Relationship between Selected Factors and Internal Rate of Return from Sagebrush Removal and Seeding Crested Wheatgrass

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Abstract

One alternative in increasing western range forage production is sagebrush removal and seeding crested wheatgrass. Of primary importance when considering such investments is economic profitability. Using internal rate of return (IRR) as a measure of economic profitability, a range improvement computer budget program (RIBPRO) was used to calculate IRR's for a specific ranch example. Factors associated with high IRR's are a constant forage production function over time, agricultural conservation payments, a 30-year or older stand, approximately 80 ha or more of improved range, low initial user cost/ha, and high additional kg of forage/ha.

Western ranch producers, public range managers, as well as others, recently have shown increasing interest in improving forage production on western private and public rangelands. This is reflected in the public sector by increased legal encouragement with respect to range improvements. In the Taylor Grazing Act of 1934, Sec. 10, the only grazing fee funds specifically directed to range improvement were. . . .

> "25 per centum of all monies collected under Section 15 of this Act during any fiscal year when appropriated by the Congress, shall be available until expended solely for the construction, purchase, or maintenance of range improvements. . ."

Section 15 lands are those acreages administered by the Department of Interior outside grazing districts established by the Taylor Grazing Act. The Federal Land Policy and Management Act of 1976 directed that 50% of the collected grazing fees "be used for on-the-ground range rehabilitation, protection, and improvements. . . . ." Half of these funds is returned to the source (usually the BLM district) and the other half is distributed by the Secretary of the Interior. The Public Rangelands Improvement Act of 1978 authorized additional appropriations for range improvement, giving priority to entering cooperative agreements with range users for building and maintenance of "...on-the-ground range improvements." Recent amendments to that part of the Code of Federal Regulations concerning administration of public lands gives first priority of permanent additional forage to permittee(s) or lessee(s) in proportion to their contribution or efforts which resulted in the additional forage (Code of Federal Regulations 1982). Previously, allocation of additional forage on the basis of quantity of current grazing preferences was listed first in the priorities (Code of Federal Regulations 1981).

Another stimulus to private land managers has come from possible reductions by the Bureau of Land Management (BLM) in grazing preferences and grazing time periods, with the latter reductions being proposed primarily for spring grazing (Paradise-Denio EIS 1981, Tonopah EIS 1980). Expected future decreases in quantity of grain for livestock feed, decreases in amount of available fossil fuels, and increases in world population seem to support arguments for increasing productivity of forage on public lands for livestock (Holechek 1981). In addition, ranch firms continue to experience what is often called the "cost-price" squeeze—the average annual percentage increase in purchased input prices being greater than the average annual percentage increase in output prices (or appearing to be, given that changes in technology may not be accounted for).

Individuals directly or indirectly concerned with western ranching and range production have reacted to the above changes by searching for management alternatives. One alternative is investment in such ranch improvements as big sagebrush *(Artemisia tridentata)* removal and crested wheatgrass *(Agropyron cristatum)* seeding. An immediate question to be answered, however, is that of project profitability relative to alternative investments.

Alternative Investment Criteria

Three capital budgeting criteria generally used in economic evaluation of range improvement projects are present net worth (PNW), benefit-cost ratio (B/C), and internal rate of return (IRR), (Workman 1981). PNW is the sum of the difference between future benefits and costs over the life of an investment project, discounted to the present. B/C is the present value of project benefits divided by the present value of project costs. IRR is that interest rate of discount which will equate the PNW of a project to zero. When investible funds are unlimited, investment projects are acceptable under the alternative criteria if PNW is greater than zero, if B/C is greater than 1, or if IRR is greater than the interest rate cost of project capital and the interest rate that could be earned in an investment that is similar (length of life, initial investment, benefit stream flow, cost stream flow, risk). With unlimited funds, all 3 criteria will accept or reject the same projects, although one potential problem with IRR may be the existence of multiple roots (IRR's) if the annual net income flows are not monotomically increasing or decreasing (Hirshleifer 1970).

Under conditions of limited investible funds or mutually exclusive projects (it is not physically possible to simultaneously undertake all projects), ranking of projects is necessary. Applying the 3 criteria separately, the decision maker would sequentially allocate funds to projects with the highest PNW values, largest B/C ratios, or highest IRR's. Unfortunately, the 3 investment criteria can yield different project rankings if projects differ in terms of initial investment, in expected life, and benefit and cost stream flows. The problem and proposed adjustments to account for these differences are outlined by Mishan (1976) and are illustrated with range improvement projects by Workman (1981). The purpose of the "adjustment" or "normalization" procedure is to give the same,

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and theoretically correct, project rankings from the 3 investment criteria.

IRR: Advantages and Limitations

IRR is used in this study because (1) investors, especially profit maximizers, can compare calculated IRR's with the interest rate of borrowed capital or rates of return expected from alternative investments, (2) it is not necessary in standard IRR calculations to initially choose an interest rate of discount, and (3) the IRR concept is the conceptual equivalent of the annual compound rate of interest used in money markets (Gardner 1963), and thus may be more readily understood by ranchers and other users as a relative measure of investment project desirability than PNW or B/C.

If the project manager's choice is to accept or reject a single investment project using capital borrowed over the life of the project, then IRR is conceptually valid. A project is acceptable if its IRR is greater than the rate of interest on borrowed capital. However, if the manager can select among 2 or more mutually exclusive projects or is in a limited investible funds situation, then "correct" project ranking may avoid "incorrect" project selection decisions. The appropriateness of adjusting or "normalizing" calculated IRR also applies to sensitivity analysis. Unfortunately, to applying the "normalization" procedure means losing some of the advantages of IRR. IRR values calculated in this study are not normalized, and should be interpreted accordingly.

A Computer Investment Evaluation Program

An additional criticism of IRR is that IRR's are not easy to calculate without computers (Randall 1981), and this criticism could be expanded to include computer programs appropriate for given types of investment projects. One computer range improvement budget program (RIBPRO) has been specifically developed to calculate internal rate of return to dollars invested in sagebrush removal and crested wheatgrass seeding (Lucier et al. 1981).

In this computer program sagebrush removal and native grass stand improvement alternatives include spray and seed, plow and seed, and spray only (Fig. 1). Herbicides to kill sagebrush may be applied using aerial spraying or ground spraying. Additional fencing and water development for grazing cattle are also included as optional management activities. To calculate an internal rate of return from all activities anticipated by the user, detailed information (INPUT DATA) must be provided by the user. A minimum number of assumptions are incorporated into RIBPRO. Annual equipment depreciation costs of equipment owned by the land manager are allocated to the range improvement project in proportion to annual hours devoted to this activity.

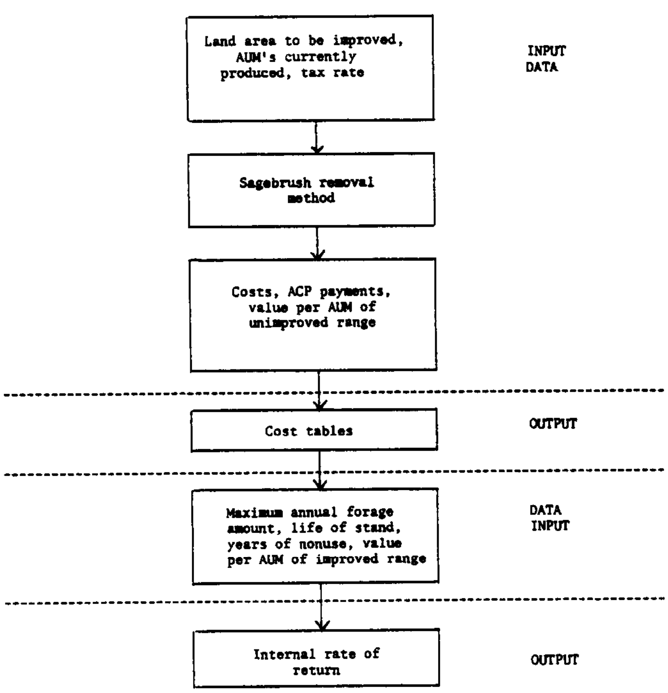

Fig. 1. *Schematic of RIBPRO.*

Application Example

An example with a given set of parameters (Table 1) can best illustrate data input requirements and output results of RIBPRO.

Table 1. Parameters and values used in internal rate of return sensitivity analysis.

Parameter	Value	Units
Area improved	182.1	ha
Area per AUM, unimproved	7.28	ha/AUM
Area per AUM, improved	.84	ha/AUM
Tax rate, unimproved	.311	$/ha
Tax rate, improved	1.04	$/ha
Spray tractor		
Current value	15,000	$
Proportion of life remaining	75	%
Annual use	450	hr.
Annual maintenance and repair costs	675	$
Fuel use	12.1	l/hr.
Fuel cost	.304	$/l
Seeding tractor		
Current value	18,000	$
Proportion of life remaining	90	%
Annual use	385	hr.
Annual maintenance and repair costs	700	$
Fuel use	13.6	l/hr.
Tractor fuel cost	.304	$/l
Sprayer		
Current value	2,000	$
Proportion of life remaining	85	%
Annual use	50	hr.
Annual maintenance and repair costs	120	$
Spray rates	1.295	ha/hr.
Rangeland drill		
Rental cost	850	$
Use rate	1.92	ha/hr.
Seeding rate	6.73	kg/ha
Seed cost	2.49	$/kg
Herbicide		
Cost	3.96	$/l
Application rate	4.68	l/ha
Labor		
Cost	6	$/hr.
Spray time	.52	hr./ha
Seed time	.44	hr./ha
Fencing		
Length	1.6	km
Cost	2,580	$
Annual maintenance cost	45	$
AUM values		
Unimproved	5	$/AUM
Improved	5.35	$/AUM
Forage production		
First-year grazing	448.3	kg/ha
Average harvestable yield over stand life	402.4	kg/ha
Life of stand	30	Years
Non-grazing time	2	Years
Expected inflation rate	8	%
ACP payments	3,500	$

Assume a rancher wants to increase quantity of spring forage available to the ranch operation by increasing the number of deeded acres in crested wheatgrass. The first step is to remove big sagebrush and green rabbitbrush *(Chrysothamnus viscidiflorus)* from 182.1 ha by spraying with low volatile butyl ester of 2,4-dichlorophenoxy acetic acid (2,4-D). The 2,4-D is sprayed at the rate of 4.68 liters/ha in the spring. In the fall of the same year, crested wheatgrass is seeded at the rate of 6.73 kg/ha with a rented standard rangeland drill.

Before improvement, the 182.1 ha produce an average 49.8 kg of consumable forage/ha, or 7.28 ha/animal unit month (AUM), where 362.87 kg of consumable forage is assumed to 1 AUM. As a result of this rangeland investment, average annual consumable forage production during the 30-year life of the crested wheatgrass stand is increased to 402.4 kg/ha (Table 1). Grazing is assumed to start 2 years after the crested wheatgrass is planted, with 448.3 kg/ha of consumable forage available the first year of grazing and 430.4 kg/ha each year thereafter for 27 years.

In this particular situation, no water development on the improved range is undertaken, although 1.6 km of fence is built to improve grazing management. Estimated value of the range in its unimproved state, e.g., rental value minus all management costs, is $5.00/AUM. Given increased forage production, likely increased quality of forage, improved seasonal availability of forage, and increased fencing, the value of improved range is slightly higher at $5.35/AUM. Recall, an AUM is defined as 362.87 kg of consumable forage. In this example, the rancher owns and uses 2 tractors and a ground sprayer in the range improvement investment. A $6.00/hr charge for labor, including owner/operator labor if used, is accounted for in labor cost. In application for decision making, all values provided by the user of RIBPRO are "expected values." Actual per unit costs and returns may be quite different from expected.

Range improvements such as sagebrush removal, crested wheatgrass seeding, and fencing may be eligible for cost-sharing under the U.S. Department of Agriculture, State, and County Agricultural Conservation Programs. Cost sharing maximum percentages for range improvement related practices vary by county (USDA 1981). In this example, the rancher receives $3,500 of Agricultural Conservation Payments (ACP).

Internal rate of return values are calculated assuming a constant rate of inflation over time. All per-unit values of factors and products given by the rancher at the time project costs and returns are estimated are compounded using a selected inflation rate over the 30-year project life. For this example, an inflation rate of 8% is assumed. That is, per unit factor costs and product prices paid or received annually are expected to increase 8% per year until end of the project.

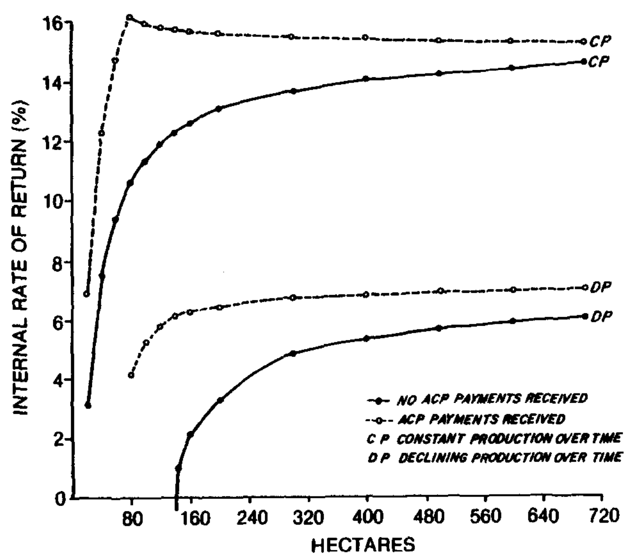

Fig. 2. *Hectares seeded to crested wheatgrass plotted against internal rate of return at constant production and declining production, with and without agricultural conservation payments. (Only items related to improvement size are varied in cost calculations.)*

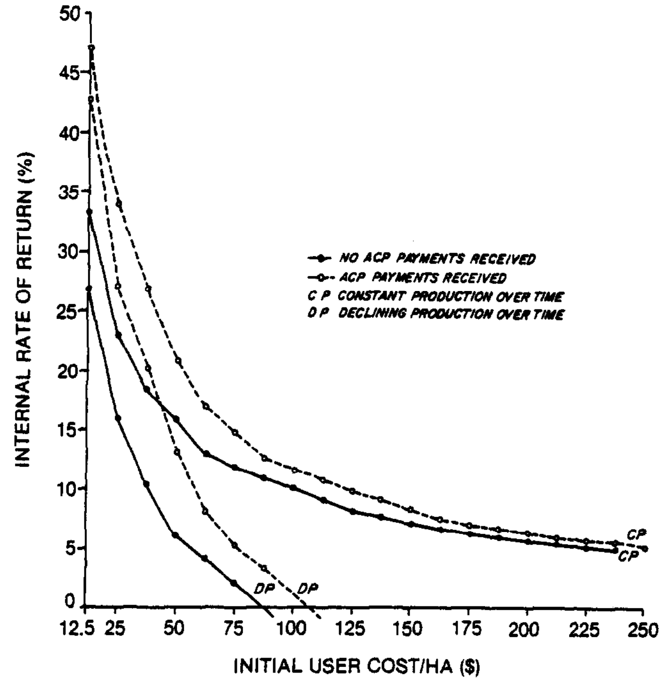

Fig. 3. *Initial cost per hectare for crested wheatgrass seeding plotted against internal rate of return at constant production and declining production, with and without agricultural conservation payments. (Initial user cost is dollar outlay by user in time period zero before any ACP payments are received.)*

If there is a seeding success the first year of planting, the internal rate of return from the investment is 15.6%. In considering whether to undertake this range improvement project, this internal rate of return is to be compared with the interest cost of money for the investment or other ranch or nonranch investment projects with similar initial investment, risk, length of life, and income and cost flows over time.

IRR Sensitivity Analysis

Procedures

IRR is calculated for 2 crested wheatgrass production functions over time and 2 alternative initial cost situations for a given set of sample parameters (Table 2). Two extreme production function alternatives are shown. The constant production function assumes maximum yield the first year of grazing, with 96% of maximum yield each year thereafter for the life of the stand. The declining production function assumes maximum yield the first year of grazing, and a constant percentage decrease in forage quantity such that at the last year of stand life, production is approximately equal to precrested wheatgrass seeding conditions (49.8 kg/ha). Where ACP payments are assumed, the user receives 50% of initial costs, with a $3,500 maximum (Fig. 2-5). IRR is calculated for varying: (1) hectares seeded to crested wheatgrass, (2) initial cost/ha for sagebrush removal and seeding, (3) stand life of the seeding, and (4) forage production first year of grazing.

Results and Discussion

For any given number of hectares and production function, IRR is greater when ACP payments are received (Fig. 2). However, the absolute difference between IRR's for a given production function narrows as hectares increase. For all sizes, IRR associated with a constant production function is greater than IRR from a declining

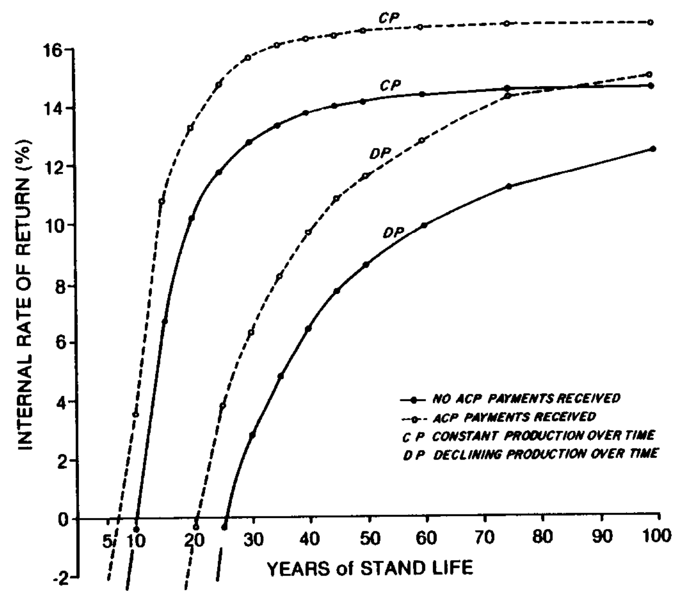

Fig. 4. *Stand life of crested wheatgrass seeding plotted against internal rate of return at constant production and declining production, with and without agricultural conservation payments.*

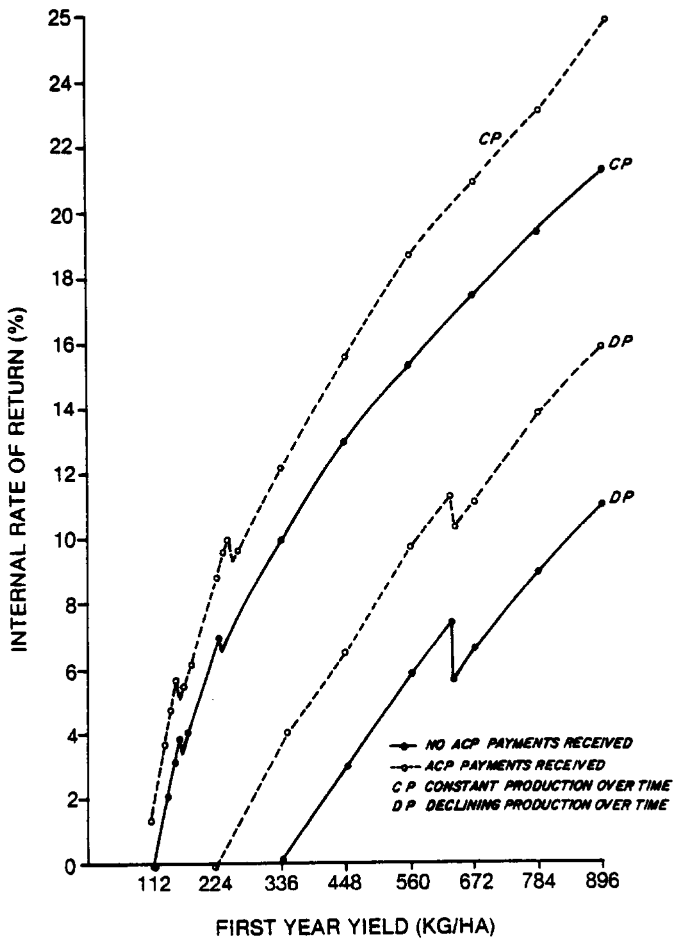

Fig. 5. *Pounds of forage per hectare first year of grazing seeded crested wheatgrass and internal rate of return at constant production and declining production, with and without agricultural conservation payments. (Discontinuous graph portions result from changes in land tax category and hence taxes paid as forage production per acre changes.)*

production. In all 4 cases, the major gains from spreading the fixed costs over more hectares are achieved at relatively small acreages (560 ha or less). In the case of constant production with ACP payments, a maximum IRR is achieved at approximately 80 ha, and the IRR decreases as hectares increase. A factor contributing to the decrease in IRR after reaching a maximum is the increase in initial cost/ha after the $3,500 ACP limit is reached. For any initial user cost/ha, IRR declines as initial dollar investment/ha increases. The rate of decline in IRR is greatest for increases in initial user costs at low cost levels.

For constant production of the wheatgrass stand, IRR does not become positive until approximately 10 years of stand life (Fig. 4). Termination of a constant production function in such a short period would likely be for legal, political, or economic reasons rather than biological. In other words, this situation would occur where initial costs are assumed by a particular user and grazing access by that user is terminated without compensation. The constant production function IRR increases rapidly as years of life increase to approximately 30 to 40 years. The rate of increase in IRR beyond this stand life is small. For the declining production function, IRR continues to increase at a higher rate for longer lived stands.

IRR curves plotted against productivity of the stand are not continuous because of the tax structure assumed in the model (Fig. 5). Lands are assessed in Nevada according to productivity. Breaks in the curves represent a shift to a higher land classification and hence a higher assessment for tax purposes. Unlike increasing hectares of the improvement (Fig. 2) or increasing years of stand life (Fig. 4), the rate of change in IRR does not tend to decrease dramatically at higher levels of forage (holding unimproved forage production level constant). Similar patterns would also be exhibited if dollar value per unit of the improved range (holding dollar value of the unimproved range constant) were used in place of kg/ha. The increase in IRR with increases in kg/ha under declining production function conditions is nearly linear with constant land taxes.

Conclusions and Management Implications

A primary determinant of whether a range investment project should be undertaken is its economic profitability, the weighing of future dollars benefits against future dollar costs. Internal rate of return (IRR) is one investment criterion which can be used to evaluate range investment projects.

A sensitivity analysis of IRR to varying parameters for a representative example range improvement of sagebrush removal and crested wheatgrass seeding yields several general implications. Profitability (IRR) is sensitive to whether crested wheatgrass production is constant or declines over time. The economic advantage of constant over declining production decreases as expected years of stand life increase. Most profitability gains associated with increasing land area are achieved rapidly (up to approximately 250 ha) for improvements with proportions of fixed and variable costs similar to that used in this study. IRR is sensitive to: (1) initial user cost/ha, declining rapidly as cost/ha increases from low levels, and (2) additional first year yield or additional dollar value per unit of improved over unimproved forage.

A subsidy to the investor, e.g., ACP payments, will always increase a given range improvement project's profitability, all else constant, but a specific dollar subsidy does not insure economic acceptability. An investment project is acceptable if the IRR is greater than the interest cost of money borrowed to undertake the project, or is greater than IRR's which can be obtained from similar projects available to the investor.

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