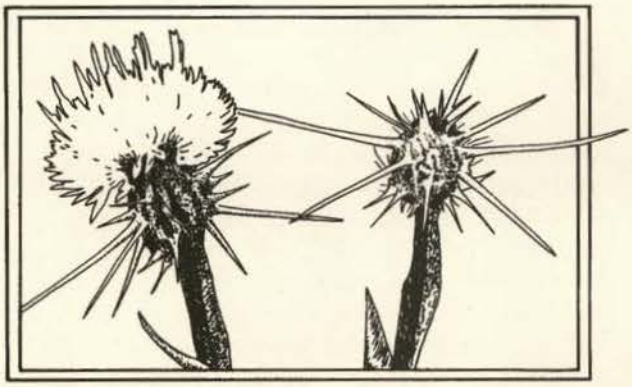

The Costs of Yellow Starthistle Management

Martha A. Hartmans, Hongpei Zhang, and Ed L. Michalson

Summary

Farmers and ranchers perceive yellow starthistle (*Centaurea solstitialis*, L.) as the most serious rangeland weed in northern Idaho. However, the high costs of controlling yellow starthistle and the relative inaccessibility of much of northern Idaho's rangeland make many landowners reluctant to adopt a yellow starthistle management system on their land. This study evaluates the costs and returns of three methods of controlling yellow starthistle, under a variety of rangeland slope conditions. Rangeland renovation for controlling yellow starthistle was profitable only on rangeland accessible to a tractor. On rangeland too steep for standard tractor operation, where aerial treatment of yellow starthistle was necessary, rangeland renovation was not profitable without some form of subsidy, either from other enterprises on the farm or from some government or public agency.

Introduction

University of Idaho field surveys show that yellow starthistle (*Centaurea solstitialis*, L.) has invaded Idaho lands at the rate of about 6,000 acres per year since 1981 and now infests more than 500,000 acres of land in the state. The largest infestations are in Clearwater, Idaho, Latah, Lewis and Nez Perce counties (Callihan et al., 1989), but areas of southern Idaho are also affected.

Yellow starthistle forms dense stands that reduce forage production and interfere with grazing. It crowds out valuable rangeland grasses and robs them of necessary plant nutrients, moisture, and light. In its mature stage, yellow starthistle's nutritional value is below the general requirements for most grazing animals.

A 1989 survey indicated that yellow starthistle was perceived by ranchers as the most serious rangeland weed problem in northern Idaho. Most north Idaho ranchers surveyed said the severity of yellow starthistle infestations had increased significantly in past years (Carlson, et al., 1989).

The spread of yellow starthistle has stimulated a great deal of interest in control methods. Farmers and ranchers ranked expense as one of the major reasons for lack of control of yellow starthistle. They were concerned about whether an investment in the weed control program is worthwhile. In the 1989 survey, 80 percent of ranchers surveyed indicated they were unwilling to pay more than $20.00 per acre to control yellow starthistle, regardless of the control method. This was true even if the control program resulted in more forage than before the program (Carlson, et al., 1989).

Knowledge about the cost of and production from different control treatments can help farmers and ranchers choose among alternative weed control programs. By developing and analyzing budgets and using the internal rate of return (IRR) of the investment as a decision-making criterion, farmers and ranchers should be better able to choose between different investments in range improvement.

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If the IRR of a weed control option is too low, ranchers would be reluctant to adopt it. Thus, the weed problem would get worse and the rangeland would lose productivity and aesthetic value. This implies fewer tax revenues and the added burden to society of managing those lands. In this situation, a subsidized yellow starthistle control program would be justified.

Three alternative management systems (no control, annual spraying, and rangeland renovation) for controlling yellow starthistle were analyzed and the costs and returns for each system compared. The economic feasibility analysis included calculating the IRR of the investment in range improvement. A sensitivity analysis was also conducted for range renovation in terms of different renovation lifetimes, and the feasibility of particular weed control programs was examined. Where weed control programs were not economically feasible, the necessary subsidy was estimated. The objectives were:

(1) To develop enterprise budgets for selected management treatments controlling yellow starthistle; and

(2) To determine the economic feasibility of controlling yellow starthistle by these control methods.

Methods

The livestock budget generating software program, LBUDGET (Stodick et al, 1996) was used to create enterprise budgets for different methods of controlling yellow starthistle. A base or reference model budget was calculated for a cow-calf operation on private range representative of northern Idaho canyonland. Budgets incorporating the costs for different weed control treatments or programs were compared to this reference model. Three yellow starthistle management systems were considered: 1) no treatment; 2) spraying annually with 2, 4-D (0.75 lb. a.i./A) to kill yellow starthistle; and 3) renovating infested land by spraying with Tordon 22K (0.38 lb. a.i./acre of picloram) and reseeding with a range grass mix. The annual spraying treatment and the rangeland renovation system were considered for tractor application (land < 30 percent slope), airplane application (land < 40 percent slope) and helicopter application (land > 40 percent slope). These weed control systems were selected as representative examples of how different treatments can be used to control yellow starthistle.

Several assumptions were made for this analysis. First, the study assumes a base acreage of 3,500 acres of deeded summer range which, if uninfested with yellow starthistle, has a carrying capacity of 2 acres per animal unit month (AUM). This base acreage provides seven months grazing for 250 head of cattle. Second, the study assumes that additional rangeland is available to rent in sufficient quantities when needed, for the different treatment systems. The rented land has a carrying capacity of 2 acres per AUM and a rental cost of $10.40 per AUM ($5.20 per acre). Third, if left untreated (no treatment), the productivity of the rangeland is reduced to 17 acres per AUM. Fourth, the annual spraying treatment raises rangeland productivity to 4 acres per AUM. This assumes that some yellow starthistle escapes or is unaffected by the 2,4-D treatment. Furthermore, the treatment must be applied at least once every year. Fifth, under the renovation system, the 3,500 base acres are not grazed for three seasons (usable productivity is zero) or until new grass is established. After that time, the productivity of the base acreage is totally restored to 2 acres per AUM and, except for minor spot treatments, will have a lifetime of several years. Finally, to simplify calculation of transportation costs in budgets for the different treatments, the study assumes a distance of 100 miles from the base acreage to rented rangeland. An interest rate of 10 percent is used for calculating the investment cost for treatments and when calculating the IRR for each treatment.

Analysis and findings

Costs for range improvement

Table 1 shows the productivity of rangeland under each of the three management systems, excluding rented land. Productivity or carrying capacity for land under each of the three treatment systems was based on data provided by the USDA Natural Resources Conservation Service (NRCS) (Cornwell, 1996). According to its productivity, the additional acreage needed to support 250 animal units under each system was calculated.

The base budget (Appendix A) prepared for a 250-head cow-calf operation presented the average costs and returns per animal unit on rangeland without infestation of yellow starthistle. A total of 3,500 acres of uninfested land were required to support 250 cows with seven months grazing. Gross receipts from production were $419.57 per animal,

Table 1 Productivity and land requirements per animal unit for three management systems (after treatment) on 3,500 acres of yellow starthistle infested rangeland.

System	Productivity[a] (acres/AUM)	Annual grazing duration (month)	Annual need (@2acre/AUM) (acres/AU/yr)	Unmet need (@2acre/AUM) (acres/AU)
No treatment	17	0.825	14.0	12.35
After spraying	4	3.500	14.0	7.00
After renovation	2	7.000	14.0	0.00

a Cornwell, 1996.

and the total variable cost is $277.73 per head.

It was assumed the rancher has only 3,500 acres to support 250 animal units for seven months grazing. When rangeland productivity is reduced by yellow starthistle infestation, the rancher is forced to rent land to provide sufficient grazing or reduce herd size. Assuming it is possible to rent additional AUMs, the cost of range improvement would have two components. One would be the rental cost of extra land. The other would be the additional variable costs of range improvements required for each system.

a.) Rental cost for each system

The management system involving no treatment and the system involving spraying annually require extra land to support 250 animal units in seven months grazing. The renovation system requires rental of additional land only during the renovation phase, after which the original 3,500 acres is assumed restored to full productivity. Table 2 lists additional land needed after treatment under each weed management system.

Table 2 Land rented annually under each management system after treatment.

Management system	Total acreage owned (acres)	Utilization of land (250 head) (acres/AU)	Grazing time owned land (months)	Grazing time rented land (months)	Acreage to be rented annual (@2ac/AUM) (acres)
No treatment	3,500	26.4	0.825	6.175	3,087.75
Annual spraying	3,500	21.0	3.50	3.50	1,750.00
Renovating					
Year 1	3,500	26.4	0.825	6.175	3,087.75
Year 2	3,500	28.0	0.00	7.00	3,500.00
Year 3	3,500	14.0	3.50	3.50	1,750.00
After	3,500	14.0	7.00	0.00	0.00
Base	3,500	14.0	7.00	0.00	0.00

Assuming that rented land is not infested with yellow starthistle, the carrying capacity is 2 acres/AUM. The rental cost for additional land was assumed to be $10.40 per AUM or $5.20 per acre. Under the management system employing no treatment, the rancher requires rental of 3087.75 acres of uninfested land. Total land rent was calculated to be $16,055.31 or $64.22 per animal unit. The spraying system requires rental of 1,750 acres of uninfested land. Total land rent was $9,100.00 or $36.40 per animal unit (Table 3). Assuming the land rental cost remains the same for the three years of the renovation phase, total rental cost for rangeland renovation would be $43,356.30. Cost per animal unit in year one of the renovation would be $64.22. Cost per animal unit in second year would be $72.80 and in third year would be $36.40. However, to determine the true rental cost per animal unit for the renovation system, total rental cost must be amortized over expected lifetimes of the renovation.

Table 3 The annual rental cost per AU under each management system.

Management system	Grazing time (month)	Rental time (month)	Rental cost ($/AUM)	Rental cost ($/AU)
No treatment	0.825	6.175	$10.40	$64.22
Spraying	3.500	3.500	$10.40	$36.40
Renovating				
Year 1	0.825	6.175	$10.40	$64.22
Year 2	0.000	7.000	$10.40	$72.80
Year 3	3.500	3.500	$10.40	$36.40
After	7.000	0.000	$ 0.00	$ 0.00

b.) Variable cost for spraying

The chemical proposed for the spraying management system in Zhang's (1993) study was 2,4-D , applied at the rate of 1.5 pints per acre. The retail price of 2,4-D is $4.30 per quart ($2.15 per pint). Thus, the cost for chemicals is $3.23 per acre. The estimated cost for tractor, sprayer, and labor is $3.49 per acre. Assuming the tractor could negotiate the entire 3,500 acres, the total annual variable cost for spraying 3,500 acres of yellow starthistle infested rangeland with a tractor-drawn sprayer is $23,520 ($6.72 per acre) or $94.08 per head.

c.) Variable cost of renovating

The procedure for rangeland renovation includes spraying Tordon 22K (picloram) in spring of the first year (yellow starthistle plants in the rosette stage) and seeding in late fall of the first year or early spring of the second year. Grazing would resume in the second half of the third year after new grass was well established and each year thereafter. Cost of range renovation includes costs for spraying, seeding, and for renting alternative rangeland, as well as the opportunity cost of not grazing for approximately two and one half years.

The herbicide proposed for the rangeland renovation system was Tordon (Zhang, 1993). The average amount of Tordon 22K used in north-central Idaho is 1.5 pints of per acre, which provides 0.38 pounds per acre of picloram (Callihan, 1996). The retail price of Tordon 22K is $98.75 per gallon ($12.34 per pint). The equipment and labor cost for applying Tordon 22K with a tractor-drawn sprayer is approximately $3.49 per acre. The total cost of spraying in the renovation system is $22.25 per acre.

A mixture of grasses, consisting of intermediate wheatgrass, tall wheatgrass, and sheep fescue, was recommended for use in rangeland renovation (Northam and Callihan, 1988; Prather et al., 1988). The cost of this seed mixture is $1.775/lb. ($14.20 per acre) for certified seed. The estimated tractor, fuel, and labor costs for seeding the grass mixture with a grain drill is $10.95 per acre. The total cost for seeding in the rangeland renovation system is $25.15 per acre.

There is also a cost (interest) for capital invested in the renovation system during the years when no grazing is done on the renovated land. Using an interest rate of 10 percent, the calculated costs for the first three years of the renovation were:

Year 1, spraying
$22.25 (1 + 10%) = $24.48
Year 2, seeding
$24.48 (10%) + $25.15 + (1 + 10%) = $30.11
Year 3, establishment
$24.48(5%) + $30.11(5%) = $2.73

Therefore, the cost of renovation is $57.32 per acre. The total cost for spraying and reseeding the entire 3,500 acres of rangeland, using a tractor-drawn sprayer and grain drill, is estimated to be $200,620.00 or $802.48 per head. At 2 acres per AUM (for renovated rangeland), the cost for renovating was $114.64 per AUM.

A capital cost would also be associated with the rental of additional rangeland on which to graze cattle while renovation takes place. Using an interest rate of 10 percent, the capital costs of renting acreage during the renovation are:

Year 1: 3087.75 acres @ $5.20 per acre
= $16056.30 (10%) = $1605.63
Year 2: 3500.00 acres @ $5.20 per acre
= $18200.00 (10%) = $1820.00
+ $1605.63 (10%) = $1980.56
Year 3: 1750.00 acres @ $5.20 per acre
= $ 9100.00 (5%) = $455 + $1605.63
(5%) + $1980.56 (5%) = $643.31

The cash outlay for renting land during the renovation is $43,355.31 and the interest or capital cost for renting land during the renovation is $4220.50. The total cost of renting during renovation is $47,575.81. The average cost per head for land rental was $190.30.

d.) Opportunity cost for rangeland renovation

Rangeland is only minimally grazed during the renovation treatment—in the early spring of the first year and the autumn of the third year of treatment. Thus, the rancher would incur an economic cost from keeping the renovated rangeland out of production (not grazing) for most of those three years. With value of rangeland at $10.40 per AUM and assuming a 10 percent interest rate for the investment, the opportunity costs for renovation would be:

Year 1: Rangeland grazed part of one month so no opportunity cost.
Year 2: $10.40 0.875 = $9.10 per AUM for 0.875 months grazing = $9.10.
Year 3: With grazing allowed in the second half of third year, no opportunity cost was accounted. However, interest cost for second year is $0.91.

Total opportunity cost for the renovation is $9.10 + $0.91 = $10.01.

Summarizing the above analysis, the estimated actual total cost for the renovation was $802.48 per

head. These costs occur during the first three years of the renovation, while benefits (reduced weed population and restored rangeland productivity) are expected to occur over a future time period. When the total costs of renovation are amortized, at 10 percent interest, over 10, 15, and 20-year expected lifetimes, the annual costs of treatment for rangeland renovation are $112.97, $97.85, and $90.34 per animal unit, respectively. The annual (amortized) cost for land rental during the renovation process are $28.20, $24.43, and $22.55, for renovations with 10, 15, and 20 year lifetimes, respectively.

The results for three management systems

The preceding cost calculations for different treatments assumed the use of a wheel tractor with sprayer for herbicide application and a grain drill for seeding. This application method is considered appropriate for most rangeland with less than 30 percent slopes. However, a considerable amount of North Idaho rangeland has a slope greater than 30 percent, and much of that rangeland is not accessible by tractor. Therefore, the same calculations were made for treatments applied by fixed-wing airplane (canyon land with slopes less than 40 percent) and by helicopter (steep narrow canyons with slopes exceeding 40 percent).

Chemical application rates are the same for aerial application as for ground (tractor) application. Seeding rates are increased to 24 lb./acre to assure good grass coverage when seed is not incorporated in the soil (NOTE: University of Idaho researchers do not recommend aerial broadcast seeding unless the seed can be subsequently incorporated into the soil. Callihan (1996) suggests confining livestock to the broadcast-seeded area, at a stocking rate of twenty or more animal units per day, for one day following aerial seeding. In fall, winter, or early spring, the movement or activity of the livestock incorporates enough seed into the moist soil to produce a healthy stand of grass).

The cost for custom application by fixed wing aircraft was $5.33 per acre for herbicide spraying (Withers, et al. 1996) and an estimated $4.00 per acre for seeding. Cost for helicopter application is estimated to be $10.00 per acre for herbicides and $8.00 per acre for aerial seeding (Valley Helicopter, 1996).

Tables 4, 5, and 6 compare the cost of the three treatment systems using the tractor application

Table 4 Total annual cost per head for each management system, using a tractor, sprayer, and grain drill (Rangeland with less than 30 percent slope).

System	Rental cost ($/AU)	Range improvement cost ($/AU)	Total cost ($/AU)
No treatment	$64.00	$ 0.00	$ 64.00
Annual spraying	$36.00	$ 94.00	$130.00
Renovating			
10 years	$28.00	$ 113.00	$141.00
15 years	$24.00	$ 98.00	$122.00
20 years	$23.00	$ 90.00	$113.00

Table 5 Total annual cost per head for each management system, using aerial application by fixed wing aircraft (Rangeland with less than 40 percent slope).

System	Rental cost ($/AU)	Range improvement cost ($/AU)	Total cost ($/AU)
No treatment	$64.00	$ 0.00	$ 64.00
Annual spraying	$36.00	$120.00	$156.00
Renovating			
10 years	$28.00	$166.00	$194.00
15 years	$24.00	$144.00	$168.00
20 years	$23.00	$133.00	$156.00

Table 6 Total annual cost per head for each management system, using aerial application by helicopter (Rangeland with greater than 40 percent slope).

System	Rental cost ($/AU)	Range improvement cost ($/AU)	Total cost ($/AU)
No treatment	$64.00	$ 0.00	$ 64.00
Annual spraying	$36.00	$185.00	$221.00
Renovating			
10 years	$28.00	$187.00	$215.00
15 years	$24.00	$162.00	$186.00
20 years	$23.00	$149.00	$172.00

Table 7 Average gross annual income and renovation cost per AU for different treatments and treatment methods.

Lifetime	Gross income	Variable renovation costs			Income above variable costs		
		tractor	airplane	helicopter	tractor	airplane	helicopter
(years)	($/AU)	($/AU)	($/AU)	($/AU)	($/AU)	($/AU)	($/AU)
Years 1-3	$420	$621	$738	$782	($201)	($319)	($362)
10 years	$420	$278	$278	$278	$142	$142	$142
15 years	$420	$278	$278	$278	$142	$142	$142
20 years	$420	$278	$278	$278	$142	$142	$142

Table 8 Weighted average annual income and cost per AU for renovation over different periods for different treatment methods.

Lifetime	Weighed average income	Weighed average variable cost		
		tractor	airplane	helicopter
(years)	($/AU)	($/AU)	($/AU)	($/AU)
10 years	$420	$357	$384	$394
15 years	$420	$335	$354	$362
20 years	$420	$322	$338	$343

method, fixed wing aerial application, and helicopter aerial application, respectively.

Budgets were generated to determine the costs and returns for each management system for controlling yellow starthistle. In the renovation system, there were two different periods: the spraying and seeding period and the grazing period. During the spraying and seeding period, the cattle were grazing on rented summer range. The variable cost of production for this period was different from the grazing period, requiring two separate budgets for the two periods within the renovation system. A weighted average was used to determine the costs and returns for the renovation system. The results from these budgets and the weighted average of costs and returns for different renovation lifetimes are shown in Tables 7 and 8, respectively.

During the first three years, renovation regardless of the treatment method (Table 7) is unprofitable. However, once these costs are spread over the entire length of the renovation (Table 8), income exceeds variable costs for all treatment methods. Weighted average variable costs for renovation using a tractor ($406/AU) were approximately equal to gross income after 5 years following renovation phase, indicating that the renovation must have a 5-year lifetime (with no further treatment necessary) for the rancher to break even. For renovation using a fixed-wing airplane, the break-even lifetime for rangeland renovation is approximately 7 years (weighted average variable costs equal $416/AU) after renovation treatment is complete. The break-even lifetime for renovation using a helicopter for spraying and seeding was approximately 8 years of grazing (weighted average variable costs equal $415/AU) after treatment.

Budget results for the three management systems and three application methods were compared to the base budget for rangeland with no infestation of yellow starthistle (Table 9). Costs exceeded benefits for annual spraying, so that management system was not considered economically feasible. Renovation treatments with 15 or more years longevity yielded the best net returns among the three systems for controlling yellow starthistle.

Annual income from rangeland without yellow starthistle infestation was estimated at $420 per head. After renovation, income above variable costs was much lower than income for the base budget. Results indicate costs of approximately $45 per animal unit ($142 - $97 = $45) to restore productivity to infested land, by whatever treatment application method was used (Table 10). Additionally, a higher than usual level of management would likely be needed to maintain restored productivity and to avoid reinfestation.

Budget analysis generally proved rangeland renovation to be the most profitable method of controlling yellow starthistle, although the duration of rangeland restoration was critical to its profitability. To determine whether investment in range renovation justifies the cost, the internal rate of return for each renovation was analyzed.

The internal rate of return (IRR) for investment in rangeland renovation is determined by setting the present value of the investment equal to zero and solving for the discount rate that brings about the equality. This was done using the formula:

$$\sum_{t=1}^{n} [(B_t - C_t)/(1+r)^t] = 0$$

Table 9 Budget analysis results for each management system and treatment method.

Management system	Total	Gross lifetime income	Average variable cost			Income above variable cost		
			tractor	airplane	helicopter	tractor	airplane	helicopter
	(years)	($/AU)	($/AU)	($/AU)	($/AU)	($/AU)	($/AU)	($/AU)
Uninfested								
No treatment	1	$420	$278	$278	$278	$142	$142	$142
Infested								
No treatment	1	$420	$392	$392	$392	$ 28	$ 28	$ 28
Spraying	1	$420	$465	$493	$563	($ 45)	($ 73)	($143)
Renovation								
10 years	13	$420	$357	$384	$394	$ 63	$ 36	$ 26
15 years	18	$420	$335	$354	$362	$ 85	$ 65	$ 58
20 years	23	$420	$322	$338	$343	$ 97	$ 82	$ 76

Table 10 Cost per animal unit to restore full rangeland productivity by treatment application method.

Renovation lifetime	Cost per AU for rangeland productivity restoration		
	tractor ($/AU)	airplane ($/AU)	helicopter ($/AU)
10 years	$79	$106	$116
15 years	$57	$ 77	$ 84
20 years	$45	$ 60	$ 66

Table 11 Internal rates of return for rangeland renovationa.

Renovation lifetime	IRR for rangeland renovation		
	tractor (%)	airplane (%)	helicopter (%)
10 years	13.9 %	6.1 %	4.0 %
15 years	16.5 %	9.8 %	8.0 %
20 years	17.4%	11.3 %	9.6 %

a. Calculated using Lotus 123, ver. 4 (Lotus Development Corporation)

where r is the discount rate, n is the number of years of the weed control program, B represents the benefits, C represents the costs, and t is the time in years. Table 11 shows the resulting internal rates of return for renovation of different lifetimes and for different treatment application methods.

The IRR of an investment represents the interest rate at which a project pays back the investment over its lifetime (marginal efficiency of capital). A negative internal rate of return indicates that benefits from a project would never repay the investment cost. An IRR lower than the interest rate of the investment (the opportunity cost of invested capital) indicates that alternative investments would be more profitable.

The IRR for rangeland renovation for all lifetimes and treatment methods were positive, indicating that investment in yellow starthistle management would pay for itself over time. However, the interest rate for this analysis was assumed to be 10 percent. The rangeland renovation done using a tractor had an IRR greater than 10 percent, indicating that renovation by this method would be profitable. Except for the renovation with a 20-year lifetime utilizing a fixed-wing airplane, all renovations requiring aircraft for spraying and seeding indicated internal rates of return less than 10 percent. Investments with IRR less than 10 percent would not be considered profitable. Farmers and ranchers could find more economically feasible alternatives for investment than investment in a yellow starthistle control program.

In general, enterprise budgets and internal rates of return for yellow starthistle management systems indicate that investment in yellow starthistle control would be unattractive from the rancher's viewpoint. Rational farmers and ranchers would be unlikely to invest in a weed management system when more profitable alternatives are available. However, without yellow starthistle control, productivity of rangeland is seriously reduced.

This analysis demonstrates that, except for land that is easily accessible with a tractor, initiation of a yellow starthistle control program on rangeland would be economically infeasible for most individual ranchers under the conditions and by the control methods discussed here. Little progress in controlling yellow starthistle can be expected unless social, as well as economic, considerations are taken into account. Society benefits, in terms of a stable beef supply, from productive, weed-free rangeland. Farm-

ers, ranchers, and other landowners whose land is currently not infested with yellow starthistle would certainly benefit from a program that would reduce its spreading. Therefore, some form of cost-sharing program for controlling yellow starthistle should be considered.

Cost-sharing program for weed control

In this analysis, the direct cost of rangeland renovation (spraying and seeding) on land accessible by tractor was $802.48 per AU or $57.32 per acre. Direct cost of renovation requiring aerial application of seed and herbicides was $1,177.40 per AU ($84.10 per acre) for fixed wing aircraft and $1,325.38 per AU ($94.67 per acre) for helicopter application. Assuming 3500 acres of infested rangeland for this ranching operation, a 100 percent subsidy based on the entire direct cost of renovation would amount to between $200,600 and $332,000. However, since the rancher, as well as society, benefits from a yellow starthistle control program in northern Idaho, a cost-sharing program would be a reasonable alternative. As benefiting parties, both ranchers and society would share the cost for controlling yellow starthistle and maintaining weed-free, productive rangeland.

Typical cost-sharing rates for agricultural programs in northern Idaho range from 50 percent to 75 percent of direct cost. However, even with 75 percent of the cost of rangeland renovation subsidized, many ranchers (especially those with steep rangeland requiring aerial application) would probably still be unwilling to make an investment in yellow starthistle control.

Carlson et al's (1989) study indicated that 80 percent of ranchers surveyed were unwilling to pay more than $20 per acre to control yellow starthistle, even if the control program resulted in more productive rangeland. Depending on the treatment application method, a cost-sharing program covering up to 80 percent of direct costs would be required to reduce the rancher's share to less than $20 per acre (Table 12). With 80 percent of the direct cost subsidized, ranchers would have a much lower initial investment with the same cash flow over the renovation lifetimes. The IRR of the investment would be significantly higher, ranging between 40 percent and 60 percent depending on the renovation method and expected lifetime of the renovation.

It may, however, be unrealistic to expect society to subsidize the ranchers' returns at greater than current interest rates. A more reasonable cost sharing rate would be one that raised the internal rate of return for the renovation to approximately the 10 percent interest rate. In that case, no subsidy would be needed for renovating yellow starthistle infested land that was accessible by tractor, as indicated by

Table 12 Cost per acre paid by subsidy and by rancher for rangeland renovation by various application methods under proportional cost sharing programs.

Cost-sharing rate	Subsidy			Rancher's share		
(%)	tractor ($/acre)	airplane ($/acre)	helicopter ($/acre)	tractor ($/acre)	airplane ($/acre)	helicopter ($/acre)
5 %	$ 2.87	$ 4.20	$ 4.73	$54.45	$79.90	$89.94
10 %	$ 5.73	$ 8.41	$ 9.47	$51.59	$75.69	$85.20
15 %	$ 8.60	$12.62	$14.20	$48.72	$71.48	$80.47
20 %	$11.46	$16.82	$18.93	$45.86	$67.28	$75.74
25 %	$14.33	$21.02	$23.67	$42.99	$63.08	$71.00
30 %	$17.20	$25.23	$28.40	$40.12	$58.87	$66.27
35 %	$20.06	$29.44	$33.13	$37.26	$54.66	$61.54
40 %	$22.93	$33.64	$37.87	$34.39	$50.46	$56.80
45 %	$25.79	$37.84	$42.60	$31.53	$46.26	$52.07
50 %	$28.66	$42.05	$47.34	$28.66	$42.05	$47.33
55 %	$31.53	$46.26	$52.07	$25.79	$37.84	$42.60
60 %	$34.39	$50.46	$56.80	$22.93	$33.64	$37.87
65 %	$37.26	$54.66	$61.54	$20.06	$29.44	$33.13
70 %	$40.12	$58.87	$66.27	$17.20	$25.23	$28.40
75 %	$42.99	$63.08	$71.00	$14.33	$21.02	$23.67
80 %	$45.86	$67.28	$75.74	$11.46	$16.82	$18.93
85 %	$48.72	$71.48	$80.47	$ 8.60	$12.62	$14.20
90 %	$51.59	$75.69	$85.20	$ 5.73	$ 8.41	$ 9.47
95 %	$54.45	$79.90	$89.94	$ 2.87	$ 4.20	$ 4.73

Table 13 Internal rates of return for various cost sharing rates for rangeland renovations of various lifetimes.

Cost Sharing Rate	IRR for rangeland renovation								
	Tractor			Airplane			Helicopter		
	10 year	15 year	20 year	10 year	15 year	20 year	10 year	15 year	20 year
0 %	13.9%	16.5%	17.4%	6.1%	9.8%	11.3%	4.0%	8.0%	9.6%
5 %				7.0%	10.6%	11.9%	4.9%	8.7%	10.3%
10 %				7.9%	11.4%	12.7%	5.7%	9.5%	11.0%
15 %				8.9%	12.3%	13.5%	6.7%	10.3%	11.7%
20 %				10.1%	13.2%	14.4%	7.7%	11.2%	12.5%
25 %							8.9%	12.2%	13.4%
30 %							10.1%	20.7%	21.4%

Table 11. Depending on the expected lifetime of the renovation, a cost sharing rate between 5 percent and 20 percent would be needed to increase the internal rate of return for infested land renovated using fixed wing aircraft to 10 percent. Subsidies between 10 percent and 30 percent would be needed to increase the IRR of renovation treatments done by helicopter. Table 13 lists the internal rates of return for renovations of different lifetimes with various cost-sharing options.

A cost-sharing program decreases the time before the renovation begins to show a profit. Renovations done by tractor and sprayer begin to break even approximately five years after the renovation phase is complete, without a subsidy. With 20 percent of direct costs subsidized by a cost-sharing program, rangeland renovation requiring the use of fixed wing aircraft would break even during the sixth year following the renovation phase (weighted average variable costs equal $409.28 per AU). With a 30 percent cost-sharing program, renovation using a helicopter would also reach the break-even point during the sixth year (weighted average variable costs equal $408.81 per au). The increased economic feasibility and shorter break-even period under a cost sharing program would serve to make a yellow starthistle treatment program more attractive to ranchers.

Summary and conclusions

This study assumed the rancher would need 3500 acres of uninfested rangeland to support 250 head of cattle with seven months' grazing. Yellow starthistle reduces rangeland productivity and ranchers must obtain additional forage to compensate for that reduced productivity.

The costs of three different management systems for controlling yellow starthistle were analyzed - no treatment, annual spraying, and complete rangeland renovation. The renovation treatment consisted of spraying, reseeding, and allowing the establishment of new grass before grazing. Additionally, since not all rangeland in north central Idaho is equally accessible, three different treatment application methods were studied. These included spraying and/or renovating using a tractor on land with less than 30 percent slope, hiring custom application of chemicals and seed using a fixed wing airplane for land with slopes greater than 30 percent and hiring custom application by helicopter for steep canyonland with slopes exceeding 45 percent.

With no treatment, the rancher could obtain needed forage by annually renting rangeland at $10.40 per AUM for 6.125 months (87.5 percent) of the grazing season. The annual spraying treatment required renting rangeland at $10.40 per AUM for 3.5 months (50 percent) of the grazing season. The renovation treatment required renting land for 6.125 months of the first year (spraying), the entire 7.0 months of the second year (seeding and establishment), and 3.5 months of the third year (establishment) before grazing could be resumed on the restored rangeland. Since it was assumed that a rangeland renovation treatment would return the land to full productivity, there was no continuing annual rental charge associated with the renovation system.

Budget analysis showed that all management systems had lower income above variable costs than if land were not infested. Additional variable cost for no treatment was $114.06 per AU, for annual rental of uninfested land and transportation of livestock to and from the rented land. The additional annual variable cost for the spraying system using tractor and sprayer was $156.33 per AU ($182.19 for airplane, $247.57 for helicopter). The total additional variable costs for rangeland renovation were $190.31 per AU for land rental plus $802.48 for treatment using tractor ($1177.40 for airplane, $1325.38 for helicopter). After amortizing the costs of the renovation system for 10, 15, and 20-year lifetimes using a 10 percent interest rate, the total annual additional variable costs per AU

for renovation using the tractor were $141.17, $122.28, and $112.89 respectively ($193.95, $167.99, and $155.09 for airplane; $214.79, $186.03, and $171.75 for helicopter).

Although economically feasible in this study (positive income over variable costs of production), doing nothing to remedy infested rangeland is not the most profitable practice and promotes further infestation. Increased rental costs or lack of available uninfested grazing land to rent would quickly reduce that positive income. Annual spraying had negative income above variable costs, indicating that the treatment was not economically feasible. Rangeland renovation provided positive income over variable costs, and assuming the treated land was returned to full productivity, was also sustainable. Compared to doing nothing, renovation also provided considerably higher returns after 10 years on all but the most inaccessible rangeland (Table 9).

When using a tractor for treatment, the internal rates of return for investment in renovations with 10, 15, and 20-year lifetimes were 13.9 percent, 16.5 percent, and 17.4 percent, respectively. The IRR for renovation using an airplane for custom spraying and seeding were 6.1 percent, 9.8 percent, and 11.3 percent, for lifetimes of 10, 15, and 20 years, respectively. The IRR for 10, 15, and 20 year renovations using custom helicopter service were 4.0 percent, 8.0 percent, and 9.6 percent respectively. Positive IRR indicates that each of the renovation treatments is profitable and will pay for itself over time. However, those treatments with IRRs lower than the assumed 10 percent interest rate of the investment indicate that investment in a weed control program would not be as profitable as investment elsewhere. Ranchers would earn lower returns from the investment in yellow starthistle control than they could earn from alternative investments.

Both enterprise budgeting and IRR analysis showed that most yellow starthistle control treatments studied here were either not economically feasible or were not economically attractive to ranchers. Higher returns to investment could be earned in alternative investments. Yellow starthistle control systems required higher levels of management and could potentially require additional investment to avoid reinfestation with yellow starthistle during the renovation lifetime. To justify the social benefits of a weed control program (more productive rangeland and control of yellow starthistle spread), some form of cost sharing might be necessary.

For renovation treatments, an ideal subsidy from the ranchers viewpoint would be a 100 percent subsidy. For treatments and costs used in this study, this could be as high as $94.67 per acre for the direct costs of treatment. Under a cost-sharing program, ranchers and society would each assume some of the financial burden of the weed control program. A subsidy for 80 percent of the direct cost of treatment would reduce the rancherís costs to below $20.00 per acre, a rate that was acceptable to most area ranchers. However, a subsidy of less than 30 percent of the direct costs of renovation would raise the internal rate of return for all renovation methods to the 10 percent interest rate, the criteria for profitability for an investment.

In summary, grazing on infested land was found to be impractical and unsustainable since the productivity of rangeland is reduced and the rancher would be dependent on annually renting additional rangeland. Of the three management systems considered, rangeland renovation was sustainable, biologically valid, relatively economically efficient, and ecologically necessary to reclaim yellow starthistle infested land. For some treatment methods, the costs of renovation were high and the IRR on the investment in weed control was lower than the interest rate used for the investment. It was not economical for farmers and ranchers with very steep rangeland, acting as individuals, to invest in a weed control program without a some form of cost sharing program. Cost sharing, with approximately 30 percent of the direct cost subsidized, would improve the practicality and feasibility of controlling yellow starthistle.

Limitations of the study

This study assumed that rangeland was restored to its full original productivity after renovation. However, farmers and ranchers face the risk that full productivity would not be restored or that additional

treatments would be needed to maintain productivity. Additional maintenance treatments would increase the overall cost of renovation and reduce the internal rates of return. This implies that a yellow starthistle control program is not only a high-cost, but a high-risk investment.

Information on rangeland productivity (acres per AUM) used for the study is based on broad estimates of productivity for private rangeland in the semi-arid region of north central Idaho. Different productivity estimates would change the calculations of rental land needed for grazing under each of the treatments and therefore, would have a large impact on the costs, returns, and the IRRs of yellow starthistle management systems.

Costs for inputs of production and for chemicals used for treatments that were used to generate the budgets for treatments are average costs for the north Idaho region. Costs will vary in different areas and for different individual producers. Differences in costs would result in different returns and IRRs than those described here. Changes in income (livestock prices) would likewise change the profitability of the management systems studied here, and could result in completely different outcomes.

Additionally, this study assumed that the entire 3500 acres would require treatment and would all be treatable by the same method (tractor, airplane, or helicopter). In actual practice, not all of rangeland would be infested with yellow starthistle and the infested portions may or may not all be treatable by the same method. Furthermore, University of Idaho researchers advise ranchers to place highest priority on renovation of the better portions of their infested rangeland, especially those areas that are accessible to ground equipment, and if possible, to control the spread of yellow starthistle on less accessible land with spot herbicide treatments (Callihan, 1996).

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About the authors Martha Hartmans works as a research associate, Hongpei Zhang is a former graduate student, and Ed L. Michalson is a retired professor. All are with the University of Idaho Department of Agricultural Economics and Rural Sociology.

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Appendix A: Base operating budget (per AU) for cow-calf operation on private range. Cow-calf operation, summer on private range, winter feeding necessary.

Item	Weight each	Unit	Price or cost/unit	Quantity	Value or cost
1. Gross receipts					
Steer Calves	5.40	CWT	86.00	2.42	$208.05
Heifer Calves	4.90	CWT	80.00	1.08	$ 86.24
Aged Bull	16.50	CWT	48.00	0.33	$ 15.84
Cull Cows	11.00	CWT	43.00	1.89	$ 81.36
Cull Replacement Heifer	9.00	CWT	78.00	0.36	$ 28.08
Total					$419.57
2. Variable costs					
Feed Barley		CWT	4.85	0.830	$ 4.03
Alfalfa Grass Hay		Tons	65.00	1.680	$109.20
Alfalfa Grass Hay		Tons	65.00	0.280	$ 18.20
Crop Aftermath		AUMs	9.00	1.220	$ 10.98
Salt		LB	0.06	22.080	$ 1.32
Trucking & Marketing		Head	21.87	1.000	$ 21.87
Vet Medicine		Head	14.40	1.000	$ 14.40
Vehicles (Fuel, Lube, Repair)		Dollars			$ 23.42
Machinery (Fuel, Lube, Repair)		Dollars			$ 9.95
Equipment (Fuel, Lube, Repair)		Dollars			$ 2.35
Housing & Improvements		Dollars			$ 5.69
Hired Labor		Hours	6.25	4.204	$ 26.27
Owner Labor		Hours	6.25	2.780	$ 17.40
Interest on Operating Capital		Dollars	0.100		$ 12.65
Total variable cost					$277.73
3. Income above variable cost					$141.84

NOTE: Values used to generate this budget are average costs, typical in the north Idaho region (Stodick, et al, 1996).

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