Economics of Improvement of Western Grazing Land[1]

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Over the past several years economists in the West have attempted, under a regional research project (W-16, Economics of Rangeland Improvement), to evaluate the costs and benefits of range improvement. Analysis of material assembled to date, while by no means conclusive, points up a few relevant considerations and shows some of the main gaps in data and methods.

An economic evaluation of range improvement, traced out through particular practices, can be approached with identical results in either of two ways. From the cost side the particular answer provides a statement that "these costs will be incurred," and from the returns side "that this level of cost would be covered." A basis for decisions about the economic feasibility of rangeland improvement is attained only after the cost and returns sides of the question have been brought together.

Despite the obvious validity of this generalization, a great deal of research relating to rangeland improvement has been done piecemeal. Costs, for example, have been studied frequently without adequate consideration of the intensity of the range improvement practice or costs of alternative practices and usually with inadequate consideration of physical and economic benefits resulting from different kinds and levels of practices. However, in fairness to what has been accomplished it should be emphasized that definitive data on rangeland production are very scarce and difficult to obtain. More will be said about data requirements later.

Background for Range Improvement

Ranchers and public land managers are becoming increasingly interested in range improvement. This interest seems to stem from three basic sources: (a) increasing competition for land, (b) a favorable economic enviroment, and (c) deterioration of significant acreage of the forage resources. The livestock industry in most, if not all, areas is primarily concerned with the feed supply, of which native or improved grasses are the most limiting item.

Many changes in the organization and use of range resources are in evidence. Investments in brush removal, reseeding, adjustments in the timing and rate of forage use, and fertilization are being made at an increasing rate. Investments of this nature are not confined to private sources. Clawson and Held (1957) state that the change from custodial management to intensive management of Federal lands, including investments to increase production, has greatly speeded up since World War II.

Relevant Economic Relationships

Before illustrating some of the results of the economic research on range improvement, let us examine the relevant relationships for economic analysis which are associated with range improvement. In the first place, a relationship exists between improvement practices and the use or uses of the rangeland. Brush control and reseeding may be the best practice for cattle range, whereas deferred grazing and fencing may be the best for watershed or game range purposes.

Secondly, costs of range improvements will vary with the size or scale of the project, the method selected, and the techniques and intensity of the practices. Costs are greater when juniper trees are grubbed by hand than when cabling is used. Costs are greater when all of the trees are killed rather than 90 percent of them. Reseeding in ashes from a brush fire generally is cheaper than in a plowed and prepared seedbed.

Third, the benefits from range improvement, determined by the nature of response, are related to (a) the method of improvement selected, (b) the level or intensity of application of the method, and (c) the type and intensity of utilization. What is done, the methods employed and their intensity, the response that is obtained, and how the improved range is used are the main factors to evaluate in range improvement work.

Emphasis should be placed on time as an economic factor in range improvement. The time between incurring costs and realizing benefits may be one of the big factors. It has a direct cost in terms of interest on the investment and may have substantial indirect costs in terms of deferred income or reorganization of operations while wait-

[1] *Giannini Foundation paper No. 188*

ing for the treated range to be ready for use.

Time and the "timing" of range improvement procedures are important also in evaluating the benefits of range improvement. Additional forage produced by the improvement may be worth a great deal more if available during a season of short feed supply than if available at a season of plentiful feed. This suggests that the benefits from range improvement can be evaluated properly only in the context of the total ranch operation, or, for public lands in the context of social criteria.

If this is true, then a great deal of information other than air dry weight of forage or pounds of beef produced is needed to appraise the benefits of range improvement. To the individual rancher, the size of ranch, accessibility to other rangeland, opportunities for reorganizing livestock and feed management, and many other considerations are involved. To the public land manager, the opportunity to relieve overgrazing, the improvement of game habitat, increased watershed values, and other similar benefits are important. Consequently, evaluation of range improvement simply in terms of weight of forage or pounds of gain on animals under limited grazing conditions usually is not adequate.

Evaluating Costs and Returns

The cost of range improvement to a rancher or public agency is uniquely determined by specific site characteristics, the machinery and related equipment selected, and operational skills. Therefore, an "average cost" of range improvements over a wide area has meaning only within limits. However, costs for representative situations can be used as guides to probable costs provided the resources, the operational sequence, and the cost accounting procedure are fully identified. From these representative situations a rancher can obtain some indication of the level of costs to expect for a given project.

The initial cash costs may not account for the bulk of all costs incurred during the life of the improvement. Other cash and noncash, deferrable and nondeferrable costs must be considered. These include the cost, if any, of deferred grazing, increased tax assessments, increased interest cost because of the timing of the use of credit, and maintenance costs of improvements. A complete analysis of the economics of an improvement program must include all of the associated elements of costs. However each element of cost need not be known precisely before a decision is reached to go ahead with a range improvement program.

Efficiency in doing the work, and risk involved may be very important in the selection of improvement practices and costs incurred. The efficiency of operations in doing such jobs as the removal of brush can depend as much on skill as on selection of equipment. With respect to each purpose and level of achievement close identity among several methods of range improvement may exist. In such instances, it would be a matter of cost indifference which method to select. Less costly methods that are also less efficient in a physical sense will probably later require additional costs because of the need for further renovation.[2]

Risk and/or uncertainty about future events must be taken into account. Failure to get a stand of grass (partial or total), variability in forage response to climatic variations, and price risk with respect to the products produced and factors purchased must be evaluated. Many ranchers may heavily discount expected returns.

Costs of associated practices must also be considered. Fencing may be required to control the grazing on the improved area or to protect it from damage by wildlife. Water may have to be developed on the area before it can be utilized by livestock. Purchases of additional livestock often are required. Therefore, the cost of range improvement may be quite different from the total direct cost of any practice. In fact, in many instances direct costs do not constitute the major portion of total cost.

In developing and carrying out range improvement, the rancher is interested in three types of cost: (a) the average cost for each different method of range improvement as a partial basis for determining relative profitability of alternatives, (b) the added or marginal cost to determine how far he should go with his improvement program by comparing added returns and costs, and (c) the opportunity costs to compare the net return from range improvement with the net return from alternative investments.

To illustrate, let us assume that the cost of preparing a seedbed and seeding an acre of land is constant at $7.50 an acre regardless of the quality of soil, and that the improvement of four different areas of rangeland, each of a different soil

[2] *We are not concluding that any measure of range improvement is perfect or that it can be applied perfectly. The statement merely implies that a better job can be done with some methods than others and that future maintenance cost is in large measure determined by the method which is selected.*

Capital rationing may require that range improvement be undertaken by selected steps or it may require selection of less thorough and less costly methods with renovation cost being paid out of the earning power of the less profitable but nevertheless economically feasible methods.

capability class adds, in order of capability, 100, 80, 60, and 20 pounds of beef per acre to the total beef production. Should any or all of the four areas be improved? When beef is priced at 15 cents, improvement of the first area adds $15 to returns per acre; of the second, $12; of the third, $9; and of the fourth $3 per acre. At a cost of $7.50 (no other costs being considered for the moment) improvement of each acre of the fourth area adds $7.50 to costs but only $3 to returns. It would not be worthwhile to improve the fourth area, at least by the given practice, until the price of beef was greater than 37.5 cents per pound. (Limitations of this type of evaluative procedure are pointed out above.)

The same considerations apply to the problem of level of range improvement, regardless of the inherent capacity of the soil. Let us assume that the best land specified above is class IV land, and that successive increments of range improvement give the same addition per acre to total beef production as in the above example. The increments might be different quantities of the same inputs, such as heavier rates of seed application or better seedbed preparation to kill more of the existing vegetation, or they might be different quantities of such other materials as fertilizer. If the four levels add, in succession, 100, 80, 60, and 20 pounds of beef per acre, and cost respectively $7.50 each, only the first three are profitable.

With beef at 15 cents per pound, the return per dollar of investment in either of the foregoing illustrations are $2.00, $1.60, $1.20, and $0.40 respectively.[3] At this point the rancher should evaluate any other investment opportunities he may have. If he has an opportunity to make a return of $1.25 per dollar of investment in some other investment opportunity, he will improve only the first two areas or will apply only the first two levels of improvement to the single acre of land, unless he has enough capital to undertake both types of investment.

Benefits of range improvement programs are not easily appraised for a number of reasons. Benefits may not take an easily recognizable form. Further, a market value may not exist with which to make ready comparisons between benefits from alternative practices. Rental fees may be available for comparison but rental costs often reflect other than productivity value for livestock production. Grazing fees on public lands are established through administrative procedures and are not a usable measure of economic returns from land.

In the course of estimating the net worth to him of securing a particular kind and quantity of forage, the rancher must compare utilization alternatives as well as the steps that must be taken to create the forage supply. Forage utilization requires that the grass be grazed during the season when it is available and at its particular location. If the cost of equivalent purchased feed is to be used as the basis of determining whether to raise or purchase feed, the appropriate figure for comparison includes the market price of purchased feed plus the cost of hauling and feeding in relation to the cost of producing the same quantity of feed through range improvement. An added consideration is the reliability of securing the amount of feed that is needed from the respective sources. If rental rates are used for comparison, the cost of driving or hauling livestock to rented or leased pasture must be included.

The type of returns which accrue to improvement programs vary in form and timing. The most obvious return is that obtained from range forage use. As indicated, the amount of direct or indirect benefit will depend on the inherent productive capacity of the land site, what improvement program is selected, and how the forage and related products are utilized. The amount and quality of forage may be highly relevant, but are not the sole criteria.

The relevancy of examining the relationship between benefits and costs has already been noted. If capital limitations exist, the rancher may have insufficient funds to obtain the number of animals needed to utilize all of the forage produced. Or, a change in the basic livestock system may be required to take full advantage of the improvement program. The extent to which this can be done will depend on the fixity of resources in their present use and on the amount of capital available.

Additional considerations in estimating costs and benefits in range improvement are introduced by Federal conservation programs. Under terms of the conservation features of agricultural programs, the cost of certain specific practices of range improvement may be shared with the Federal Government. Ranchers participating in any of several conservation programs may get help in financing costs of improvements. Rates of payment vary by State and local areas for approved soil and water conservation practices.

Tax provisions must also be considered in evaluating alternative range improvement programs. All government pay-

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[3] *These comparisons are valid only under the assumption that all inputs in the improvement practice were fully consumed in the one production period. Treatment of residual benefits is included in a subsequent empirical example.*

ments, such as those for approved conservation practices, must be included in gross income. A depreciation deduction may be claimed for any investments which are of a depreciable nature. Tax laws contain a special provision which permits a rancher to deduct as business expenditures, a list of qualified expenditures made for conservation or for the prevention of erosion.

In summary, for each range improvement program a stream of costs will be incurred through time. It is assumed that costs associated with each practice in the program are minimized through selection of least-cost methods to accomplish the desired level of performance. Interdependence usually exists between inputs and their costs in one time period and those in other time periods. The input and cost structure for a given range improvement program on an individual ranch may be generalized as follows:

$$TC = \sum_{i=1}^{m}\left(\sum_{j=1}^{n} q_j p_j\right)_i$$

where: TC = total costs
i = year in the improvement program
j = specific practice
q = input for a specific practice
p = cost of specific input

and where:

$$\left(\sum_{j=1}^{n} q_j p_j\right)_m = f\left[\left(\sum_{j=1}^{n} q_j p_j\right)_{m-1}, \left(\sum_{j=1}^{n} q_j p_j\right)_{m-2}, \ldots\ldots\right]$$

Associated with a range improvement program is a stream of returns accruing through time. It is assumed in estimating returns from the utilization of improved range forage that optimum utilization practices for the available kinds and amounts of forage are approximated. Grazing practices and production are interdependent through time. The output and revenue structure for a given quantity of forage and method of utilization can be expressed as follows:

$$TR = \sum_{k=1}^{r}\left(\sum_{i=1}^{s} q_i p_i\right)_k$$

where: TR = total revenue
i = utilization practices
q = output of a specific utilization practice followed
p = net price of specific utilization practice followed
k = year in utilization program

and where:

$$\left(\sum_{i=1}^{s} q_i p_i\right)_r = f\left[\left(\sum_{i=1}^{s} q_i p_i\right)_{r-1}, \left(\sum_{i=1}^{s} q_i p_i\right)_{r-2}, \ldots\ldots\right]$$

Since costs are incurred and returns accrue over time, allowances must be made for the time element in comparing alternative improvement and utilization programs. This is accomplished by discounting future values to their present worth. Either the cost and income stream can be discounted separately or the net return for each year can be estimated and these net values discounted. The latter method involves less calculation. Present value of future net returns can be determined as follows:

$$PV = \sum_{k=1}^{n} \frac{NR_k}{(1+d)^k}$$

where: PV = present value of future net returns
NR_k = net returns in k^{th} year
d = discount rate

Alternative improvement programs are then compared on the basis of their respective present values of net returns through time.

The foregoing reveals the complex nature of the problem of evaluating range improvement programs. Each major relationship was included in order to indicate clearly the scope and character of the task of a complete economic analysis. While the task is formidable, it is certainly not without hope. The rate of progress will depend in part on the rate at which information concerning essential physical relationships as specified becomes available. Even without complete information, tentative specifications concerning the economic relationships can be formulated in a system of logical hypotheses. These may be developed largely on present observation and experience together with good judgment.

Certainly the range livestock industry has wanted for better information but decisions have been made and will continue to be made by "rules of thumb". That these "rules of thumb" have at least been positively directional is reflected in the economic growth of the western livestock industry. The contention here is that a more systematic expression of relationships will result in better grounds for decisions in spite of the absence of extensive quantitative proof. By the processes of inductive reasoning, the economist must determine to what extent general truths with respect to profitability of range improvement practices can be drawn from particular instances.

The rancher in substance concerns himself with the following questions in range improvement: (a) to what extent and under what conditions forage productive capacity can be profitably increased, (b) the levels above which resource inputs and management practices are no longer profitable, (c) the extent to which labor and capital restrictions and shifts in demand require a shift to a different type livestock production program, and (d) the changes which take place with respect to risk and uncertainty and opportunity cost as use of capital on rangeland increases. The use of credit is likewise an important part of cost. As far as the cost of credit goes, skill in borrowing can materially influence the magnitude of the cost. Essentially two elements are involved: (1) to borrow only so much as is needed at the lowest possible cost and (2) to insure, at the outset of the improvement program, that the required amount of credit can be obtained as it is needed.

Costs of Western Range Improvement

Some progress is being made in evaluating benefits (Caton and Beringer, 1959; Pingrey and Dortignac, 1957). But despite the generalizations made in the preceding sections about evaluating costs and benefits of range improvement most of the work done by economists in recent years in this area has dealt with costs only. Part of the data on costs of range improvement which were developed in contributing projects to regional research project W-16 are summarized below.

Data from studies in two states, Idaho and New Mexico, were selected to illustrate costs of eradicating and reseeding sagebrush rangelands. In New Mexico the costs of mechanical clearing of sagebrush and seeding 5 pounds of crested wheatgrass on national forest sites varied from $6.20 to $8.95 an acre depending on the type of equipment used. Estimated costs incurred by the Bureau of Land Management for clearing and seeding sagebrush to crested wheatgrass on its lands in New Mexico during the period 1948 to 1954 averaged $7.87 per acre. This compares with a cost of $7.57 an acre for seeding native grasses on abandoned or idle cropland. Clearing and seeding costs, where the work was done under contract, during the same period, varied from $4.67 to $8.84 per acre—averaging $6.37. Land clearing and seeding represent two-thirds and seed one-third of the contract cost.

On southern Idaho rangeland, the average cost for mechanical seedbed preparation for typical seedings was $3.61 per acre at 1956 prices, ranging from $1.42 to $11.07. On most seedings, the cost fell between $2.00 and $7.00 per acre with heaviest concentration in the $2.00 to $4.00 range. Variation in cost per acre was due to differences in (a) terrain and soil characteristics; (b) height, size, and density of vegetative cover; (c) type and size of equipment and labor force; (d) size of seeding and (e) the price of the respective inputs.

The average per-acre cost of application of seed was $1.67 in Idaho. Most of these costs fell within the range of $0.50 to $2.00 per acre. The average per-acre cost for seed for selected seedings was $4.15. However, costs of seed ranged from a low of $0.61 per acre to a high of $12.17. The per-acre cost of seed for most seedings fell between $1.50 to $3.00. Crested wheatgrass was the major component of the seed mixture used. Consequently, the cost was materially affected by the price of crested wheat seed and the amount of this seed used.

The average cost for seeding, including the seed, mechanical methods for preparing the seedbed, and seeding was $7.52 per acre. For the majority of seedings, costs fell between $5.00 and $12.00 per acre. A very definite inverse correlation was found between the size of the tract reseeded and cost per acre up to about 3,000 acres.

In addition to costs of mechanical seedbed preparation and associated practices, some data were obtained in Idaho on costs of using fire as a tool for brush clearing. Sample costs per acre for burning averaged $1.69 in 1956 with a range of $0.49 to $5.99 per acre. Size of burn and costs were inversely correlated. (Table 1.)

Labor is a big item of cost in using fire for range improvement. Labor requirements declined from 1.30 hours per acre for a burn of 230 acres to 0.182 hour per acre for a burn of 1,600 acres. Some part of the irregularity in costs per acre is inherent in the characteristic differences from site to site, but part is due to the fact that there is a tendency to add inputs in blocks or complements. Consequently, a surplus in input capacity may exist. Minimum levels of per-acre costs are approached as the full capacities of equipment and labor are utilized.

Table 1. Total Cost and Cost Per Acre for Seedbed Preparation by Burning, Selected Burns in Idaho at 1956 Prices.

Acres	Total Cost	Cost Per Acre
350	$2,096.50	$5.99
515	834.30	1.62
600	2,202.20	3.67
860	404.20	.47
1,300	642.00	.49

Many range seedings, to be successful, must be protected from livestock grazing until ready for use. Fencing to protect seedings in southern Idaho cost $760 per mile on the average for a 4-wire fence. Cost of fencing ranged from a low of $480 per mile to a high of $1,117 per mile. Fencing costs have been estimated to be between $1.00 and $7.00 per acre depending on type of fence, topography, and size of area fenced.

The average initial total cost for clearing and seeding in Nevada (1955 price level) was $7.61 per acre with a range of $0.60 to $9.92 per acre. The average total cost in Oregon ran somewhat higher. Both estimates were derived from limited samples.

Much different costs are incurred in improvement of brush rangeland in the Sierra Nevada foothills and coast ranges in California. Because of greater variation in climatic, soil and topographic conditions, considerably greater variation exists between sites and vegetative conditions. Consequently, a greater variation in costs is encountered. The brush areas of California are cleared primarily by burning in conjunction with mechanical preparation and clearing. The minimum mechanical preparation is the construction of firelines, though mechanical treatment often evtends to the mashing or piling of brush for burning. The presence of trees, some of which may have to be removed by mechanical means, adds materially to the cost. Estimates of per-acre costs for brush removal by fire on California rangelands are:

Size of burn	Fireline Construction	Burning	Total Cost per Acre
80-120 acres	$ .15-.30	$2.10	$2.25-2.40
320-400 acres	.10-.20	1.00	1.10-1.20
700-1,000 acres	.05-.10	.50	.55- .60
1,000 acres and over	.04-.08	.40	.44- .48

These data may be compared to costs of mechanical brush removal of $8.00 to $11.00 an acre depending on the size and density of the brush and many other factors. However, the results obtained are rarely identical and relative costs can be correctly compared only in light of relative returns.

Labor and equipment requirements for using fire as a tool in rangeland improvement are illustrated in Figure 1. As in other situations an inverse correlation exists between size of tract and the inputs required per acre. In this instance, relatively little cost advantage is gained with increasing size if tracts are larger than 400 acres in size, but the per-acre costs mount quite steeply as tracts decrease below 100 acres.

Burning is often an effective method of eradicating brush, but it requires thorough planning for proper control and best results. Reseeding after burning is necessary if there is insufficient understory of desired perennial or annual grasses, if it is desired to change the grass composition, or if the desired grasses are severely damaged by the fire. Proper burning and the management required after burning are the two critical features of this method. Frequently reburns are necessary where the first burn was not effective or where sprouting species were not destroyed.

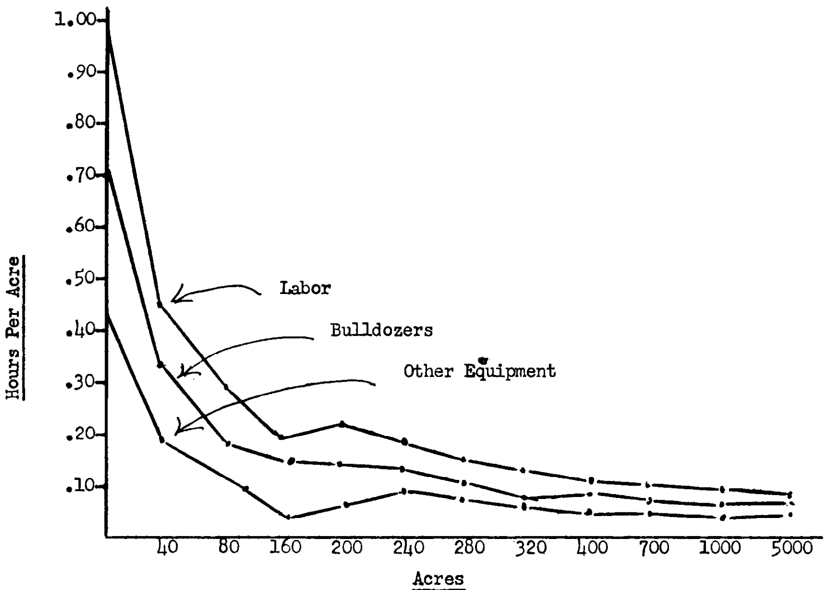
Chemical sprays 2-4-D, 2-4-5-T, and others have been used successfully to control brush and trees for range improvement. New chemicals are being developed and tested. In California the two primary uses of chemical brush control are to kill brush and trees prior to burning and to control brush sprouts and seedlings following initial improvement. In other range types, chemical methods have been used alone and in combination with mechanical treatments and fires. Sufficient data have not been obtained on the costs of chemical methods in the course of the work reported here to permit generalization about it. Bohmont (1954) lists the cost for material and airplane application on sagebrush as $3.00 to $6.00 per acre, with an average of $3.50 to $4.00. Heavier rates of application will, of course, average more cost per acre. Present total costs for spraying brush in California would probably run $8.00 to $10.00 per acre. Topography and method of application are important in determining success of chemical control and its cost.

One of the purposes of this paper has been to point up the need for considering all factors in appraising range improvement practices. Range managers are provided only limited answers by budgets that concentrate strictly on the input or output side of the improvement practice. More complete budgeting that would appraise alternative ranch operations may be required to give adequate information for management decisions.

Evaluation of Alternative Reseeding Programs— An Example

The procedure for evaluation of an investment such as reseeding would be relatively simple if it were not for the presence of uncertainty in determining expected values—yield, price, and life of the stand. Uncertainty exists about the results that are to be expected in each particular situation even though considerable information may be available about the results in similar situations.

Placing a value on reseeding has little usefulness unless it helps answer particular questions. What effect does the investment have on other costs or



a/ Data from report being prepared on Costs and Methods of Clearing California Brushlands.

FIGURE 1. Requirements per acre of labor, bulldozers and other equipment by size of burn in using fire and associated practices for range improvement in California.

operational aspects of the ranch operation? Should this investment be made, or some other investment, or no investment? In the example that follows, no attempt is made to carry the evaluation beyond what could be reasonably expected to be the pounds of beef forthcoming. Comparisons are made between alternative plans. The returns are "net" of the return from unimproved range.

In the following illustration Plan II is Plan I modified primarily through the rate of development. This type of modification was introduced to show the sequence followed by the respective values where the rate of improvement is controlled by a capital restriction.

The returns were determined as follows: (a) the accounting period is twenty years (b) on improved range the gain per head is 1.5 pounds per day in the spring grazing period (May 1-June 15) and 0.5 pound per day during the fall grazing period (September 15-September 30). The comparative gains from unimproved range were estimated to be 1.0 pound and 0.5 pound for the respective periods; (c) the seedings were assumed to reach full capacity at the grazing level specified in the fourth year. That is, they were not grazed the first two years, grazed lightly the third year, and grazed at a level which would maintain the stand from the fourth year through the twentieth year.

The procedure used in this example is to compare the initial investment cost with the sum of the discounted future "net" returns from the investment. The costs associated with two alternative plans for reseeding a 500-acre tract are indicated in Table 2. Under Plan I the entire 500 acres is reseeded the first year; under Plan II 250 acres are cleared and seeded the first year and the remaining 250 acres are cleared and seeded in the third year. Since the capital required in the third year could be employed in other uses, the actual present third year cost is $3,535.27. Costs which may occur, but which are not shown, are: (a) added labor, (b) maintenance cost (spraying), (c) failure to obtain a stand, and (d) water development. Further, fencing may not be required. If this were the case, the initial costs would be materially reduced.

In Table 3 the year-by-year annual returns net of opportunity cost have been discounted at 5 percent. The purpose of discounting is to indicate the present value of future incomes for purposes of comparison. The present value of a dollar to be received 10 years from now is 61 cents at 5 percent rate. Therefore, if a rancher is interested in obtaining one dollar 10 years from now, he may invest 61 cents now, and, with a compound interest rate of 5 percent, at the end of 10 years it will have increased to one dollar. Future income for each of the years, 1 through 20, is given in terms of present value at the time the reseeding cost is incurred (Table 3).

Table 2. Cost of Reseeding a 500-Acre Tract, Under Two Alternative Programs, Sagebrush-Grass Rangeland Reseeded to Crested Wheatgrass.

Cost item	Plan I 500 acres	Plan II 250 acres (2)
	Dollars	
Reseeding cost, year 1[a]	5,025.00	2,512.50
Fencing[b]	3,160.00	2,370.00
Reseeding cost, year 3	....	2,512.50
Fencing, year 3	....	1,580.00
Total cost, year 3 discounted at 5%[c]	....	3,535.27
Total initial cost, year 1 basis	8,185.00	8,417.77

[a] Mechanical clearing $4.25 per acre, seed (crested wheatgrass) and seeding $5.80 per acre, total $10.05 per acre.
[b] Estimated cost $790.00 per mile.
[c] ($4,092.50)/$(1.05)^3$=(4,092.50) (0.86384).

Table 3. Annual Returns, Net of Opportunity Cost For Alternative Reseeding Programs.

	Discounted at 5 Percent			
	Plan I		Plan II	
Year	With beef at 15c per pound	With beef at 20c per pound	With beef at 15c per pound	With beef at 20c per pound
	Dollars			
1	— 374.99	— 499.99	0	0
2	— 357.14	— 476.19	0	0
3	242.96	323.94	48.20	64.27
4	833.11	1,110.81	410.94	547.92
5	793.44	1,057.92	502.44	669.91
6	755.66	1,007.55	755.66	1,007.55
7	719.67	959.56	719.67	959.56
8	685.40	913.87	685.40	913.87
9	652.76	870.35	652.76	870.35
10	621.68	828.90	621.68	828.90
11	592.08	789.43	592.08	789.43
12	563.88	751.85	563.88	751.85
13	537.03	716.04	537.03	716.04
14	511.46	681.95	511.46	681.95
15	487.11	649.47	487.11	649.47
16	463.91	618.54	463.91	618.54
17	441.82	589.09	441.82	589.09
18	420.78	561.04	420.78	561.04
19	400.74	534.32	400.74	534.32
20	381.66	508.87	381.66	508.87
Total	9,373.02	12,497.32	9,197.22	12,262.93

Returns and costs are brought together in Table 4. The profitability estimates have some definite limitations. In the first place, no variation in forage yield was allowed for; but it seems safe to assume that weather variation would affect unimproved and improved range proportionately. Another type of livestock system than the one used could not be expected to give the same results. Some of the variable costs have, in all likelihood, been omitted. At the same time, if the reseeding could be reasonably expected to last longer than the period indicated the additional return would continue to help offset the reduced income at the beginning of the period. And viewed from the over-all ranch operation, the reduced initial income from this particular tract may not be important when the expected total income is considered. These are but a few of the ways of evaluating profitability; there are many other ways.

Evaluation of Research Findings

The extensive nature of range improvement techniques has precluded a thorough study of each technique in the time devoted to the contributing projects under the regional research program on the economics of range improvement. Not all improvement techniques nor all range types have been examined. Adequate economic evaluation of common range improvement practices in all major range types would be an enormous job. Resources available made it necessary to select only sample situations for study.

Of the techniques considered, some were not studied initially because it was soon learned that adequate physical information was not available. Economic studies on chemical control of sagebrush have not been made up to this point; however, Wyoming, a state in which considerable work on chemical control of sagebrush has been done in recent years, is undertaking such a study.

The physical burden of studying a large number of techniques used in each state led to selecting one or two of the practices in use in each state. Some duplication was necessary from state to state because of the dissimilarity of physical and climatic features. Heterogeniety of the physical bases also reduced the applicability of cost and other estimates below that desired.

Despite the large task remaining on the "cost side" of the economics of range improvement, the most formidable task facing economists working in this field lies in the evaluation and analysis of benefits. Some very worthwhile work has been done but much work remains, especially in analysis of range improvements in the total context of range, livestock, and ranch management and in the evaluation

Table 4. Total Returns, Net of Opportunity Cost, Discounted Returns and Rate of Return on Investments, Alternative Plans at Two Different Price Levels.

	Plan I		Plan II	
	With beef at 15c per pound	With beef at 20c per pound	With beef at 15c per pound	With beef at 20c per pound
	Dollars			
Return	23,796.30	31,203.40	22,292.55	29,723.40
Returns discounted at 5 percent	9,373.02	12,497.32	9,197.22	12,262.93
Total costs	8,185.00	8,185.00	8,417.77	8,417.77
Return over costs	1,188.02	4,312.32	779.45	3,845.16
Rate of return on investment	14.5 %	52.7 %	9.3 %	45.7%

of the so-called "nonmarket" benefits of range improvements. Here range technicians and public land agencies can make a very significant contribution.

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