Economics of Tall Larkspur Control

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Highlight: Tall larkspur (*Delphinium barbeyi* Huth.) was chemically controlled in the subalpine areas of the Manti Canyon Cattle Grazing Allotment in Central Utah, and the reduction in cattle losses on controlled areas was observed. Without control, an average of 36 mature cattle were lost per year over a 15-year period, and an average of 11 calves were lost per year over an 8-year period. Cost of control ranged from \$15–\$22 per acre of larkspur for the first application, and from \$13–\$17 per acre for the second application. Cattle losses were reduced over 90% in the sprayed pastures. Thus, the estimated annual value for adult cattle saved was \$8,250 and for saved calves it was \$1,200. Internal rates of return ranged from 72.25% to 60%, with the rate dependent upon whether calves saved were included. A return of 10% can be expected from larkspur control if eight to nine cows are saved each year for 10 years.

Larkspur (*Delphinium*) species cause greater economic loss to the range cattle industry than any other group of poisonous plants in the 17 western states (Cronin 1971). Tall larkspur (*Delphinium barbeyi* Huth.), the most poisonous species (Kingsbury 1964), is particularly important on the Wasatch Plateau in central Utah.

In the mid 1950's, a group of ranchers who grazed cattle on the Manti Canyon Allotment, Manti-La Sal National Forest, Utah, requested research on the problem of tall larkspur poisoning. They wanted to know: if the plant could be controlled with herbicides; if cattle deaths could be prevented; and and if tall larkspur control was economical. The Agricultural Economics Department, Utah State University, and the Agricultural Research Service, U.S. Dep. Agr., responded with a joint research effort.

The Manti Canyon Allotment ranges in elevation from 5,800 ft to 10,400 ft. It is divided into three main grazing units according to vegetation type determined by elevation. Most problems involve poisonous plants on the 8,000 acres of the subalpine grazing zone. This pasture unit produces about 2,000 animal unit months (AUM's) of forage, which makes it of major importance to the overall management of the allotment. These 8,000 acres are grazed from about the middle of July until about the first of October. This range is infested with 344 acres of dense, moderate, and sparse patches of tall larkspur. Larkspur occurs throughout the area in low densities along the edges of permanent streams, springs, and seeps (Ellison 1954).

Records have been kept since 1956 on the number of adult cattle presumed killed from tall larkspur poisoning (Table 1); however, not all of these losses were verified as larkspur poisoning by autopsies (Cronin et al. 1976). In the early years of this study (1956–1971), it was assumed that calf losses on the upper allotment were not caused by tall larkspur poisoning. During the 1972 grazing season, however, direct observations showed that calves weighing from 350–500 lb can and occasionally do ingest enough tall larkspur to get a lethal dose (Cronin et al. 1976). Since complete records have not been kept on calf losses on this high elevation pasture, it is impossible to determine the exact magnitude of this larkspur-induced loss.

After several years of research, it was concluded that control sufficient to reduce livestock losses substantially could be accomplished with 2,4,5-T [(2,4,5-trichlorophenoxy)acetic acid] or silvex [2-(2,4,5-trichlorophenoxy)propionic acid] (Cronin and Nielsen 1972; Cronin 1974; Cronin et al. 1976). Control was most effective when the chemicals were applied at the rate of 4 lb acid equivalent per acre each year for two consecutive years. No attempt was made to eradicate the plant on the allotment.

Table 1. A record of the yearly losses of cattle from tall larkspur poisoning on the Manti Canyon Allotment, Utah, 1956–75.

Year	Calves	Mature cattle
1956	12	53
1957	14	58
1958	30	103
1959	15	45
1960	NA[3]	19
1961	NA	17
1962	NA	37
1963	NA	13
1964	NA	13
1965	NA	19
1966	NA	18
1967	NA	22
1968	NA	57
1969	NA	32
1970[2]	NA	34
1971[1]	NA	14
1972	5	14
1973	3	3
1974	2	7
1975	9	32
Total	90	610

[1] First large-scale spray project took place in 1971 on the North Fork unit.
[2] Total cattle losses for the period 1956–1970 were 540 head, with an average loss of 36 head per year.
[3] Not available.

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This is a report on the current status of research involving use of certain chemicals that require registration under the Federal Insecticide, Fungicide, and Rodenticide Act. It does not contain recommendations for the use of such chemicals, nor does it imply that the uses discussed have been registered. All uses of these chemicals must be registered by the appropriate State and Federal agencies before they can be recommended.

Table 2. Actual costs for transportation, application, and herbicides for tall larkspur control on Manti Cattle Allotment, Utah, 1975.

	Cost
Herbicide:	
2,4,5-T (4 lb acid equivalent per gallon) [(2,4,5-trichlorophenoxy)acetic acid]	
Ranch cost bulk rate	$15.00/gallon
Forest Service cost (August, 1974)	$ 7.75/gallon
Labor cost:	
Hired labor	$ 2.50/hour
Permittee labor	$25.00/day
Mileage:	
Pickup truck—to and from allotment, also water carrying	$ 0.12/mile
Pickup—4-wheel drive	$ 5.00/hour

Control efforts were concentrated on the dense patches of larkspur found on snowdrift areas. Treatment of these patches the year after the initial spraying was essential. Larkspur plants that are missed or not completely killed with the first treatment can be treated individually. The 2 years of treatment reduced the probability of new larkspur plant establishment and effectively stopped livestock losses. Natural establishment of a plant community dominated by grasses resulted after the larkspur and other forbs were removed (Cronin and Nielsen 1972). Late-season grazing in the initial treatment year and rest the next year appear to encourage establishment of a grass cover on the treated areas.

Several types of spray equipment were tested. Aircraft spraying was ruled out because of the danger of flying over the terrain. Various types of boomless sprayers proved ineffective. Cost estimates cited later in this paper are based on the use of a spray-rig specifically developed for the project. Two lightweight hoses were mounted on retractable reels. Upright, spring-mounted hose supports helped get the hoses over brush and rocks. The finished sprayer requires 3 persons for efficient operation. A 225–240-ft swath can be sprayed, with the chemicals applied directly to the target plants.

Cost of Tall Larkspur Control

Specific costs cited in this report are based on the Manti Canyon Larkspur Control Project for the summer of 1975. Labor costs are based on rates paid by the Manti Cattleman's Grazing Association in 1975. Mileage and rental on trucks are based on actual costs to the Association. These costs are summarized in Table 2. Cost of the spray-rig is based on data provided in Table 3. Most of the salvage value is in the retractable reels and the pump unit, exclusive of the engine. Chemicals used were provided by the ranchers and the Forest Service. The rancher cost, based on the best bulk rate they could obtain, was $15 per gallon for 4 lb acid equivalent, 2,4,5-T. The Forest Service cost was $7.75 per gallon, based on a purchase from GSA in August of 1974.[1] Two cost estimates per acre of larkspur controlled are, therefore, indicated in Tables 4 and 5.

Based on data from 4 years, 3 acres per hour is the average rate for the first application with this specially designed spray-rig. About 6 hours per day is the average spraying time one can expect. The remainder of the day is spent filling the sprayer, moving from one pasture to another, making repairs, cleaning filters, etc. Thus, 18 acres per day could be sprayed on sites similar to the upper allotment of Manti Canyon.

At the ranchers' cost for the herbicide, spraying cost about $23 per acre of larkspur treated (Table 4). When the Forest Service provided the herbicide and the ranchers provided the labor and equipment, the cost was about $15.50 per acre of larkspur controlled (Table 4).

The second application of herbicide to a given patch of tall larkspur should be made the year following the initial spraying. This application is intended to control the larkspur plants not killed in the first treatment. The same area must be covered and

[1] The 1977 GSA price for 2,4,5-T in 55-gallon drums is $10.30/gallon of 4 lb acid equivalent.

Table 3. Cost of power pump and retractable hoses for larkspur spraying, 1975.

Item	Cost
30-gallon capacity power sprayer	$ 392.00
2 @ retractable reels × 125 ft of hose per reel	782.00
2 @ spray heads, nozzles, and fittings	36.00
Platform and upright hose holders with guides	336.00
	$1,500.00
Estimated salvage value	−500.00
Net cost	$1,000.00
Estimated minimum useful life of spray-rig 750 hrs spray time	
Cost per hr $= \frac{\$1,000}{750 \text{ hrs}}$	$1.33
Repairs and fuel cost per hr	0.20
Interest on investment at 10% annually for 4 years = $600	
Hours required to treat 344 acres of larkspur (twice)—253 hrs*	
Cost per hr $= \frac{\$600}{253 \text{ hrs}}$	2.37
Total cost per hour	$3.90

* This assumes the sprayer could be sold for its remaining value after 4 years.

Table 4. Cost per acre of spraying tall larkspur (first application)—Manti, Utah, 1975.

	Cost
Data Base:	
Average spraying time—3 acres/hour or 20 minutes/acre	
Actual spraying time per day—6 hours/day	
(Other time used to fill sprayer, repairs, etc.)	
3 acres/hour × 6 hours spray time/day = 18 acres/day.	
Labor costs:	
1 permittee	$25.00
2 laborers at $2.50/hour	
2 × $2.50 × 8 hours/day =	40.00
	$65.00
Equipment costs:	
4-wheel drive pickup $5/hour × 8 hours =	$40.00
Sprayer $3.90/hour × 6 hours =	23.40
Water truck and cost of getting crew on job	
45 miles/day on spray truck × $0.12/mile =	5.40
35 miles/day on water truck × $0.12/mile =	4.20
	$73.00
Chemical costs:	
4 lb acid eq/acre = 1 gallon/acre at $15/gallon (Rancher cost) $15× 18 acres	$270.00
4 lb acid eq/acre = 1 gallon/acre at $7.75 (FS cost) $7.75 × 18 acres	139.50
Rancher cost per acre:	
$65 + $73 + $270 = $408 ÷ 18 acres =	$22.67/acre
FS cost per acre:	
$65 + $73 + $139.50 = $277.50 ÷ 18 acres =	$15.42/acre

Table 5. Cost per acre of spraying tall larkspur (second application—1 year after first application)—Manti, Utah, 1975.

	Cost
Basis for calculations:	
Second application required 50%[1] as much herbicide per acre but increased time required per acre by 25%.[2]	
20 minutes/acre × 1.25 = 25 minutes/acre	
360 minutes (6 hours) ÷ 25 minutes/acre = 14.4 acres/day	
Labor costs:	
1 permittee ($25/day)	$25.00
2 laborers at $2.50/hour	40.00
	$65.00
Equipment costs:	
4-wheel drive pickup—$5/hour × 8 hours =	$40.00
Sprayer $3.90/hour × 6 hours =	23.40
Mileage water truck 45 miles × $0.12/mile =	5.40
Mileage spray truck 35 miles × $0.12/mile =	4.20
	$73.00
Chemical costs:	
4 lb acid eq/acre of larkspur—½ gallon/acre at $15/gallon (Rancher cost) $7.50 × 14.4 acres	$108.00
4 lb acid eq/acre of larkspur—½ gallon/acre at $7.75/gallon (FS cost) $3.875 × 14.4 acres	55.80
Rancher cost per acre:	
$65 + $73 + $108 = $246 ÷ 14.4 acres =	$ 17.08/acre
FS cost per acre:	
$65 + $73 + $55.80 = $193.80 ÷ 14.4 acres =	$ 13.46/acre

[1] Density of larkspur reduced, although application is still made at a rate of 4 lb acid per acre to each surviving plant.
[2] Time increased because sprayers must search out small and scattered plants that survived the first spray application.

more time spent finding the small, scattered plants that still survive. On the Manti Allotment, about half the herbicide and 25% more time was required for the second application than for the first. About 14.4 acres per day were sprayed the second year, with an application rate equal to 4 lb acid equivalent. The costs per acre of making the second application are ranchers $17, Forest Service $13 (Table 5).

An estimated 344 acres are infested with tall larkspur on the upper elevations of the Manti Canyon Allotment. Research has indicated that cattle losses can be reduced by about 90% if the dense patches of larkspur are controlled (Table 6, Cronin et al. 1976). Losses without control would have been 52 head on the North Fork Grazing Unit. Actual losses were 3 head; thus, losses were reduced by about 94%.

The total cost of controlling tall larkspur on the high elevation Manti Allotment is estimated below:

1st application: 344 acres × $22 per acre = $7,912
2nd application: 344 acres × $17 per acre = 5,848
Total = $13,760

Benefits from Tall Larkspur Control

The benefits from control of tall larkspur on cattle ranges include not only the value of animals saved from poisoning but also increased management flexibility and increased forage production. Ranchers on the Manti Allotment were reluctant to move cattle onto larkspur ranges when the plants were most palatable and toxic (Williams and Cronin 1963). Thus, they tended to use the lower elevation pastures longer than range readiness on the upper pastures dictated. Control of larkspur on the high-elevation pastures could permit their use earlier in the season and reduce pressure on the lower-elevation pastures. Larkspur control also permitted heavier utilization of the high-elevation pastures during September, which is desirable in a rest-rotation system. It is reasonable to expect that the increased flexibility in range use brought about by control of larkspur could result in increased AUM's for the entire allotment. An increase in efficiency in the use of resources would result through the cattle saved. Cows and calves are fed and cared for almost completely through the production cycle; then a portion of them are lost to these poisonous plants. Thus, all of the inputs expended on these animals are wasted. Also, as larkspur plants were sprayed, they were replaced with high quality forage species. The net effect is an increase in forage produced.

Table 6. Cattle losses from 1971 through 1975 in North Fork Grazing Unit as compared with predicted losses expected without control of larkspur.

Year	Total losses recorded in Manti Canyon Allotment (numbers)	North Fork Grazing Unit[1] Cattle losses with Unit: Actual losses (numbers)	Predicted[2] losses (numbers)	Grazing period in Unit
1971	14	0	7	Sept. (late)
1972	14	3	25	July 15–Aug. 10 (early)
1973	2[3]	0	1	Aug. 10–Sept. 1 (mid-season)
1974	6[4]	0	3	Sept. 1–Oct. 1 (late)
1975	32	0	16	Sept. 1–Oct. 1
Total	68	3	52	

[1] The tall larkspur control program was initiated in the North Fork Grazing Unit in 1969, with small areas of the unit treated each year.
[2] The predicted losses are based on losses that occurred on the remaining, nontreated subalpine grazing units in each of the 5 years.
[3] After these two cattle were poisoned, the herd was moved into the North Fork-Jolly's Hole Grazing Unit to prevent further losses.
[4] Some patches of tall larkspur in the South Fork-Hougard Fork Grazing Unit were treated in 1973, which probably reduced losses for 1974.

Although the benefits of larkspur control are important, only the value of animals saved will be used in this analysis. The other benefits are difficult to measure and land managers and/or ranchers may not agree on their magnitude.

Cattle losses from larkspur poisoning have been reduced by over 90% on the treated areas of the Manti Canyon Allotment. Since the grazing unit that historically had the highest loss was the one treated and used to estimate the effectiveness of control, one might expect an even higher reduction in losses as the other subalpine grazing units are sprayed. Adult cattle losses on this allotment averaged 36 head annually from 1956 through 1970 (Table 1). If the loss reduction on the North Fork-Jolly's Hole Grazing Unit (94%) is applied to the entire larkspur loss area, an expected 33 cows could be saved annually. In addition, calf losses could be reduced. The recorded calf losses for 8 of the 20 years listed in Table 1) averaged 11.25 head per year. A 90% saving would average about 10 calves per year.

The following assumptions are made on the value of cattle lost. First, cows of all ages are equally likely to be poisoned and the long-term (20-year) average value of production breeding cows is $250 per head. Second, steer and heifer calves are equally susceptible to poisoning; they will aveage 400 lb at weaning and have an average value of $30 per cwt. When a rancher loses a calf, regardless of its weight at the time of death, he is losing the opportunity of selling the calf at weaning time.

The expected value of cattle saved each year would, therefore, be:

33 cows × $250 per head = $8,250
10 calves × $120 per head = 1,200
Total = $9,450

Ranchers who run cattle on this allotment must spend $13,760 for larkspur control, and the expected value of animals saved equals $9,450 per year for the effective life of the spraying. What then is the effective life of spraying or, for how may years after spraying can one expect this reduction in losses to persist?

Based on observation, the expected larkspur control should last at least 10 years. Even with an almost immediate reinvasion of larkspur plants, it would take several years before they would be large enough and dense enough to become a significant factor in the grazing by cattle (Holman 1973). Also, research has shown that grasses quickly fill the spaces where larkspur and other forbs have been removed and retard the rate at which larkspur plants reestablish themselves (Cronin 1976).

Cattle occasionally consume tall larkspur after it has been sprayed, even if it looks dry and unpalatable. Because the sprayed plants still retain their poisonous properties (Williams and Cronin 1963), grazing should be deferred on a sprayed area until after a heavy frost. Such late-season grazing, after the first application of herbicide, is critical for the establishment of grasses on the spray site. The grazing action of the cattle scatters the grass seeds and covers some of them with soil. After the second year's spraying, grazing should again be deferred to protect new grass seedlings. If livestock must be completely removed from a grazing unit, nonuse costs[2] should be included in the cost of larkspur control. However, nonuse costs can often be higher than the value of lost animals, so ranchers would probably prefer to manage grazing on the sprayed areas, even if losses are sustained.

The Manti Grazing Allotment has a rotation grazing system that allows the grazing units being rested to be sprayed without a loss of grazing. Such an approach, however, increases the number of years required to control the larkspur. For example, it would take at least 4 years or more to complete the control work if the pastures are sprayed initially the year before they are rested.

Can one afford to spend $13,760 in order to obtain an annual income stream of $9,450 for 10 years? The return of a dollar each year for 10 years is not worth $10 today. Therefore, the income stream expected over these 10 years has to be put in terms of the present. The process by which the flow of future returns are brought to the present is called discounting.

The concept of discounting may be understood easier by working through a simple example. Suppose a project is expected to return $10 per year for 5 years; this amounts to $50. If our discount rate is 5%, this $10 per year for 5 years is only worth $43.29 today. Let's look at this problem in more detail. The present value of $10 for each of the 5 years is given below:

	Present value of $10
1st year	$ 9.52
2nd year	9.07
3rd year	8.64
4th year	8.22
5th year	7.84
	$43.29

If a rancher borrows $10 at 5% interest for 1 year, at the end of the year he will have to pay the $10 plus $.50 interest or $10.50. Most ranchers have experienced this situation where they pay for the use of money. Suppose the rancher has an obligation to pay $10 at the end of 1 year. He wants to know how much money he will have to put in a savings account at 5% interest today in order to have $10 one year from now. He would have to put $9.52 in the bank today. At the end of 1 year he would have $9.52 + .48 interest = $10. Therefore, the present value of $10 1 year from now is $9.52 if the interest rate is 5%.

The above method has the disadvantage of forcing one to select an interest rate or discount rate. In this paper a method will be used that gets around this problem. The discount rate which makes the discounted returns equal to the cost of obtaining the income stream will be computed. The discount rate which makes these two sums equal is known as the "internal rate of return." The decision to invest or not to invest is based on the magnitude of the internal rate of return.

With two simplifying assumptions, the internal rate of return on spraying tall larkspur can be approximated. The first assumption is that all costs occur the same year. The second is that the benefits begin the year after treatment and continue for 10 years. The equation used to compute this return is:

$$I = R \left[\frac{1 - (1+i)^{-n}}{i}\right]$$

where,

I = initial cost of spraying
R = expected annual benefit of spraying (value of cattle saved)
n = number of years that benefits will last
i = internal rate of return.

The unknown in this equation, as applied to spraying larkspur on the Manti Grazing Allotment, is i.

$$\$13,760 = \$9,450 \left[\frac{1 - (1+i)^{-10}}{i}\right]$$

The internal rate of return, i, is equal to 68.68%. This rate is above the cost of capital and should rank high as a use of capital.

If the value of calves saved is not included in the benefits, because the evidence for calves saved is not as conclusive as it is for adult cattle, the internal rate of return then becomes:

$$\$13,760 = \$8,250 \left[\frac{1 - (1+i)^{-10}}{i}\right]$$

i = 59.95%.

A more realistic analysis can be made if we assume that the actual larkspur spraying takes place over a 4-year time period. Under this plan, half the larkspur acreages are sprayed while the other half are grazed. Two years are required to complete the control on each half. However, some grazing is allowed late in the grazing season following the initial application of herbicide. The unsprayed half of the larkspur will receive the initial treatment in year 2 (the third year of the project, Table 7), and the cattle will graze the area that was treated the previous 2 years. Since grazing takes place on an area where the larkspur has been controlled, one would expect losses to be reduced by about 90%; thus, the benefits from spraying start in year 2 (the third year of the project).

The benefits and costs of spraying tall larkspur over a 4-year period with an expected life of 10 years are presented in Table 7. Expected net benefits each year of the project life are discounted separately. Finding a discount rate that makes the sum of the discounted returns equal to the initial investment made in year "0" is the problem. The discount rate that does this is the internal rate of return. In the case used in Table 7, where both cattle and

[2] Nonuse costs are the costs of providing an alternative source of forage while cattle are off the grazing land.

Table 7. Internal rate of return for tall larkspur spraying done over 4 years; cows and calves saved included in benefits.

Year	Cost	Net benefits	Discounted benefits at 72.25% Annual	Accumulated
0[1]	$3,956[2]			
1	2,924[3]	−$2,924	−$1,698	−$1,698
2	3,956	5,494[4]	1,852	154
3	2,924	6,526	1,277	1,431
4	0.0	9,450	1,073	2,504
5	0.0	9,450	623	3,127
6	0.0	9,450	362	3,489
7	0.0	9,450	210	3,699
8	0.0	9,450	122	3,821
9	0.0	9,450	71	3,892
10	0.0	9,450	41	3,933
11[5]	0.0	9,450	24	3,957
Internal rate = 74.5%				

[1] Year "0" is the year the decision is made to spray.
[2] Spray half the area (344 acres ÷ 2 = 172 acres) 172 × $23 = $3,956.
[3] Second application on 172 acres. 172 × $17 = $2,924.
[4] First application on remaining 172 acres, cost $3,956. It is assumed that animals will graze the sprayed areas and the benefits will be $9,450. Net benefits $9,450 − $3,784 = $5,494.
[5] Year "11" used because no benefits assumed in year "1."

Table 8. Internal rate of return for tall larkspur spraying done over 4 years with calf losses excluded in benefits.

Year	Cost	Net benefits	Discounted benefits at 63.5% Annual	Accumulated
0[1]	$3,956[2]			
1	2,924[3]	−$2,924	−$1,788	−$1,788
2	3,956	4,294[4]	1,606	−182
3	2,924	5,326	1,219	1,037
4	0.0	8,250	1,154	2,191
5	0.0	8,250	706	2,897
6	0.0	8,250	432	3,329
7	0.0	8,250	264	3,593
8	0.0	8,250	162	3,755
9	0.0	8,250	99	3,854
10	0.0	8,250	60	3,914
11[5]	0.0	8,250	37	3,951
Internal rate = 65.5%				

[1] Year "0" is the year the decision is made to spray.
[2] Spray half the area (344 acres ÷ 2 = 172 acres) 172 × $23 = $3,956.
[3] Second application on 172 acres. 172 × $17 = $2,924.
[4] First application on remaining 172 acres, cost $3,956. It is assumed that animals will graze the sprayed areas and the benefits will be $8,250. Net benefits $8,250 − $3,956 = $4,294.
[5] Year "11" used because no benefits assumed in year "1."

calves saved are used as benefits, this rate of return is about 72.25%. When calves are not included, the internal rate of return is about 63.5% (Table 8).

All of the internal rates of return computed in this analysis of the economics of tall larkspur control are quite high. If the success of spraying tall larkspur is measured by numbers of animals saved from poisoning as compared to the costs of spraying, one can look at the problem in a different way. Suppose that 10% is acceptable as a reasonable rate of return on an investment in larkspur spraying. If this is the case, only eight to nine cows would have to be saved per year over 10 years to yield the return of 10%. However, results of this research indicate that about 33 cows and 10 calves could be saved annually if 344 acres of larkspur are controlled. This problem can also be analyzed in another way. If the 33-cow estimate is accepted, one could afford to pay $147 per acre to treat the 344 acres of larkspur and still get a 10% return on investment.

Summary

The average loss of mature cattle on the Manti Canyon Cattle Grazing Allotment over a 15-year period was 36 head per year. In addition, average calf losses, based on 8 years of data, were about 11 head per year.

Tall larkspur can be successfully controlled if it is sprayed for two consecutive years with 4 lb acid equivalent of 2,4,5-T [(2,4,5-trichlorophenoxy)acetic acid]. Cost of control ranges from about $15–$22 per acre of larkspur for the first application and from $13–$17 per acre for the second application. The difference in cost for each application is dependent on the cost of the herbicide.

Assuming the higher herbicide costs, it would cost $13,416 to control the 344 acres of tall larkspur on this grazing allotment.

The value of 33 head of adult cattle saved each year was estimated at $8,250. The value of 10 calves was estimated at $1,200 per year. Internal rates of return for this control project ranged from 72.25% to about 60%, depending on the time sequence of control and whether calves saved were included in the analysis. If a 10% return on investment is considered adequate, the project would have been economically feasible if only eight or nine cows were saved each year for 10 years.

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