AN ABSTRACT OF THE THESIS OF

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Title: AN ECONOMIC EVALUATION OF THE RANGE IMPROVEMENTS ADMINISTERED BY THE BUREAU OF LAND MANAGEMENT IN THE VALE DISTRICT OF OREGON

Abstract approved: ________________________
Joe B. Stevens

The federal government has spent considerable sums of money to rehabilitate range lands administered by the Bureau of Land Management (BLM). These investments have had varying effects on the production and utilization of forage on these lands.

One of the most surprising results, according to BLM officials, of the investments undertaken during the Vale Project has been the increased productivity of native lands in the Vale District of the BLM. This study was initiated to examine these effects and to evaluate the investments that have been undertaken during the project.

The theoretical relationships that exist between the production, utilization, and administration of resources were developed to explain how various range improvements may affect forage production. This body of theory was also used to develop two hypotheses. The first hypothesis stated that increased forage production on native lands in the Vale District have resulted from increased forage production on improved areas. The second hypothesis stated that increased forage

on improved areas have resulted from increased production of native areas in the Vale District.

Parameters of a system of simultaneous equations were estimated by least squares using cost and forage response data obtained from BLM officials at the Vale District.

Statistical tests, based on the preceding parameter estimates, indicated that forage production on native lands has been significantly affected by forage production on improved areas (first hypothesis). These tests also indicated that increased forage production on native areas has increased the production of forage on improved areas.

Parameter estimates were also used to evaluate the returns necessary to earn a five percent return on the investments undertaken during the Vale Project. This evaluation indicated that an Animal Unit Month (AUM) of federal forage must be worth more than $6.00 for spray and seed areas, $5.00 for spray areas, $2.50 for native areas, $2.00 for plow and seed areas, and $1.00 for Old Rehab areas.

Three major conclusions were derived from the results of this study. First, utilization rates have significant bearing on the returns that may be expected from an investment for range improvement. Second, investments that increase the production of forage in one area can affect the production of forage in other areas if utilization practices (management of the forage resource) such as those used by the BLM are followed. Third, many of the rehabilitation projects that have been undertaken by the BLM during the Vale Project have yielded less than a five percent return on the investments.

An Economic Evaluation of the Range Improvements Administered by the Bureau of Land Management in the Vale District of Oregon

by

Erik Bruce Godfrey

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

AN ECONOMIC EVALUATION OF THE RANGE IMPROVEMENTS ADMINISTERED BY THE BUREAU OF LAND MANAGEMENT IN THE VALE DISTRICT OF OREGON

I. INTRODUCTION

Man has historically depended upon land to provide him with enough goods and services to sustain life and satisfy his wants. Lands used by man have not produced sufficient goods to sustain life during some periods of time, however. Man has, therefore, found it worthwhile to undertake such practices as cultivation and irrigation. Practices such as these have commonly increased the productivity of land used to produce the goods and services desired by society. Man's effort to increase the productivity of a given land base has sometimes resulted in the destruction of the productive potential of an area for a considerable length of time.

Man has found that productivity which has been temporarily lost can often be regained, however. For example, funds may be invested in such "conservation" practices as leveling. Another method that has been used is the alteration of the historical utilization pattern of an area. These methods, as well as others, have increased the productivity of areas whose productivity had declined. Sometimes, however, lost productivity may not be physically or economically regainable.

As man has altered the productivity of land, he has found that complex interdependencies exist between the production, utilization, and administration of lands used to produce the goods and services desired by society. These interdependencies have made the necessary evaluation of man's actions complex.

A Framework for Viewing Production and Utilization Interdependencies

To visualize the complex interdependencies that may exist between the production, utilization, and administration of land, it is helpful to illustrate those relationships in functional form. Many of the terms and ideas closely follow the general ideas concerning production and utilization that were originally expressed by Ciriacy-Wantrup (14).

Production

The production of resources (R) may be expressed in the following manner:

$$R_{ijst} = F_1(NC_{st}, C_{st}, A_{st}, U_{hkst})$$

R_{ijst} - denotes the amount of a specific type of resource j of general type i that exists or is produced in area s during time t.

Note The ij resource indices may be visualized as a matrix

$$\begin{bmatrix} R_{11} & \cdots & R_{1j} \\ \vdots & \ddots & \vdots \\ R_{i1} & \cdots & R_{ij} \end{bmatrix}$$

where R_i refers to a general type of resource (forage, water, minerals, etc.) and j refers to the amount of a specific type of resource such as Crested Wheatgrass or Scotch Thistle. It should be emphasized that any cell or group of cells, for any area or time, may be zero (empty), indicating, for example, that there is no timber or no timber of a specific type.[1] Different vectors of a resource type (i) will be referred to by a second subscript, such as j_1, j_2, etc. Thus j_1 may be a vector of primarily grass species and j_2 may be a vector primarily of shrubs, for example.

NC - denotes the natural characteristics (soil, topography, etc.)

C - denotes the climatic conditions (rainfall, wind, etc.)

A - denotes the actions of the decision maker that governs the use of area s during time t.

U_{hk} - denotes the utilization that is allowed to take place.

Note a The utilization (U_{hk}) may likewise be visualized as a matrix similar to the resource matrix above, where h refers to a general type of use such as livestock grazing and k refers to the rate of utilization by a particular type, such as sheep. It should be emphasized that any cell (k) or vector (h) may be null for some area or time.[2]

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[1] It should be noted that under this notation a resource may be a stock or flow type (14). It should also be noted that this notation generally includes only resources of types I, and II-2-b, as listed by Wantrup (14, p. 42).

[2] It should be noted that lands administered by a public agency, such as the Forest Service, are required by law to consider multiple use of an area (55).

Note b The time and area subscripts are of special importance to the following discussion. The area subscript will be deleted in the following discussion if the area is the same for any problem under consideration. Different areas, however, will be indicated by different numbers (1, 2, etc.). The time subscript is an interval of time and is defined to be the period of time within which changes in use rates and other economic variables may be neglected. A specific time interval will be denoted by a single number (1, 2, . . .). Several time intervals will be indicated by a second subscript (t_1). Thus any vector of time intervals (t_1) may include a specific time interval included by another vector (t_2).

Thus the production of any resource during some period of time (t) will be affected by the natural characteristics (NC), climatic conditions (C), actions of the decision makers (A), and the utilization (U_{hk}) of the resource in some preceding period or periods of time.

Utilization

The utilization of resources that exist in area s during time t may be expressed in the following way:

$U_{hk} = F_2(R_{ij}, M, A)$ where

M - denotes the man-introduced facilities that exist in area s during time t. These facilities may include such things as fences, ditches, fire stations, etc. (R_{ij} and A are defined above.)

Thus the utilization of the resources in area s during some time t depends upon the type and the amount of the resources available, the man-introduced facilities, and the actions of the decision maker. Man-introduced facilities commonly allow utilization of an area that may not be usable without them. For example, a new road into a forested area would physically enable lumbermen to harvest timber in an area that had not been harvested before. Administrative action, however, probably has the largest influence over the utilization of an area. For example, a large mineral deposit may exist is some area of land but the administrator (public or private) of the area may not allow these deposits to be utilized.

Administration

Reasons why a decision that would not allow some type or types of utilization to take place in an area or during some period of time can be symbolically expressed in the following manner:

$A = F_3(LA, G, D_p, D_o)$ where

LA - denotes the laws or regulations that govern the actions of the administrator of area s during time t.

G - denotes the goals of the administrator of area s during time t.

D_p - denotes the demand for product p, where p = 1, . . . , P, during time t.

Note These demands would be derived from the wants and desires of society as expressed either through the market place (for example, the demand for beef steak) or through the political process (for example, the demand for "conserving our natural resources").

D_o - denotes the amount of money available to the decision maker for administering the area.

Thus the administrator may not allow some use to take place for one or a combination of the following reasons: (a) there may be some law which does not allow some types of utilization to take place, such as mining in a "wilderness" area, (b) the administrator may find some use to be incompatible with his goals, (c) the demand for a competing product, such as recreation, may be sufficiently great that it is economically or politically infeasible to allow the use of some resource in an area, or (d) the amount of money given to the administrator may not be sufficient to allow the utilization of a resource in a manner compatible with other goals or laws. For example, supervisory costs that result from allowing motorbike riding in some areas, such as National Parks, may make this use infeasible. An administrator, therefore, can often be placed in a position whereby one or more of the determinates (G, LA, D_p, D_o) that govern his actions may be in conflict.

If the demands for a particular use are sufficient, however, some conflicts may be minimized because the dollars returned to a private administrator (or given to, in the case of a public administrator) are generally some function of the demands of society. This relationship is expressed in the following manner:

$$D_o = F_4 (D_p)$$

Thus, as the demand for some use (D_p) increases, the returns (D_o) for that use generally tends to increase. These increased returns may allow some utilization to take place that may not have been feasible had administrative returns (D_o) been lower.

As the use of an area changes, however, the administrator is often placed in a position which necessitates making a decision that involves complex relationships. The complexities that may be introduced when a utilization pattern is altered may be visualized when one realizes that the actions of a decision maker (A) may affect the production of resources (R_{ij}) in the area, which may lead to further utilization alterations and conflicts in the determinates that govern his actions.

The Problem

The preceding framework is sufficiently broad that numerous interactions between the production, utilization, and administration of public or private resources could be identified and studied. It, therefore, is necessary to denote the lands that will be studied in this thesis.

The federal lands administered by the Bureau of Land Management (BLM) have been of interest to economists and range managers for a number of years. Furthermore, the use of these lands has historically been controversial. Much of the controversy that has received national attention has originated in the Vale District of Eastern Oregon. Much of this controversy came to a head in the late 1950's and early 1960's when the BLM tried to adjudicate some of the allotments in the district.[3]

From this controversy, and by considerable political maneuvering, a large appropriation was given to the BLM to rehabilitate more than one million acres of federal rangeland within the Vale District.[4] The magnitude of the work that has been completed in this district is unequaled in any other BLM district.

The investments that have been undertaken during the Vale Project represent a significant change in administrative action (A). Furthermore, this change in administrative action would, theoretically, alter the production and utilization of resources in the Vale District. Therefore, the Vale Project provided an opportunity to measure what effect these range rehabilitation investments have had on the production and utilization of the forage resource in the district.

The Objectives of the Study

Range managers have, for a number of years, recognized that an investment which alters the forage available for grazing in one area may have significant positive benefits to other areas which are used conjunctively with these lands and which receive relatively small amounts of investments.[5] Max Lieurance, Vale District Manager,

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[3]Additional details concerning the Vale District are contained in Chapter 2 and Appendix A.

[4]Appendix B contains a tabulation of the proposed work that was to be conducted during the Vale Project and a summary of the work that had been completed by July 1, 1969.

[5]This relationship can be expressed, using the preceding framework, in the following manner: $\partial R_{ij2t_2}/\partial R_{ij1t_1} > 0$. Thus the amount

recently emphasized the possible importance of this relationship to the production of forage in the Vale District when he said, "We expect the native range not treated to increase its carrying capacity through the use of these rehabilitated areas, and through management. Thus, the total carrying capacity of this land will be greatly increased" (47). At the time of this writing no one has tried to test the hypothesis that this expectation is true. Therefore, the first objective of this thesis is to test the hypothesis that the carrying capacity of native rangelands have not increased as a result of rehabilitating other areas in the district.

There have been a number of excellent economic studies which have estimated the benefits and costs of range improvements. These studies, however, have been concerned with the benefits and costs from the rancher's point of view and have not, with the exception of studies by Nielsen (56, 60) and Lloyd and Cook (48),[6] been concerned with range improvements on public lands. Furthermore, none of the studies reviewed have attempted to evaluate the benefits and costs of rehabilitation work that had been completed but rather have been concerned with the anticipated <u>ex-ante</u> benefits and costs. Thus, of the studies reviewed, none have specifically studied range improvements from an <u>ex-post</u> point of view.

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of forage in area 2 during a period of time (t_2 vector) is increased by changing the amount, and/or type of forage that exists in area 1 in some previous period of time (t_1).

[6]Neither study, however, evaluated the benefits expressly from a public point of view.

Of greatest interest to this study, however, is the influence of rehabilitated areas on native areas and how this may alter the estimation of benefits resulting from range improvements. The second objective of this study, therefore, is to estimate what benefits have accrued, in the form of forage for livestock grazing,[7] as a result of the Vale Project--given the management of the forage resource by the BLM.

[7]Other benefits have accrued, but their evaluation is beyond the scope of this study.

II. THE VALE PROJECT

The Vale District is located in the southeastern corner of Oregon and is bordered by Nevada to the south and by Idaho to the east. It comprises an area of approximately 6.5 million acres and represents nearly 30 percent of the total land area administered by the BLM in Oregon.

Rangeland within the Vale District is typical of most high mountain desert areas in the Western United States. Elevations in the district vary between two and nearly eight thousand feet. The long-run average yearly rainfall in the district varies from seven inches at lower elevations to thirteen at higher elevations. Summers in the area are dry and generally hot, with readings in the nineties not uncommon. Winters are generally cold--the average mean daily temperatures for December through March in the low thirties.

The Vale District is one of the most sparsely populated areas in the United States. The major agricultural industries in the district are row cropping in the northeastern corner and ranching in the remainder. With the major portion of the land in the district being used for ranching by a relatively small population, it is not surprising that the use of BLM lands within the district is of crucial importance to the economy of the area.

History of the Vale Project

Little can be said concerning the use of the Vale area prior to the settlement of the area in the 1860's, except for what forage was taken by wildlife (U_1). The resources of the area primarily consisted of forage (R_1), water (R_2), and minerals (R_3). The forage vector (R_1) was made up primarily of native bunchgrasses and the water vector (R_2) was primarily run-off water into the Owyhee and Malhuer River Basins.

With the advent of ranching in the area during the 1850's and 1860's, however, the historical utilization pattern began to change as a new use, grazing by domestic livestock (U_2), was introduced. Large numbers of livestock commonly grazed these lands throughout the year. This utilization pattern enabled livestock to graze nearly all of the grass that these lands produced.[8] This heavy use resulted in a change in the forage vector from a composition of mainly grasses to more shrubs which did not produce as much useable forage for domestic livestock.[9] The productivity of these range lands, therefore, began to decline.

In the early 1900's the conservation movement gained national attention. This movement caused a new demand (D_2) to be added to the existing demands placed upon the use of these lands. The conservation

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[8]Nomadic herds or bands of horses and sheep were also common to the area during this period. These herds generally grazed all available grass in an area and then moved to other areas. This grazing practice was in addition to the grazing by livestock of homestead ranchers that had settled in the area.

[9]This change in forage composition had both positive and negative effects. Because there was less forage that could be used by cattle and sheep, livestockmen felt the range was declining. The additional shrubs did, however, provide a better habitat for some wildlife. The decreased ground cover allowed an increase in soil erosion and streams that once ran relatively clear began to be silty during most periods of runoff.

movement gained sufficient popularity that in 1934 Congress passed the Taylor Grazing Act, "to stop injury to the public lands by preventing overgrazing and soil deterioration; to provide for their orderly use, improvement, and development; to stabilize the livestock industry dependent upon the public range; and for other purposes" (77). This act allowed the Secretary of the Interior to establish grazing districts to change the use of resources in a manner that was more compatible with the new demand (conservation) being expressed by society. Thus, for the first time, an administrator was placed over Vale area lands to which the Federal Government retained title.

Placing an administrator over these lands with the responsibility to "stop overgrazing"[10] was not sufficient to achieve the "conservation" desires expressed by society in the Taylor Grazing Act. This task required a considerable amount of money to staff an effective organization, and Congress was not willing to provide these funds.[11]

One of the things that administrators could do with the limited funds given to them was to stop the migrant herds that often came to an area, "mined"[12] all available grass, and moved to other areas. If

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[10]Overgrazing is generally said to occur whenever the amount of forage in period t_2 is less than the amount of forage in t_1 ($R_{ijt_2} < R_{ijt_1}$) and if it had been caused by utilization rates in t_1 that were "too great."

[11]In fact, in 1947 the appropriation to the Grazing Service was so small that it was only possible to maintain one grazer (administrator) in each district (18).

[12]This "mining" was so effective in some areas that little or no forage grew in the area for a number of years. This phenomenon of one livestockman taking all of the grass before another could, is one

these practices were stopped, it was implicitly thought that the people who used the area as part of their home ranch would use the forage resource more in accordance with "conservation" guidelines. Therefore, a detailed licensing system was developed that limited the number of users that grazed an area. Grazing boards, composed of local ranchers, were also established to help the district administrator obtain needed information concerning the use of resources in the district as well as other information. However, the opinions of the board and the district administrator concerning the use of the resources were commonly in conflict (10, 18). Thus, as one may expect, administrators were generally unsuccessful in their attempt to stop overgrazing.[13] This presented an especially thorny problem with four possible solutions.

First, the administrator could leave things as they were, which was essentially the alternative undertaken by the BLM until sometime in the late 1940's. However, the law under which BLM administrators acted specifically stated that these administrators were to ". . . stop injury to the public lands by preventing overgrazing and soil deterioration . . . " (77).

The second alternative open to the Federal Government was to allow title to these lands to pass to private ownership. Laws such as the Desert Land Act and the Homestead Act, however, made this

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of the early examples of a general problem termed by economists as problems of common property (27).

[13]It should be noted, however, that the BLM and its predecessor, the Federal Grazing Service, probably slowed the rate (changed the magnitude) of range deterioration due to overgrazing.

alternative economically infeasible for most lands in the West. Furthermore, it was felt that the social values associated with public ownership were high enough that this alternative was generally not feasible from either a political or economic point of view (13).

The third alternative was to change the utilization rate (U_{2kt_1}) so that the amount of forage in one period was not less than the amount of forage in a preceding period ($R_{ijt_2} \geq R_{ijt_1}$). An adjudication process was instituted in the early 1950's whereby ranchers' permits could be "cut" until the level of utilization (U_{hk}) was made compatible with the carrying capacity (R_{ij}) of the range.[14] However, this procedure has adverse effects upon the income of permittees and local economies (5, 58, 61, 73, 79, 80). A few areas in the Vale District were adjudicated, but not without considerable vocal and legal dissent.[15] This dissent was soon expressed to the members of the Oregon delegation to Congress and in the election year of 1962, primarily through the efforts of the Mahogany Grazing Association (2), Senator Wayne Morse and Congressmen Al Ullman were invited to Vale to see the problems of the area firsthand. Later that year Congress passed Senator Morse's motion to allocate a considerable amount of

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[14]Appendix A contains additional detail concerning the structure of the BLM and the "rules" governing administrative action, such as adjudication.

[15]The adjudications in the Vale District began in the late 1950's. One of these adjudications led to the "Battle of Soldier Creek" (18) that has since become nationally famous among those familiar with range management problems. It should also be noted that Congress had appropriated more money to the administrators of the district by this time so that there was sufficient staff in many of the districts to accomplish this often troublesome procedure.

money to the district to ". . . advance conservation work in four key areas where erosion and ravages of time had largely destroyed the ability of several million acres of public land to make their proper contribution to the economy of the West" (54). Thus, the Vale Project was born.

The objectives of the Vale Project were:

a. To correct erosion and accompanying downstream sedimentation--and prevent further soil losses.
b. To increase the forage supply for wildlife and livestock.
c. To stabilize the livestock industry at the present or an increased level of production.
d. To facilitate fire control by replacing high hazard cheatgrass and sagebrush with low hazard perennial grasses and improved detection and suppression facilities.
e. To prevent the encroachment and spread of noxious and poisonous weeds.
f. To accomplish necessary land tenure adjustments.
g. To safeguard public lands from improper recreational use.
h. To provide for the development of access roads and service roads in the vast area of untapped recreation potential. (78, p. 9-10)

Thus the fourth solution, securing enough money to alter the resources of the area in a direct manner, was provided for the first time to the Vale District. This large sum of money, however, required that a number of difficult questions be asked. Not only did administrators have to decide where in the district to spend funds, but they also had to choose when and in what manner these funds were to be spent.[16]

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[16]These funds were to be spent by the district in seven years with the greatest amounts being spent the first two years. However, all of the proposed amount was never allocated and it is not known, at this time, how much has been allocated.

Possible Effects of Investment Allocations in the Vale District

A synopsis of the proposed allocation that was to be given to the district and how the BLM intended to spend these funds is contained in Table 1. The largest allocation ($13,615,000) was for rehabilitation, improvement, and conservation of soil and moisture. These investments were to be made in an effort to increase the amount of forage available for grazing.[17] The consequences of these investments on the production and utilization of forage is outlined below, using the framework of Chapter 1. The measurement of these consequences is the topic of Chapters 3 and 4.

Brush control

The control of sagebrush in an area would enable the production of forage to increase. As the density of sagebrush stands decline ($\partial R_{1j_1 1t_o}/\partial A_{t_o} < 0$),[18] the amount of grass tends to increase ($\partial R_{1j_2 1t_1}/\partial R_{1j_1 1t_o} < 0$) because competition for moisture and nutrients by sagebrush is diminished. After sagebrush has been controlled in an area of the Vale District, grazing is generally deferred for two years.

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[17] Some of these investments, such as seeding, directly affect the production of forage. Other investments, such as fencing, indirectly affect production by changing the historical utilization of an area. It should be noted that practices that directly affect production should take considerably less time than those that indirectly affect it.

[18] In this subsection R_{ij_1} will refer to a forage vector that is composed of large amounts of sagebrush and small amounts of other types of forage and R_{ij_2} will refer to a forage vector composed of primarily grasses.

TABLE 1. PROPOSED ALLOCATION FOR THE VALE PROJECT[a]

	TOTALS	
	Units	Cost ($1,000)
Range Management and Protection:		
Administration of Grazing Lands		1,539
Resource Inventory (Acres)	2,764,000	
Dependent Property Survey (Cases)	143	
Range Management (Including Supervision and Adjustment, Range Studies and Wildlife Management, etc.)		(1,299)
Fire Presuppression (Including Education, Detection, Training, etc.)		578
Rehabilitation, Improvement, and Conservation of Soil and Moisture		13,615
Brush Control (Acres)	715,500	
Fencing (Miles)	2,100	
Seeding (Acres)	428,500	
Water Development (Number)	1,227	
Water Control Structures (No.)	22,000	
Lands and Minerals Management and Recreation Planning:		
Lands		265
Land Tenure Analysis (Acres)	6,500,000	
Recreation Planning (Sites)	105	
Minerals		49
Construction and Maintenance of Roads, Buildings and Recreation Facilities:		
Construction		4,222
Roads (Miles)	437	
Buildings (Number)	13	
Recreation (Number)	20	
Maintenance (Including Maintenance of Roads, Buildings, and Recreation Facilities)		164

TABLE 1. Continued

	TOTALS	
	Units	Cost ($1,000)
General Administration		416
TOTAL BY APPROPRIATION		
Management of Lands and Resources		16,486
Construction		4,222
Range Management		140
PROJECT GRAND TOTAL		20,848

[a]Source: Vale Project, United States Department of Interior, Bureau of Land Management, Oregon State Office, May, 1963. 25 p.

This deferred grazing would also affect the production of forage in an area $(\partial R_{1j_2 1t_1}/\partial U_{1k1t_0} < 0)$.

As the production of forage in brush control areas increases after spraying (A) and/or deferred grazing (U), utilization would generally increase $(\partial U_{1k1t_1}/\partial R_{1k1t_1} > 0)$. Brush control areas whose physical accessibility may have been limited by dense sagebrush stands may also experience increased utilization $(\partial U_{1k1t_1}/\partial R_{1j_1 1t_0} < 0)$ as the density sagebrush stands decline. It should be noted that as the utilization of forage increases production may decline $(\partial R_{1k1t_2}/\partial U_{1k1t_1} < 0)$. However, the overall effect of the elimination of sagebrush in an area should be a significant increase in the production of forage and utilization of the area by cattle.

Seeding

It may not be feasible to spray areas that have relatively small amounts of existing perennial grasses and expect a significant increase in production. Therefore, the BLM planned to seed 428,500 acres of land. Such a seeding program usually includes the elimination of much of the sagebrush in the area by spraying, plowing, or in some cases burning, before the area is seeded.

Each of the above preparation alternatives has differing effects upon the existing forage. Spraying generally does not initially change the amount of forage in an area, except for species that are killed by applied chemicals. However, plowing and burning destroys most forage that existed in the area ($R_{ij} \simeq 0$ after plowing or burning).

After one of the above preparation methods has been completed, the area is seeded.[19] Thus, the forage in an area is changed from R_{ij_1} to R_{ij_2} where j_2 may be a vector of only one element, the species planted in the area.

Water development

Many areas in the Vale District have average yearly precipitation amounts of less than 12 inches. Therefore, many areas in the district require some form of water development before utilization by livestock can occur.[20] Therefore, water developments would primarily

[19]The primary grass being seeded in the Vale District is Crested Wheatgrass (Agropyron cristatum).

[20]The major water developments in the district include reservoir construction, spring development, and wells or springs with pipelines that deliver water to areas significant distances from the source.

affect the utilization of an area ($U_{hk} \simeq 0$ before development). Changes in the utilization of areas that receive some water development ($\partial U_{1k1t_0}/\partial A > 0$) may cause the production of forage in other areas to increase if: (a) the increased utilization of one area resulted in decreased utilization of a second area ($\partial U_{1k2t_1}/\partial U_{1k1t_0} < 0$), and (b) if the decreased utilization of the second area resulted in increased forage production in later periods ($\partial R_{1j2t_2}/\partial U_{1k2t_1} < 0$).

Fences

Fencing is another practice that generally changes the utilization pattern of an area. Most of the fences that have been constructed in the Vale District serve two purposes. The first type is used primarily to protect a rehabilitation project, such as a seeding, until the forage in the area has achieved enough growth to be utilized. These fences are later used to alter the historic grazing pattern of an allotment by management practices such as rotation grazing.

Management practices of this type (rotation grazing) may affect forage production if the utilization of one area (either in timing and/or level of utilization) changes the utilization in a second area so that forage production in the second area increases as a result of the decreased utilization of that area ($\partial U_{1k2t_1}/\partial U_{1k1t_1} < 0$ and $\partial R_{1j2t_2}/\partial U_{1k2t_1} < 0$).

Cross fences are the second major type of fence that have been constructed in the Vale District. This type of fence, like protective fences, allow management practices such as rotation grazing which would affect forage production if the relationships outlined above occur.

The preceding discussion outlines the effects that would have to occur if forage production were to increase as a result of the alternative investments discussed above. Investments in one area, however, may affect the production of forage in other areas that are used conjunctively with areas that receive some form of investment. Of particular interest to this study is the possible effect improved areas (seeded or brush control) have on the production of forage on native areas. The effects that theoretically may occur are outlined below.

Theoretical Development of Hypotheses

A number of complex effects may exist between the production of forage on native and improved areas. To facilitate a clearer exposition of crucial theoretical effects resulting from changes in the production of improved areas, it is assumed that the area of interest contains an improved area (I) and two native areas (N_1 and N_2) and that all investments on native and improved areas occur during period t_0.

First hypothesis

It is hypothesized that the amount of forage produced on the native areas in period t_2 increases as the amount of forage produced on the improved area increases in period t_1 $(\partial R_{1jNt_2}/\partial R_{1jIt_1} > 0)$. Increases in native forage production, however, may be attributable to increases in improved area forage production or investments on native areas.

Influence of improved forage production

Increased production on native areas would result if all of the following relationships held: (a) if investments on the improved area in period t_0 increases the production of forage in this area in period t_1 ($\partial R_{1jIt_1}/\partial A_{t_0} > 0$), (b) if utilization of the improved area increases in period t_1 as a result of increased production ($\partial U_{1kIt_1}/\partial R_{1jIt_1} > 0$), (c) if increased utilization of the improved area results in decreased utilization of the native areas in period t_1 ($\partial U_{1kNt_1}/\partial U_{1kIt_1} < 0$), (d) then an increase in the production of forage on native areas in period t_2 could result from the decreased utilization in period t_1 ($\partial R_{1jNt_2}/\partial U_{1kNt_1} < 0$). This general result ($\partial R_{1jNt_2} / \partial R_{1jIt_1} > 0$) is basically the hypothesis to be tested. Increases in forage production resulting from investments on native areas would have to be taken into account, however, before the preceding hypothesis could be tested.

Influence of investments on native areas

If investments on native areas allowed a better distribution pattern so that: (a) the utilization of native area, N_2 for example, increased as a result of investments in that area ($\partial U_{1kN_2t_1}/\partial A_{t_0} > 0$), (b) the increased utilization of area N_2 resulted in decreased utilization of area N_1 during period t_1 ($\partial U_{1kN_1t_1}/\partial U_{1kN_2t_1} < 0$), (c) then increased production in area N_1 could result in period t_2 from the decreased utilization of area N_1 in period t_1 ($\partial R_{1jN_1t_2}/\partial U_{1kN_1t_1} < 0$). It should be noted, however, that the increased utilization of area N_2 may result in decreased production in that area in period t_2 but the overall effect, to both areas, should be an increase in the production of forage from the native area.

Second hypothesis

It is hypothesized that the production of forage on improved areas increases in period t_3 as the amount of forage produced in period t_2 from native areas increases ($\partial R_{1jIt_3}/\partial R_{1jNt_2} > 0$). Theoretical reasons why this might occur would be analogous to the effect improved forage production in period t_1 may have on the production of native areas in period t_2 as outlined above.

It should be noted that the above influences could affect the production and utilization of native and improved areas in periods t_4, t_5, ... It is felt, however, that the effects that would occur during periods t_1, t_2, and t_3 would be larger in magnitude than the effects in later periods. Furthermore, the effects in later periods would become increasingly hard to measure.

The measurement of the effects that have occurred, thus far, in the Vale District is the subject of Chapters 3 and 4.

III. ANALYTICAL DESIGN AND DATA CONSIDERATIONS

The framework of Chapter 1 outlined the general interdependencies that may exist between the production, utilization, and administration of grazing lands. Chapter 2 outlined the possible effect of various range improvement investments on forage production of a given area and how changes in production of one area may affect the production of another area. The development of a model to test the hypothetical effects discussed in Chapter 2 is outlined in this chapter. Estimation of the parameters of the model outlined in this chapter is the topic of Chapter 4.

Planned Estimation

To conceptualize the relationships that are involved in the theoretical arguments outlined in Chapters 1 and 2, the following functional relationships were developed. The amount of forage (R)[21] produced on an improved area (I) during time t may be expressed in the following form:

$R_{It} = f_1(X_1, X_2, X_3, X_4, X_5, X_6)$ where

X_1 = total rehabilitation costs (such as seeding and/or brush control),

X_2 = other development costs on improved areas (fences, water developments, etc.)

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[21] In the following discussion the only resource considered will be forage. The ij subscripts, therefore, will be dropped in an effort to make the exposition less cumbersome.

X_3 = rainfall during a previous time period(s),

X_4 = amount of forage produced in a previous time period(s),

X_5 = percent of the improved forage grazed in a previous time period(s), and

X_6 = productivity of soils in the improved area.

The amount of forage produced on native lands (N) during period t can likewise be expressed in the following manner:

$R_{Nt} = f_2(Y_1, Y_2, Y_3, Y_4, Y_5)$ where

Y_1 = development costs on native areas (fencing, water development, etc.),

Y_2 = rainfall during a previous time period(s),

Y_3 = amount of forage produced on native areas in a previous time period(s),

Y_4 = percent of the native forage grazed in a previous time period(s), and

Y_5 = productivity of soils in native areas.

If the use of the improved and native areas is conjunctive, the total amount of forage grazed during period t is expressed as:

$U_{At} = U_{It} + U_{Nt}$

U_{It} = the amount of forage taken from improved areas in time t.

U_{Nt} = the amount of forage taken from native areas in time t.

U_{At} = the total amount of forage taken from a management area in time t.

Furthermore, the amount of forage taken from any area during period t is some function of the amount of forage produced in that period ($U_{It} = h_1(R_{It})$ and $U_{Nt} = h_2(R_{Nt})$). Total utilization (U_{At}), therefore, is a function of the production on the native and improved areas.

Increases in the production of forage on improved areas, for example, may be attributable to investments ($\partial R_{It}/\partial X_1 \geq 0$, $\partial R_{It}/\partial X_2 \geq 0$) or to changes in utilization ($\partial R_{It}/\partial X_5 \geq 0$). The production of forage from an area during some time t, therefore, depends upon the management of the forage resource in a previous period(s). Estimating what effect changes in utilization have had on the production of forage on improved (native)[22] areas would, therefore, require estimates of the production and utilization of forage for each area being considered for a number of consecutive grazing periods.

Within this framework, an effort was made to obtain measurements of each of the relevant variables (X_i, Y_j, R_{It}, R_{Nt}). It was found that: (1) the BLM did not have production nor utilization data for consecutive periods for any area in the Vale District, (2) rainfall data for most areas within the district were not available,[23] and

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[22]It should be noted that this would provide a direct test of the hypotheses of Chapters 1 and 2. One would be able to measure how changes in production of improved (native) areas may lead to changes in the utilization of native (improved) areas in one period and thus to changes in the production of native (improved) forage in a later period(s).

[23]Sneva and Hyder (70) and others have attempted to relate the influence of rainfall on production. The methods proposed thus far, however, generally apply only to the range types from which the data and estimates were made (6).

(3) soil productivity estimates for most areas within the district were not available.

The BLM did feel, however, that they could provide forage data for the 1969 and 1960 grazing seasons for some allotments.[24] Furthermore, this forage data would be adjusted for the influence of rainfall on the production of forage in those years. Cost data for each project undertaken in the district since the beginning of the Vale Project were also available from the BLM. These data made it possible to develop an alternative model that could be used to test the hypotheses of Chapter 2.

Modified Model

The following model was developed to correspond to the data available from the BLM. It was postulated that the 1969 grazing capacity[25] of improved areas (FIM_1) in each allotment was of the following functional form:

$FIM_1 = g_1(X_1, X_2, X_3, X_4, FIM_0, FNA_1)$ where

X_1 = total investment costs on spray (S) areas,[26]

X_2 = total investment costs on spray and seed (SS) areas,

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[24] An allotment is an administrative area grazed by livestock that are owned by one or more permittees. Detail concerning the role of allotments in the overall administration of the Vale District is contained in Appendix A.

[25] The relationship of "grazing capacity" to production and utilization is discussed later in this chapter.

[26] The three types of investments S, SS, PS (X_1, X_2, X_3) are generally alternative methods of rehabilitation. Each method should, *a priori*, cause different amounts of forage to be produced, however.

X_3 = total investment costs on plow and seed (PS) areas,

X_4 = total investment costs on Old Rehab (OR)[27] areas,

FIM_0 = grazing capacity of improved areas in 1960.

FNA_1 = grazing capacity of native areas in 1969.

It was also postulated that the 1969 grazing capacity of native areas in each allotment was of the following functional form:

$FNA_1 = g_2(Y_1, FNA_0, FIM_1)$ where

Y_1 = total investment costs on native lands,

FNA_0 = grazing capacity of native areas in 1960.

It should be noted that some of the variables in this model represent an aggregation of relationships that were explicit in the previous model. The 1960 grazing capacities, for example, represent a proxy variable for the combined effect of soil productivity and past use of the areas of interest. Perhaps the most important aggregation, however, involves the postulated effect of native production on improved areas and the influence of improved on native areas. This model implies that the management (utilization allowed by the BLM) of the forage resource within an allotment has been such that changes in the production of improved (native) areas have allowed changes in the historical utilization of native (improved) areas so that increased production from native (improved) areas may occur. If the forage resource has not been managed in this manner, then changes in production of one type would not be attributable to changes in the

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[27] Old Rehab areas are lands that had been rehabilitated (seeded and/or brush control) prior to the Vale Project (July 1, 1962).

production of other types.[28]

This model, therefore, represents a system of simultaneous equations where: $FIM_1 = g_1 [X_1, \ldots, X_4, FIM_0, g_2(Y_1, FNA_0, FIM_1)]$ and $FNA_1 = g_2[Y_1, FNA_0, g_1(X_1, \ldots, X_4, FIM_0, FNA_1)]$.

It is important to point out that the method[29] used to estimate these relationships does not represent the simultaneous relationship for a particular area but rather represents the relationship as grazing capacities and input levels (X_i, Y_1, FNA_0, FIM_0, FIM_1, FNA_1) vary from area to area. This model, therefore, required data for a number of areas within the district. The first data problem encountered, therefore, was choosing which areas to include in the study.

Data

The first step in determining which areas to include in the study was to find out where the BLM had spent substantial investment funds. The amount of money spent within each planning unit[30] was obtained from BLM records at the Vale office. From these data, it was found that nearly all of the rehabilitation work had occurred in the

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[28]This relationship is analogous to the hypothesis outlined in Chapter 2 ($\partial FNA_1/\partial FIM_1 \simeq \partial R_{1jNt_2}/\partial R_{1jIt_1} > 0$) with the major difference being the specification of time.

[29]The relationships were estimated using least squares regression, with cross-sectional data.

[30]A planning unit is an administrative area that contains one or more allotments. Allotments are administrative units grazed by cattle owned by one or more permittees. A discussion concerning the relationship of planning units to allotments and how these are administratively handled in found in Appendix A.

Westfall, Skull Springs, Harper Basin, Mahogany, Cow Creek, Soldier Creek, Fifteen Mile, and Antelope planning units. Allotments within other planning units, therefore, were not considered.

Of the 61 possible allotments that could have been included in the study, 19 were excluded because no rehabilitation work had been completed in these allotments. Twenty allotments were excluded because the area managers could not provide reliable forage data for these allotments. Two allotments were not included because they involved individual allotments whose permittees had substantial grazing privileges in other districts which were used with the forage obtained in the Vale District. This left the 20 allotments illustrated in Figure 1. Cost and forage data were then obtained from the BLM for each of these allotments.

Cost data

Table 2 contains a summary of the average investment costs incurred in the development of each of the various area types. Average costs for each area type do not vary greatly from estimates provided by other researchers,[31] except that deferred costs per AUM[32] are higher than those reported by other researchers.[33] This

[31]A discussion of these costs is contained in Appendix B.

[32]An AUM is defined to be the amount of feed or forage required by an animal unit for one month. An animal unit is considered to be one mature cow and calf or their equivalent (1).

[33]Gardner (22,25) and Nielsen (56, 57) used private grazing fees to determine deferred costs. This was based on the assumption that ranchers would (could) rent the "cut" AUM's from private sources. The rates used were \$3.03, \$3.00, and \$3.50 per AUM, respectively. McCorkle and Caton (51) assumed \$4.00/AUM, and Lloyd and Cook (48) used \$ .46/AUM to represent the "costs of providing alternative feed" from which they subtracted grazing fees.

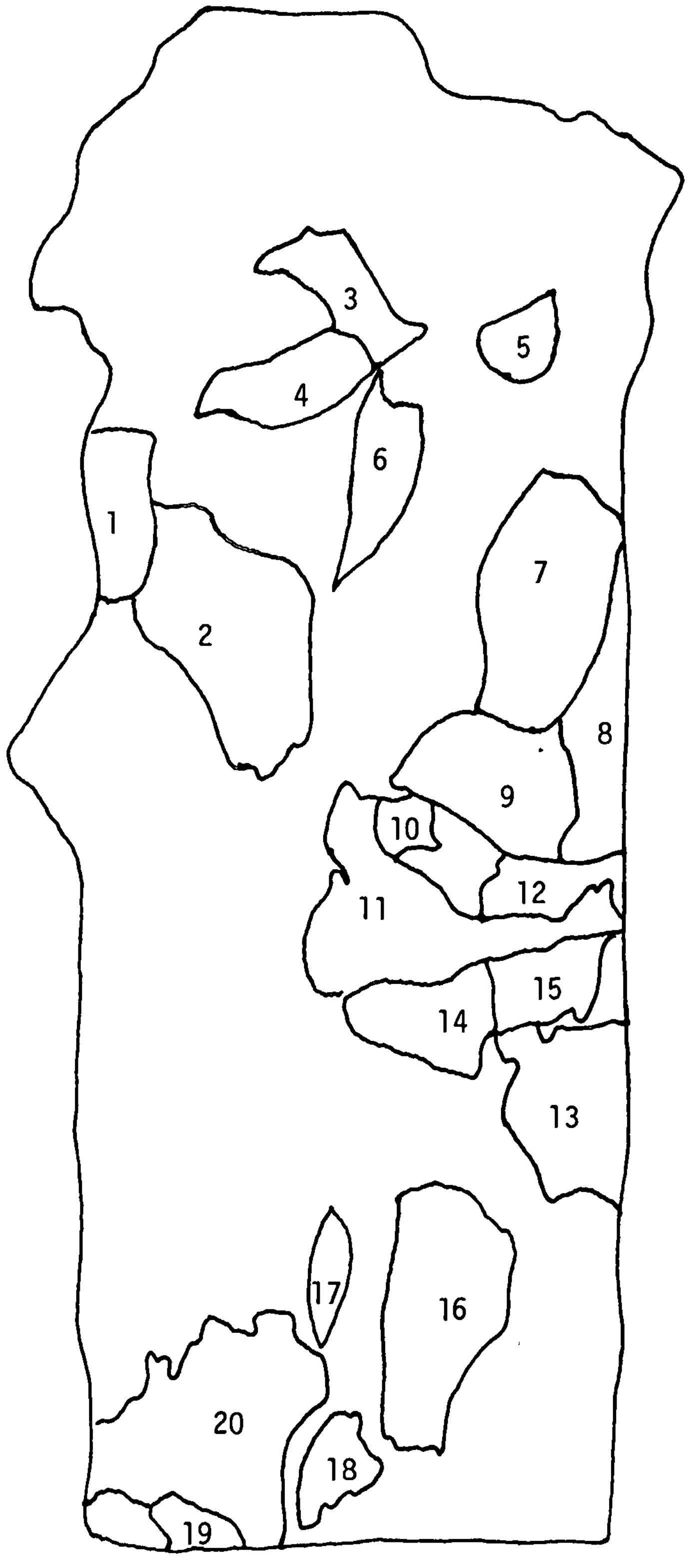

Figure 1. Sampled allotments.

TABLE 2. AVERAGE COST PER ACRE FOR THE VARIOUS TYPES OF PRACTICES STUDIED

	S	SS	PS	OR	N
Rehabilitation	$2.23	$4.69	$8.56	$0.24	----
Fencing	0.88	1.07	1.67	0.14	$0.15
Cattleguards	0.07	0.13	0.36	0.14	0.01
Water development	0.57	1.16	1.76	1.93	0.14
Other	0.02	----	0.01	----	0.01
Deferred costs	0.80	0.53	0.60	----	----
Total costs[a]	4.57	7.59	12.96	2.45	0.32

[a]Summary of the preceding components may not equal the total due to rounding.

difference is a result of the use of a different system of computation here than in other studies.

When the BLM undertakes a rehabilitation project in an allotment, they generally require permittees to take regular non-use[34] for the amount of forage that was being grazed in the rehabilitation area. The AUM's of non-use can be taken in either of two ways--time or number. Thus a permittee may graze the same number of animals on federal range for a shorter period of time or he may graze the same length of time with fewer animals. Bain (2) and BLM personnel stated that most ranchers prefer to take the "cut" in time rather than number. They also said that permittees generally can obtain sufficient hay from ranch sources to feed cattle on the home ranch during this period of time.

[34]Regular non-use should be differentiated from suspended non-use. The latter is relatively permanent and generally results from an adjudication. Regular non-use is a cut in the license that can be restored at any time.

Dean Frischknecht, Extension Animal Science Specialist at Oregon State University, stated that ranchers in the Vale area feed approximately 20 to 25 pounds of hay per day to brood cows (21). One ton of hay would, therefore, feed from 2.7 to 3.3 cows one month. It was then assumed that each ton of hay would feed three cows a month. It was further assumed that native hay was worth $19.00 per ton[35] or $6.33 per AUM, if a ton fed three cows. The average grazing fee charged permittees ($0.33/AUM) was subtracted from this amount giving a net value of $6.00 per AUM.

It was assumed that permittees took non-use for the amount of forage that was not made available during the deferred grazing period BLM officials felt was necessary to establish a stand of grass on rehabilitated areas. Yearly deferred costs were determined by multiplying the "before" forage amounts by $6.00/AUM. These costs were discounted at six percent for two years.[36]

Forage data

Forage data for consecutive grazing periods were not available from any source in the Vale area. The next alternative was to obtain estimates of the productivity of the range "before" and "after"[37] the

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[35]This is slightly less than the average value of wild hay reported by the Cooperative Extension Service (11).

[36]These costs represent investments incurred by ranchers in the form of forgone ranch income above investment costs paid by public funds that were given to the BLM. These costs are "out of pocket" costs paid by ranchers because their costs are higher during the deferred grazing period than they would have been had these ranchers been able to graze the public range.

[37]The "before" and "after" figures obtained are respectively for the 1960 and 1969 grazing seasons.

Vale Project. Data of this type were obtained from Vale District area managers for each of the allotments included in the study.

It should be noted that these data do not fall clearly into "before" and "after" categories for the following reasons. First, the range surveys conducted by the BLM in the district took a number of years to complete. Therefore, estimates for some areas "before" the Vale Project may be from a range survey that was completed after the Vale Project began. Second, the "after" data are not after the Vale Project had been completed because substantial investments are currently being added to those that have been spent by the BLM.

It should be emphasized that the forage data obtained from the area managers do not represent the total amount of useable forage available on the range nor do they represent the amount actually utilized by livestock. The forage data represent the "normal grazing capacity" of the range, for the grazing seasons indicated previously. The forage data obtained from and defined by the BLM, therefore, have two aspects that are very important to the remainder of this thesis. First, the data are "normal" in the sense that they represent the grazing capacity of the range, given "normal" climatic conditions. This implies that the grazing capacity of the same area under the same grazing system, may be more or less than indicated in this study if climatic conditions (primarily precipitation) departed from "normal" conditions. Second, the forage data represent the "grazing capacity," i.e., "the amount of forage in any given year on a given area that can be used by a specific grazing animal [permittee livestock in this case] at a level of consumption that is proper for range management purposes" (50). The forage data, therefore, represent the amount of forage allocated by the BLM for grazing by permittee livestock. Allocations to permittee livestock are consistent, therefore, with other management considerations of the BLM such as allocations for soil and water conservation and wildlife. Therefore, the total grazing capacity of the range may be more or less than the amounts indicated by BLM personnel had a different allocation to other users been made. It should further be noted that these grazing capacities are at a level of utilization that will not decrease the productivity of the range. Hence, actual utilization in any year may be significantly less than the amount that could be grazed, given "normal" conditions.

The data obtained from the BLM provide the necessary inputs for estimation of the parameters of the modified model. After the parameters of the model have been estimated, a test of the hypotheses outlined in Chapter 2 may be made.

IV. RESULTS AND DISCUSSION

The theoretical effects that may result from investments in range improvements were outlined in Chapters 1 and 2. The development of a model to estimate these effects is contained in Chapter 3. This chapter contains the statistical estimation of the parameters of the modified model outlined in Chapter 3 and an economic evaluation of the range improvements undertaken by the BLM during the Vale Project.

This chapter is divided into four main sections. The statistical considerations involved in estimating the parameters of the modified model are discussed in section one. The second section contains the results of this statistical estimation. The third section contains a test of the hypotheses of Chapter 1. This test is based upon the parameters estimated in section two. The results of sections two and three are used in section four to evaluate the range improvement investments undertaken by the BLM in the areas of the Vale District selected for study in this thesis.

Statistical Considerations

Multiple regression analysis was used to estimate the parameters of the simultaneous equations of the modified model outlined in Chapter 3. The regression models used in this study are of the following general form:

$$Y = \beta_0 + \beta_1 X_1 + \ldots + \beta_n X_n + \mu \text{ where}$$

β_i - represents the parameters to be estimated.

X_i - represents independent variables.

Y - represents the dependent variable (there is one dependent variable for each equation considered).

μ - represents a stochastic error term.

Several properties of parameter estimations have been accepted as being desirable. These properties include: (1) a good fit, (2) parameter estimates that are unbiased, and (3) parameter estimates that are efficient--have minimum variance. Reasons why the procedures used in this study, given the data obtained from the BLM, may lead to estimates that do not have these desirable properties are outlined in the following sub-section.

Anticipated problems

If the parameters of a system of simultaneous equations such as the modified model of Chapter 3 are estimated directly by least squares, they will have the property of being biased and inconsistent because the dependent variable will, in general, be correlated with the error term.[38] Indirect methods may be used, however, to estimate these parameters. One of the methods that may be used is two-stage least squares which, according to Johnston (36), is the best practical method presently available to estimate the parameters of a simultaneous

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[38]A complete discussion of the problems involved in the estimation of simultaneous equations is contained in Klein (43, 44), Foote (17), and Chapters 9 and 10 of Johnston (36). These references also contain definitions of the statistical terms such as bias and consistency that are used but not defined in this chapter.

system of equations which is not exactly identified. This method was used to estimate the parameters of the structural equations[39] developed from the modified model of Chapter 3 and are presented in section two of this chapter. It should be noted, however, that the use of these indirect methods result in parameter estimates that ". . . will also, in general, be biased, but they do have the desirable large-sample property of consistency" (36, p. 275).

When variables that are measured with error are used as independent variables, estimated parameters are biased and inconsistent because ". . . a dependence exists between the error term and the explanatory variable . . . " (36, p. 149). The second anticipated statistical problem, therefore, concerns the effect the above possible measurement errors have on parameter estimations.

The forage estimates obtained from the BLM may be subject to the following types of measurement error. First, the basic unit of measure used was an AUM. This is a very broad measurement of productivity that does not, generally, take into consideration such things as quality and type of forage. It is, however, the most widely used indicator of range productivity and is the unit of measurement upon which grazing fees are assessed. Second, the "before" (1960) figures are based largely upon survey data and are subject to judgment

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[39]Structural equations are defined to be "individual equations which define the process by which a set of economic variables are believed to be generated" (17, p. 213). Their role in this study will become clearer in later sections.

errors on the part of the persons conducting the survey.[40] Third, the "after" figures include estimated forage data from improved areas that were not grazed in 1969, due to the newness of these rehabilitation projects, whereas the remaining rehabilitated areas had been grazed. Areas that had not been grazed are subject to considerable judgment error in estimating the potential production of the area. The number of acres of this type is relatively small, however, and should therefore not bias the "after" estimates greatly. Fourth, "before" forage estimates on Old Rehab areas are subject to considerable judgment error. Some Old Rehab areas were not being utilized during the 1960 grazing season because grazing on these areas, like some improved areas in 1969, was being deferred. The area managers were, therefore, asked to estimate the grazing capacity of these areas as if they had been grazed. These areas may, therefore, show a larger increase in forage than actually occurred. Most of the Old Rehab areas were old enough, however, that this problem did not arise. Chadwick McBurney, Head of the Range Management section of the Vale District, felt, however, that all forage figures would be within 10 percent of the actual grazing capacity in "normal" years.

The theoretical development of Chapters 1 through 3 was concerned with the production and utilization of forage on a <u>given</u> land area. The use of cross sectional data, therefore, introduced a problem concerning how differences in acreage among the units of observation

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[40]"After" (1969) figures are based upon survey and grazing data and, therefore, are not as subject to judgment errors as are the "before" figures.

(allotments) should be taken into account. This acreage problem was further complicated by the fact that the proportion of improved land (AI) to native (AN) varies considerably among allotments.

The inclusion of acres as an independent variable in the models discussed thus far may cause problems of multicollinearity[41] because acres and investment costs would tend to be highly correlated. This high correlation would make the desired property of minimum variance estimators difficult to obtain. The exclusion of acres as a variable, however, may bias parameter estimates (5). This possible dilemma illustrates one of the problems of obtaining parameter estimates that have desirable properties.

It should be noted that ". . . the possible joint presence of simultaneous equation problems and some of the complications such as errors in variables, autocorrelation and heteroscedasticity . . ." (36, p. 294) are unsolved issues that further complicate the preceding problems. It, therefore, became necessary to develop a number of structural equations or models. Each fitted model is discussed in the second section of this chapter in light of the anticipated problems discussed above. These problems also made the following a priori restrictions important as criterion for a "good" fit.

A priori restrictions

The theoretical discussion contained in Chapter 3 was used to outline the following a priori restrictions.[42] First

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[41]A good discussion of multicollinearity and its consequences is contained in Chapter 8 of Johnston (36).

[42]These restrictions are also implied in the theoretical

$\partial FIM_1/\partial X_i \geq 0$ (i = 1,2,3,4) should not be negative, i.e., as the amount of investment increases, the amount of forage from improved areas should also increase. If this derivative was negative, it would infer that less forage was being produced on improved areas as a result of range improvement investments. Furthermore, a negative sign is not substantiated by inspection of the data obtained from the BLM. Second, the amount of forage produced on native lands should not have decreased as a result of investments on these areas ($\partial FNA/\partial X_5 \geq 0$).

Based upon the history of the area, had there been no rehabilitation work completed, the production of forage in the area in 1969 would probably have been less than or equal to the production in 1960 ($FIM_1 \leq FIM_0$--$FNA_1 \leq FNA_0$). This implication also provides a restriction that is used in part of the following discussion of the various models.

The preceding restrictions, together with the anticipated statistical problems outlined above, provide criterion for choosing one model over another. In the final analysis, however, models that provide a "good" fit should be accepted with reservation until they have been tested, with new data, for their ability to predict (19).

Statistical Models

The models presented in remaining sections of this chapter will use the following notation:

FIM_1 = 1969 grazing capacity of improved lands, as estimated by the BLM.

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discussion of Chapters 2 and 3.

FIM_o = 1960 grazing capacity of improved lands, as estimated by the BLM.

FNA_1 = 1969 grazing capacity of native lands, as estimated by the BLM.

FNA_o = 1960 grazing capacity of native lands, as estimated by the BLM.

FI = $FIM_1 - FIM_o$

FN = $FNA_1 - FNA_o$

AI = acres of improved land

AN = acres of native land

X_1 = total investment costs for spraying (S)

X_2 = total investment costs for spraying and seeding (SS)

X_3 = total investment costs for plowing and seeding (PS)

X_4 = total investment costs for improvements on Old Rehab (OR) areas

X_5 = total investment costs for improvements on native (N) areas.

Model I

The first statistical model was closely patterned after the modified model that was discussed in Chapter 3. The structural form of statistical Model I was, therefore, of the following form:

$$\text{I-a)} \quad FIM_1 = \alpha_o + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 FIM_o + \alpha_6 (AI) + \alpha_7 (FNA_1)$$

$$\text{I-b)} \quad FNA_1 = \beta_o + \beta_1 X_5 + \beta_2 \, FIM_1 + \beta_3 \, (AN) + \beta_4 \, (FNA_o)$$

Tables 3 and 4 contain the estimated coefficients for these equations.

The first thing that should be noticed concerning the estimated coefficients in Table 3 is that the coefficients for the X_1, X_2, X_3, and X_4 variables are all negative. These negative signs are contrary to what one would expect, a priori, and are thus contrary to the restrictions discussed earlier. The negative signs indicate that either the structural equations are not correctly specified or some statistical problem is causing the coefficients to have the wrong sign.

It was noted earlier in this chapter that the estimated grazing capacities were subject to errors of measurement. It was further noted that the 1960 grazing capacities were probably subject to larger measurement errors than the 1969 grazing capacities. If the 1960 grazing data were measured with error, the estimated coefficients in Table 3 and Table 4 are biased (36).

If no investment had occurred in the Vale District ($X_1 = X_2 = \ldots = X_5 = 0$), then the estimated grazing capacity would have been greater than the beginning grazing capacity (for example, $FIM_1 = 675.41 + .9185\ (FIM_o) + (.2375)\ (AI) + (.0391)\ (\hat{FNA}_1) > FIM_o$). This result is unlikely in light of the historical decrease in the grazing capacity that existed prior to the Vale Project. It was, therefore, felt that the estimated coefficients were biased and that a different specification of the model should be made to possibly eliminate the bias.

TABLE 3. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION I-a

	Constant term	X_1	X_2	X_3	X_4	FIM_o	AI	$\hat{FNA}_1$[a]	FIM_1	R^2
Estimated coefficients	675.41	-.0355	-.0188	-.0053	-.0148	.9185	.2375	.0391		.883
Standard errors		.0233	.0169	.0110	.0306	.4821	.0979	.0901		
T values		-1.52	-1.11	-.48	-.48	1.91	2.43	.434		
				Simple correlation coefficients						
X_1		1.0	.128	-.106	-.274	.706	.648	.634	.545	
X_2			1.0	-.320	-.105	.105	.717	.243	.519	
X_3				1.0	-.215	.029	-.031	-.070	.109	
X_4					1.0	-.157	-.046	-.113	.030	
FIM_o						1.0	.558	.636	.680	
AI							1.0	.514	.876	
$\hat{FNA}_1$								1.0	.503	
FIM_1									1.0	

[a]Estimated variables from the first stage which were used as independent variables in the second stage are designated, in the remainder of this thesis, by a hat (^).

TABLE 4. ESTIMATED COEFFICIENTS AND CORRELATIONS
FOR REGRESSION EQUATION I-b

	Constant term	X_5	$\hat{FIM}_1$	AN	FNA_0	FNA_1	R^2
Estimated coefficients	756.8	.0098	.0484	.0053	.989		.8317
Standard errors		.0147	.3096	.0114	.1970		
T values		.67	.16	.47	5.01		
			Simple correlation coefficients				
X_5		1.0	.568	.505	.550	.581	
$\hat{FIM}_1$			1.0	.691	.439	.480	
AN				1.0	.681	.683	
FNA_0					1.0	.903	
FNA_1						1.0	

Model II

Since the coefficients for FIM_0 and FNA_0 in Tables 3 and 4 are nearly equal to 1.0,[43] these variables can be subtracted from both sides of Equations I-a and I-b to yield new variables. This procedure would allow any measurement error associated with FNA_0 and FIM_0 to become part of the error term associated with new dependent variables, FN (FNA_1 - FNA_0) and FI (FIM_1 - FIM_0).

[43]We fail to reject the hypothesis that a_5 and b_4 are equal to 1.0 (H_0:a_5, b_4 = 1.0 vs H_A:a_5, $b_4 \neq 1.0$) at probability levels greater than 0.20.

Model II, therefore, specified equations of the following structural form:

$$\text{II-a)}\quad FI = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 (FN) + \alpha_6 (AI)$$

$$\text{II-b)}\quad FN = \beta_0 + \beta_1 X_5 + \beta_2 (FI) + \beta_3 (AN)$$

Estimated coefficients for this model are contained in Tables 5 and 6.

The sign of the a_1, a_2, b_2, and b_3 coefficients are negative indicating that (1) investments for spraying and spraying and seeding have decreased the amount of improved forage, and (2) as acres of native land and improved forage increase, native forage decreases. These results do not correspond to what one would expect, _a priori_.

It is noticed that the a_0 coefficient is negative. This indicates that the change in improved forage may be negative if no investments had occurred ($FI = -241.92 + .7327(\hat{FN}) + (.1810)(AI)$). The sign for the b_0 coefficient is positive, however, indicating that increases in native forage would have resulted in the absence of any investment ($FN = 1278.2 - .0351(\hat{FI}) - .0027(AN)$). If mean values for $\hat{FI}$, $\hat{FN}$, AN, and AI are substituted into the above equations when $X_1 = . . . = X_5 = 0$, FI and FN are positive, however. This result is contrary to the historical production of the area.

Klein (43) states that multicollinearity problems probably exist when the inter-correlation between the explanatory variables is relatively greater than the overall correlation of the whole equation (R^2). Johnston states that significant increases in the standard error of a coefficient, as more variables are added to a model, gives ". . . ample warning of the imprecision attaching to the estimates of the separate effects . . . " (36, p. 204) of two (or

TABLE 5. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION II-a

	Constant term	X_1	X_2	X_3	X_4	$\hat{FN}$	AI	FI	R^2
Estimated coefficients	-241.92	-.0305	-.0129	.0034	.0034	.7327	.1810		.831
Standard errors		.0188	.0144	.0123	.030	.7209	.0932		
T values		-1.62	-.90	.28	.12	1.02	1.94		
				Simple correlation coefficients					
X_1		1.0	.128	-.106	-.274	.753	.648	.383	
X_2			1.0	-.320	-.104	.543	.717	.585	
X_3				1.0	-.215	-.426	-.031	.122	
X_4					1.0	-.230	-.460	.106	
$\hat{FN}$						1.0	.749	.551	
AI							1.0	.847	
FI								1.0	

TABLE 6. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION II-b

	Constant term	X_5	$\hat{FI}$	AN	FN	R^2
Estimated coefficients	1278.2	.0336	-.0351	-.0027		.143
Standard errors		.0349	.4056	.0138		
T values		.96	-.09	-.20		
			Simple correlation coefficients			
X_5		1.0	.751	.873	.375	
$\hat{FI}$			1.0	.738	.260	
AN				1.0	.301	
FN					1.0	

more) variables when these variables are highly correlated. The criterion given by both authors indicate that significant multicollinearity problems exist in estimation of the parameters of Equation II-a. In fact, the standard error of a_6 increased nearly 6 fold from the first to the last step of the step-wise program. Johnston's criterion did not, however, indicate that multicollinearity problems exist in the estimation of the parameters of Equation II-b, but Klein's criterion did. To the extent that multicollinearity problems exist in the estimation of the α_i and β_j parameters, the estimated coefficients lack precision and thus little confidence can be placed in these estimates. This probable lack of precision and the negative signs for the a, a_2, b_2, and b_3 coefficients led to the following model.

Model III

This model is like Model II except α_0 and β_0 are assumed to be equal to zero because one would expect no (or very little) change in forage (FN = FI = 0) in the absence of any investments. The structural equations of Model III, therefore, are of the following form:

$$\text{III-a)} \quad FI = \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 (FN) + \alpha_6 (AI)$$

$$\text{III-b)} \quad FN = \beta_1 X_5 + \beta_2 (FI) + \beta_3 (AN)$$

Estimated coefficients for this model are found in Tables 7 and 8. The estimates for $\alpha_1(a_1)$ and α_2 (a_2) are negative, which again does not correspond to the a priori restrictions. Furthermore, there is evidence that multicollinearity problems exist, using Klein's criterion. For example, R^2 for Equation III-b equals .481 and the correlation between X_5, $\hat{FI}$ and AN are respectively .835, .925, and .885.

The sign of the a_1 and a_2 coefficients implies that a problem of mis-specification may exist as well. The following discussion outlines reasons why this mis-specification is probably the most important problem.

If acres are used as an independent variable, given the procedure being used, this implies that the productivity of a dollar

TABLE 7. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION III-a

	Constant term	X_1	X_2	X_3	X_4	$\hat{FN}$	AI	FI	R^2 [a]
Estimated coefficients	0.0	-.0218	-.0110	.0028	.0055	.1031	.1966		.948
Standard errors		.0321	.0163	.0092	.0296	1.286	.0812		
T values		-.68	-.68	.31	.19	.08	2.42		
			Simple correlation coefficients[a]						
X_1		1.0	.419	.471	.790	.938	.834	.778	
X_2			1.0	.107	.061	.645	.736	.658	
X_3				1.0	.789	.528	.557	.637	
X_4					1.0	.221	.246	.333	
$\hat{FN}$						1.0	.974	.911	
AI							1.0	.954	
FI								1.0	

[a]Regression coefficients for models forced through the origin ($\alpha_o = \beta_o = 0$) are not comparable to coefficients for variables not forced through the origin because regression coefficients for models not forced through the origin are not adjusted for the mean(s).

TABLE 8. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION III-b

	Constant term	X_5	$F\hat{I}$	AN	FN	R^2
Estimated coefficients	0.0	.0205	.3281	.0003		.4813
Standard errors		.0345	.2821	.0015		
T values		.59	1.16	.02		
		Simple correlation coefficients				
X_5		1.0	.835	.925	.650	
$F\hat{I}$			1.0	.885	.676	
AN				1.0	.651	
FN					1.0	

is the same if spent on one acre or twenty.[44] The investments undertaken by the BLM were on specific parcels of land which varied greatly in size. Thus, the intensity of investment is more applicable to this study than is the extensity of investments. From an economic point of view, therefore, the variables should be specified such that the intensity of investment is reflected.

The models presented below involve a change in specification that takes into account the intensity of investment that has occurred in the areas included in this study (all variables are put on a per acre basis). These models vividly point how this change in

[44]This implication was pointed out to the author by Dr. John A. Edwards.

specification alters the results of the estimation of the parameters of the investment variables.

Model IV

The structural equations of Model IV were derived by dividing the variables of Model III by AI and AN,[45] to form Equations IV-a and IV-b. These equations are, therefore, of the following form:

$$\text{IV-a)} \quad FI/AI = \alpha_1(X_1/AI) + \alpha_2(X_2/AI) + \alpha_3(X_3/AI) + $$

$$+ \alpha_4(X_4/AI) + \alpha_5(FN/AI)$$

$$\text{IV-b)} \quad FN/AN = \beta_1(X_5/AN) + \beta_2(FI/AN)$$

The first thing that should be noted concerning the algebraic specification of these structural equations is that they do not represent a system of simultaneous equations because the dependent variables of Equations IV-a (FI/AI) and IV-b (FN/AN) are no longer independent variables in the other equation. It should be noted, however, that the forage values (FI and FN) remain simultaneous in nature[46] but the algebraic formulation of Equations IV-a and IV-b is

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[45]The hypothesis that a_6 is equal to zero is rejected with probability greater than .95 ($H_0{:}a_6 = 0$ vs. $H_A{:}a_6 \neq 0$) but we fail to reject the hypothesis that b_3 is equal to zero at probability levels greater than .10 ($H_0{:}b_3 = 0.0$ vs. $H_A{:}b_3 \neq 0.0$).

[46]Klein (44) advocates using a more complex method than was used in this study when parameters of a non-linear system of simultaneous equations are being estimated. He also discusses the circumstances that should exist when this method is used.

such that a simultaneous system of equations is not inferred. Therefore, Equations IV-a and IV-b could be estimated by simple least squares (two stage regression was not used).

Estimated coefficients for Equations IV-a and IV-b are found in Tables 9 and 10. It is noted that all coefficients have the signs that were expected, a priori, and that all coefficients, except b_1, are significantly different from zero.[47] Furthermore, there is little evidence, using Johnston's criterion, that problems of multicollinearity exist. As noted earlier, this model does not involve a system of simultaneous equations but there is an interaction between changes in native and improved forage. This interaction is important, as indicated by the significance of the a_5 and b_2 coefficients.

The algebraic specification of this model may not be the "best" specification, but it does have desirable implications which will be discussed in sections three and four of this chapter. An alternative specification is discussed in Models V, VI, and VII.

Model V

Model V is of the following structural form:

$$\text{(V-a)} \quad FI/AI = \alpha_1(X_1/AI) + \alpha_2(X_2/AI) + \alpha_3(X_3/AI) + \alpha_4(X_4/AI) + \alpha_5(FN/AN)$$

[47]The a_1, a_2, a_3, a_4, a_5, b_1, and b_2 coefficients are different from zero ($H_0: a_i, b_j \leq 0.0$ vs. $H_A: a_i, b_j > 0.0$), respectively, at the 0.05, 0.15, 0.005, 0.025, 0.15, 0.25, and 0.005 significance levels.

TABLE 9. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION IV-a

	Constant term	X_1/AI	X_2/AI	X_3/AI	X_4/AI	FN/AI	FI/AI	R^2
Estimated coefficients	0.0	.0150	.0087	.0228	.0537	.2619		.8375
Standard errors		.0084	.0072	.0053	.0224	.1973		
T values		1.79	1.20	4.27	2.40	1.33		
		Simple correlation coefficients						
X_1/AI		1.0	.261	.334	.094	.565	.583	
X_2/AI			1.0	.128	.090	.457	.388	
X_3/AI				1.0	.074	.542	.761	
X_4/AI					1.0	.155	.359	
FN/AI						1.0	.730	
FI/AI							1.0	

TABLE 10. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION IV-b

	Constant term	X_5/AN	FI/AN	FN/AN	R^2
Estimated coefficients	0.0	.0184	.4080		.657
Standard errors		.0237	.1175		
T values		.78	3.47		
		Simple correlation coefficients			
X_5/AN		1.0	.721	.654	
FI/AN			1.0	.803	
FN/AN				1.0	

$$(V\text{-}b)\quad FN/AN = \beta_1(X_5/AN) + \beta_2(FI/AI)$$

The only difference between this model and Model IV is the specification of the interaction between changes in improved and native forage. Model IV specified the interaction between FI/AI and native forage as FN/AI, whereas Model V[48] specifies the interaction as being between FI/AI and FN/AN. Thus the difference in specification lies in how the native and improved acreages are included in the model.

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[48]Model IV more nearly corresponds to the original specifications of Models I, II, and III than does Model V. Model V basically states that changes in a type of stocking rate, (FI/AI and FN/AN) are interdependent, whereas the interaction in Model IV is less direct.

The structural equations of Model V are of a simultaneous nature and, therefore, require the use of two-stage regression. Estimated coefficients for this model are contained in Tables 11 and 12. The first thing that should be noted concerning these estimates is that there is evidence of interdependence, as reflected by the significance of the a_5 and b_2 coefficients. However, one would not expect, a priori, the coefficients for X_i/AI $(i = 1,2,3,4)$ to be negative. There is evidence, using Johnston's criterion, that problems of multicollinearity are present in the estimation of these coefficients, however. For example, the standard error of a_5 increased nearly eight fold from the first to the last stage of the estimating regression. The degree of multicollinearity in these estimates is dramatically illustrated in Model VI.

Model VI

The presence of multicollinearity in the estimation of the parameters of Equation V-a, makes estimates of the significance of each coefficient in Model V questionable. It was, therefore, assumed that the dependence between changes in native and improved forage production was one way.[49] This assumed one-way dependence is illustrated by the following structural equations:

$$\text{VI-a)}\quad FI/AI = \alpha_1(X_1/AI) + \alpha_2(X_2/AI) + \alpha_3(X_3/AI) + \alpha_4(X_4/AI)$$

[49]This assumption is based on the physical relationship, suggested by range scientists, that changes in improved forage production have not been influenced as greatly by changes in native production (or that sufficient time has not lapsed for this relationship to become evident) as changes in native production have been influenced by changes in improved forage production.

TABLE 11. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION V-a

	Constant term	X_1/AI	X_2/AI	X_3/AI	X_4/AI	$\hat{FN}/AN$	FI/AI	R^2
Estimated coefficients	0.0	-.00008	-.00004	-.00008	-.00018	1.00322		.838
Standard errors		.0168	.0116	.0202	.0479	.7537		
T values		-.005	-.003	-.004	-.004	1.33		
		Simple correlation coefficients						
X_1/AI		1.0	.261	.334	.099	.639	.584	
X_2/AI			1.0	.128	.090	.424	.388	
X_3/AI				1.0	.074	.832	.761	
X_4/AI					1.0	.392	.359	
$\hat{FN}/AN$						1.0	.915	
FI/AI							1.0	

TABLE 12. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION V-b

	Constant term	X_5/AN	$\hat{FI}/AI$	FN/AN	R^2
Estimated coefficients	0.0	.0005	.1753		.4784
Standard errors		.0617	.1305		
T values		.008	1.33		
		Simple correlation coefficients			
X_5/AN		1.0	.944	.654	
$\hat{FI}/AI$			1.0	.692	
FN/AN				1.0	

VI-b) $FN/AN = \beta_1(X_5/AN) + \beta_2(FI/AI)$

Tables 13 and 14 contain the estimated coefficients for Equations VI-a and VI-b. These coefficients all have the signs that were expected, *a priori*. Furthermore, all coefficients, except b_1, are significant at the .05 level or less.[50] These results are a significant departure from the results of Model V. Reasons why this departure may have been expected are discussed below.

[50]The hypothesis that $a_i(b_j)$ are less than or equal to zero ($H_0: a_i, b_j \leq 0.0$ vs. $H_A: a_i, b_j > 0.0$) is rejected at the following respective probability levels a_i:0.025, 0.05, 0.0005, 0.025; b_2: 0.05. b_1 was not significantly different from zero but will be retained in the model for economic reasons discussed later.

TABLE 13. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION VI-a

	Constant term	X_1/AI	X_2/AI	X_3/AI	X_4/AI	FI/AI	R^2
Estimated coefficients	0.0	.0199	.0126	.0261	.0565		.8184
Standard errors		.0077	.0067	.0048	.0228		
T values		2.57	1.87	5.43	2.48		
			Simple correlation coefficients				
X_1/AI		1.0	.261	.334	.094	.583	
X_2/AI			1.0	.128	.090	.388	
X_3/AI				1.0	.074	.761	
X_4/AI					1.0	.359	
FI/AI						1.0	

TABLE 14. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION VI-b

	Constant term	X_5/AN	$FI\hat{/}AI$	FN/AN	R^2
Estimated coefficients	0.0	.0172	.1480		.5017
Standard errors		.0420	.0903		
T values		.41	1.64		
		Simple correlation coefficients			
X_5/AN		1.0	.881	.654	
$FI\hat{/}AI$			1.0	.705	
FN/AN				1.0	

Investments on improved areas have significantly increased the grazing capacity of these areas, as indicated by the significance of the a_i (i = 1,2,3,4) coefficients of Models IV and VI. This increased forage production has probably allowed the BLM to graze native areas less heavily. Furthermore, this decreased utilization has probably resulted in increased production of native forage. The X_1, X_2, X_3, and X_4 variables would, therefore, tend to move in the same direction as FN (positive correlation). This correlation (see Models II and III) could easily lead to problems of multicollinearity (this was important in Models II, III, and V). Multicollinearity was not evident in Model IV, however (Johnston's criterion). The probable reason for this difference lies in the specification of the structural equations [FI = f_1 (FN), FI/AI = f_2 (FN/AI), and FI/AI = f_2 (FN/AN) in

Models II-III, IV and V-VI, respectively]. Model V specified that changes in grazing capacity per acre of one type (FI/AI) were a function of changes in forage per acre of the other type (FN/AN). Model IV, however, made changes in forage per acre of one type (FI/AI) a function of forage of the other type; but these changes (FN) were weighed by acres of the first type (FN/AI). This difference in weighing (a specification problem) can apparently cause specification bias, as evidenced by the negative values for a_i in Model V, as well as multicollinearity.[51] Therefore, little confidence can be placed in the estimated coefficients of Model V.

It should be noted that multicollinearity is not significant in the estimation of Equations IV-b, V-b, and VI-b, using Johnston's criterion. Klein's criterion, however, indicates that multicollinearity problems are quite significant in each equation. Thus, the general low significance of the b_1 coefficients may not be as meaningful as it would be, had there been no evidence of multicollinearity. The importance of this conclusion is discussed further when the hypothesis of Chapter 1 is tested in the next section.

Model VII

Given an assumed one-way dependence between native and improved forage production, a more efficient measure of the productivity of the

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[51] Further research in this area may develop alternative specifications, such as the ones discussed in Chapter 3 and Appendix D, that would result in a better fit. The development of other models, however, is beyond the scope of this study.

investments on improved areas is determined by the following structural equation:[52]

$$FI_i/AI_i = k_j\beta_1(X_1/AI_i) + k_j\beta_2(X_2/AI_i) + k_j\beta_3(X_3/AI_i) + + k_j\beta_4(X_4/AI_i)$$

where

$$i,j = 1,2,3,4 \text{ and } k = \begin{pmatrix} 0 \text{ if } i \neq j \\ 1 \text{ if } i = j \end{pmatrix}$$

This model, unlike the preceding models, has 46 observations associated with it because the units of observation are no longer allotments but are improved areas of a certain type. Thus, FI_i/AI_i represents the change in grazing capacity per acre for each improvement type (S, SS, PS, or OR).

Estimated coefficients for this model are contained in Table 15. The a_i coefficients all have the expected signs and are significantly different from zero.

To the extent, however, that changes in native grazing capacity have affected the grazing capacity of improved areas, an omission of an important variable has resulted. Brown (5) has illustrated how bias may be introduced by omitting a relevant variable. Therefore, parameter estimates for Models VI and VII may be biased. This possible bias directly affects the conclusions of sections three and four, as is pointed out in the discussion contained in those sections.

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[52]This model was proposed to the author by Dr. William G. Brown.

TABLE 15. ESTIMATED COEFFICIENTS AND CORRELATIONS FOR REGRESSION EQUATION VII

	Constant term	X_1/AI_i	X_2/AI_i	X_3/AI_i	X_4/AI_i	FI_i/AI_i	R^2
Estimated coefficients	0.0	.0236	.0194	.0152	.0532		.813
Standard errors		.0039	.0034	.0016	.0113		
T values		6.04	5.78	9.54	4.69		
			<u>Simple correlation coefficients</u>				
X_1/AI_i		1.0	0.0	0.0	0.0	.403	
X_2/AI_i			1.0	0.0	0.0	.386	
X_3/AI_i				1.0	0.0	.636	
X_4/AI_i					1.0	.313	
FI_i/AI_i						1.0	

Test of Hypotheses

The first hypothesis of Chapter 2 stated that increases in improved forage production had led to increased production on native areas ($\partial R_{1jNt_2}/\partial R_{1jIt_1} > 0$). The second hypothesis stated that increased forage production on native lands have led to increased forage production on improved land ($\partial R_{1jIt_3}/\partial R_{1jNt_2} > 0$).

Data available from the BLM did not allow the estimation of models that would directly test the above hypotheses. An indirect test of these hypotheses may be made, however, using the results of Model IV. For example, Model IV states that

$$FI/AI = \alpha_1(X_1/AI) + \alpha_2(X_2/AI) + \alpha_3(X_3/AI) + \alpha_4(X_4/AI) + \alpha_5(FN/AI)$$

and

$$FN/AN = \beta_1(X_5/AN) + \beta_2(FI/AN)$$

If the first equation is multiplied by AI and the second by AN we obtain the following:

$$FI = \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 FN$$

and

$$FN = \beta_1 X_5 + \beta_2 FI$$

If the first derivative of the first equation is taken with respect to FN and the first derivative of the second equation is taken with respect to FI, we obtain the following respective derivatives,

$$dFI/dFN = \alpha_5 \quad \text{and} \quad dFN/dFI = \beta_2$$

These coefficients (α_5 and β_2) provide a test of the hypothesis under consideration, i.e., that changes in improved forage production may have changed the production of native areas (b_2) and changes in native forage production may have changed the forage production of improved areas (a_5).

To statistically test the above theoretical hypotheses, it is hypothesized that a_5 and b_2 are less than or equal to zero ($H_0: a_5, b_2 \leq 0.0$ vs. $H_A: a_5, b_2 > 0.0$).

The "t" values for the respective coefficients provide the basis for the statistical test of this hypothesis. The t values for the a_5 and b_2 coefficients of Model IV are respectively 1.33 and 3.47. Both of these "t" values are positive and infer that a_5 and b_2 are different from zero at the 0.10 and 0.005 significance levels, respectively.

The b_2 coefficient for Model VI may also be used to test the influence of changes in forage production on improved areas and native areas. This test ($H_0: b_2 \leq 0.0$ vs $H_A: b_2 > 0.0$) indicates that b_2 is significantly different from zero at the 0.10 level ($t = 1.64$).

The other models that were estimated also indicate that there has been a positive interaction between changes in the production of native and improved areas. Tests based on other models, however, are subject to specification bias, which may be significant in many cases, as indicated by the negative signs of the coefficients for the X_1, X_2, X_3, X_4, and X_5 variables in most of these models.

It should be noted that the influence of improved area forage production on native production has been greater in magnitude than has been the influence of native production on improved area forage production ($b_5 = .4080$, $a_5 = .2619$--Model IV). Furthermore, b_2 was statistically more significant than was a_5 ($t_{b_2} = 3.47$, $t_{a_5} = 1.33$). It is, therefore, concluded, based on the a_5 and b_2 coefficients of Model IV, that the management of the forage resource in the Vale District has resulted in (a) increases in improved forage production that has significantly increased the production of forage on native areas, and (b) increases in native area forage production that has increased the production of improved areas but not to the extent that improved areas have affected the production of native areas. Sufficient time, however, may not have lapsed for some influences that were theoretically expected to become apparent. These conclusions have significant bearing upon the economic evaluation of the range improvement investments that have occurred during the Vale Project. The effect these conclusions have on this evaluation is the topic of the following section.

Economic Evaluation of Range Improvements in the Vale District

This section contains an economic evaluation of the benefits and costs of range improvements conducted by the BLM in the Vale District. A full evaluation of these improvements, however, is not possible at this time because data are not available to evaluate some of the benefits and costs. Therefore, only the effect these improvements have had on grazing by livestock will be evaluated.

This evaluation is divided into two parts. The first part assumes that there has been no dependence between the production of forage between native and improved areas in the Vale District. This part uses methods (traditional or budgeting approach) and assumptions that other economists have used to evaluate the benefits of range improvements. This part also includes an evaluation using the regression models of the previous section (Model VII and Equation VI-a). The second part evaluates the range improvements undertaken during the Vale Project using Models IV and VI of the previous section. The major difference between parts one and two is that part one assumes that there has been no dependence between native and improved forage production; and part two assumes, based on the tested hypothesis of section three, that there has been dependence. The different results of the two parts vividly points out the complex problems that arise when the utilization (management that may allow an interaction) of the forage resource is taken into account. The difference in results also indicates some of the weaknesses of the procedures that have been used to evaluate the benefits of range improvements.

Traditional approach

The traditional methods used to evaluate the returns to grazing resulting from range improvements is explained in a number of sources. The discussions by Nielsen (57), Caton and McCorkle (51), and Gardner (22), however, are probably the clearest and most straightforward. The general approach advocated by these and other researchers will be used in the remainder of this sub-section.

In an effort to make an evaluation of the results of the previous section somewhat amenable, the following assumptions are made.[53] First, it is assumed that the difference between pre- and post-practice grazing capacity is due to the improvements made by the BLM on these areas. Second, the increased grazing capacity (FIM_1 - FIM_0 or FNA_1 - FNA_0) is assumed to exist throughout the assumed life of the project after which time the pre-practice grazing capacity is assumed to prevail. Third, it is assumed that areas are utilized at the grazing capacity levels estimated by the BLM.[54] Fourth, it is assumed that there is a deferred grazing period of two years on improved areas.[55] Fifth, it is assumed that the grazing capacity and cost data obtained from the BLM are accurate.

Gardner (23) has advocated using the internal rate of return as the standard criterion to be used in evaluating the benefits of range

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[53]These assumptions parallel the assumptions made by Gardner (22).

[54]Assumptions 1, 3, and 5 will be altered later in this section to see how they affect the evaluation of range improvements.

[55]The estimation of these costs is contained in Chapter 3.

improvements. Roberts and Wennergren point out, however, that

> Sometimes the increase in the annual flow of net ranch returns cannot be estimated adequately. In that case the rate of interest associated with credit sources in the area can be used as a criterion and the increased annual net ranch returns required to yield that rate are calculated. (68, p. 121)

The procedure advocated by Roberts and Wennergren for private investments will be applied in this study to the public investments undertaken in the Vale District because estimating the average value of an AUM of federal forage in the Vale District is beyond the scope of this study.

One of the crucial problems of an evaluation of range improvements is to make the returns and costs comparable. This is accomplished by the method of discounting. The general discounting formula used for areas with deferred grazing is of the following form:[56]

$$C = R \left[\frac{1-(1+i)^{-n}}{i}\right] \left[(1+i)^{-2}\right] \qquad (4\text{-}a)$$

where

$C = C_o + C_d$ = total investment costs

= initial investment costs (C_o) plus deferred costs (C_d)

R = increased grazing capacity (F)[57] times the value of an AUM of forage (P_a)

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[56]This formula would be equivalent to the formula given by Gardner (22) if deferred costs were included in this computation.

[57]This would be the difference between the 1969 and 1960 grazing capacities estimated by the BLM for each of the area types considered (FI or FN).

n = life of the project

i = the discount rate

The discounting formula for areas with no deferred grazing (native and Old Rehab areas) is of the following form:

$$C_o = R\left(\frac{1-(1+i)^{-n}}{i}\right) \tag{4-b}$$

This discounting procedure generally requires some assumption to be made concerning the value of some of the parameters (n, i, P_a, F, C_o, or C_d) because all of the parameters commonly cannot be measured. Thus, the data that are available to the researcher often dictates which method to use to evaluate the results of some investment. For example, if P_a, F, C_o, C_d, and n were known and some assumption was made concerning the value of i, a benefit-cost ratio could be determined or the value of i (internal rate return) that would make the returns and costs equal may be determined.

Estimates of F, C_o, and C_d were derived from the data obtained from the BLM. Therefore, in this study assumptions concerning the value of n and i[58] will be made and using the criterion advocated by Roberts and Wennergren, P_a will be determined.

The current rate at which Federal land and water investments are being discounted is four and seven-eighths percent (52), but a rate of five percent was used in this study because tables were not available for four and seven-eighths percent.

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[58]The life of a project (n) is uncertain. Therefore, a range of possible lives will be assumed for each project type included in this study.

The value that an AUM of federal forage must be worth to yield a five percent return, using both budgets and regression estimates, was determined. This determination is found by using the following formula[59]

$$P_a = \frac{C}{[(\frac{1-(1.05)^{-n}}{.05}) F] [(1.05)^{-2}]} \qquad (4\text{-}c)$$

for improved areas that received deferred grazing and

$$P_a = \frac{C}{[\frac{(1-1.05)^{-n}}{.05}] F} \qquad (4\text{-}d)$$

for areas on which grazing was not deferred.

Budgets

Economists have used the budgeting technique explained below for a number of years. This technique is illustrated in the following example. In plow and seed area 17, the beginning (1960) grazing capacity on the 8800 acres was 98 AUM's. The ending (1969) grazing capacity for the area was 4400 AUM's or a difference of 4302 AUM's (F). Rehabilitation costs (C_o) for the area were $83,222 and deferred costs (C_d) were $1,137 for a total cost (C) of $84,359. If we assume a life of 20 years (n) for this project then

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[59]These formulas are slight variations of Formula 4-a and 4-b. The "F" using budgeting techniques is $FIM_1 - FIM_o = FI$ for improved areas. The F using regression estimates, however, is the marginal physical product of X_i. These marginal productivities are derived in the discussion of the regression estimates and in Appendix D.

$$P_a = \frac{84,359}{[(\frac{1-(1.05)^{-20}}{.05})\ 4302][(1.05)^{-2}]} = \$1.73$$

Thus an AUM of federal forage in plow and seed area 17 must be worth \$1.73 to yield a five percent return on the investment of \$84,359.

Budget estimates for each of the various practices are found in Tables 16 through 20. Perhaps the most obvious characteristic of these estimates is the large variability within a given investment type, such as plowing and seeding. This indicates that the benefits of range rehabilitation work in the district varies considerably from area to area. It also indicates that the selection of sites to receive each type of rehabilitation is extremely important. These data also indicate that the total costs of rehabilitation need to be considered and weighed against possible increases in forage.

The influence of ending grazing capacities on the "pay off" of range rehabilitation is evident as one studies the results of Tables 16, 17, and 18. For example, spray and seed projects in area 11 had a relatively large increase in forage (511%) and relatively low investment costs per acre (\$6.28). However, the area had the lowest beginning grazing capacity (69.9 acres/AUM) and also the lowest ending grazing capacity (9.9 acres/AUM). This indicates that there was a large percentage of increase but a small absolute increase in forage production. This phenomenon is present particularly in areas that have been sprayed and seeded and indicates that either this practice commonly results in relatively poor seeding stands or that the technology of getting a good stand by using this method has not been as fully

TABLE 16. THE VALUE PER AUM NECESSARY TO PAY THE COSTS OF SPRAYING EACH SAMPLED ALLOTMENT AT FIVE PERCENT INTEREST

Area	Total cost per acre	Percent increase in total forage	Assumed life of project		
			9	12	15
1	3.87	216	4.39	3.52	3.01
2	4.40	192	5.19	4.16	3.55
3	6.17	422	4.73	3.79	3.24
5	4.42	152	5.69	4.57	3.90
6	7.85	444	8.96	7.19	6.14
7	5.91	107	9.56	7.66	6.54
8	4.73	97	6.72	5.39	4.60
9	4.66	120	5.16	4.14	3.54
10	3,71	238	3.27	2.62	2.24
11	3.93	426	5.72	4.59	3.92
12	3.94	171	4.51	3.62	3.09
13	4.94	155	7.34	5.89	5.03
14	2.37	360	4.71	3.77	3.22
15	4.14	170	4.53	3.63	3.10
16	3.87	142	6.14	4.92	4.20
18	5.57	100	25.96	20.82	17.78
19	6.45	151	13.33	10.69	9.13
20	5.47	567	5.77	4.62	3.95
Ave.[a]	4.57	175	5.92	4.75	4.05

[a]Average values in Tables 16 through 20 were determined from the totals for each rehabilitation type. For example, total rehabilitation costs were $888,773 for the 194,444 acres sprayed or an average cost of $4.57 per acre.

TABLE 17. THE VALUE PER AUM NECESSARY TO PAY THE COSTS OF SPRAYING AND SEEDING EACH SAMPLED ALLOTMENT AT FIVE PERCENT INTEREST

Area	Total cost per acre	Percent increase in total forage	Assumed life of project		
			15 yrs	18 yrs	21 yrs
2	6.44	382	2.59	2.30	2.00
3	10.42	424	5.46	4.85	4.42
4	6.72	100	5.72	5.08	4.63
6	10.84	215	6.74	5.99	5.46
11	6.28	511	7.97	7.08	6.45
13	6.58	281	3.17	2.81	2.56
16	7.07	141	7.68	6.82	6.22
19	9.96	470	8.98	7.97	7.27
20	7.44	700	4.51	4.01	3.66
Ave.	7.59	333	5.16	4.58	4.18

TABLE 18. THE VALUE PER AUM NECESSARY TO PAY THE COSTS OF PLOWING AND SEEDING EACH SAMPLED ALLOTMENT AT FIVE PERCENT INTEREST

Area	Total cost per acre	Percent increase in total forage	Assumed life of project		
			15 yrs	20 yrs	25 yrs
1	15.75	291	8.97	7.47	6.61
2	16.84	329	7.95	6.62	5.85
3	14.50	422	7.62	6.34	5.61
4	14.49	60	20.51	17.08	15.10
5	11.92	351	8.14	6.78	5.99
7	17.95	401	7.14	5.95	5.26
8	10.10	394	4.86	4,05	3.58
9	19.26	275	8.36	6.96	6.16
11	14,14	972	13.25	11.04	9.76
12	12.42	473	4.80	3.99	3.53
14	13.12	1033	6.13	5.10	4.51
15	12.73	413	4.91	4.09	3.62
17	9.59	4389	2.08	1.73	1.53
Ave.	12.96	464	5.73	4.77	4.22

TABLE 19. THE VALUE PER AUM NECESSARY TO PAY THE COSTS INCURRED ON OLD REHAB AREAS AT FIVE PERCENT INTEREST

Area	Total cost per acre	Percent increase in total forage	Assumed life of project		
			5 yrs	10 yrs	15 yrs
9	.52	139	.92	.52	.38
12	2.11	253	2.04	1.14	.85
13	4.73	191	5.00	2.80	2.09
14	5.03	748	4.96	2.78	2.07
15	.49	10	3.68	2.07	1.54
20	.05	13	4.48	2.51	1.87
Ave.	2.45	217	3.88	2.17	1.62

TABLE 20. THE VALUE PER AUM NECESSARY TO PAY THE COSTS INCURRED ON NATIVE AREAS AT FIVE PERCENT INTEREST

Area	Total cost per acre	Percent increase in total forage	Assumed life of project		
			15 yrs	20 yrs	25 yrs
1	.48	97	.74	.62	.55
2	.39	82	.66	.55	.49
3	.24	161	.29	.25	.22
4	.34	0	**	**	**
5	0	104	0.0	0.0	0.0
6	.25	230	.34	.28	.25
7	.15	.7	26.50	22.07	19.52
8	.32	5	6.30	5.25	4.64
9	.30	24	1.12	.93	.82
10	.04	110	.04	.04	.03
11	.08	0	**	**	**
12	.43	76	1.08	.90	.80
13	.26	20	1.51	1.26	1.11
14	.50	43	1.69	1.40	1.24
15	.41	25	1.56	1.30	1.15
16	.27	65	.57	.48	.42
17	.65	81	1.56	1.30	1.15
18	.56	.5	4.83	4.02	3.56
19	.31	125	1.08	.90	.80
20	.44	.5	4.10	3.42	3.02
Ave.	.32	44	1.19	.99	.88

** Indicates that the value would have to be infinite because no additional forage was produced.

developed as with spraying or plowing and seeding.[60] However, this phenomenon is not unique to spray and seed areas. This general conclusion indicates that the success of a rehabilitation project is particularly important if range improvements are to be "profitable."

In general, the budget estimates indicate that, for typical project lives, the forage values necessary to earn a five percent return are nearly equal for the three intensive rehabilitation types (P, S, SS). For example, if we assume project lives of 12, 18, and 20 years for S, SS, and PS areas (these lives are the most common values used), the returns necessary to earn a five percent return are respectively $4.75, $4.58, and $4.77 for the average S, SS, PS area. This suggests that the BLM has done a fairly good job of equating the benefits from each of the practices over the district. However, this conclusion is not justified within all allotments.

The estimated forage values required for a five percent return on the investments for native and Old Rehab areas are considerably less than the estimates for S, SS, or PS. This indicates that the money spent by the BLM could have yielded higher returns if part of it had been spent on Old Rehab and native areas (a different allocation). It should be emphasized, however, that this conclusion will be modified when the effect S, SS, and PS areas have had on native areas is taken into account.

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[60] It should be noted that the latter case is probably more indicative because this practice is a relatively new investment alternative.

Regression estimates

The regression models estimated earlier can also be used to evaluate the benefits of range improvements. For example, if Equation VI-a was used, we would have the following relationship:

$$FI/AI = \alpha_1(X_1/AI) + \alpha_2(X_2/AI) + \alpha_3(X_3/AI) + \alpha_4(X_4/AI)$$

If we multiply both sides of this equation by AI and add the initial (1960) grazing capacity to both sides we obtain:[61]

$$FIM_1 = \alpha_1 X_i + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + FIM_o$$

The estimated coefficients (a_i) then represent the marginal productivity of capital[62] (the change in forage from investing one dollar). These estimates can then be used together with formulas 4-c and 4-d[63] to estimate the benefits of range improvements.

No interdependence assumed

The estimated coefficients of Equation VI-a and Model VII can, using the method outlined above, be used to compare the regression

[61]It should be noted that if $X_1 = X_2 = X_3 = X_4 = 0$, then $FIM_1 = FIM_o$ as one would expect.

[62]The procedure for determining marginal productivities for more complicated models is found in Appendix D.

[63]The formula for sprayed areas, using Equation VI-a, would be:

$$P_a = \frac{C}{[(\frac{1-(1.05)^{-n}}{.05})\ a_1][(1.05)^{-2}]}$$

estimates with the budgets of the previous section, because all three estimates assume no interdependence between native and improved forage production. Forage value estimates for each model are found in Table 21. It is noted that the budgets and Model VII estimates follow the same general pattern but the budget estimates are lower than the Model VII estimates. Equation VI-a estimates, however, follow a different pattern. This is caused by a different aggregation of the forage data. Equation VI-a estimates relate how the various investment dollars affect the total forage (FI) for an allotment, whereas the budget and Model VII estimates relate the investment dollars to the change in forage (FI_i) for specific types (S, SS, PS, OR) of investment. It is, therefore, not surprising that plow and seed investments have a relatively larger effect upon the total change in forage (FI) in an allotment than do investments in spraying or spraying and seeding.

Given the preceding assumed project lives (12, 18, and 20 years) for each of the project types, Model VII and budget estimates indicate that the relative payoff is of the following order (by types): OR, S, SS, and PS. Equation VI-a estimates alter this order to OR, PS, S, SS. This indicates that plowing and seeding is more important to the allotment than are S and SS projects. These conclusions, however, need to be tempered with the estimates that include the estimated dependency between native and improved forage production.

Interdependency included

It was assumed that the difference between "pre- and post-practice grazing capacity is due to the improvement made by the BLM

TABLE 21. ESTIMATED VALUE OF FORAGE PER AUM NECESSARY TO EARN A FIVE PERCENT RETURN ON INVESTMENT WITH NO INTERDEPENDENCE

Type	Assumed life of project in years	Estimated values		
		Budget	Equation VI-a[a]	Model VII[a]
Spray	9	5.92	7.80	6.57
	12	4.75	6.26	5.27
	15	4.05	5.34	4.50
Spray and seed	15	5.16	8.42	5.47
	18	4.58	7.48	4.86
	21	4.18	6.82	4.43
Plow and seed	15	5.73	4.07	7.00
	20	4.77	3.39	5.83
	25	4.22	3.00	5.15
Old Rehab	5	3.88	4.09	4.34
	10	2.17	2.29	2.44
	15	1.62	1.70	1.81
Native	15	1.19	----	----
	20	0.99	----	----
	25	0.88	----	----

[a]See pages 57 and 63 for the functional form of these equations.

on these areas." However, the b_1 coefficient (investments on native areas--X_5) in Models IV and VI indicate that investments on native lands have not significantly increased the production of forage on native areas. Furthermore, it was shown theoretically in Chapter 2 that if the utilization of native and improved areas decreased, production on these areas could generally be expected to increase. This theoretical discussion led to the hypothesis outlined in Chapters 1 and 2.

Models to test these hypotheses were developed in Chapter 3, and parameters of these models were estimated in section two of this chapter. Models IV and VI were used in section three of this chapter to test the hypothesis outlined in Chapters 1 and 2. These tests indicated that the management of the forage resource in the selected areas studied has been such that there are interdependencies between the production of forage on native and improved areas. These tests also indicate, given the management of the area, that the assumption that "the difference between pre- and post-grazing capacity is due to the improvements made in these areas" is invalid. Therefore, estimates of the returns of the various investments in the Vale Project should take into account the interdependencies between the production of forage on native and improved areas.

The marginal productivity of capital is substantially altered when the dependency of improved and native forage production is taken into account. For example the marginal productivity for each investment type (X_1, X_2, X_3, X_4) using Model VII or Equation VI-a is α_i; but if the dependency is included, productivity estimates become $(1 + \beta_2 AN/AI)\ \alpha_i$ for Model VI and $[1/(1 - \beta_2\alpha_5)][1 + \beta_2]\ \alpha_i$ for Model IV (see Appendix D for these derivations). Hence, the productivity of capital is greater when a dependency is assumed. This change in productivity alters the conclusions of the preceding sections.

Table 22 shows the value of forage necessary to earn a five percent return for each of the investment types. These forage values are less than those estimated by Equation VI-a in Table 21 (same aggregation of forage data). This difference indicates the importance forage dependency has on the returns necessary to earn a five percent return on the investments.

The forage estimates in Table 22 indicate that investments on PS and OR areas have been more profitable than investments on S, SS, and N areas. The reader, at this point, would probably appreciate an explanation concerning why this conclusion would be valid. Assume a certain number of acres in an allotment could be either sprayed or plowed and seeded. A plow and seed project would, in general, produce more forage than would a spray project. This difference in forage production would allow a larger decrease in the utilization of the remaining (native) area if plowed and seeded rather than sprayed. Therefore, the plow and seed area would, in general, have a larger impact on native forage production than would an alternative spray project. Therefore, the estimated dependency is especially important to investment alternatives, such as seeding, that result in relatively large increases in forage production.

The results in Tables 21 and 22, in general, imply that the value of an AUM of federal forage must be fairly high if a five percent return has accrued on the investments undertaken during the Vale Project. This conclusion has a number of interesting implications that are discussed in the following chapter.

TABLE 22. ESTIMATED VALUE OF FORAGE PER AUM NECESSARY TO EARN A FIVE PERCENT RETURN ON INVESTMENT--DEPENDENCE ASSUMED

Type	Assumed life of project in years	Estimated values	
		Model VI	Model IV
Spray	9	5.17	6.54
	12	4.14	5.24
	15	3.54	4.48
Spray and seed	15	5.58	7.77
	18	4.95	6.90
	21	4.52	6.29
Plow and seed	15	2.70	2.96
	20	2.24	2.47
	25	1.98	2.18
Old Rehab	5	2.71	2.73
	10	1.52	1.53
	15	1.13	1.14
Native	15	5.59	3.70
	20	4.66	3.08
	25	4.12	2.72

V. SUMMARY AND CONCLUSIONS

Summary

Rangelands of western America have been used by livestock operators to graze domestic livestock since the mid-1800's. These lands also provide forage for wildlife, recreation space, and serve as important watershed areas. The use of these lands, however, has had both negative and positive effects on the production of forage, water, and other resources. Furthermore, the production of resources on these lands has largely dictated what use is made of these lands. It is, therefore, seen that changes in production have affected utilization and that utilization has affected production. An effort was made to relate how production and utilization may also be affected by administrative action.

Theoretical relationships between the production, utilization, and administration of public and/or private rangelands were developed in Chapter 1. This discussion showed that the production of various resources depends upon the natural characteristics of the area, the climatic conditions that exist during the production period, actions of the decision makers who administer the use of the area, and the utilization of the area that has taken place in earlier periods of time. It was also shown that the utilization of an area depends upon the type and amount of resources that exist in an area, the man-introduced facilities that exist in the area, and the actions of the decision maker of the area. Furthermore, it was shown that the actions of the decision maker depends upon the laws that govern his actions, the goals that he is trying to achieve, the demands for products that may be produced on lands he administers, and the amount of administrative funds available. These theoretical relationships provided the basis for a study of the range improvements that have been undertaken by the Bureau of Land Management (BLM) in the Vale District of Eastern Oregon since the inception of the Vale Project.

People interested in rangeland management have recognized that the production of forage in an area may be altered by such practices as brush control and seeding. They have also recognized that other investments, such as fencing or water development, may be necessary to enable the utilization of an area that has received some form of rehabilitation. Investments such as fencing and water development have also been spent on native lands in an effort to increase their productivity and utilization. Investments on native and improved lands during the Vale Project have resulted in a significant increase in the amount of forage produced in the District. The most surprising effect, according to BLM officials, however, has been the increase in forage production on native lands.

Reasons why investments may increase the production of forage were outlined. This discussion, based on the theory developed in Chapter 1, provided the basis for the synthesis of two hypotheses. First, it was hypothesized that the management of the forage resources in the Vale District has been such that increased production on native lands has occurred because improved lands have experienced an increase in forage production. It was also hypothesized that the management of the forage resource has been such that improved areas have experienced an increase in forage production because increased forage has been produced on native lands.

The first objective of this study was to test the hypotheses that had been proposed. The second objective was to evaluate the investments undertaken by the BLM during the Vale Project. A model was developed in Chapter 3 that would allow estimation of the relationships that had been theoretically outlined. It was found, however, that sufficient data, to estimate the parameters outlined in the model, were not available. A modified model was developed and used in Chapter 3 to estimate the parameters under consideration. This model implied a simultaneous system of equations that related changes in the carrying capacity of native and improved areas.

Multiple linear regression was used to estimate the parameters of the simultaneous relationships inferred by the modified model. This estimation, however, was beset with a number of econometric problems including errors in the variables, multicollinearity, and simultaneous equation estimations. Problems of estimation required the development of a number of statistical models. Parameter estimates required the rejection of some of the statistical models that had been estimated. This rejection was based upon a priori restrictions that had been developed in the first section of Chapter 4.

Statistical Model IV was used to test the two hypotheses outlined above. These tests indicated that a large proportion of the variation in native forage production was explained by changes in improved forage production. Thus the first hypothesis was statistically substantiated. It was also concluded that the grazing capacity of improved areas has increased as a result of increases in the carrying capacity of native areas in the Vale District. The second hypothesis was not as statistically conclusive as was the first hypothesis, however.

Range improvements undertaken during the Vale Project were evaluated using several of the models with varying degrees of interdependency between native and improved carrying capacity assumed. Estimates varied considerably between the assumed dependency levels. Budgets, Model VII and Equation VI-a estimates, for example (no dependency) show that for a five percent return to have occurred on the investments for average areas that were plowed and seeded (assumed life, 20 years) the forage produced must be worth $4.77, $5.83, and $3.39 per AUM. Model VI estimates for plowing and seeding the average area in the Vale District indicate that an AUM of forage must be worth $2.58 for a five percent return to occur. (Model VI assumed that improved areas influence the production of native areas but native areas do not influence the production of improved areas.) Model IV, however, assumes that native and improved forage production affect each other. The estimated value of an AUM of forage necessary to return five percent on the investment for the average plow and seed area, using Model IV estimates, was $2.47.

The estimated value of an AUM necessary to return five percent on most investment types for models assuming some interaction (Models IV and VI) indicate that the value must be greater than $3.00. The major exception to this conclusion was Old Rehab areas. Investments on these areas generally require relatively low forage values to earn a five percent return. Native areas were also found to require low forage values if no interaction was assumed. However, these estimates, given the tested hypothesis, are too low.

Conclusions

The conclusions that can be drawn from this study fall into two general categories: (1) an appraisal of the methods used to estimate the benefits of range improvements and (2) the policy implications that are derived from the estimated returns.

Appraisal of methods

A review of the studies conducted by economists who have evaluated the benefits of range improvements will show that mention is seldom made of the relation between production and utilization. The two general methods used by economists give some indication why this relationship is not mentioned. A number of studies (8, 9, 29, 45, 48, 51) have estimated the probable returns from increased utilization expected from a rehabilitation project. This procedure properly estimates the benefits from range improvements but no assumption or mention is made concerning whether utilization is at a level that is increasing, decreasing, or maintaining the production of the area. It is felt, however, that most researchers have implicitly assumed that the utilization levels were such that the productive potential of the area would be maintained. The second procedure, which has generally utilized "clipping" data, has either assumed that all of the increased production will be utilized (which may grossly overestimate the amount actually utilized) or some utilization level is assumed, such as "take half and leave half." This method, therefore, is subject to considerable over or under estimation of the actual amount of forage grazed (which is the only forage that has value, if grazing is the only use being made of the area) and depends heavily upon the assumed level of utilization.

The different assumptions that have been made concerning forage utilization levels is probably one reason why wide variations in return estimates have been reported.[64] Different utilization levels may also be one of the most important factors affecting the life of projects.

The methods that have been used in this study are also subject to the preceding qualification. However, this problem has been explicitly recognized in this study. The grazing capacity figures obtained from the BLM represent the amount of forage allocated to livestock grazing that would maintain or improve the production of the forage resource. The increased grazing capacity figures, therefore, represent amounts of forage that may be more or less than the increased production or utilization that have resulted from the investments undertaken during the Vale Project. Return estimates in this study, therefore, may be higher or lower than estimates that may have been made with actual utilization data.

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[64]Gardner (23) showed that the evaluation method used was probably the major reason. However, the studies he reviewed differed in the assumptions (either implicit or explicit) made concerning utilization levels.

This general problem also raises some question concerning the cost data used in this study and thus the returns that have been reported. The following example illustrates the problem being considered: Suppose an allotment was utilized such that 1000 AUM's were taken from the area before any investments had been incurred, and that this utilization rate was such that it would just maintain the forage production of the allotment. Now suppose the BLM plowed and seeded half the allotment. Assume further that the rehabilitated area was the lowest producing area within the allotment and that rehabilitation required deferred use of 300 of the 1000 AUM's that could have been used if no rehabilitation had occurred. Now suppose that, after the two years of deferred grazing, this area produced 700 usable (amount that could be used and maintain the production of the area) AUM's. The total AUM's that could be taken from the allotment would, therefore, be 1400 AUM's (700 from the improved area and 700 from the unimproved--native--area). However, suppose the first year the rehab area was used the BLM allocated the forage in a manner such that 700 AUM's were taken from the improved area and 400 AUM's were taken from the native area. The decreased utilization of the native area (300 AUM's) should result in increased production in succeeding years. For example, this decreased utilization may be such that 1200 AUM's (an increase of 500 AUM's) could be taken from the native area during later periods. The decreased utilization of the native area (300 AUM's) represents investment in the area in the form of an opportunity cost.

It should be emphasized that these costs are not directly paid by the ranchers nor are they investments from public funds because the amount taken from the area is greater than it was before any investment occurred (1100 vs 1000 AUM's). The decreased utilization represents an investment in the form of less livestock production than could have been produced had the native area been used at a rate that would have just maintained the production of the area.

Investments in the form of "low" utilization could not be measured from the data available from the BLM. They do, however, represent a variable that was left out of the estimation models if all costs were included. Thus the estimated parameters of the models may be biased and, therefore, may significantly differ from the "true" parameters.

Investments in the form of low utilization rates do not represent, however, costs paid by society. They do, however, represent social opportunity costs that have been incurred. These opportunity costs need not be considered, however, if one accepts the institutional framework under which forage is allocated in the Vale District. Thus low utilization rates may be justified if these rates allow the BLM to achieve goals (or laws) other than livestock production. Given the management of the forage resource by the BLM, therefore, it is felt that the estimates contained in Table 22 indicate the value an AUM of forage necessary for a five percent return on the investments undertaken during the Vale Project.

Implications

Public projects currently undertaken by the federal government are being discounted at four and seven-eighths percent (52). This implies that the socio-political complex has dictated that all public projects must yield at least this return to be economically efficient.[65]

Assume that the marginal value product (MVP) of federal forage in the production of beef is $2.50[66] and that permittees are allowed to graze the amounts of forage indicated by the grazing capacity figures obtained from the BLM. The forage values estimated in Tables 21 and 22 are generally significantly greater than $2.50. This indicates that returns on most investments undertaken by the BLM have generally been less than the five percent required by other federal projects (B/C < 1.0).

One of the reasons why many of these investments may not be profitable is because extensive water developments, cattle guards, and fencing have increased total investment costs beyond the point of economic feasibility. It is, therefore, questioned whether many of these additional investments could be economically justified.

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[65]This is equivalent to requiring a benefit-cost ratio of one, if benefits and costs are discounted at 4-7/8 percent. But, as Kalder et al. (37) pointed out, this is not a necessary condition for investments in a public project because objectives other than economic efficiency may be important.

[66]An estimation of the value of federal forage to ranchers in the Vale District is beyond the scope of this study, but other studies (6, 24, 25, 34, 59, 61, 66, 67) indicate that $2.50 is probably close to its average value. It should be noted, however, that federal forage may be worth considerably more or less than this amount during some periods of use or in some areas.

The forage estimates in Table 22 indicate that investments on Old Rehab areas have generally yielded greater returns than S, SS, or PS investments. This indicates that the BLM could have profitably spent more money on Old Rehab areas. In fact, the returns on these areas have probably yielded returns greater than five percent. The qualifications mentioned earlier make estimates of the returns to investments on native areas somewhat questionable. It should be noted, however, that the significance of the β_1 estimates for each of the models discussed in section two of Chapter 4 indicate that these investments have not resulted in very large increases in the production of forage on native areas. It can, therefore, be inferred that the returns on these investments have probably been quite low.

Forage estimates for plow and seed areas in Table 22 indicate that these investments have been somewhat marginal, depending upon the length of life assumed.[67] Investments for spraying and spraying and seeding have generally earned less than the five percent required, given the assumed value of $2.50 per AUM. This infers that more funds have been allocated for these practices than would have been economically efficient.

It should be noted, however, that the increased forage production resulting from the Vale Project may have value other than

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[67]The BLM indicated that they felt plow and seed areas may last from five to fifty years. This variation makes any evaluation depend upon what project life is assumed. Much of the variation in project life is probably due to the rate areas are utilized (U_{1k}) as well as the success of establishing a stand of grass in an area that has been rehabilitated. Project lives for other area types (S, SS, OR, N) may also be greatly influenced by utilization rates.

for grazing (perhaps soil conservation). If this is true the above remarks need to be modified.[68] It appears, nevertheless, that the money allocated to the BLM to rehabilitate rangelands in the Vale District was, in general, an "inefficient" allocation.

Perhaps the most important policy conclusion derived from this study, however, is the implication that if society decides to improve all rangelands administered by the federal agencies, they will not have to invest in intensive practices on all of these lands to improve the total. Increasing the production of native rangelands by decreasing their utilization is relatively slow, but the response of native lands in the Vale District to this "management" practice has been surprising to many skeptical range managers. One range manager recently summed up this situation best when he said, in essence, that probably the greatest benefit of intensive range improvements is that they allow management of the total resource. It should be emphasized, however, that "management practices" involving "low" utilization rates are not cost-free.

It should also be noted that the investments undertaken by the BLM averted a large cut in grazing for permittee livestock. In some allotments the cut would have been as much as 80 percent of the permitted use. Investments in the District, therefore, represent a substantial income distribution to the area (4, 73, 79, 80). This

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[68]The impact that range improvements have on wildlife is not very well known. However, a recent study conducted by the Oregon Game Commission in the Vale District gives some indications. A summary of this study is contained in Appendix E. Trueblood (72) also lists some benefits of improvement practices to wildlife in the Vale District.

distribution may have been politically acceptable and, therefore, may have made the Vale Project feasible on grounds other than "economic efficiency."

Areas for future research

This study has illustrated the problems involved in an evaluation of range improvements when interdependence between utilization rates and production cannot be specifically taken into account. The importance of this problem was likewise emphasized by Hopkin when he noted that

> . . . the solution to this problem [season and intensity of grazing] is basic to the solution of nearly every other problem of range management. In every phase of range research we attempt to project benefits derived from a given improvement practice. These benefits differ substantially with the intensity of use that is assumed following the improvement. In the past, we have simply assumed the "best" or "proper" level of grazing for each alternative being considered. We can no longer afford the luxury of assuming that our primary problem is solved by assumption. (32, p. 79)

Hopkin's charge, however, has gone unheeded by economists that have evaluated range improvements in all of the studies reviewed, with the exception of a note by Kearl (38) that emphasized the need for research in this area. It is time for economists to get together with range scientists to determine criteria for an "optimum" or "best" rate of utilization. Furthermore, this general area of research is probably as applicable to other resources such as forests, water, and minerals, as it is to forage.

The Public Land Law Review Commission recently recommended that ". . . range investments should be shared by the Federal Government and users on the basis of identifiable benefits." (64, p. 114) If this recommendation is instituted, considerable amounts of research will be necessary to identify the benefits that accrue to society as well as specific users from investments in range rehabilitation. These evaluations will, however, have to consider the interrelationships that exist between the production and utilization of resources that may be used on public range lands.

BIBLIOGRAPHY

1. American Society of Range Management. Range Glossary Committee. A glossary of terms used in range management. Portland, Oregon. 1964. 32 p.

2. Bain, George. Associate Professor, Oregon State University, Federal Cooperative Extension Service. Personal communication. Ontario, Oregon. April 23, 1970.

3. Brewer, Michael F. Public pricing of natural resources. Journal of Farm Economics 44(1):35-49. 1962.

4. Bromley, D. W., G. E. Blanch, and H. E. Stoevener. Effects of selected changes in federal land use on a rural economy. Corvallis, Oregon, Oregon State University, 1968. 27 p. (Oregon Agricultural Experiment Station Bulletin No. 604)

5. Brown, William G. Effect of omitting relevant variables in economic research. Unpublished paper. Corvallis, Oregon, Oregon State University, Department of Agricultural Economics. n.d.

6. Bunch, Thomas. Associate Professor, Federal Cooperative Extension Service. Personal communication. Corvallis, Oregon. July, 1970.

7. Caton, Douglas D. Selection of optimum season and intensity of grazing. In: Economic Research in the Use and Development of Range Resources; Conference Proceedings of the Committee on Economics of Range Use and Development of the Western Agricultural Economics Research Council, Logan, Utah, 1959. p. 41-61. (Report No. 2)

8. Caton, D. D., and Christoph Beriger. Costs and benefits of reseeding range lands in Idaho. Moscow, Idaho, University of Idaho, 1960. 31 p. (Idaho Agricultural Experiment Station Bulletin 326)

9. Caton, Douglas D., Chester O. McCorkle, and M. L. Upchurch. Economics of improvement of western grazing land. Journal of Range Management 13(3):143-151. 1960.

10. Calef, Wesley. Private grazing and public lands: studies of the local management of the Taylor Grazing Act. Chicago, Illinois, The University of Chicago Press, 1960. 292 p.

11. Cooperative Extension Service. Oregon commodity data sheet: hay. Corvallis, Oregon, Oregon State University, August 26, 1969.

12. Costelle, David F. Economic methodology of deciding season and intensity of grazing--the biological background. In: Economic Research in the Use and Development of Range Resources; Conference Proceedings of the Committee on Economics of Range Use and Development of the Western Agricultural Economics Research Council, Logan, Utah, 1959. p. 61-73. (Report No. 2)

13. Ciriacy-Wantrup, S. V. Criteria for public and private ownership of range resources. Journal of Range Management 11(1):10-14. 1958.

14. Ciriacy-Wantrup, S. V. Resource conservation economics and policies. Berkeley, California, University of California Division of Agricultural Sciences, Agricultural Experiment Station, 1968. 395 p.

15. Committee on Economics of Range Use and Development. Range and ranch economics bibliography. In: Economic Research in the Use and Development of Range Resources; Committee on Economics of Range Use and Development of the Western Agricultural Economics Research Council, Las Cruces, New Mexico, 1969. 199 p. (Report No. 11)

16. Draper, N. R., and H. Smith. Applied regression analysis. New York, John Wiley and Sons, 1966. 407 p.

17. Foote, Richard J. Analytical tools for studying demand and price structures. Washington, D. C., United States Department of Agriculture, 1958. 217 p. (Agriculture Handbook No. 146)

18. Foss, Phillip O. Politics and grass: the administration of grazing on the public domain. Seattle, Washington, University of Washington, 1964. 236 p.

19. Friedman, Milton. Essays in positive economics. Chicago, Illinois, University of Chicago Press, 1953. 328 p.

20. Frischknecht, Neil C., and Lorin E. Harris. Grazing intensities and systems on crested wheat grass in central Utah: response of vegetation and cattle. Washington, D. C., United States Department of Agriculture, Forest Service. 1968. 47 p. (Technical Bulletin No. 1388)

21. Frischknecht, Wilford Dean. Extension Animal Scientist, Oregon State University. Personal communication. Corvallis, Oregon. May, 1970.

22. Gardner, B. Delworth. Costs and returns from sagebrush range improvements in Colorado. Fort Collins, Colorado, Colorado State University, 1961. 18 p. (Colorado Agricultural Experiment Station Bulletin 511-S)

23. Gardner, B. Delworth. The internal rate of return and decisions to improve the range. In: Economic Research in the Use and Development of Range Resources; Conference Proceedings of the Committee on Economics of Range Use and Development of the Western Agricultural Economics Research Council, Laramie, Wyoming, 1963. p. 87-109. (Report No. 5)

24. Gardner, B. Delworth. Misallocation in grazing public range. Journal of Farm Economics 44(1):50-63. 1962.

25. Gardner, B. Delworth. Rates of return to improvement practices on private and public range. Land Economics 38(1):43-50. 1962.

26. Getty, Russell E. New hope for public land watersheds. American Forests 70(12):14-19. 1964.

27. Gordon, H. Scott. The economic theory of a common-property resource: the fishery. Journal of Political Economy 62:124-142. 1954.

28. Gray, James R. Ranch economics. Ames, Iowa, Iowa State University, 1968. 534 p.

29. Gray, James R., and H. W. Springfield. Economics of lambing on crested wheatgrass in northcentral New Mexico. Las Cruces, New Mexico, New Mexico State University, 1962. 32 p. (New Mexico Agricultural Experiment Station Bulletin 461)

30. Gray, James R., Thomas M. Stubblefield, and N. Keith Roberts. Economic aspects of range improvements in the southwest. Las Cruces, New Mexico, New Mexico State University, 1965. 47 p. (New Mexico Agricultural Experiment Station Bulletin 498)

31. Henderson, James M., and Richard E. Quandt. Microeconomic theory. New York, McGraw-Hill Book Company, Inc., 1958. 291 p.

32. Hopkin, John A. Economic versus ecological criteria for deciding season and intensity of grazing--a discussion. In: Economic Research in the Use and Development of Range Resources; Conference Proceedings of the Committee on Economics of Range Use and Development of the Western Agricultural Economics Research Council, Logan, Utah, 1959. p. 73-79. (Report No. 2)

33. Houston, Walter R., and R. R. Woodward. Effects of stocking rates on range vegetation and beef cattle production in the northern great plains. Washington, D. C., United States Department of Agriculture, Agricultural Research Service, 1966. 58 p. (Technical Bulletin No. 1357)

34. Jensen, Bartell, and Don Thomas. Determining grazing fees on national forests. In: Economic Research in the Use and Development of Range Resources; Conference Proceedings of the Committee on Economics of Range Use and Development of the Western Agricultural Economics Research Council, Reno, Nevada, 1967. p. 47-60. (Report No. 9)

35. Johnson, Glenn L., and Lowell S. Hardin. Economics of forage evaluation. Lafayette, Indiana, Purdue University, 1955. 20 p. (Indiana Agricultural Experiment Station Bulletin 623)

36. Johnston, J. Econometric methods. New York, McGraw-Hill Book Company, Inc., 1963. 300 p.

37. Kalter, Robert J., et al. Criteria for evaluation of resource investments. Ithaca, New York, Cornell University, Water Resources and Marine Sciences Center, 1969. 11 p.

38. Kearl, W. Gordon. A survey of big sagebrush control in Wyoming, 1952-1964. Laramie, Wyoming, University of Wyoming, 1965. 42 p. (Wyoming Agricultural Experiment Station Mimeo Circular 217)

39. Kearl, W. Gordon, and Maurice Brannan. Economics of mechanical control of sagebrush in Wyoming. Laramie, Wyoming, University of Wyoming, 1967. 35 p. (Wyoming Agricultural Experiment Station Science Monograph 5)

40. Kelso, M. M. Current issues in federal land management in the western United States. Journal of Farm Economics 29(4, part II): 1295-1313. 1947.

41. Kindschey, Robert. Wildlife Biologist, U. S. Department of Interior, Bureau of Land Management, Vale District. Personal communication. Vale, Oregon. August 10, 1970.

42. Kipple, G. E., and David F. Costello. Vegetation and cattle responses to different intensities of grazing on shortgrass ranges on the central great plains. Washington, D. C., United States Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, 1960. 82 p. (Technical Bulletin No. 1216)

43. Klein, Lawrence R. An introduction to econometrics. Englewood Cliffs, New Jersey, Prentice-Hall, 1962. 280 p.

44. Klein, Lawrence R. A textbook of econometrics. Evanston, Illinois, Row, Peterson, 1953. 355 p.

45. Krenz, Ronald D. Costs and returns from spraying sagebrush with 2, 4-D. Laramie, Wyoming, University of Wyoming, 1962. 31 p. (Wyoming Agricultural Experiment Station Bulletin 290)

46. LeBaron, Allen. A discussion--the internal rate of returns and decisions to improve the range. In: Economic Research in the Use and Development of Range Resources; Conference Proceedings of the Committee on Economics of Range Use and Development of the Western Agricultural Economics Research Council, Laramie, Wyoming, 1963. p. 117-127. (Report No. 5)

47. Lieurance, Maxwelle T. Unpublished Vale District report. Vale, Oregon, United States Department of Interior, Bureau of Land Management, 1967. 9 p.

48. Lloyd, Russell D., and C. Wayne Cook. Seeding Utah's ranges. Logan, Utah, Utah State University, 1960. 19 p. (Utah Agricultural Experiment Station Bulletin 423)

49. Love, Harold C., and Mellville L. McMillan. Albertas pasture resources and estimated potential beef production from improvement of privately owned land. Edmonton, Alberta, University of Alberta, Department of Extension, 1968. 52 p. (Agricultural Economics Research Bulletin 6)

50. McBurney, Chadwick W. Range staff officer, United States Department of Interior, Bureau of Land Management, Vale District. Personal communication. Vale, Oregon. August 11, 1970.

51. McCorkle, C. O., and D. D. Caton. Economic analysis of range improvement. Davis, California, University of California, 1962. 79 p. (California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics Bulletin No. 255)

52. Miller, Stanley F. Economist, United States Department of Agriculture, Economic Resource Service. Personal communication. Corvallis, Oregon. July, 1970.

53. Moore, Christine S. The Vale project. Western Livestock Journal 44(1):58-64. 1966.

54. Morse, Wayne L. Message of Senator Wayne L. Morse to the national advisory board council, March 22, 1965. In: United States Bureau of Land Management. Proceedings of the National Advisory Board Council. Washington, D. C., 1965. (Appendix No. 4)

55. Multiple Use-Sustained Yield Act. Public Law 86-517, 86th Congress. (June 12, 1960)

56. Nielsen, Darwin B. Economics of federal range use and improvements. PhD thesis. Corvallis, Oregon, Oregon State University, 1965. 165 numb. leaves.

57. Nielsen, Darwin B. Economics of range improvements: a ranchers handbook to economic decision making. Logan, Utah, Utah State University, 1967. 47 p. (Utah Agricultural Experiment Station Bulletin 466)

58. Nielsen, Darwin B. The potential impact of fee adjustments. Logan, Utah, Utah State University, 1967. 34 p. (Utah Agricultural Experiment Station, Ag. Econ. Series 67-1)

59. Nielsen, Darwin B. Valuation of public range land for grazing purposes. Master's thesis. Logan, Utah, Utah State University, 1962. 50 numb. leaves.

60. Nielsen, Darwin B., et al. Economics of range use and improvement for livestock production. Corvallis, Oregon, Oregon State University, 1966. 40 p. (Oregon Agricultural Experiment Station Technical Bulletin 92)

61. Nielsen, Darwin B., and N. Keith Roberts. Position statement on current grazing fee issues and problems. Logan, Utah, Utah State University, 1968. 13 p. (Utah Agricultural Experiment Station, Ag. Econ. Series 68-3)

62. Ostle, Bernard. Statistics in research. Ames, Iowa, The Iowa State University, 1963. 585 p.

63. Pingrey, H. B., and E. J. Dortignac. Costs of seeding northern New Mexico rangelands. Las Cruces, New Mexico, New Mexico College, 1957. 43 p. (New Mexico Agricultural Experiment Station Bulletin 413)

64. Public Land Law Review Commission. One third of the nation's land: a report to the president and to the Congress by the public land law review commission. Washington, D. C., 1960. 342 p.

65. Reeher, James A. The effect of large scale livestock range rehabilitation on game species. (Unpublished Final Project Report, Oregon Game Commission. Portland, Oregon, 1969. 46 numb. leaves.)

66. Roberts, N. Keith. Economic foundations for grazing use fees on public lands. Journal of Farm Economics 45(4):721-732. 1963.

67. Roberts, N. Keith, and Mardell Tephan. Discovering grazing values. Logan, Utah, Utah State University, 1965. 29 p. (Utah Agricultural Experiment Station, Ag. Econ. Series 65-3)

68. Roberts, N. Keith, and E. Boyd Wennergren. Economic evaluation of stockwater developments. Journal of Range Management 18(3): 118-123. 1965.

69. Sharp, Wayne W., and Calvin C. Boykin. A dynamic programming model for evaluating investments in mesquite control and alternative beef cattle systems. College Station, Texas, Texas A & M University, 1967. 38 p. (Texas Agricultural Experiment Station Technical Monograph 4)

70. Sneva, Forrest A., and Donald N. Hyder. Forecasting range herbage in Eastern Oregon. Corvallis, Oregon, Oregon State University, 1962. 11 p. (Oregon Agricultural Experiment Station Bulletin No. 588)

71. Springfield, H. W. Cattle gains and plant responses from spring grazing on crested wheatgrass in northern New Mexico. Washington, D. C., United States Department of Agriculture, Forest Service, 1963. 46 p. (Production Research Report No. 74)

72. Trueblood, Ted. Test plot of the public lands. Field and stream 74(4):12-16, 92-94. 1969.

73. United States Bureau of Land Management. Adjustments in grazing use: an evaluation of adjustments in grazing use as they occur in the management of the federal range by the Bureau of Land Management. Washington, D. C., 1962. 100 p.

74. United States Bureau of Land Management. Bureau of Land Management Manual. (Full manual not seen--Sections 4110-4116, held by author) Washington, D. C., n.d., n.p.

75. United States Bureau of Land Management. Grazing regulations for the public lands. Washington, D. C., 1968. 31 p. (Circular No. 2246)

76. United States Bureau of Land Management. Public land statistics. Washington, D. C., 1969. 188 p.

77. United States Bureau of Land Management. The Taylor Grazing Act: as amended and supplemented. Washington, D. C., n.d. (Information Bulletin No. 5)

78. United States Bureau of Land Management. Vale Project. Portland, Oregon, Oregon State Office of the Bureau of Land Management, 1963. 25 p.

79. United States Department of Agriculture. Economic Research Service. Effects of changes in grazing fees and permitted use of public rangelands on western livestock ranches. Washington, D. C., 1965. 33 p. (Report No. 248)

80. United States Department of Agriculture. Economic Research Service. Farm Economics Division. Economic relationship of grazing fees and permitted use of public rangelands to net income of western livestock ranches: a regional analysis. Administrative Report to Bureau of Land Management, U. S. Department of Interior and Forest Service, United States Department of Agriculture. Washington, D. C., n.d. 74 p.

81. Workman, D. R., K. R. Tefertiller, and L. C. Leinweber. Profitability of aerial spraying to control mesquite. College Station, Texas, Texas A & M University. 1965. 12 p. (Texas Agricultural Experiment Station MP-784)

APPENDIXES

Appendix A
Administration of the Vale District

The Vale District is administratively divided into 15[69] major administrative planning units which are grouped into three resource areas: Northern, which includes the Willow Creek, Westfall, Skull Springs, and Harper Basin units; Central, which includes the Mahogany, Cow Creek, Soldier Creek, and Jackies Butte units; and Southern, which includes the Stockade, Sheepheads, Barren Valley, Fifteen Mile, Antelope, and Star Valley planning units. The administration of these three areas (Northern, Central, and Southern) is the primary responsibility of three natural resource managers[70] who act directly under the leadership of the District Manager, Maxwell T. Lieurance. It is primarily through the administration of these men and their respective staffs that the everyday problems of range management are solved.

Within or among the planning units a number of allotments[71] have been developed through time. These allotments are of two general

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[69]The district has 19 planning units, of which 5 are minor. These include Brogan, Rose Creek, Vale-Ontario, Jordan Creek, and Brown Ridge. It should also be noted that Brown Ridge is also commonly called Forty-Five.

[70]These three managers, Phil Rumpel, Al Logosz, and Bob Sherve, worked very closely with the author to obtain the data necessary for this thesis.

[71]An allotment is defined to be "an area designated for grazing use." An allotment may contain several use areas or pastures and may be used by one or more livestock operators. It may be an integral part of a planning unit or overlap into several planning units.

types: group, where a number of permittees graze the lands in the allotment jointly; and individual, where the livestock of one permittee grazes these lands.

The administration of all BLM lands is governed by the Taylor Grazing Act. General rules of administration that indicate procedures that BLM managers are to follow are contained in a document commonly referred to as the Range Code (75). Further instructions that clarify the rules contained in the Range Code are found in a group of papers commonly referred to as the BLM Manual (74). The range code and BLM Manual serve as the basic references within which BLM personnel must act in administering the affairs of any district.

Appendix B
Basic Cost and Forage Data

This appendix contains the basic cost and forage data that were obtained from Vale District files and personnel.

Cost data

After the allotments that were to be sampled had been determined, as described in Chapter 3, the resource area managers were asked to list the projects that existed within each allotment in 1969. They were further asked to specify which type of area, such as a plow and seed area, that each project was associated with. These data are summarized for each of the allotments in Tables 23 through 42. These tables also contain the grazing capacity figures discussed in Chapter 3.

Each project is listed in two places at the Vale District office, the original project files and in a summary project ledger. It was found that the "summary ledger" contained a number of errors in posting, some omissions of data, and other various mistakes. Therefore, the original project files were used to determine the cost of developing each project. The file data specifically list all contract costs; costs for materials provided by the BLM such as wire, seed, etc.; labor costs incurred by the BLM that were necessary to supervise or perform the development of each project; and a justification and description of each project.

Cost allocation assumptions

Several assumptions were necessary to determine the costs associated with a particular type of area.

Fencing. It was assumed that fences that were established around a rehabilitated area were primarily for the protection of these areas during the deferred grazing period. Thus all fences that bordered both a native and a rehabilitation area were charged to the rehabilitated area. Cross fences, however, that were put in primarily to facilitate rotational grazing were charged to the areas that contained these fences. If a fence bordered two different types of improved areas, such as a plow and seed and a spray area, one half the cost of the fence was charged to each area. If a fence formed the border for two allotments, one half the cost of the fence was charged to each allotment. If a fence contained sections that served two or more purposes, such as a border for a rehabilitation area and another section that was the cross fence for a native area, the costs to each area was charged on a mileage basis.

Wells or springs with pipelines. Wells and springs that included extensive pipeline systems presented the largest number of problems associated with cost allocation. Many of the wells and springs in the district serve a number of areas and often more than one allotment. It was found that the marginal cost incurred in the development of any one pipeline or trough was nearly impossible to determine. Therefore, the costs of the full system were charged on a per trough basis. An example may help clarify this procedure. Suppose a well and pipeline costing $40,000 was developed to serve two allotments--one of which was sampled. Furthermore, suppose that the system contained 20 troughs of which 15 were within the sampled allotment. Further, suppose that 5 troughs were in a spray area, 6 on native areas, and 4 were on a plow and seed area. Then, five-twentieths of the total cost ($40,000) were charged to the spray area, six-twentieths to the native areas, and four-twentieths to the plow and seed areas in the allotment sampled. Five-twentieths of the cost were charged to the other allotments.

Reservoirs and springs. If a reservoir or spring served more than one area or allotment, the cost associated with any area or allotment was charged on a one-half, one-third, etc. basis.

Cattle guards. Cattle guards were charged to the areas that these facilities primarily served--as designated by the area managers.

Average costs

Average costs for each of the above costs were determined in each area and are summarized in Table 2 of Chapter 3. These costs do not vary greatly from estimates that have been published by other researchers but significant departures from the average may be found in some allotments.

Spray. The rehabilitation costs for spraying are lower than the costs reported by Kearl--$2.60 to $3.34 (38); Nielsen--$3.42 (56); Krenz--$2.70 to $4.00 (45); and McCorkle and Caton--$3.00 (51).

Spray and seed. This alternative has not been analyzed by other researchers.

Plow and seed. Other researchers have reported the following costs for plowing and seeding: Lloyd and Cook--$8.92 (48); Gardner--$7.74 (25); Caton and Beriger--$7.52 (8); Pingrey and Dortignac--$6.00 to $9.00 (63); McCorkle and Caton--$11.25 (51); and Nielsen--$9.71 (56). Therefore, the average costs reported in this study are near the estimates reported by these researchers.

Fencing. The costs of fencing various types of areas has not been reported by many researchers. Nielsen (56) reported an estimated $ .28 per acre for spray areas and $ .99 for plow and seed areas. Lloyd and Cook (48) reported fencing costs of $ .96 per acre on plow and seed areas, and McCorkle and Caton (51) reported costs of $ .60 per acre. The estimates reported in this study are thus somewhat higher than these studies.

Water developments. Nielsen (56) reported the following average water development costs per acre for plow and seed and spray areas, respectively, $2.20 and $ .67. These estimates are greater than those shown in Table 2.

Cattleguards and other. These costs are included because BLM personnel felt that they allowed better management and utilization of the areas considered. They need not, however, be incurred by ranchers investing in range improvement practices. An evaluation of the separable benefits of these investments is beyond the scope of this study. These investments as well as fencing and water developments are costs that facilitate the utilization of an area and, therefore, do not, in the short run, alter production. However, if these investments do alter the historical grazing pattern of an area, they can increase the forage production of the area.

TABLE 23. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 1

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	11.8		4.2		10.6
Cost	7,933		3,168		8,881
Cattle guards					
Number			2		4
Cost			1,385		2,152
Water developments					
Springs--Number	6		1		3
Cost	1,385		740		926
Reservoirs--Number	1				3
Cost	1,012				4,220
Wells and pipelines					
Cost					
Rehabilitation					
Cost	21,729		13,937		
Other					
Cost					
Total cost	32,059		19,230		16,179
Acres of each type	10,233		1,281		34,019
AUM's					
Before	648		82		2,154
After	2,047		321		4,253

TABLE 24. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 2

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	23.35	.8	9.9		19.3
Cost	21,007	711	7,206		17,651
Cattle guards					
Number	2		1		7
Cost	977		334		1,870
Water developments					
Springs--Number	1				4
Cost	339				1,215
Reservoirs--Number	9	4	2		8
Cost	7,001	191	242		10,916
Wells and pipelines					
Cost	5,492		3,118		4,246
Rehabilitation					
Cost	55,760	2,763	17,298		
Other					
Cost			685		7,541
Total cost	90,576	3,665	28,883		43,439
Acres of each type	25,141	650	1,800		111,442
AUM's					
Before	1,721	45	123		7,634
After	5,028	217	528		13,931

TABLE 25. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 3

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	12.1	2.2	18.3		13.4
Cost	6,486	1,474	14,797		8,723
Cattle guards					
Number		1	3		6
Cost		1,151	1,847		3,105
Water developments					
Springs--Number					8
Cost					2,869
Reservoirs--Number					
Cost					
Wells and pipelines					
Cost	6,840	1,140	16,602		
Rehabilitation					
Cost	9,362	3,050	58,738		
Other					
Cost					
Total cost	22,688	6,815	91,984		14,697
Acres of each type	4,047	691	6,598		62,244
AUM's					
Before	194	33	316		2,978
After	1,012	173	1,650		7,780

TABLE 26. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 4

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles			18.8		11.1
Cost			12,156		8,980
Cattle guards					
Number		1	2		1
Cost		503	1,067		514
Water developments					
Springs--Number		2	2		3
Cost		576	1,145		1,413
Reservoirs--Number					4
Cost					3,632
Wells and pipelines					
Cost					
Rehabilitation					
Cost		17,311	56,863		
Other					
Cost					
Total cost		18,390	71,231		14,539
Acres of each type		3,490	5,462		42,623
AUM's					
Before		437	683		5,328
After		873	1,093		5,328

TABLE 27. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 5

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	58.0		8.8		
Cost	26,946		6,088		
Cattle guards					
Number	8		1		
Cost	3,330		542		
Water developments					
Springs--Number	1				
Cost	873				
Reservoirs--Number	7		1		
Cost	12,029		1,081		
Wells and pipelines					
Cost					
Rehabilitation					
Cost	58,296		25,507		
Other					
Cost					
Total cost	101,474		33,218		
Acres of each type	28,986		2,913		24,893
AUM's					
Before	2,302		129		1,527
After	5,797		582		3,112

TABLE 28. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 6

Practice	Spray	S & S[a]	P & S	O.R.	Native
Fencing					
Miles		19.8			
Cost		14,315			
Cattle guards					
Number		5			
Cost		2,500			
Water developments					
Springs--Number					
Cost					
Reservoirs--Number					1
Cost					472
Wells and pipelines					
Cost	4,628	22,597			4,222
Rehabilitation					
Cost	8,110	21,978			
Other					
Cost		326			
Total cost	12,738	61,716			4,694
Acres of each type	1,700	6,220			18,976
AUM's					
Before	52	493			575
After	283	1,555			1,898

[a]This is a burn and seed area that is included with spray and seed areas because its cost pattern and forage response is nearly the same as other spray and seed areas and because it was the only burn and seed area sampled.

TABLE 29. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 7

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	43.9		12.0		6.2
Cost	31,457		10,994		4,788
Cattle guards					
Number	8		3		1
Cost	4,777		1,719		627
Water developments					
Springs--Number			4		28
Cost			1,685		9,739
Reservoirs--Number	7		1		11
Cost	6,815		510		9,960
Wells and pipelines					
Cost					
Rehabilitation					
Cost	45,415		22,810		
Other					
Cost					2,119
Total cost	88,464		37,718		27,233
Acres of each type	18,176		2,196		176,842
AUM's					
Before	1,623		146		13,673
After	3,366		732		13,772

TABLE 30. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 8

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	8.6		21.7		9.0
Cost	6,884		13,954		6,184
Cattle guards					
Number			12		2
Cost			7,129		1,065
Water developments					
Springs--Number			5		24
Cost			1,798		6,817
Reservoirs--Number	3		3		
Cost	4,161		3,981		
Wells and pipelines					
Cost					
Rehabilitation					
Cost	20,485		57,066		
Other					
Cost	1,087				
Total cost	32,617		83,928		14,066
Acres of each type	9,560		8,880		43,333
AUM's					
Before	1,080		497		4,379
After	2,124		2,457		4,594

TABLE 31. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 9

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	9.1		6.8		7.7
Cost	6,601		4,048		7,517
Cattle guards					
Number	1		3		
Cost	514		1,484		
Water developments					
Springs--Number			2		11
Cost			530		3,628
Reservoirs--Number	7		5	3	4
Cost	5,815		1,574	2,744	3,369
Wells and pipelines					
Cost					
Rehabilitation					
Cost	34,907		29,093		
Other					
Cost	2,523				
Total cost	50,360		36,729	2,744	14,514
Acres of each type	15,235		2,015	5,236	47,842
AUM's					
Before	1,772		179	494	5,116
After	3,905		672	1,183	6,367

TABLE 32. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 10

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	5.7				
Cost	3,410				
Cattle guards					
Number	1				
Cost	550				
Water developments					
Springs--Number					
Cost					
Reservoirs--Number	3				1
Cost	1,443				400
Wells and pipelines					
Cost					
Rehabilitation					
Cost	13,928				
Other					
Cost					
Total cost	19,331				400
Acres of each type	6,792				11,219
AUM's					
Before	503				833
After	1,698				1,752

TABLE 33. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 11

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	18.7		21.5		7.3
Cost	15,374		13,143		3,458
Cattle guards					
Number	2		4		1
Cost	1,044		1,956		485
Water developments					
Springs--Number					
Cost					
Reservoirs--Number	1	1			2
Cost	1,592	50			2,688
Wells and pipelines					
Cost	7,609	11,247	32,694		1,816
Rehabilitation					
Cost	39,133	37,736	81,934		
Other					
Cost					
Total cost	64,752	49,033	129,727		8,447
Acres of each type	17,796	8,048	9,265		104,028
AUM's					
Before	445	132	108		3,128
After	2,340	806	1,158		3,128

TABLE 34. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 12

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	1.8		9.3	7.0	8.1
Cost	1,673		5,988	4,425	6,565
Cattle guards					
Number			4	5	2
Cost			2,371	3,163	1,428
Water developments					
Springs--Number			1	1	1
Cost			533	238	286
Reservoirs--Number					3
Cost					2,594
Wells and pipelines					
Cost	1,174		14,847	3,340	1,015
Rehabilitation					
Cost	8,993		45,562		
Other					
Cost					
Total cost	11,840		69,301	11,166	11,888
Acres of each type	3,931		5,900	5,296	27,688
AUM's					
Before	312		343	500	1,382
After	844		1,966	1,765	2,438

TABLE 35. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 13

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	5.6	14.0		2.2	1.6
Cost	4,281	9,215		1,299	1,335
Cattle guards					
Number		2			1
Cost		1,092			697
Water developments					
Springs--Number					
Cost					
Reservoirs--Number	3	1			11
Cost	2,155	1,073			10,015
Wells and pipelines					
Cost				19,763	
Rehabilitation					
Cost	5,267	35,118			
Other					
Cost					
Total cost	11,703	46,498		21,062	12,047
Acres of each type	2,820	8,200		4,450	45,974
AUM's					
Before	190	643		510	3,830
After	484	2,452		1,483	4,597

TABLE 36. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 14

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles			2.8		24.1
Cost			1,812		14,365
Cattle guards					
Number			3	3	3
Cost			1,192	1,217	1,117
Water developments					
Springs--Number					
Cost					
Reservoirs--Number				1	6
Cost				721	8,050
Wells and pipelines					
Cost				52,909	
Rehabilitation					
Cost	9,754		4,010	9,734	
Other					
Cost					
Total cost	9,754		7,014	64,581	23,532
Acres of each type	4,600		545	12,847	46,904
AUM's					
Before	100		12	402	3,127
After	460		136	3,408	4,472

TABLE 37. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 15

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	1.6		19.3		4.4
Cost	1,425		13,560		2,496
Cattle guards					
Number			6	2	1
Cost			3,226	989	545
Water developments					
Springs--Number					2
Cost					643
Reservoirs--Number			1		5
Cost			762		6,789
Wells and pipelines					
Cost	2,374		25,122		4,423
Rehabilitation					
Cost	8,880		90,558		
Other					
Cost					
Total cost	12,679		133,228	989	14,896
Acres of each type	4,000		11,142	2,015	36,310
AUM's					
Before	333		743	610	3,631
After	900		3,810	672	4,553

TABLE 38. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 16

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	8.0	7.4			13.1
Cost	5,134	2,575			10,160
Cattle guards					
Number	3	1			1
Cost	1,624	537			252
Water developments					
Springs--Number	1				4
Cost	589				1,350
Reservoirs--Number	3	1			17
Cost	6,763	2,070			15,691
Wells and pipelines					
Cost		12,304			5,063
Rehabilitation					
Cost	47,411	69,689			
Other					
Cost					
Total cost	61,521	87,175			32,516
Acres of each type	20,098	13,910			122,485
AUM's					
Before	1,386	959			8,447
After	3,350	2,318			13,919

TABLE 39. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 17

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles			6.9		20.7
Cost			4,344		14,373
Cattle guards					
Number					
Cost					
Water developments					
Springs--Number					2
Cost					854
Reservoirs--Number					10
Cost					11,567
Wells and pipelines					
Cost			10,581		
Rehabilitation					
Cost			68,297		
Other					
Cost					
Total cost			83,222		26,794
Acres of each type			8,800		41,412
AUM's					
Before			98		2,040
After			4,400		3,697

TABLE 40. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 18

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	14.3				
Cost	10,005				
Cattle guards					
Number					
Cost					
Water developments					
Springs--Number					2
Cost					1,048
Reservoirs--Number	1				2
Cost	1,005				2,914
Wells and pipelines					
Cost	8,709				
Rehabilitation					
Cost	13,134				
Other					
Cost					
Total cost	32,853				3,962
Acres of each type	6,343				7,122
AUM's					
Before	211				159
After	422				238

TABLE 41. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 19

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	5.0	17.4			13.1
Cost	3,541	12,156			11,355
Cattle guards					
Number	1	4			1
Cost	478	2,251			563
Water developments					
Springs--Number	2	1			1
Cost	910	401			100
Reservoirs--Number	1				7
Cost	100				2,715
Wells and pipelines					
Cost		5,928			
Rehabilitation					
Cost	2,866	32,519			
Other					
Cost					
Total cost	7,895	53,255			14,733
Acres of each type	1,345	5,505			47,153
AUM's					
Before	67	138			1,048
After	168	787			2,358

TABLE 42. BASIC FORAGE AND COST DATA FOR ALLOTMENT NO. 20

Practice	Spray	S & S	P & S	O.R.	Native
Fencing					
Miles	27.5	69.0			97.7
Cost	19,681	48,018			74,113
Cattle guards					
Number	1	6		1	5
Cost	639	3,079		620	3,236
Water developments					
Springs--Number	1	4			26
Cost	872	2,937			10,283
Reservoirs--Number	2	4			18
Cost	2,010	2,408			17,973
Wells and pipelines					
Cost	16,783	33,145			16,363
Rehabilitation					
Cost	30,482	167,709			
Other					
Cost					
Total cost	70,467	257,296		620	121,968
Acres of each type	13,641	35,997		11,520	275,011
AUM's					
Before	354	900		256	5,730
After	2,361	7,199		288	8,594

Appendix C

Summary of Development Work Conducted in the Vale District Fiscal Years 1962-1969

This appendix contains a summary of the total work that has been completed under the Vale Project--as of June 30, 1969. The data in Table 43 were taken from the "summary ledger" that was compiled by district personnel and which summarized the work completed in the district in each fiscal year since the Vale Project began. The summary of the proposed work was taken from an unpublished Vale District report dated October 26, 1966, which contained specific detail concerning the proposed work that was to be conducted in the district.

Several comments of explanation are needed to clarify some of the figures listed in Table 43, however. First, the 311,837 acres of brush control listed in Table 43 is the smaller figure of two possible figures that were taken out of the summary ledger. It was felt, however, that the larger figure (313,152 acres) contained errors of addition. Second, the 42 proposed guzzlers included not only guzzlers but other proposed wildlife watering facilities of a smaller nature. Third, the $20,848,000 listed as the proposed allocation for the project is probably considerably more than the actual allocation given to the project by Congress. It is not known, however, how much was allocated to the district for the Vale Project. Fourth, the 494 enclosures and exclosures included an undeterminable number of study plots and cattle guards.

TABLE 43. PROPOSED AND COMPLETED DEVELOPMENT WORK IN THE VALE DISTRICT, FISCAL YEARS 1962-1969

Type of project	No. or units planned	No. or units completed	Cost of completed units	Ave. cost per unit or no.
Reservoirs)		420	$436,132	$1,038.41
Springs)	1,227	326	148,246	454.74
Wells)		25	154,571	6,182.84
Pipelines	220 miles	193.1 mi.	270,369	1,400.15
Fences	2,100	1,341.2 mi.	946,072	705.39
Cattleguards		290	158,411	546.00
Seeding	428,500	209,345 A.	1,323,420	6.32
Brush control	715,500	311,837 A.	690,907	2.22
Stock trails		227 mi.	33,482	147.50
Enclosures and exclosures	494	13	7,501	577.00
Guzzlers	42	16	11,938	746.00
Study plots		15		
Gully plugs	22,000	1,090		
Thistle control		320 A.		
Total cost	$20,848,000		$4,183,000	

Appendix D

Marginal Productivity Derivations

This appendix contains the development of the formula necessary to determine the marginal productivity of capital for investment Models IV, V, and VI.

Model IV

Model IV has the following structural form

$$\text{IV-a)}\quad FI/AI = \alpha_1(X_1/AI) + \alpha_2(X_2/AI) + \alpha_3(X_3/AI) + $$

$$+ \alpha_4(X_4/AI) + \alpha_5(FN/AI)$$

$$\text{IV-b)}\quad FN/AN = \beta_1(X_5/AN) + \beta_2(FI/AN)$$

If Equaton IV-a is multiplied by AI and if Equation IV-b is multiplied by AN, we obtain the following

$$FI = \alpha_1 X + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 FN$$

and

$$FN = \beta_1 X_5 + \beta_2 FI$$

If the value of FN is substituted into the first equation and FI into the second equation we obtain,

$$FI = \alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4 + \alpha_5(\beta_1X_5 + \beta_2FI)$$

$$= [\frac{1}{1 - \alpha_5\beta_2}][\alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4 + \alpha_5\beta_1X_5]$$

and

$$FN = \beta_1X_5 + \beta_2 [\alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4 + \alpha_5FN]$$

$$= \frac{1}{1 - \alpha_5\beta_2} [\beta_1X_5 + \beta_2(\alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4)]$$

Then, by definition, FT = FI + FN or

$$FT = [\frac{1}{1 - \alpha_5\beta_2}][(1 + \beta_2)(\alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4)$$

$$+ (1 + \alpha_5)(\beta_1X_5)]$$

If the original forage ($FTO_o = FNA_o + FIM_o$) is added to both sides of the above equation, we obtain

$$FTO_1 = [\frac{1}{1 - \alpha_5\beta_2}][(1 + \beta_2)(\alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4)$$

$$+ (1 + \alpha_5)(\beta_1X_5)] + FTO_o$$

If the first derivative of this equation is taken with respect to X_i (i = 1,2,3,4), we obtain

$$\frac{dFTO_1}{dX_i} = [\frac{1}{1 - \alpha_5\beta_2}][1 + \beta_2] \alpha_i$$

If $\beta_2 = 0$ (native forage production does not depend on improved production) the above derivative is equal to α_i. If $\alpha_5 = 0$ (native does not affect improved forage production), this derivative is equal to $(1 + \beta_2)(\alpha_i)$. Therefore, as long as α_5 and β_2 are greater than zero and their product $(\alpha_5\beta_2)$ is less than one, the marginal productivity of capital for any investment will be greater than just the effect of the investments on just the area being considered $[\alpha_i < (1 + \beta_2)\ \alpha_i < (\frac{1}{1 - \beta_2\alpha_5})(1 + \beta_2)\ \alpha_i]$. Similar results would be obtained if the first derivative of FTO_1 was taken with respect to X_5 (investments on native areas).

Model VI

Model VI has the following structural form

$$FI/AI = \alpha_1(X_1/AI) + \alpha_2(X_2/AI) + \alpha_3(X_3/AI) + \alpha_4(X_4/AI)$$

$$FN/AN = \beta_1(X_5/AN) + \beta_2(FI/AI)$$

If each equation is multiplied by AI and AN, respectively, we obtain the following

$$FI = \alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4$$

$$FN = \beta_1X_5 + \beta_2FI\ AN/AI$$

If the value of FI is substituted into the second equation, we obtain

$$FN = \beta_1 X_5 + \beta_2 (AN/AI)(\alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4)$$

By definition FT = FI + FN or

$$FT = \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \beta_1 X_5 + \beta_2 (AN/AI)(\alpha_1 X_1 + $$

$$+ \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4)$$

or

$$FT = [1 + \beta_2 (AN/AI)][\alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4] + \beta_1 X_5$$

If original forage values are added to each side of this equation, we obtain

$$FTO_1 = [1 + \beta_2 (AN/AI)][\alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4] + \beta_1 X_5 + FTO_o$$

If the first derivative of this equation is taken with respect to each of the variables, we obtain

$$\frac{dFTO_1}{dX_i} = [1 + \beta_2 (AN/AI)]\ \alpha_i \qquad i = 1,2,3,4$$

$$\frac{dFTO_1}{dX_5} = \beta_1$$

If $\beta_2 = 0$ then $dFTO_1/dX_i = \alpha_i$. Thus, as long as $\beta_2 > 0$, $dFTO_1/dX_i$ will be greater than it would have been if there was no dependence between native and improved forage.

Model V

Model V has the following structural form

$$FI/AI = \alpha_1(X_1/AI) + \alpha_2(X_2/AI) + \alpha_3(X_3/AI) + \alpha_4(X_4/AI) +$$

$$+ \alpha_5(FN/AN)$$

$$FN/AN = \beta_1(X_5/AN) + \beta_2(FI/AI)$$

If the first equation is multiplied by AI, the second by AN, and the resultant values substituted into each equation (as before), we obtain the following:

$$FI = \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5(AI/AN)(FN)$$

$$FN = \beta_1 X_1 + \beta_2(AN/AI)FI$$

Then, by definition

$$FTO_1 = FNA_1 + FIM_1 = FT + FTO_o = FN + FNA_o + FI + FIM_o$$

or

$$FTO_1 = \frac{1}{1 - \beta_2\alpha_5} [(1 + \beta_2(AN/AI))(\beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4) +$$

$$+ (1 + \alpha_5(AI/AN))(\beta_1X_5) + FTO_o$$

If the first derivative of this equation is taken with respect to each of the variables, we obtain

$$\frac{dFTO_1}{dX_i} = (\frac{1}{1 - \alpha_5\beta_2})(1 + \beta_2 \frac{AN}{AI}) \alpha_i \qquad i = 1,2,3,4$$

$$\frac{dFTO_1}{dX_5} = (\frac{1}{1 - \alpha_5\beta_2})(1 + \alpha_5 \frac{AI}{AN}) \beta_1$$

Thus, as long as $\alpha_5\beta_2 > 0$ and $\alpha_5\beta_2 < 1.0$, the preceding derivatives will be larger than α_i or β_1 (no dependency). It should be noted that as $AN \rightarrow 0$ this infers that

$$\frac{dFTO_1}{dX_i} \rightarrow \alpha_i$$

and as $AI \rightarrow 0$, then by inference $\frac{dFTO_1}{dX_5} \rightarrow \beta_1$, as one would expect.

It is recognized, however, that as investment dollars of types X_1, X_2, and X_3 increase, AI increases and AN decreases. This is true only for rehabilitation costs and not for other costs included in X_1, X_2, and X_3 such as water development and fencing. If this relationship was included in this model, the following structural equations are suggested

$$FI/AI = \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 X_5 + \alpha_6 X_6 + \alpha_7 X_7 + \alpha_8 (FN/AN)$$

$$FN/AN = \beta_1 X_8/AN + \beta_2\ FI/AI$$

where

X_1, X_2, X_3 = rehabilitation costs of S, SS, and PS areas, respectively

X_4 = investment costs on OR areas

X_5, X_6, X_7 = "other costs" on S, SS, and PS areas, respectively.

Then

$$AT = AN + AS + ASS + APS + AOR$$

We could obtain the linear relationship that

$$y_1 X_1 + y_2 X_2 + y_3 X_3 = \text{change in AI}$$

where

y_i = the rehabilitation costs per acre.

This would yield, after considerable algebraic manipulation, the following function

$$FT = k\ \{[(1 + \beta_2)(\frac{AT - (y_1 X_1 + y_2 X_2 + y_3 X_3 + AOR)}{y_1 X_1 + y_2 X_2 + y_3 X_3 + AOR})]$$

$$[\beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_7 X_7] +$$

$$[1 + \alpha_8 (\frac{y_1 X_1 + y_2 X_2 + y_3 X_3 + AOR}{AT - (y_1 X_1 + y_2 X_2 + y_3 X_3 + AOR)})]\ \beta_1 X_8\}$$

where

$$k = \frac{1}{1 - \beta_2 \alpha_8}$$

If the first derivative of this equation is taken with respect to each of the variables, we obtain the following

$$\frac{dFT}{dX_i} = \frac{dFTO_1}{dX_i} = k \; \{[1 + \beta_2(\frac{- y_i \; AT}{(y_1X_1 + y_2X_2 + y_3X_3 + AOR)^2})] \; \alpha_i$$

$$+ [\alpha_8(\frac{y_i \; AT}{(AT - y_1X_1 - y_2X_2 - y_3X_3 - AOR)^2}) \; \beta_1 X_8]\}$$

$i = 1,2,3,$

$$\frac{dFTO_1}{dX_j} = k \; [1 + \alpha_2(\frac{AN}{AI})] \; \beta_j \qquad j = 4,5,6,7$$

$$\frac{dFTO_1}{dX_8} = k \; [1 + \alpha_8 \; \frac{AI}{AN}] \; \beta_1$$

These derivatives imply that the productivity of each investment type depends upon the ratio of native and improved land.

The estimation of this model (extension of Model V) was not possible in this study. The estimation of this as well as other models may be a fruitful extension of this study.

Forage Value Derivations

The following example illustrates how the preceeding productivity derivations are used to obtain the forage values that are found in Tables 21 and 22. The marginal productivity of X_1 (Model IV) was found to be (see page 136):

$$\frac{dFTO_1}{dX_1} = [\frac{1}{1 - \beta_2\alpha_5}] [1 + \beta_2] \alpha_1$$

If the estimated values for α_5, β_2, and α_1 (see Tables 9 and 10) are substituted into the above equation, we obtain the following:

$$\frac{dFTO_1}{dX_1} = \frac{1}{1 - (.2619)(.4080)} (1.4080)(.015) = .0237$$

If this value is substituted into formula 4-C (see page 72) we obtain the following (.0237 = F):

$$P_a = \frac{1}{[(\frac{1 - (1.05)^{-12}}{.05})(.0237)] (1.05)^{-2}}$$

$$= \frac{1}{(8.8633)(.0237)(.90703)} = \$5.24$$

Thus, an AUM of forage must be worth at least \$5.24 to return five percent on an investment of one dollar for spray areas whose life expectancy is 12 years, given the productivity estimates of Model IV. Forage values for other models, project lives, or investment alternatives may be obtained by applying the above procedure to the model or alternative being considered.

Appendix E

Notes on the Impact of Rehabilitation Projects on Game

This appendix contains the abstract and conclusions from an unpublished study conducted by James Reeher of the Oregon Game Commission concerning the effect of large-scale range rehabilitation on game species and some minority conclusions to the study by Bob Kindschey, Wildlife Specialist at the Vale District.

Abstract and conclusions of the study

Abstract

In 1962, the Bureau of Land Management began an extensive livestock range rehabilitation program on the Vale District. To determine the effect this rehabilitation might have on certain wildlife species, the Oregon State Game Commission initiated a six-year evaluation study. Seven rehabilitation and six control areas were randomly selected to represent various range rehabilitation practices in various animal habitats. The evaluation was based on a comparison of animal use (as determined by pellet counts) on rehabilitated and adjacent control areas.

The study areas that were rehabilitated by plowing and seeding to wheatgrass were found to be of the most benefit to antelope and sage grouse. The seedings received only light use from deer and chukars. On areas sprayed with 2-4D to kill big sage (*Artemisia tridentata*), chukar use was found to be equal or greater than that on the control area. The deer use of one study area was found to be reduced after the area was sprayed with 2-4D. The rabbit use on four rehabilitated areas was found to be equal to or greater than the use on natural areas. On the two sprayed areas that received a snow cover, the rabbit use was less than that on the control area.

Antelope production information was gathered from herds on rehabilitated and native ranges. The better livestock range conditions on rehabilitated areas did not affect the antelope kid production.

Conclusions

The following preliminary conclusions are based on the six year study information and personal observations on other rehabilitated areas on the Vale District.

1) Killing of big sage and other woody species by spraying does not make an area attractive to antelope. (Starvation spray)
2) The seeding of wheatgrass into a sprayed area does not make the area attractive to antelope. (Starvation spray)
3) A plow and seed area will receive more antelope use than a sprayed or a spray and seed area. (Rawhide and Starvation units)
4) A plow and seed project on an antelope range will increase the use of the area by antelope. (Chicken Creek and Rawhide)
5) On spring and summer antelope range the amount of use on a seeding will be greatest the first few years, then it will drop to a lower level. (Rawhide)
6) The antelope kid production rate of herds on rehabilitated range will not be greater than that of herds on better native ranges.
7) A spray project on deer summer ranges will reduce the deer use of the area. (Horse Flat)
8) A spray project on good chukar habitat will not reduce and may increase the chukar use of the area. (Horse Flat and Bas)
9) Crested wheatgrass seedings receive little use by chukars. (Chicken Creek)
10) Spraying of a big sage area will reduce the sage grouse use on the area. (Starvation units)
11) A plow and seed project in a big sage area will increase use by sage grouse. (Rawhide)
12) Range rehabilitation does not appear to affect rabbit populations or their use of an area unless the area is snow covered in winter.

Selected comments on the study by Bob Kindschey

Bob Kindschy was asked to make any comments he had concerning the study conducted by the Game Commission. The following are some of the statements he made.

> Most [land treatments] have been placed in areas unimportant to wildlife game species. This is an important fact in that it indicates a bias concerning the Game Commission's study, viz. that there was little game use of the area prior to treatment. Jim Reeher's sampling methods consequently showed little

result--either positively or negatively--due to the vegetational alterations.

Jim's report contained a number of opinions and, on page 19, a list of conclusions--often based on a single instance of observation. I would like to comment on several of these.

Page 7 ". . . antelope do not use extensive stands of big sage." This is a significant change in thinking, and I fully agree that a heterogeneous vegetative complex is much better habitat.

Page 8 ". . . killing the big sage and increasing forage production does not make an area attractive to antelope." This is a true statement for the first years of a brush control project due, in my opinion, to the fact that the brush is still standing. The aspect has changed but little. With the passage of time--10 or 20 years--the aspect will be greatly changed to a bunchgrass stand with isolated sagebrush stands. Then I believe one could anticipate an increase in antelope use. ". . . The seedings are most attractive to antelope the first few years after plowing." Agreed, in fact the first three years seem to be the heaviest usage. Our plantings of dryland (nomad) alfalfa and our rotation grazing schemes seem to be changing this, however. Heavy use and close use by cattle favors forb growth and maintains a short-grass plains aspect which the antelope favor.

Page 9 ". . . an increase in antelope numbers since the rehabilitation work." We have observed an influx of antelope into seeded areas for years. Now district-wide antelope populations are climbing. This may--or may not--be a result of the BLM rehabilitation work. Many factors are involved. One may safely conclude that the rehab work has not been adverse to antelope. More time will show more definite results.

Page 10 ". . . sage range rehabilitation did not increase the rate of kid production above that on native range." A very complex situation here. Production is no problem. It is the survival through the first summer that seems to eliminate nearly fifty percent of the young of the year. Yet, as mentioned on page 9, the antelope numbers are increasing. I believe insufficient data were collected. Something doesn't jibe.

Page 16 On sage grouse. Jim's observations are good and parallel mine. The vast majority of our projects--both plow and seed and herbicide treatment--contain live sagebrush within a short time following treatment. I feel that there is ample forage for all species of wildlife that use sagebrush species; the cover may be lacking, however. Sage grouse populations are very cyclic. Recently the district area has been experiencing a definite increase in this species. I am told this is true elsewhere in adjacent Idaho too. Consequently I believe our vast treatment has not been grossly detrimental and, in fact, may have been helpful.

Page 17 On jackrabbits. Here I feel Jim's conclusions, based on the one site, are not typical of the general effects of the two methods of land treatment. I have repeatedly observed that jackrabbit use is increased along the edge or perimeter of the seeded area but greatly reduced further into the treated area where protective cover is less. Ground squirrels, on the other hand, have protective burrows to escape predation, etc. We have experienced astronomical numbers of the Townsend's ground squirrel in seedings near Vale recently. I believe this abnormal population level was related to the unusual amount of forage available in the form of crested wheatgrass.