purchases made from the retail trade sector were

Table 3. Parameters and direct expenditure estimates used as inputs for the expenditure-based (I/O model) loss estimates.

Variable/ parameter	Scenario estimate		
	Lower	Middle	Higher
η	0.12	0.17	0.22
ϕ	0.35	0.50	0.65
CE (expenditures)	$599.6 m	$599.6 m	$599.6 m
RE (direct losses on recreation)	$26.3 m	$55.7 m	$100 m
Estimated nonresident direct losses	$4.47 m	$9.47 m	$17.0 m

margined at 31.8 percent, the average retail mark-up of goods purchased from the Bureau of Census Annual Survey of Retail Trade (U. S. Bureau of the Census, 2000). The margined figure allows only the impacts of the retail trade purchases rather than total purchases, which would overstate the overall impact on the regional economy.

RESULTS AND DISCUSSION

Loss Estimates: Table 4 illustrates estimates from the I/O model of the economic impacts (direct, indirect, and induced) of alien weeds to Nevada's economy using the middle scenario assumptions. The middle estimate is $12.4 million per year. Using the lower and higher scenarios' inputs results in loss estimates of $5.9 million per year and $22.3 million per year, respectively. These results provide reasoned estimates of recreational use losses to invasive weeds in Nevada.

Table 4. Middle scenario estimate of the impacts of a weed-induced reduction in recreational expenditures to Nevada's economy.

Expenditure loss ($ m)	-$9.47	Retail/service sector split ($ m)	Estimated direct impacts ($ m)
Retail trade expenditures	67%	-$6.34	-$2.02
Service expenditures	33%	-$3.13	-$3.13
Retail trade margin	31.8%		
Total impacts	Direct impacts ($ m)	Indirect/ induced impacts ($ m)	Total impacts ($ m)
Industry	-$5.14	-$3.60	-$8.74
Labor income	-$2.33	-$1.32	-$3.65
Employment	-85	-44	-129
Economic	-$7.48	-$4.92	-$12.40

The width of the range of economic losses may be somewhat overstated because the lower (higher) scenarios use all low (high) parameters jointly. Gaps in knowledge lead to these under and over estimations, particularly regarding infestation rates of individual species within particular ecological systems and management schemes, if managed.

Table 5 presents estimates of the discounted present value of future flows of economic losses (foregone benefits). We predict losses for four alternative average

annual rates of expansion for invasive species (5 percent, 10 percent, 15 percent, and 20 percent) over a time horizon of five years. Conservatively, we use the approximate mean of the lower scenario estimates of recreation losses ($5 million per year) to predict foregone benefits over future periods. If any of the other scenario estimates more accurately describe true losses, then our predictions in Table 5 will understate future losses. Conservative estimates of the present value of the future flow of recreation losses range from about $25 million to about $35 million over the next five years. Three points deserve mention. The present value stream of foregone benefits depends upon the average annual expansion rate for invasive species. The longer the future time horizon, the greater the uncertainty regarding future expansion rates will be. Uncertainty in future expansion rates is at least as important as uncertainty in current annual recreation losses. Also, uncertainty regarding the expansion rate easily leads to estimates that differ greatly. Smith et al. (1999) examined the growth rates of a variety of invasive weeds in diverse locations around the western United States and found an average expansion rate of 24 percent per year, with relatively high rates in early years and lower growth rates as an infestation matures. Based on this information, it is likely that the expansion rates in Table 5 are lower than the intrinsic growth rates many Western states will experience without control of alien invasive species. If this is the case, these overall economic impacts herein may be understated.

Table 5. Future flows of wildlife-related recreation losses using the lower scenario annual loss estimate as the starting point, by expansion rate.

Mean annual expansion rate	Present value streams of future recreation losses [a, b]
	T = 5 y
5%	$26 m
10%	$28 m
15%	$31 m
20%	$34 m

[a] Discount rate = 4 percent.

[b] As the starting point for current annual recreation losses, we use the approximate mean of the lower scenario estimates in Table 4 ($5 million per year). For this and other reasons, the present value streams in this table likely understate the true recreation use losses that would accrue over the next five years in the absence of weed management measures.

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Photo by Sue Donaldson

Perennial pepperweed roots break easily. They do not stabilize soils, but increase bank sloughing and soil erosion, which contributes to poor water quality, degraded fish habitat and lost recreational opportunities.

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