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Economic Analysis of Conservation Practices on Rangeland

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Cover photo: A view from the red-sandstone ridge of the family cattle/sheep ranch located on the north slope of the Uinta Mountains in northeastern Utah. (Photo courtesy of Hal Gordon, NRCS.)

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Economic Analysis of Conservation Practices on Rangeland

Introduction

NRCS offers voluntary technical assistance to ranch owners in managing grazing land resources. The agency's core "product" is a conservation plan that provides a guide to solve natural resource problems on private land. The most successful conservation plans should conserve natural resources and address the landowner's resource concerns while improving ranch viability. Therefore, it is the policy of the NRCS that economic principles are included in all planning and agency resource allocation activities (Title 200, General Manual, Part 400, Subpart A).

The goal of any conservation activity is for benefits to exceed costs. Most landowners want to know the benefits and costs of their conservation plan before they make important land use decisions. Basic "benefit and cost analysis" techniques will be utilized in this technical note and applied to rangeland situations.

This technical note describes the process to determine if a range improvement is "economical" and "financially feasible." It takes effort to collect and organize information to make informed land use decisions. Cost data is relatively easy to obtain from many data sources. However, the monetary benefits from grazing improvement activities are often a challenge to estimate with an acceptable level of reliability. This is especially true on arid rangelands where vegetative changes can take months to occur and last for decades. For example, if a livestock water development is installed in a previously under-grazed site it may take months to see livestock stocking rates or weight gain increase and years to see plant communities' change. In addition, most of the increase in forage availability occur in small increments over many years into the distant future.

This technical note assumes the most significant beneficial effect to the rancher, from implementing a conservation activity, is an increase in forage production and greater livestock production. Increased forage may increase animal gain or allow increased stocking rates. For brevity, only increases in stocking rates are considered in the example that follows. Increases in gains could be addressed using the same methods. Secondary benefits may also include reducing soil erosion, improving water quality, and enhancing wildlife habitat. (These benefits may be important to individuals and in some cases may be monetized. They are not considered in this example but should be identified in the conservation plan.) This technical note was written for use by NRCS State economists, grazing land technical specialists, and field planners working directly with ranchers.

Economic analysis in most natural resource settings are unique in that most costs are incurred the first few years of the project and the benefits may stretch over many years, even decades, into the future. The goal of a grazing improvement plan is for benefits to exceed costs. Benefits and costs can be quantitative and qualitative. If a monetary value cannot be assigned, the physical, environmental, or social benefit (or cost) should be quantified and included in the analysis. Range economic analysis requires the use of several analytical processes that are covered in this technical note and include—

- Nine Steps of Conservation Planning.—The scientific planning process used by NRCS to help clients plan and apply conservation treatments or make land use and treatment decisions: This technical note demonstrates how economics is incorporated into each of the nine steps.
    - Step 1: Identify Problems and Opportunities

- Step 2: Determine Objectives
- Step 3: Inventory Resources
- Step 4: Analyze Resource Data
- Step 5: Formulate Alternatives
- Step 6: Evaluate Alternatives
- Step 7: Make Decisions
- Step 8: Implement the Plan
- Step 9: Evaluate the Plan

- Forage Response Curves.—Graph that describes the time period and magnitude of livestock forage (expressed as a stocking rate per unit of time) that are expected as a result of a conservation practice or activity, where the X-Axis is time and the Y-Axis is forage production.
- Benefit and Cost Analysis.—An economic analysis of an investment alternative in which estimated total costs are compared with estimated total benefits.
- Partial Budgeting.—Used to analyze the change in costs and returns associated with the agricultural enterprise affected by the adoption of proposed alternatives (also called marginal analysis).
- Net Present Value Analysis.—Net present value analysis converts future flows of benefits and costs to the present, thus allowing for comparisons of alternatives on a common time basis.
- Amortization.—Converting a one-time capital cost to periodic payments, given the payment per time period needed to pay off a debt at a given interest rate.

Economic analysis requires four straight-forward steps (as shown below), and can be further expanded, in the pages identified, specifically for range improvement analysis:

(1) Estimate Costs
- Estimate current one-time installation costs (p. 5)
- Estimate future one-time installation costs (p. 7)
- Estimate annual operation, maintenance and replacement costs (p. 8)

(2) Estimate Benefits
- Identify current "benchmark," "without treatment" and "with treatment" forage production over time (p. 10)
- Estimate forage utilization factors and forage value (p. 11)
- Estimate maximum livestock carry capacity (regardless of forage production) (p. 11)
- Calculate difference in forage availability between with and without treatment (p. 12)

(3) Convert Costs and Benefits to "Like Terms" (p. 13)

(4) Compare Costs and Benefits and make an Informed Decision (p. 15)

Example Range Improvement Economic Analysis

The following detailed ranch example demonstrates the basics of doing range improvement economic analysis. The example may be more complicated than what would be typically encountered in the field, but it is used to demonstrate all the concepts and techniques discussed in this paper.

Project, Location and Site Setting

A stocker-steer ranch is in the foothills of the intermountain Western United States and is dominated by cool season perennial grasses and infested with juniper. The grazing allotment is 2,000 acres that is evenly divided by a permanent fence into two paddocks of 1,000 acres each. Livestock water and a trough is in the center of the west paddock, there is no water in the east paddock. A gate in the fence is left open so livestock can graze both the east and west paddocks. The west paddock with livestock water is heavily grazed, currently produces 200 animal unit months (AUMs), and juniper is encroaching creating a downward trend losing 2 percent of forage each year the juniper is not treated. The east paddock is lightly grazed, stable, has minor juniper encroachment, and produces 200 AUMs due to poor livestock distribution.

Figure 1: Intermountain West Case Ranch

Resource Concerns to be Addressed

As a result of fire suppression and over grazing, juniper is encroaching and reducing livestock forage production on the west paddock. The east paddock forage is underutilized because of poor livestock distribution from lack of livestock water.

Ranch Owner's Goals and Objectives

The goals are to increase livestock carrying capacity and create stable sustainable forage supply for the stocker-steer operation, and possibly increase herd size or lease forage to a neighbor.

Range Improvement Alternatives

The grazing specialist has developed three alternatives that include: Juniper control, cross fencing, livestock water development, and grazing management. Each alternative is additive and includes the previous alternative.

<u>Alternative 1</u>
A water development (pipeline, screen, and tank) is installed in the east paddock for $7,000. The water development will last 25 years, but the tank will need to be replaced in 12 years. The bank will lend

money at 6 percent interest rate. The gate between the two paddocks is closed and the two paddocks alternatively grazed. The water development allows an additional 200 AUMs in the east paddock to be grazed that were not being grazed before due to lack of water. The downward trend for the west paddock is stabilized.

Alternative 2 Resource Management System (RMS)
Alternative 1 is implemented plus a cross fence is built in the middle of the west and east paddocks so a four-pasture rotation system can be developed. About two and one-quarter miles of fence are installed for a total cost of $15,000 with a yearly maintenance cost of $150. The trend of the east and west paddock is improving and forage production increases 100 AUMs over 10 years.

Alternative 3 (RMS)
Alternative 2 is implemented plus juniper control on 500 acres for $50 per acre or $25,000. The trend of the west paddock is improving and total forage production increases 100 AUMs over Alternative 2 over 5 years. After year 20 juniper begins to reinvade and decreases forage production 10 AUMS per year each year.

(1) Estimate Cost

Range improvement costs may be one-time installation costs, a one-time cost in a future year, or reoccurring annual costs. Cost data can be organized into nine cost categories:

- Materials.—Materials are inputs used to make, develop, or implement a practice or activity. Examples of materials may include items such as sand, gravel, grass seed, soil amendments, plants, piping, and concrete.
- Equipment.—Equipment is defined as tools, machinery, or similar items needed to implement a practice or activity. Equipment may stay onsite, be used annually, or only used during practice installation. Equipment can be purchased, leased, custom hired, or bartered with a neighbor to perform work.
- Labor.—Labor is the time and wage rate for hiring individuals or self-labor needed to implement the practice or activity. Labor can be described in terms of cost per hour or as a fixed contract price for completion of a particular task. Labor cost is occasionally included in materials or equipment cost. This does not include labor costs associated with operation or maintenance of a practice.
- Mobilization.—The cost of moving equipment, materials, and labor to and from the installed practice/activity site. It may also include site access costs such as a temporary road, bridge, or trail.
- Operation and Maintenance (O&M).—Operation includes the administration, management, and performance of non-maintenance actions needed to keep the completed practice/activity safe and functioning as intended. Maintenance includes work to prevent deterioration of the practice/activity, repairing damage, or replacement of the practice/activity to its original condition if one or more components fail.
    - O&M costs, as utilized in cost data, are annual costs. O&M costs are assumed to be constant throughout the life of the practice or activity. In some cases, O&M is higher the first year (such as brush management and spot treatment of missed plants). In other cases, costs are incurred every several years (such as cleaning out a sediment basin every 3 years). And in other cases, O&M may not be a significant cost until the last few years of

the practice life (such as a water pump). For the purposes of cost data, O&M is assumed to be a constant, annual cost.

- Acquisition of Technical Knowledge.—Cash expenditures to obtain direct technical assistance, over and above what is offered freely from government or private sources. It is the cost to the land manager of acquiring technical knowledge, through personal study or educational course, to operate or manage a practice activity that is "new" to the land user. It may include the cost of hiring a private consultant or specialist to assist in implementing the practice.
- Foregone Income.—The annual net income lost from a change in land use or land taken out of production, or the opportunity cost of accepting less income in exchange for improved resource conditions due to the practice. Foregone income may be a one-time cost during the installation year, or may be an annual cost, such as taking land out of production.
- Risk.—Risk is the probability of loss of income including the cost of uncertainty or the probability of financial loss associated with implementing a practice or activity.
- Administration and Permit Costs.—The costs of completing paperwork, attending meetings, and regulatory management costs of implementing a practice or activity. Permit cost is the cost of obtaining all necessary legal documents to implement the practice or activity.
    - Cost data may be obtained from various data sources including contractors, vendors, agricultural suppliers, conservation partners, external cost databases, Internet data sources, published catalogs, agricultural statistics, cost estimating models or tools, discipline experts, and other reliable sources. The best source of cost data is the landowner. It is recommended that the analyst document the cost data sources in the event the economic analysis needs to be updated in the future.
    - Estimate the improvement's "useful" life based on how long the materials or activity is expected to last or when they are expected to be replaced by newer technology. Typically, this the life of the most expensive or longest-lived improvement component.
    - Finally, select an interest rate and discount rate that is most appropriate for the analysis. The interest rate is what the banker, family, or friend offers the rancher to borrow money. The discount rate is used to evaluate the benefits and costs over time of conservation practices or activities. It is very similar to the interest rate and is the rate by which monetary benefits and costs that accrue in the future are adjusted so that they can be compared with current values. A common discount rate may be a several year average bank loan interest rate.

Current Installation Costs

The water development will be built in the center of the east paddock and will include a pipeline from the existing watering facility in the west paddock, a trough and appurtenances. The water development cost is $7,000. The fence will be built through the center of both east and west paddocks. The fence length is 12,000 feet, the cost $1.25/foot, for a total cost of $15,000. Juniper control will cost $40/acre and 500 acres will be treated for a total cost of $20,000. The local conservation district has a program that pays 75 percent of juniper control costs. The juniper control cost to the producer is $5,000.

Table 1A: Year 1 installation costs

Range Improvement and Lifespan	Alternatives		
	Develop Water	Water and Cross Fence	Water, Fence, and Juniper Control
Develop Livestock Water (25 yr)	$7,000	$7,000	$7,000
Replace trough appurtenances (12 yr)	-	-	-
Grazing Management (1 yr)	-	-	-
Cross-Fencing (25 yr)	-	$15,000	$15,000
Fence Maintenance (1 yr)	-	-	-
Juniper Control (50 yr)	-	-	$5,000
Total	$7,000	$22,000	$27,000

The next step is to convert the one-time installation costs to annualized costs using amortization. Amortization is the process of converting a one-time value to a yearly value (i.e., calculating a loan payment). Four pieces of information are required for amortization: (1) Initial cost, (2) Interest rate (often bank loan rate), (3) Life of the practice or activity (years), and (4) amortization table (or equation). In this example a livestock watering facility will cost $7,000 to install and last 25 years. If the rancher could get a loan from the bank at 6-percent interest, use the 6 percent as the interest rate over the 25-year life of the facility. The amortization factor is .078 (from the amortization table below where the 6-percent interest column intersects with the 25-year row). Multiplying 0.078 by $7,000 results in an annualized cost of $546 per year.

Note: Even though the installed practices may have different lifespans, the annualized costs will be the same regardless if they have to be reinstalled after their useful life (i.e., if the fence is installed every 25 years, four times over 100 years, it will still have the same annualized cost, because the inflation rate is included in, and off-set by, the discount rate).

Figure 2: Amortization table (annualized payment factors) *

LIFE	% INTEREST RATE												
YEARS	3	4	5	6	7	8	9	10	11	12	13	14	15
2	0.523	0.530	0.538	0.545	0.553	0.561	0.568	0.576	0.584	0.592	0.599	0.607	0.615
3	0.354	0.360	0.367	0.374	0.381	0.388	0.395	0.402	0.409	0.416	0.424	0.431	0.438
4	0.269	0.275	0.282	0.289	0.295	0.302	0.309	0.315	0.322	0.329	0.336	0.343	0.350
5	0.218	0.225	0.231	0.237	0.244	0.250	0.257	0.264	0.271	0.277	0.284	0.291	0.298
6	0.185	0.191	0.197	0.203	0.210	0.216	0.223	0.230	0.236	0.243	0.250	0.257	0.264
7	0.161	0.167	0.173	0.179	0.186	0.192	0.199	0.205	0.212	0.219	0.226	0.233	0.240
8	0.142	0.149	0.155	0.161	0.167	0.174	0.181	0.187	0.194	0.201	0.208	0.216	0.223
9	0.128	0.134	0.141	0.147	0.153	0.160	0.167	0.174	0.181	0.188	0.195	0.202	0.210
10	0.117	0.123	0.130	0.136	0.142	0.149	0.156	0.163	0.170	0.177	0.184	0.192	0.199
11	0.108	0.114	0.120	0.127	0.133	0.140	0.147	0.154	0.161	0.168	0.176	0.183	0.191
12	0.100	0.107	0.113	0.119	0.126	0.133	0.140	0.147	0.154	0.161	0.169	0.177	0.184
13	0.094	0.100	0.106	0.113	0.120	0.127	0.134	0.141	0.148	0.156	0.163	0.171	0.179
14	0.089	0.095	0.101	0.108	0.114	0.121	0.128	0.136	0.143	0.151	0.159	0.167	0.175
15	0.084	0.090	0.096	0.103	0.110	0.117	0.124	0.131	0.139	0.147	0.155	0.163	0.171
16	0.080	0.086	0.092	0.099	0.106	0.113	0.120	0.128	0.136	0.143	0.151	0.160	0.168
17	0.076	0.082	0.089	0.095	0.102	0.110	0.117	0.125	0.132	0.140	0.149	0.157	0.165
18	0.073	0.079	0.086	0.092	0.099	0.107	0.114	0.122	0.130	0.138	0.146	0.155	0.163
19	0.070	0.076	0.083	0.090	0.097	0.104	0.112	0.120	0.128	0.136	0.144	0.153	0.161
20	0.067	0.074	0.080	0.087	0.094	0.102	0.110	0.117	0.126	0.134	0.142	0.151	0.160
25	0.057	0.064	0.071	0.078	0.086	0.094	0.102	0.110	0.119	0.127	0.136	0.145	0.155
50	0.039	0.047	0.055	0.063	0.072	0.082	0.091	0.101	0.111	0.120	0.130	0.140	0.150
100	0.032	0.041	0.050	0.060	0.070	0.080	0.090	0.100	0.110	0.120	0.130	0.140	0.150

Payment ($/Year) = Present Value* (Interest Rate/ (1-(1/ (1+Interest Rate) ^Years)))

*Computer calculated numbers in tables 1 through 5 may be slightly different than the hand-calculated numbers in the text using the above Amortization Table. Both are included here to enable the reader to follow the example.

Table 1B. Current One-Time Installation Costs Converted to Annualized Costs

Range Improvement and Lifespan	Alternatives		
	Develop Water	Water and Cross Fence	Water, Fence, and Juniper Control
Develop Livestock Water (25 yr)	$546	$546	$546
Replace trough appurtenances (12 yr)	-	-	-
Grazing Management (1 yr)	-	-	-
Cross-Fencing (25 yr)	-	$1,170	$1,170
Fence Maintenance (1 yr)	-	-	-
Juniper Control (50 yr)	-	-	$315
Total	$546	$1,716	$2,031

Future One-Time Installation Costs

After the practices are installed there may be additional costs for replacing parts that wear out before the entire practice wears out. In our example the livestock water development practice utilizes screens, valves, and floats that need to be replaced every 12 years (while the complete livestock development lasts 25 years).

Table 1C. Estimate Future Year One-Time Installation Costs

Range Improvement and Lifespan	Alternatives		
	Develop Water	Water and Cross Fence	Water, Fence, and Juniper Control
Develop Livestock Water (25 yr)	-	-	-
Replace trough appurtenances (12 yr)	$1,000	$1,000	$1,000
Grazing Management (1 yr)	-	-	-
Cross-Fencing (25 yr)	-	-	-
Fence Maintenance (1 yr)	-	-	-
Juniper Control (50 yr)	-	-	-
Total	$1,000	$1,000	$1,000

The future one-time installation costs need to be brought back to a year 1 present value before they can be amortized to an annualized cost. The $1,000 cost in year 12 is brought back to the present by using the present value equation: Future Value*(1/ (1+Interest Rate) ^Years) or $1,000*(1/ (1+.06)12) = $496. The interpretation is that if $496 is put in the bank today as a one-time deposit, with interest at 6 percent compounded annually and added to the account, it would be worth $1,000 in 12 years.

Now the present value cost can be amortized to get annualized costs. The water development replacement present value cost of $496, amortized over 12 years at 6 percent interest is $59 per year. The interpretation is that if $59 per year is placed in the bank, at 6 percent compounded interest, it would be worth $1,000 in 12 years. The Present Value concept will be discussed in more detail in a subsequent section of this technical note.

Note: It is not necessary to inflate the future value of the improvement in present value analysis. For example, $1,000 today may be worth about $2,012 in 12 years at 6 percent interest. In present value analysis the inflation rate is cancelled out by the 6 percent discount rate.

Estimate Total Annualized Costs

Once all the costs are identified for each alternative (regardless of when the cost occurs) and converted to an annualized cost, the total annualized costs can be calculated. In this example the amortized capital cost items are augmented by producer-provided costs of grazing management of $500 per year and fence maintenance costs of $150 per year.

Table 1D. Estimate Total Annualized Costs

	Alternatives		
Range Improvement and Lifespan	**Develop Water**	**Water and Cross Fence**	**Water, Fence, and Juniper Control**
Develop Livestock Water (25 yr)	$546	$546	$546
Replace trough appurtenances (12 yr)	$59	$59	$59
Grazing Management (1 yr)	$500	$500	$500
Cross-Fencing (25 yr)	-	$1,170	$1,170
Fence Maintenance (1 yr)	-	$150	$150
Juniper Control (50 yr)	-	-	$315
Total	$1,105	$2,425	$2,740

The annualized costs can now be compared to the annual benefits. It may also be useful to convert the annualized costs to a lump-sum present value so they can be compared to a lump-sum present value benefit (see Present Value methodology on page 13). The analyst can present the results using two methods: Net Annual Benefits & Costs or Net Present Value, depending which is preferred by the decision maker.

Estimate Present Value of Costs

Next the "annualized" costs are converted to "present value" one-time costs. The present value does not represent the actual cash outlay in year one, but represents how much money would need to be invested today, at a fixed interest rate, to provide adequate funds in the future to pay for the future improvement. The yearly costs include grazing management and fence maintenance. Using the present value of a stream of payments equation: present value equals the annualized cost divided by the annual Payment Factor in figure 2, "Amortization table" on page 6. Finding the present value of a stream of costs is the inverse of annualizing the costs to present value. The present value of $500 annualized costs for grazing management for 25 years at 6 percent ($500/.078) is $6,410 and is $1,923 for fence maintenance (over 25 years). The present value of replacing trough appurtenances (in 12 years) is $496. Note that the present value analysis is only done for items that occur in the future or continue in the future. Items that occur in year 1 are valued at their current cost.

Table 1E. Estimate Total Present Value Costs

Range Improvement and Lifespan	Alternatives		
	Develop Water	Water and Cross Fence	Water, Fence, and Juniper Control
Develop Livestock Water (25 yr)	$7,000	$7,000	$7,000
Replace trough appurtenances (12 yr)	$497	$497	$497
Grazing Management (1 yr)	$6,392	$6,392	$6,392
Cross-Fencing (25 yr)	-	$15,000	$15,000
Fence Maintenance (1 yr)	-	$1,918	$1,918
Juniper Control (50 yr)	-	-	$5,000
Total	$13,889	$30,806	$35,805

2. Estimate Benefits

Estimate Annual Benefits

In this analysis the benefits are captured in the increase in forage production measured by the increase in stocking rate. The additional forage can be used to increase herd size, calf weight gain, or leased out to a neighbor. Other noncash benefits can also be identified.

- **Alternative 1**. - Water development.—The water development allows an additional 200 AUMs in the east paddock to be grazed that were not being grazed before due to lack of water. The downward trend of 2 percent per year (4 AUM on a stocking rate of 200 AUM) from overgrazing in the west paddock is stopped.
- **Alternative 2 (RMS)**.—The water development (Alternative 1) is implemented plus a cross fence. Forage production is improving in both paddocks by dividing each paddock into two pastures allowing for an increase in 50 AUMs per paddock (100 AUMs total) over 10 years.
- **Alternative 3 (RMS)**.—The water development and cross fence (Alternative 2) are implemented plus juniper is controlled in both paddocks. West paddock forage production increases 100 AUMs over Alternative 2 in 5 years. In the east paddock, which had a less serious juniper encroachment, forage production is increased 50 AUMs over Alternative 2 in 5 years. After year 20 (15 years after treatment) juniper begins to reinvade and decreases forage production 10 AUMS per year each year.

Note: Predicting responses to grazing lands treatment is both an art and a science. Because perfect information is not always available, the range manager must make an educated guess on future forage production, in order to complete an economic analysis. Where the analyst is uncomfortable making forage predictions into the future, the analyst may conduct "sensitivity analysis" where low, average, and high forage responses are estimated to show a distribution of outcomes. This will provide additional information for the decision maker and perhaps make their required decision easier.

Identify current "benchmark" total annual production.

This year, a total of 400 AUMs are produced in both the east and west paddocks. An AUM is defined as 912.5 pounds air-dried forage (or 780 pounds oven-dried forage.)

Estimate "without treatment" total forage production over time.
Two percent of the "benchmark" AUMs in the west paddock are lost each year (4 AUMs per year) as juniper invades and range condition continues to deteriorate.

Estimate "with treatment" total forage production over time for each Alternative.

- Alternative 1.—Develop Livestock Water
- Alternative 2.—Develop Livestock Water and Cross-Fence
- Alternative 3.—Develop Livestock Water, Cross-Fence and Control Juniper

Total forage production is presented in figure 3 and table 2A. These values are the total forage biomass produced most of which is not "harvestable" by grazing animals (see next sections). However, the forage standing in the pasture also provides benefits to wildlife, soil health, and moisture retention, as well as the grazing potential.

Figure 3. Forage Production Curves

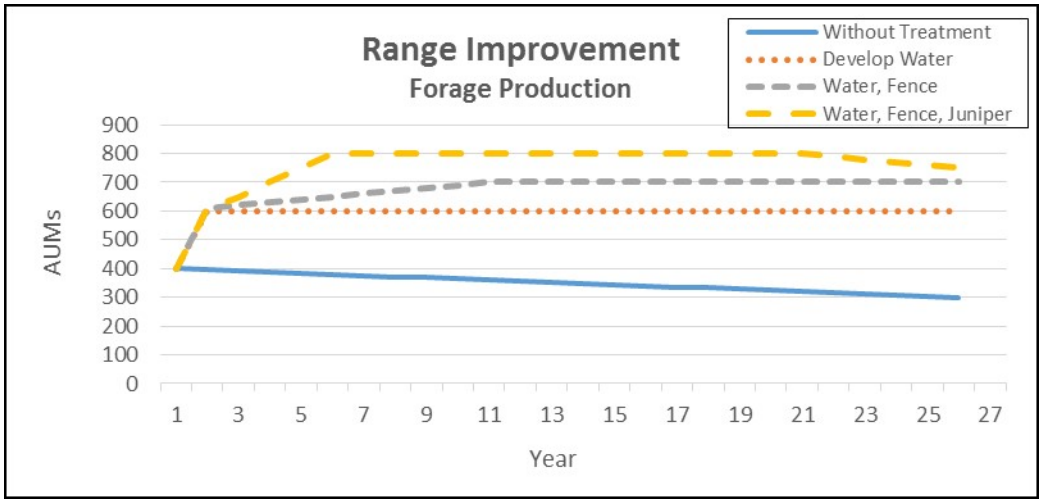

Table 2A. Total Annual Production of Forage (AUMs)

Year	Without Treatment	Develop Water	Water and Fence	Water, Fence, Juniper
0	400	400	400	400
1	396	600	610	610
2	392	600	620	650
3	388	600	630	700
4	384	600	640	750
5	380	600	650	800
6	376	600	660	800
7	372	600	670	800
8	368	600	680	800
9	364	600	690	800
10	360	600	700	800
11	356	600	700	800
12	352	600	700	800
13	348	600	700	800
14	344	600	700	800
15	340	600	700	800
16	336	600	700	800
17	332	600	700	800
18	328	600	700	800

Year	Without Treatment	Develop Water	Water and Fence	Water, Fence, Juniper
19	324	600	700	800
20	320	600	700	800
21	316	600	700	790
22	312	600	700	780
23	308	600	700	770
24	304	600	700	760
25	300	600	700	750

Estimate forage utilization factors, consumable forage, and maximum carry capacity.
Not all annual production can be consumed. Some of it is trampled, defecated on, left to protect the soil, or maintain a healthy plant community. On this site 25 percent of the total forage biomass can be consumed by livestock. This example applies a .25 harvest efficiency factor (or forage utilization factor) to the total annual forage in table 2B to find the consumed forage below in table 2C. Given the soils, slope, plant community, and available ranch labor, at most, 200 AUMs could be consumed.

Table 2B. Total Consumable Livestock Forage Production (AUMs)

Year	Without Treatment	Develop Water	Water and Fence	Water, Fence, Juniper
0	100	100	100	100
1	99	150	153	153
2	98	150	155	163
3	97	150	158	175
4	96	150	160	188
5	95	150	163	200
6	94	150	165	200
7	93	150	168	200
8	92	150	170	200
9	91	150	173	200
10	90	150	175	200
11	89	150	175	200
12	88	150	175	200
13	87	150	175	200
14	86	150	175	200
15	85	150	175	200
16	84	150	175	200
17	83	150	175	200
18	82	150	175	200
19	81	150	175	200
20	80	150	175	200
21	79	150	175	198
22	78	150	175	195
23	77	150	175	193
24	76	150	175	190
25	75	150	175	188

Calculate the difference in forage availability between with and without treatment.
The change between Without Treatment and each of the Alternatives represents the benefits of the range improvement. For example, in year 5 if the "without treatment" forage production was 95 AUMs and the "livestock water development and cross fence" forage production was 163 AUMs, then the benefit of the range improvement was 68 AUMs in year 5. Visually this can be seen in Figure 3 the "Range Improvement – Forage Production" graph. The benefits are represented as the area between the

"Without Treatment" and the "Develop Water," "Develop Water and Cross-Fence" and "Develop Water, Cross-Fence and Juniper Control" lines on the graph.

Table 2C. Change in Total Consumable Livestock Forage Production (AUMs)

Year	Develop Water	Water and Fence	Water, Fence, Juniper
0	0	0	0
1	51	54	54
2	52	57	65
3	53	61	78
4	54	64	92
5	55	68	105
6	56	71	106
7	57	75	107
8	58	78	108
9	59	82	109
10	60	85	110
11	61	86	111
12	62	87	112
13	63	88	113
14	64	89	114
15	65	90	115
16	66	91	116
17	67	92	117
18	68	93	118
19	69	94	119
20	70	95	120
21	71	96	119
22	72	97	117
23	73	98	116
24	74	99	114
25	75	100	113

Forage value is typically described in terms of dollars per AUM. If the analyst is not aware of local or published AUM values, it can be roughly calculated with data typically found in livestock budgets. The equation is:

Value of an AUM = (Annual Gross Livestock Income – Non-Forage Costs) / AUMs Needed

For example, if a 300 cow/calf operation's income is $190,000 per year, "nonforage costs" are $30,000 per year (does not include fed hay or grazing costs) and the total AUMs needed is 4,500, then the value of an AUM is estimated to be $35 per AUM.

<u>Calculate the value of the change in forage production between with and without treatment</u>
The increase in forage production can be leased out to a neighbor or fed to the existing livestock operation. The assumption is made that the forage is worth $35 per AUM. For example, in year 5 if the difference between "without treatment" and "livestock water development and cross fence" forage production was 68 AUMs, then the benefit of the range improvement is 68 * $35 = $2,380 in year 5.

Table 2D. Value of the Change in Consumable Forage Production (AUMs)

Year	Develop Water	Water and Fence	Water, Fence, Juniper
0	0	0	0
1	$1,785	$1,890	$1,890
2	$1,820	$1,995	$2,275
3	$1,855	$2,135	$2,730
4	$1,890	$2,240	$3,220
5	$1,925	$2,380	$3,675
6	$1,960	$2,485	$3,710
7	$1,995	$2,625	$3,745
8	$2,030	$2,730	$3,780
9	$2,065	$2,870	$3,815
10	$2,100	$2,975	$3,850
11	$2,135	$3,010	$3,885
12	$2,170	$3,045	$3,920
13	$2,205	$3,080	$3,955
14	$2,240	$3,115	$3,990
15	$2,275	$3,150	$4,025
16	$2,310	$3,185	$4,060
17	$2,345	$3,220	$4,095
18	$2,380	$3,255	$4,130
19	$2,415	$3,290	$4,165
20	$2,450	$3,325	$4,200
21	$2,485	$3,360	$4,165
22	$2,520	$3,395	$4,095
23	$2,555	$3,430	$4,060
24	$2,590	$3,465	$3,990
25	$2,625	$3,500	$3,955

3. Convert Costs and Benefits to "Like Terms"

To complete an economic analysis, all monetary values should be in the same unit (project area) and timeframe (Annualized: $/Project Area/Year and/or Present Value: $/Project Area). Costs and benefits may occur during installation and throughout the improvement's life. For example, the cost of a new cross-fence may all occur during installation and require additional operation, maintenance, and replacement expenditures throughout its life. The monetary benefits of the fence may also change over time. To develop annualized costs and benefits we used amortization to annualize a present value one-time cost or benefit. Present value analysis may have been used to identify a one-time current year cost, a future one-time cost or a flow of future costs or benefits, which will next be annualized to compare alternatives.

Present Value Analysis

Present value analysis allows costs or benefits incurred in the future to be described in today's dollars. The process of calculating present value is simply converting a future value to a current (present) value. Four pieces of information are required for determining present value: (1) Future value, (2) Year the value occurs, (3) Discount rate, and the (4) Present value equation: Sum of: Future Value*(1/ (1+Interest Rate) ^Years).

For example, a livestock watering facility will produce $2,100 in benefits in year 10. The present value of the benefit is: $2,100*(1/ (1+.06) ^10) = $2,100 * .5583 = $1,172. This "one time" present value cost can now be converted to an annualized cost using amortization.

Future costs do not need to be inflated to a future value, but are described in current dollars, because present value calculations assume future costs are inflated by an interest rate that is heavily influenced by inflation, and then discounted to bring the future costs to current dollars using a discount rate that also includes inflation. Thus, inflation is cancelled out and can be ignored in present value analysis. It is important to understand the difference between interest rate and discount rate. By definition:

- Interest Rate.—The cost of borrowing money, or the rate charged against a loan. It is a known value and agreed upon by the client and lender. It is used with amortization. It includes a return to the lender, risk, and inflation. Interest rates are used when current values are known, and you are trying to find a future sum; interest rates are used to "grow" funds.
- Discount Rate.—The "cost of capital" or the "market rate of return." It is used when there is uncertainty about future cash flows and interest rates. It is used in place of interest rate in present value analysis. It includes a return to the lender, risk, and inflation. Greater uncertainty increases the discount rate. Discount rates are used when future values are known, and you are trying to find a current sum; discount rates are used to "shrink" funds.

In summary, we have taken all the costs over the life of an activity and converted them to a one-time cost through present value analysis and then converted that one-time cost ($/Unit) to an annualized cost ($/Unit/Year) through amortization. Now each alternative can be compared to other alternatives with the same cost basis.

Table 3A. Present Value of Change in Consumable Forage Production (AUMs)

Year	PV Factor	Develop Water	Water and Fence	Water, Fence, Juniper
0	$0	$0	$0	$
1	0.94340	$1,684	$1,783	$1,783
2	0.89000	$1,620	$1,776	$2,025
3	0.83962	$1,557	$1,793	$2,292
4	0.79209	$1,497	$1,774	$2,551
5	0.74726	$1,438	$1,778	$2,746
6	0.70496	$1,382	$1,752	$2,615
7	0.66506	$1,327	$1,746	$2,491
8	0.62741	$1,274	$1,713	$2,372
9	0.59190	$1,222	$1,699	$2,258
10	0.55839	$1,173	$1,661	$2,150
11	0.52679	$1,125	$1,586	$2,047
12	0.49697	$1,078	$1,513	$1,948
13	0.46884	$1,034	$1,444	$1,854
14	0.44230	$991	$1,378	$1,765
15	0.41727	$949	$1,314	$1,679
16	0.39365	$909	$1,254	$1,598
17	0.37136	$871	$1,196	$1,521
18	0.35034	$834	$1,140	$1,447
19	0.33051	$798	$1,087	$1,377
20	0.31180	$764	$1,037	$1,310
21	0.29416	$731	$988	$1,225
22	0.27751	$699	$942	$1,136
23	0.26180	$669	$898	$1,063
24	0.24698	$640	$856	$985
25	0.23300	$612	$815	$922
		$26,877	$34,923	$45,159

* At 6 percent discount rate

Now that we have the sum of the present value benefits for each alternative, we can calculate annualized benefits using amortization. Using a 25-year life and a 6 percent interest rate, the amortization factor is .078. The annualized benefit of each alternative is—

	Develop Water	Water and Fence	Water, Fence, Juniper
Total annualized benefits	$2,096	$2,724	$3,522

4. Compare Costs and Benefits and make an Informed Decision

It is important to understand that rangeland economic analysis utilizes both present value and annualized analysis techniques. The results can be presented as either one-time costs (present value analysis) on annualized costs (amortization). When dealing with natural resources and making time value of money decisions, where it is often difficult to monetize benefits, annualized costs are the preferred method to compare with annual nonmonetary benefits.

The monetary benefits exceed the costs of Alternatives 1, 2, and 3. Developing water will increase income on average $1,013 per year; the water improvement and the cross fence will increase income on average $321 per year, and; water development, cross fencing, and juniper control will increase income on average $730 per year. All three alternatives are profitable, but the water improvement is the most profitable. The water development will cost $13,889 in today's dollars, but return $26,877 in today's dollars over time, meaning that $13,889 invested today at 6 percent will produce the sum of beneficial cash flow identified above in table 3A.

Table 4A. Total annualized costs and benefits

	Alternatives		
	Develop Water	Develop Water Cross Fence	Water, Fence, Juniper Control
Total annualized costs*	$1,083	$2,403	$2,793
Total annualized benefits	$2,096	$2,724	$3,522
Net annual benefits	$1,013	$321	$730

4B. Total present value costs and benefits

	Alternatives		
	Develop Water	Water and Fence	Water, Fence, Juniper
Total PV costs	$13,889	$30,806	$35,806
Total PV benefits	$26,877	$34,923	$45,159
Net present value	$12,989	$4,117	$9,353

5. Financial Analysis

Care should be taken when presenting cost and benefit information and making recommendations to the decision maker. An "economic" analysis was just completed, but a "financial" analysis has not been examined. Economic analysis amortizes costs over the practice life, while financial analysis amortizes costs over the life of the bank loan. In both analysis benefits accrue over the life of the practice. It is one thing to say a project is "economical," quite another thing to say it is "financially feasible" and "cash-flows." Note that if the installation costs are paid off early in the project's life, the benefits will continue to accrue until the end of the project life. Assume the landowner gets a 5-year loan to do range

improvements. Using the previous information, we will identify the year one installation costs (table 5A below), amortize the installation costs in year one over 5 years (rather than 25 years (table 5B)) , add in other annual costs such as grazing management and fence maintenance (table 5C). The water trough replacement cost will be excluded because it does not occur until year 12. The annual benefits will remain the same. Table 5D shows that the Net Annual Benefits are negative for all three alternatives. This exercise demonstrates that all three alternatives are economical, but none are financially feasible over the first 5 years. Alternative 1 being the most feasible because only $63per year is lost over the first 5 years rather than over $3,000 per year for alternatives 2 and 3.

Table 5A. Year-One One-Time Installation Costs

Range Improvement and Lifespan	Alternatives		
	Develop Water	**Water and Cross Fence**	**Water, Fence, and Juniper Control**
Develop Livestock Water (25 yr)	$7,000	$7,000	$7,000
Replace trough appurtenances (12 yr)	-	-	-
Grazing Management (1 yr)	-	-	-
Cross-Fencing (25 yr)	-	$15,000	$15,000
Fence Maintenance (1 yr)	-	-	-
Juniper Control (50 yr)	-	-	$5,000
Total	$7,000	$22,000	$27,000

Table 5B. Convert one-time installation costs to annualized costs using (5 years and 6%)

Range Improvement and Lifespan	Alternatives		
	Develop Water	**Water and Cross Fence**	**Water, Fence, and Juniper Control**
Develop Livestock Water (25 yr)	$1,659	$1,659	$1,659
Replace trough appurtenances (12 yr)	-	-	-
Grazing Management (1 yr)	-	-	-
Cross-Fencing (25 yr)	-	$3,555	$3,555
Fence Maintenance (1 yr)	-	-	-
Juniper Control (50 yr)	-	-	$1,185
Total	$1,659	$5,214	$6,399

Table 5C. Estimate total annualized installation, operation, maintenance, and replacement costs.

Range Improvement and Lifespan	Alternatives		
	Develop Water	**Water and Cross Fence**	**Water, Fence, and Juniper Control**
Develop Livestock Water (25 yr)	$1,659	$1,659	$1,659
Replace trough appurtenances (12 yr)	-	-	-
Grazing Management (1 yr)	$500	$500	$500
Cross-Fencing (25 yr)	-	$3,555	$3,555
Fence Maintenance (1 yr)	-	$150	$150

Range Improvement and Lifespan	Alternatives		
	Develop Water	Water and Cross Fence	Water, Fence, and Juniper Control
Juniper Control (50 yr)	-	-	$1,185
Total	$2,159	$5,864	$7,049

Table 5D. Cash Flow Years 1–5

	Alternatives		
	Develop Water	Develop Water Cross Fence	Water, Fence, Juniper Control
Total annualized costs*	$2,159	$5,864	$7,049
Total annualized benefits	$2,096	$2,724	$3,522
Net annual benefits	−$63	−$3,140	−$3,527

*Paying all year 1 installation costs, excludes water trough replacement in year 12.

If the land user can borrow money or use other resources to survive the cash deficit during the first 5 years, the next few years are profitable because the practice implementation loan is paid, and they must cover only the annual grazing management and fence maintenance costs. Table 5E below shows that all three alternatives are profitable during years 6 through 11, once the implementation costs are paid.

Table 5E. Cash Flow Years 6–1

	Alternatives		
	Develop Water	Develop Water Cross Fence	Water, Fence, Juniper Control
Total annualized costs*	$500	$650	$650
Total annualized benefits	$2,096	$2,724	$3,522
Net annual benefits	$1,596	$2,074	$2,872

*Paying annual O&M cost, excludes water trough replacement in year 12.

In year 12 the land user must replace the stock water trough and appurtenances (table 5F). They take out a loan for 5 years and 6 percent interest rate and include the annual grazing management and fence maintenance costs (table 5G). Table 5H below shows that all three alternatives are profitable during years 12 through 16. Once the trough replacement loan is paid, table 5I below shows that all three alternatives are profitable once again through years 17 through 25.

Table 5F. Estimate future year one-time installation costs.

Range Improvement and Lifespan	Alternatives		
	Develop Water	Water and Cross Fence	Water, Fence, and Juniper Control
Develop Livestock Water (25 yr)	-	-	-
Replace trough appurtenances (12 yr)	$1,000	$1,000	$1,000
Grazing Management (1 yr)	-	-	-
Cross-Fencing (25 yr)	-	-	-
Fence Maintenance (1 yr)	-	-	-
Juniper Control (50 yr)	-	-	-
Total	$1,000	$1,000	$1,000

Table 5G. Estimate total annualized installation, operation, maintenance, and replacement costs.

Range Improvement and Lifespan	Alternatives		
	Develop Water	Water and Cross Fence	Water, Fence, and Juniper Control
Develop Livestock Water (25 yr)	-	-	-
Replace trough appurtenances (12 yr)	$237	$237	$237
Grazing Management (1 yr)	$500	$500	$500
Cross-Fencing (25 yr)	-	-	-
Fence Maintenance (1 yr)	-	$150	$150
Juniper Control (50 yr)	-	-	-
Total	$737	$887	$887

Table 5H. Cash Flow Years 12–16

	Alternatives		
	Develop Water	Develop Water Cross Fence	Water, Fence, Juniper Control
Total annualized costs*	$737	$887	$887
Total annualized benefits	$2,096	$2,724	$3,522
Net annual benefits	$1,359	$1,837	$2,635

*Paying annual O&M costs and water trough replacement in year 12 (5 year and 6% loan).

Table 5I. Cash Flow Years 17–25

	Alternatives		
	Develop Water	Develop Water Cross Fence	Water, Fence, Juniper Control
Total annualized costs*	$500	$650	$650
Total annualized benefits	$2,096	$2,724	$3,522
Net annual benefits	$1,596	$2,074	$2,872

*Paying annual O&M costs.

The landowner could not "cash flow" any of the three range improvements during the first 5 years. However, after year 5 through year 25 there was not a cash flow problem—the annual benefits covered all the annual costs. This example demonstrates several alternatives that are economical but are not necessarily financially feasible. Where the alternatives are not financially feasible the solution may be to accept the initial loss, reduce costs, increase benefits or seek additional financial assistance through various cost-share programs.

Ranch Owner's Decision, Implementation, and Evaluation

The above economic and financial analysis was intended as a demonstration of the type of analysis needed for ranchers to evaluate conservation plan alternatives in a rangeland setting. Fortified by this information, the rancher will hopefully decide to proceed with plan implementation (steps 7 and 8 in the planning process). The final planning step, evaluate the plan, can only be accomplished with time and continued cooperation. As pointed out earlier, adjusting forage production in the arid west can be a multiyear event as the weather conditions vary from year to year. Even with the difficulty in evaluating changes in forage production, evaluation is critical to confirm the art and science of the evaluation process and should conducted.

Conclusion

Range improvement economic analysis is not difficult to accomplish; it only takes thoughtful preparation to collect the appropriate data and apply basic economic principles and mathematics. Incomplete information is better than no information in decision making. High, average, and low forage production estimates can be used in place of perfect data to determine how much risk the range manager is willing to take. If the analyst discovers that low forage response estimates result in positive economic and/or financial returns, then the rancher will have increased confidence to implement the project. However, poor monetized economic results do not mean the land user should not implement the project. If the perceived benefits from environmental and social improvement outweigh the economic considerations, then the land user may choose to implement the project.