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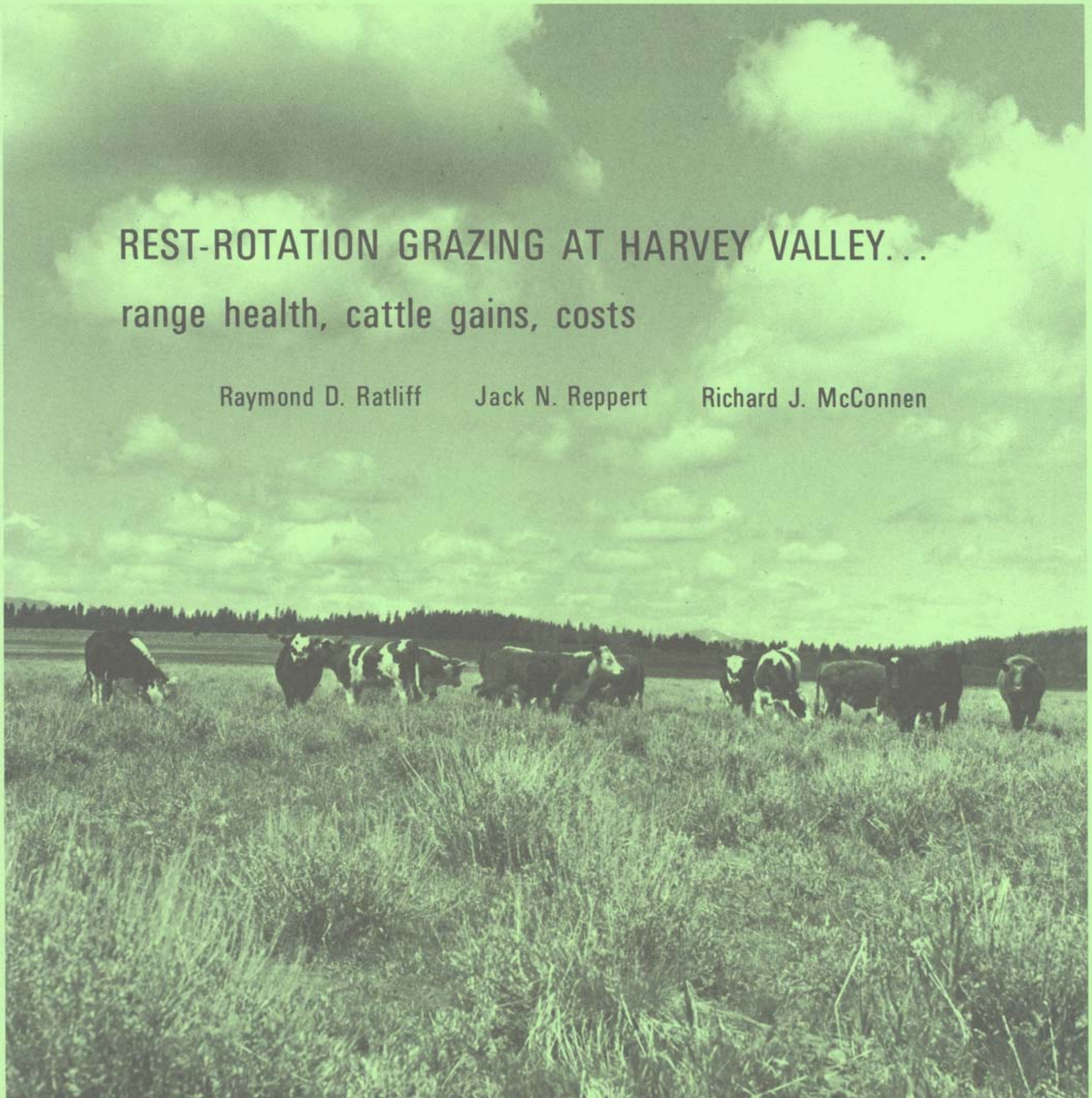

REST-ROTATION GRAZING AT HARVEY VALLEY...

range health, cattle gains, costs

Raymond D. Ratliff Jack N. Reppert Richard J. McConnen

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"Rest-Rotation Grazing at Harvey Valley...range, health, cattle gains, costs," by Raymond D, Ratliff, Jack N, Reppert, and Richard J. McConnen (USDA Forest Service Research Paper PSW-77)

ERRATUM

On page 12, under the graph, add this caption:

Figure 4--Year-to-year differences in daily gains of cattle on the Harvey Valley allotment, 1954-66, inclusive:

CONTENTS

The Authors

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Special credit is due *A. L. (Gus) Hormay,* formerly of the Pacific Southwest Forest and Range Experiment Station and now with the U.S. Bureau of Land Management, who headed research at Harvey Valley until 1961; *E. J. (Joe) Wolfolk,* formerly Assistant Director for range and wildlife habitat research at the Station, who gave valued guidance and direction to our efforts; *Roney Brothers,* the Harvey Valley permittee whose cooperation made it possible to collect data and apply rest and grazing treatments; members of the *Lassen National Forest* staff—particularly Philip B. Lord, Fred J. Alberico, and Bill Sanderson—and of the Forest Service's *California Region; Donald W. Seegrist,* formerly of the Experiment Station staff and now with the Northeastern Forest Experiment Station, who guided the data analyses; and *Beecher Crampton,* University of California, Davis, who helped with plant identification.

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One objective of U.S. Forest Service range management is to provide economic stability to livestock operations and rural communities that depend upon rangelands for support. Mountain rangelands in the National Forests of northeastern California produce forage for livestock during a 4- to 5-month season—the season when forage at home, on foothill ranges of the Sacramento Valley, is dry and of lower grazing value. These mountain rangelands also support deer and antelope and are important as producers of timber, water, and recreation. Therefore, these ranges should be managed on an ecologically sound basis.

The history of early grazing suggests that range management was not ecologically sound (74th Congress 1936). Rather, rangelands of northeastern California were badly mismanaged. Overstocking led to overgrazing of the range, and with improper seasonal use resulted in severe deterioration of the range resource.[1]

Traditionally, in these mountain rangelands, cattle were brought to the summer range as soon as snow conditions permitted. They were left to graze the range at will during summer and then gathered for the drive home just before the fall storms. This "free choice" grazing program (hereafter referred to as season-long grazing) is still used on most of the ranges.

In the past, little attention was paid to the prime elements of livestock grazing management: stocking rates, season of use, livestock distribution, and frequency of use. A range improves or deteriorates and livestock production is efficient or inefficient as a result of manipulation of these four elements. All other influences on range health and production efficiency are generally beyond the control of the range manager or ranch operator.

After the National Forests in northeastern California were established, management aimed at moderate use of the ranges. Stocking rates were gradually reduced, season of use was shortened, and techniques of improving livestock distribution were employed. The ranges continued to be grazed season-long, however. Some improvement in range condition was achieved in those areas not preferred by livestock, but the preferred grazing areas did not improve. On many range allotments, improved livestock grazing management was needed to arrest and then reverse the downtrend in range condition, increase range livestock production, and enhance other range values.

The Harvey Valley allotment on the Lassen National Forest was chosen as a representative area on which to test a rest-rotation grazing program for range improvement. The program was begun in 1954, after 3 years of preparatory work.

Records of livestock use on the Harvey Valley allotment date from 1870. From then until 1906, when the Lassen National Forest was established, about 7,200 animal-unit months (one animal-unit month (A.U.M.) represents one 1,000-pound cow grazing for 1 month) of grazing were obtained from the allotment each season. After 1906, except for a temporary increase from 1914 to 1918, stocking rate and season of use were gradually reduced, but the health of the range declined until by 1951 the animal-unit months of grazing were only one-third of that obtained in the late 1800's *(fig. 1).* Nearby allotments have a similar history of early use and reduced grazing capacity. Harvey Valley was the first Forest Service allotment to be placed under rest-rotation grazing. Nearby allotments have continued to be grazed season-long.

[1]Hormay, A. L. *Management and study plan—Harvey Valley Experimental Range.* 1954, rev. 1956. (Unpublished report on file at Pacific SW. Forest & Range Exp. Sta., U.S. Forest Serv., Fresno, Calif.)

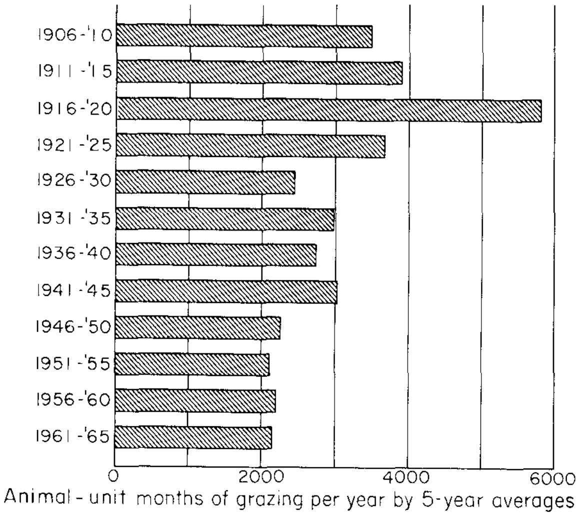


Figure 1—Grazing use on Harvey Valley allotment, in the Lassen National Forest, northeastern California, showed fluctuations during the period 1906-1965.

This paper reports an evaluation of progress observed on the Harvey Valley allotment to 1966. It summarizes findings in (a) comparative range health and apparent condition trends, (b) cattle weight gains, and (c) cost/return analysis from the standpoint of both the Forest Service and the permittee. In the cost analysis, the basis for comparison was the estimated cost of managing the Harvey Valley allotment under a season-long grazing program, rather than costs on a nearby allotment.

THE HARVEY VALLEY AREA

Harvey Valley and nearby allotments are in the southern Cascades, in a region characterized by valleys with broad, fairly level lowlands and terraces between volcanic peaks *(fig. 2).* Elevations vary from 5,600 feet to about 7,500 feet.

Climate

Rather dry summers and cold wet winters with considerable snowfall are the rule. Summer precipitation makes up less than 3 percent of the yearly mean of 18.4 inches (Ratliff and Reppert 1965); 20 percent comes in fall and a similar amount in spring, whereas winter accounts for 57 percent. Shortages in seasonal and yearlong precipitation are frequent. The area had drought in one-third of the years from 1935 through 1963, and spring drought in more than half of the years of that period.

Average monthly air temperatures are usually below freezing during November through February, at or near freezing in March, and above freezing in all other months. Hormay and Talbot (1961) reported a low of -27°F. in January 1937 and a high of 98°F. in July of 1946.

Soils and Vegetation

Soils of the area are quite diverse, ranging in thickness from a few inches to more than 5 feet. Surface textures range from loamy sand in the higher areas to clay in the lower areas. Calcareous hardpans developed in some soils a few inches to 2 feet or more below the surface. On the slopes of the mountains, formed from Pleistocene and recent basalt, soils are primarily residual. Soils on the lowlands formed over ancient lake and more recent alluvial deposits.

Meadows in the drainage bottoms are watered by winter snows and spring runoff. Most meadows are on moderately deep to deep soils; hardpans are found at some of the ephemeral lake sites.

Vegetation consists of five principal types. The silver sagebrush *(Artemisia cana)*[2] type grows slightly above the meadows, but the soil is often covered with water early in spring. Here the most important grasses are Nevada blue grass *(Poa nevadensis)* and bottlebrush squirreltail *(Sitanion hystrix).* Soils are generally dark-colored and moderately deep, with an occasional hardpan at moderate depth.

The black sagebrush type *(Artemisia arbuscula)* is usually intermediate between the silver and big sagebrush types *(Artemisia tridentata).* Soils under black sagebrush are usually very shallow and often have a calcareous hardpan. This type of soil is generally the least productive of forage and has the least potential for improvement. The most abundant grasses here are Sandberg bluegrass *(Poa sandbergii)* and bottlebrush squirreltail; there is some Idaho fescue *(Festuca idahoensis),* western needlegrass *(Stipa occidentalis),* and Junegrass *(Koeleria cristata).*

Big sagebrush occupies fairly deep, well-drained soils. Idaho fescue, bottlebrush squirreltail, Sandberg

[2]Scientific names follow *A California Flora,* by P. A. Munz and D. D. Keck. Berkeley: University of Calif. Press. 1959.

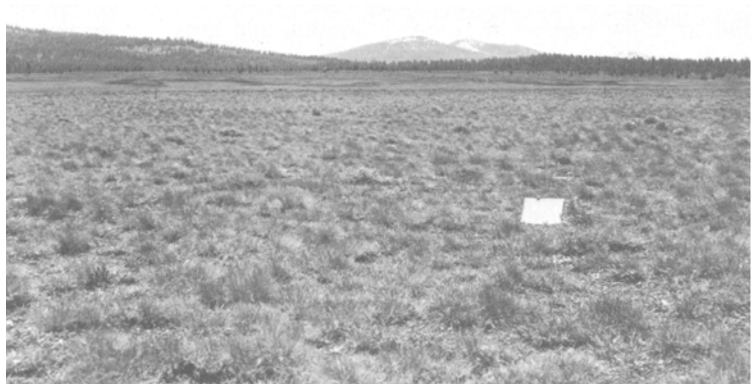


Figure 2—Broad, level lowlands and volcanic peaks are typical of this view of the Harvey Valley area, taken June 15, 1967.

bluegrass, and various needlegrasses are the principal grasses in this type. Ross sedge *(Carex rossii),* an important grasslike plant, occurs here and is well liked by cattle.

The open grassland type, sometimes called the shorthair sedge *(Carex exserta)*—bunchgrass type, occupies a physiographic position very close to that of big sagebrush. The two types often blend together and the soils are similar. Shorthair sedge often dominates this vegetation type, but bunchgrasses may dominate and even exclude it.

On the lower slopes of the mountains, vegetation is the ponderosa pine *(Pinus ponderosa)*—big sagebrush transition type. Idaho fescue, various needlegrasses, and bottlebrush squirreltail are the major forage components in most of this zone. Soils are usually moderately shallow to a fractured bedrock, and produce good forage where tree canopy and needle layers are not too heavy.

In the pine type proper, the slopes are steeper than in the transition zone. Soils are very similar in depth, texture, and color. Where the canopy is open, good forage is produced. Perennial bromes *(Bromus)* are fairly abundant on the higher elevations.

In the fir *(Abies)* type, important forage plants include brome, bottlebrush squirreltail, and needlegrasses. Openings are often occupied by big sagebrush, and greenleaf manzanita *(Arctostaphylos patula)* may form dense stands on burnt areas.

Additional information on soils and vegetation of the area was reported by Hormay and Talbot (1961).

REST-ROTATION GRAZING

The principles of rest-rotation grazing management were developed through research by Hormay and Talbot (1961) at the Burgess Spring Experimental Range. Rest-rotation controls all four elements of grazing management and is intended to provide for both ecological and cultural range improvement.

The basic principles of rest-rotation grazing have been discussed in detail by Hormay (1970). They may be summarized as follows:

- A major cause of range deterioration is selective close grazing of plants and range areas in similar yearly patterns of use.
- The only effective way to control this selective grazing by livestock and counter its harmful effects is to rest these areas from grazing at appropriate intervals.
- To encourage maximum rate and degree of improvement in range condition, the exact prescription of rest and grazing must be correlated with the growth and reproduction requirements of the key species of a specific range or allotment.

In preparation for the test of rest-rotation begun in 1954, the Harvey Valley allotment (consisting of 34,775 acres) was cross-fenced into five range units of about equal capacity. The prescription called for each range unit to be rested two full grazing seasons out of five. In addition, two half seasons of rest were planned for each range unit. Thus one full season and two half seasons were available for grazing use. Cattle were confined to assigned range units during periods of grazing.

The prescription was based on the requirements of Idaho fescue. After a full season of use, a given range unit was rested a full season to permit recovery of plant vigor. The third season the unit was rested until midseason to permit plants to ripen seed and then was fully grazed in order to trample seed into the soil and to allow maximum forage utilization and livestock production. During the fourth year of the rotation, the range unit was rested to permit seedlings to become established. In the fifth year, it was grazed moderately to midseason and rested the second half of the season as a further aid to seedling establishment. In the following year the unit was again grazed season-long, and the 5-year cycle was repeated. The prescription provided for emergency use of those range units scheduled for rest. Their use was permitted in years of low forage production, thus assuring ample feed for the cattle for the full grazing season. Grazing of units scheduled for rest would tend to slow the rate of range improvement. However, their use was allowed only late in the grazing season when the effects of grazing are least severe.

From 1954 through 1962 the season of use on Harvey Valley was June 1 to September 30. Since 1963, the closing date has been October 31. During the period of study, however, there was no increase in the total animal-unit months of grazing obtained each season from the allotment.

Expected Responses

Rest-rotation grazing and the improvement program for Harvey Valley were expected to double the grazing capacity in 20 years, or by 1974.[3] This increase was to come from three sources: rest-rotation grazing (43 percent), cultural practices (42 percent), and logging (15 percent).

Specific changes in plant, soil, and stand characteristics were expected to produce an improved condition and greater grazing capacity.

The plant characteristics were.. .

- Greater vigor of established plants as indicated by size of plant parts.
- Greater seed production.
- Higher nutrient content.

The soil characteristics were.. .

- More litter cover and less exposed bare soil.
- Faster water absorption and less soil compaction.

The stand characteristics were.. .

- Larger cover percentages for desirable species.
- Better species composition, indicating a higher successional stage.
- More seedlings of desirable species.

[3]Hormay, A. L. 1954, rev. 1956 (unpublished report on file at Pacific SW. Forest & Range Exp. Sta., U.S. Forest Serv., Fresno Calif.)

In addition, it was expected that the rotation of grazing would permit spraying and seeding without the restriction on use of land units otherwise required for this purpose. Seedings were expected to be maintained without special fencing to separate them from areas of native range.

Evaluation of Program

From 1954 through 1962 almost all Forest Service evaluation of the effectiveness of rest-rotation grazing was made in Harvey Valley. Collection of comparable data (livestock as well as vegetation) from other allotments—although originally intended—was not accomplished owing to lack of adequate funding.

Only by comparisons with other ranges is it possible to learn whether rest-rotation grazing has been doing the job for which it was designed; specifically, to improve range health while maintaining an acceptable level of livestock production. Therefore, from 1963 to 1966, special effort was made to evaluate the effects and value of rest-rotation grazing as used at Harvey Valley through comparisons with nearby allotments.

The evaluation of range health was made by means of a scoring system that allowed comparisons of plots in Harvey Valley with comparable plots in other allotments. On the basis of the scoring, the apparent condition trend was estimated.

Methods and Logic

Following the system described by Ratliff and Reppert (1966), 26 pairs of plots, each 1/4 or 1/2 acre, were set up in several vegetation types within Harvey Valley and four nearby allotments. Plot pairs formed two position groups—boundary plots and interior plots. The members of boundary pairs were usually within 100 yards of each other and were placed to avoid unusual cattle concentration areas or pathways along fence lines. The members of interior pairs were from 1 to several miles apart. The 26 plot pairs also fell into four generalized vegetation types—hereafter referred to as *major vegetation types.* Nine were in timber-bunchgrass, seven in open grassland, and six in the open shrub-grass type. The other four plot pairs were in meadows.

Comparison of a Harvey Valley plot with its "partner" in another allotment required two assumptions: First, given the same management, the site capability of either member of a pair of plots was the same for producing a general community of plants. Second, both members of a pair of study plots were producing a quantity of herbage and a quality of plant community at some unknown degree below their natural capabilities. On the basis of these assumptions, certain differences between the members of a plot pair provided an indication of the "relative" range conditions-the conditions of plots grazed under rest-rotation as compared to that of plots grazed season-long. Relative range condition for each pair of plots was determined by rating the plots on nine major condition characteristics reflecting the expected goals of rest-rotation grazing.

In order to use the results of the rating as an estimate of apparent trend in range condition on the Harvey Valley plots it was necessary to assume also that: first, the grazing program and range condition were essentially the same on a pair of plots at the time rest-rotation grazing was started in 1954; and second, the trend in range condition was near static after 1954 on nearby allotments under season-long use. Statements in this report that imply responses of plants and other elements of range health are also based upon these assumptions.

TRENDS IN RANGE HEALTH AND CONDITION

As has been stated, some influences on range conditions are outside management control, and we do not have data on these. One climatic influence on the results of the evaluation may be noted, however. Rest-rotation was in full operation at Harvey Valley near the end of a period of abundant precipitation. The status of range condition in Harvey Valley and the apparent condition trends, relative to neighboring allotments, were determined after the most severe period of drought since 1936. Prolonged, severe drought is not conducive to range condition improvement, and the range resource may have made a slower response to rest-rotation at Harvey Valley than it would have under better conditions.

Relative Range Condition

A relative condition score was developed for each plot-pair test, using a 100-point maximum rating. Nine characteristics were rated as follows: basal cover, 25 points; plant vigor, 20 points; species composition, 15 points; litter cover and herbage yield, 10 points each; and bare soil, water absorption, soil compaction, and perennial grass seedlings 5 points each. The individual plot scores *(table 1)* were arrived at by assigning a number of points for each characteristic measured to each member of a plot pair and then summing the points for all characteristics. All nine characteristics were not measured on all plot pairs; no points were assigned for characteristics not measured.

The points assigned to a plot for a particular characteristic reflected the number of counts of significant differences in the characteristic that were favorable to each plot. For example, plant vigor was assessed by using five indicators. Let us say that four of the differences between a pair of plots favored Harvey Valley and one the nearby allotment. Then, 16 points were given to the Harvey Valley plot and four to the other plot.

Absolute or true range condition cannot be measured from these scores. Instead, they amplify the important differences between plot pairs to show

Table 1– *Relative range condition scores of 26 pairs of comparable plots in Harvey Valley and nearby allotments. 1964-66, by major vegetation types: scores based on a 100-point, 9-characteristic rating system*

Timber bunchgrass			Open grassland			Open shrub-grass			Meadow		
Plot pair	Harvey Valley plot	Other plot	Plot pair	Harvey Valley plot	Other plot	Plot pair	Harvey Valley plot	Other plot	Plot pair	Harvey Valley plot	Other plot
4	9.5	30.5	16	71.2	13.8	2	57.1	27.9	49	77.7	12.3
12	38.8	36.2	25	82.9	17.1	3	26.9	48.1	70	56.9	38.1
13	83.7	6.3	41	55.1	14.9	17	64.6	10.4	78	38.4	51.6
14	43.3	41.7	47	63.7	21.3	18	33.6	41.4	82	52.9	37.1
15	51.7	33.3	64	78.0	22.0	71	43.9	36.1			
19	71.7	8.3	79	64.3	20.7	72	28.3	61.7			
20	67.6	12.4	80	57.3	22.7						
21	53.5	21.5									
81	56.0	24.0									
Av.	52.9	23.8		67.5	18.9		42.4	37.6		56.5	34.8

whether a given plot is in better or worse condition than its partner.

Relative range condition scores *(table 1)* were higher for the plot under rest-rotation in 21, or 81 percent, of the 26 comparisons. For all seven of the open grassland plot pairs, scores were higher under rest-rotation, and the average score of the season-long plots was only 28 percent of the average score of the rest-rotation plots. In the timber-bunchgrass type only plot pair 4 scored higher for the season-long member. Eight others were higher under rest-rotation, and the average score of the rest-rotation plots was twice as large as for season-long grazing. In the meadow type, plot pair 78 (undrained basin site) scored lower for the Harvey Valley member. The other three meadow pairs scored higher for the plot under rest-rotation, and the average score for the season-long plots was 62 percent of that for meadows on Harvey Valley. For the open shrub-grass type, half of the scores were higher for the season-long members of the plot pairs. The average score of the season-long plots was 89 percent of the score for the plots under rest-rotation.

Thus, the open grasslands have apparently made greatest gains in relative range condition under rest-rotation, followed by the timber-bunchgrass and meadow types. The better condition of the open grasslands is very apparent on the Harvey Valley member of plot pair 79 *(fig. 3).* The scores of plot pairs 17 and 72 are worth noting. Plot pair 17 is on a silver sagebrush site that is heavily used under both types of grazing. Plot pair 72 is on a less productive, more lightly grazed big sagebrush site. Hence, although, on the average, the open shrub-grass type has not done as well as the others, the more productive sites within the general type apparently are improving under rest-rotation grazing.

Apparent Trend in Range Condition

The differences between plots can be seen more easily to show a trend if they are analyzed by plot location *(table 2).* The plots under rest-rotation along the boundary with the Champs Flat allotment—where the fence was put in at the start of rest-rotation—were generally in better condition than those grazed season-long, indicating an improving range condition on the Harvey Valley allotment. Seven plot pairs are along this boundary, and for six of them the relative condition scores were higher for the rest-rotation plot. Only on plot pair 18 was the score higher for the season-long plot.

Table 2—*Average relative range condition scores of comparable plot pairs. by location*

Location	Grazing treatment		Number of plot pairs
	Rest-rotation	Season-long	
Champs Flat boundary	59.5	20.6	7
Lower Pine Creek boundary	55.3	28.1	3
Grays Valley boundary	43.0	30.0	5
Interior of allotments	57.4	30.3	11

Along the other boundaries and in the interiors of the allotments, differences in pattern and duration of season-long use may have resulted in different conditions at the time rest-rotation was started. Still, apparent trend in condition on most of the plots under rest-rotation is upward. Only two of the other eight boundary plot pairs had higher scores on the season-long plot. On only two of the 11 interior plot pairs were scores higher for season-long plots.

The upward trend in relative range condition on Harvey Valley does not necessarily imply that condition trend is down on neighboring allotments; it may in fact be up, but if so, it is not as pronounced as on Harvey Valley.

Findings of an upward trend in range condition on Harvey Valley tend to be contradicted by results from permanent condition and trend transects.[4] These results indicate that condition trend was down between 1957 and 1963 on Harvey Valley. With three consecutive years of drought (1959-60-61) such a decline is not unlikely. But, if range condition of Harvey Valley is now better than that of neighboring allotments, an important conclusion may be drawn. The Harvey Valley allotment was not hurt as much by the drought and was able to recover and respond more rapidly with good years, or it was in better condition by the start of the drought than the neighboring allotments. Under either or both of these circumstances, progress in improving range condition is being made at Harvey Valley.

Range Condition Characteristics

The rating scores give a broad picture of the results of the rest-rotation grazing program. Data from the studies that contributed to the point ratings serve to

[4]These are permanently marked belt transects established on a variety of range sites. They were first measured in 1957 and again in 1963. (The unpublished data are on file at Pacific SW. Forest & Range Exp. Sta., Fresno, Calif.)

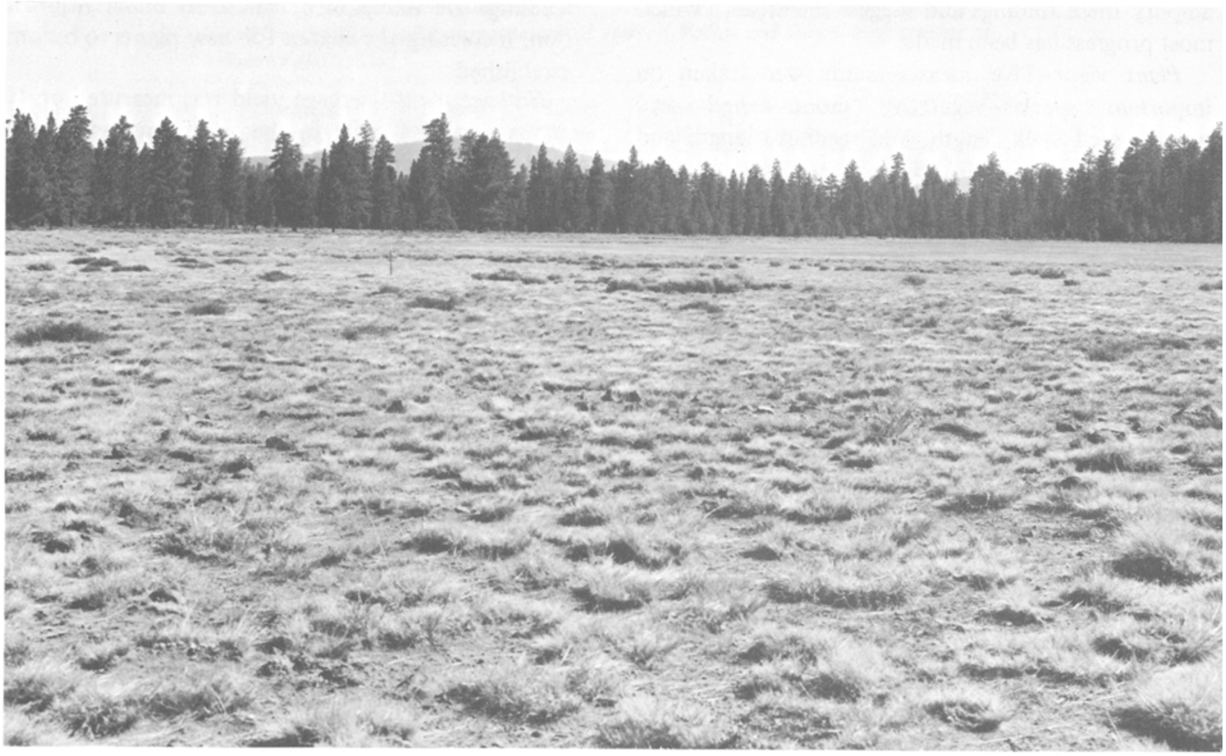


Figure 3—Comparable plot pair No. 79 is of the open grassland type.
Above, Harvey Valley; *below*, Gray's Valley, in 1965.

amplify these findings and suggest the areas in which most progress has been made.

Plant vigor–Five measurements were taken on important species-vegetative shoot length and weight, seed stalk length, and seedhead length and weight.

Idaho fescue vegetative shoot weight and length were 16 and 26 percent greater on the Harvey Valley plots *(table 3)*. Length of both seed stalks and seedheads was significantly greater under rest-rotation. There was no difference, however, in the weights of the seedheads. As a further indication, results of regrowth studies using plant cores showed that some Idaho fescue plants from Harvey Valley have a better supply of root reserves than do those from the allotments grazed season-long. Thus, rest-rotation grazing has resulted in improved vigor of the key forage species.

The vegetative shoots of western needlegrass were 15 percent longer and 26 percent heavier *(table 3)* under rest-rotation. Although there were no differences in the other indicators, the results suggest a generally favorable response to management.

Perennial grass seedlings–Seedlings were more plentiful under rest-rotation grazing in 1965–a bumper seedling year both in and around Harvey Valley. Of 19 upland plot pairs examined in 1965, 11 had significantly higher seedling frequencies for the rest-rotation plot. Only two had higher frequencies for the season-long plot, and for six there was no difference. The average difference (2.05 more seedlings under rest-rotation per 100 nearest-plant observations) was significant by chi-square test at the 95-percent probability level. Thus, the data indicate that–given a good seedling year-more perennial grass seedlings are likely in upland areas under rest-rotation, increasing the chance for new plants to become established.

Herbage yield–Herbage yield was measured on 10 comparable plot pairs in the open grassland, open shrub-grass, and meadow types. Results indicate that yield of herbage increased under rest-rotation grazing *(table 4)*. On open grassland and open shrub-grass plot pairs, yield under rest-rotation was one-third more than the yield under season-long grazing. For meadows, yield was about one-fifth more under rest-rotation.

Assuming that range condition was the same on each plot of a pair at the start of rest-rotation, the yield data allow estimation of the present grazing capacity of the Harvey Valley allotment. In 1951, the estimated grazing capacities for the open grassland, open shrub-grass and meadow types were 118.8, 636.8, and 599.2 A.U.M., respectively. All plot pairs considered, the increases in yield are 33.7, 35.6, and 12.3 percent, respectively, giving an estimated increase of 340 A.U.M. This is about 15 percent of the total 1951 allotment capacity (2,060 A.U.M., timber-bunchgrass type included).

Litter cover and bare soil–Litter cover increased under rest-rotation *(table 4)*. Sixteen of the 26 plot-pair comparisons showed more litter cover under rest-rotation, three the reverse, and seven no difference.

Bare soil, gravel, rock, and wood were expected to be better covered by litter and plants under rest-rotation. More bare soil was exposed under season-long grazing on 16 of the 26 plot pairs compared, and less on five. Since the increase in litter cover is about equal to the decrease in bare soil *(table 4)*, it appears

Table 3–*Differences in plant vigor indicators for Idaho fescue and western needlegrass under rest-rotation (RR) at Harvey Valley and season-long (SL) grazing at nearby allotments*

Item	Vegetative shoot weight	Vegetative shoot length	Seedhead length	Seed stalk length	Seedhead weight
	Mg.	*Ft.*	*Ft.*	*Ft.*	*Mg.*
IDAHO FESCUE					
Average size, RR	100.07	0.52	0.36	1.80	222.92
Average size, SL	79.03	.45	.34	1.74	220.16
Difference	21.04***	.07***	.02***	.06**	2.76
WESTERN NEEDLEGRASS					
Average size, RR	195.00	.54	.91	1.40	480.22
Average size, SL	143.96	.46	.87	1.38	492.06
Difference	51.04*	.08***	.04	.02	-11.84

*Statistically significant at 20 percent level of probability by paired t test.
**Statistically significant at 10 percent level of probability by paired t test.
***Statistically significant at 5 percent level of probability by paired t test.

Table 4–*Differences in herbage yield, litter, bare soil, water absorption, and soil compaction under rest-rotation at Harvey Valley and season-long grazing at nearby allotments*

Grazing program	Herbage yield	Litter cover	Bare soil	Water absorption	Soil compaction Spring	Soil compaction Fall
	Lb./acre	*Pct.*	*Pct.*	*Min./inch*	*——P.s.i.——*	
Rest-rotation	1,238.2	53.8	21.8	6.1	283.6	432.9
Season-long	1,050.9	46.4	28.9	7.0	297.5	484.1
Difference	187.3**	7.4***	-7.1***	.9***	-13.9	-51.2*

*Statistically significant at 20 percent level of probability by paired t test.
**Statistically significant at 10 percent level of probability by paired t test.
***Statistically significant at 5 percent level of probability by paired t test.

that the area of exposed soil is becoming less under rest-rotation with a corresponding increase in litter cover.

Although individual plot pair differences occurred for gravel, rock, and wood, there were no differences between methods of grazing for these characteristics.

Soil characteristics–Water absorption is faster under rest-rotation. Half of 24 tests of water absorption rates showed significant differences; in these, it took 1.8 minutes less for 1 inch of water to be absorbed on the plots under rest-rotation.

Soil compaction, an important factor on many rangelands, appears to be less important in the Harvey Valley area. Soils were less compacted in the fall *(table 4)* on plots under rest-rotation, but no difference between plots was found in the spring. Apparently, frost action tends to break up compacted layers on many sites. Also, on 15 upland plot pairs we found no difference due to method of grazing in the average within-plot increase in compaction between spring and fall.

Table 5–*Average differences between paired plots*[1], *in basal cover for plants of primary, secondary, and low value by major vegetation type.*

Vegetation type	Plant grouping Primary	Secondary	Low value	All plants
	Percent			
Timber-bunchgrass	0.05	0.18*	-1.76	-1.53*
Open grasslands	1.32***	.58*	-1.62*	.29
Open shrub-grass	.44*	.13	1.28	1.86*
Meadows	3.23***	-.05	-.31	2.88*
All types	.97***	.25**	-.80	.42

[1] Season-long plot value subtracted from rest-rotation plot value.
*Statistically significant at 20 percent level of probability by paired t test.
**Statistically significant at 10 percent level of probability by paired t test.
***Statistically significant at 5 percent level of probability by paired t test.

Basal cover–Basal cover of desirable species should increase as a result of better plant vigor, greater seedling numbers, and better soil surface conditions under rest-rotation grazing, and such an increase is evident.

The meadows show the most favorable responses in basal cover to rest-rotation grazing *(table 5).* The open grasslands have also responded well, but only minor gains have been made in the timber-bunchgrass and open shrub-grass vegetation types.

Since there was no significant difference in cover of low-value species and no significant difference in total plant cover, either primary or secondary species have replaced some low value ones or have advanced into previously unoccupied soil on the plots under rest-rotation. Either way it is a step toward improvement in the resource.

Thus far, bottlebrush squirreltail has been the grass most responsive to rest-rotation grazing. Under rest-rotation, bottlebrush squirreltail made up three times more of the cover than under season-long grazing *(table 6).* Idaho fescue has not shown nearly as much response, although the difference (22 percent) was significant.

Junegrass was encountered in basal cover studies on six pairs of plots *(table 6).* In five plot pairs there was significantly more cover of Junegrass under rest-rotation than under season-long grazing. Considering the small number of tests and the large difference in average cover values, Junegrass appears to be responding well to rest-rotation.

All upland plot pair tests considered, western needlegrass, Sandberg bluegrass, Ross sedge, and shorthair sedge have shown no response in basal cover to rest-rotation *(table 6),* but important differences between members of plot pairs were noticeable.

It is likely that the seed dispersal mechanism (wind), and high seedling vigor of bottlebrush squir-

Table 6–*Differences between paired upland plots in basal cover of some important plant species and species groups*

Species or Group	Average basal cover: Plot pairs	Rest-rotation plots	Season-long plots	Differences RR-SL
	No.	*—Percent—*		*Percent*
Bottlebrush squirreltail	19	0.35	0.11	0.24**
Idaho fescue	17	1.25	1.02	.23*
Junegrass	6	.39	.06	.33**
Western needlegrass	18	.53	.56	-.03
Sandberg bluegrass	10	.60	.51	.09
Ross sedge	17	1.03	.95	.08
Shorthair sedge	8	3.52	3.03	.49
All grasses	22	2.30	1.67	.63**
All grasslike plants	22	2.13	1.86	.27*
Forbs[1]	21	.43	.85	-.42
Shrubs	22	7.07	7.60	-.53

[1]No forbs were found in basal cover on one upland plot pair.
*Statistically significant at 20 percent level of probability by paired t test.
**Statistically significant at 5 percent level of probability by paired t test.

reltail account for its noticeably good response to rest-rotation. Slower responses of other important species may reflect their relative sensitivity to grazing, competitive ability, and requirements for seedling establishment.

The absolute differences–0.24 and 0.23 percent *(table 6)*–in basal cover of bottlebrush squirreltail and Idaho fescue are small, but they are nevertheless important. In 1957–a drought year–Idaho fescue produced 1.75 and bottlebrush squirreltail 3.81 grams of herbage per square inch of live basal area. With such yields, the differences in cover mean an additional 56 pounds of Idaho fescue and 126 pounds of bottlebrush squirreltail per acre on the plots under rest-rotation.

On the four pairs of meadow plots, basal cover of grasslike plants was greater under rest-rotation grazing. Except for the ephemeral lake site, there was less basal cover of forbs. Buttercup *(Ranunculus)* species made up much of the forb values on the plots grazed season-long. No differences in cover values of the clover *(Trifolium longipes)* were found in the meadows. These results indicate that grasslike plants are replacing some forbs on those plots under rest-rotation grazing. Successionally, this is a desirable trend.

Species composition–Data on species composition reflects the relative competitive stance of a particular species and the kind of competition it must face. Hence, if the better plant species are increasing and spreading out under rest-rotation, this would suggest that under freer competition, succession is proceeding to a higher stage, as the better "climax" species gain stronger control of the site.

Evidence from our species composition data show that (1) relative to plots grazed season-long, the competitive position of primary species is stronger, of secondary species is as strong, and of low value species is weaker under rest-rotation *(table 7)*; (2) on upland areas, some of the better grasses and grasses generally are in relatively stronger competitive positions under rest-rotation *(table 8);* (3) the position of forbs is much stronger under season-long grazing, but those of grasslike plants and shrubs are equal; and (4) under rest-rotation, grasslike species presently have the upper hand on meadows. Thus in general, the evidence supports the expectation of a better species composition and hence a higher successional stage with rest-rotation grazing.

Hormay and Talbot (1961) stated, "In effect, grazing is eliminated as an environmental factor under rest-rotation grazing." In actuality, however, grazing is an important factor under rest-rotation grazing. Although overgrazing of desirable plants is avoided, periods of full use are planned so that less desirable as well as the most desirable vegetation is grazed. Grazing is employed as a method of planting seed. During the rest periods plants regain vigor, seedlings become established, and the species are free to compete with each other. Thus grazing and rest are combined to permit succession to proceed on a course toward more desirable climax species.

Ellison, *et al.* (1951) stated, "Natural vegetation on high range-watersheds in good condition consists of a mixture of many species, practically all of which are perennials." Under rest-rotation, the number of annual plant species present on study plots made up no larger percentage of the total number of species

Table 7–*Average differences between paired plots*[1] *in species composition in percent of primary, secondary, and low value plants. by major vegetation type*

Vegetation type	Plant grouping: Primary	Secondary	Low value	Others
	Percent			
Timber-bunchgrass	5.53*	1.43	-6.96*	0.00
Open grasslands	9.05*	3.60	-12.67*	.02
Open shrub-grass	1.86	-1.38	-.54	.06
Meadows	20.73*	-4.53*	-16.14*	-.06
All types	7.96*	.46	-8.43*	.01

[1]Season-long plot value subtracted from rest-rotation plot value.
*Statistically significant at 5 percent level of probability by chi-square test

Table 8–*Differences in species composition between paired upland plots, in percent of some important plant species and species groups*

Species or group	Number of plot pairs	Average percent composition: Rest-rotation	Season-long	Difference, RR-SL
Bottlebrush squirreltail	21	6.68	3.98	2.70*
Idaho fescue	19	10.29	8.60	1.69
Junegrass	10	3.01	.62	2.38*
Western needlegrass	21	18.56	19.90	-1.34
Sandberg bluegrass	11	5.14	4.25	.89
Ross sedge	17	11.62	11.45	.17
Shorthair sedge	9	25.39	23.57	1.82
All grasses	22	39.61	33.65	5.96*
All grasslike plants	22	21.08	19.91	1.17
Forbs	22	25.24	30.50	-5.26*
Shrubs	22	14.07	15.93	-1.86

*Statistically significant at 5 percent level of probability of chi-square test.

encountered than it did under season-long grazing. In terms of species composition, however, annual plants were 60 percent more prevalent under season-long grazing in the open grasslands *(table 9).* For the meadows and open shrub-grass type, annual plants were about one-third more prevalent. Thus we have additional evidence that the wet meadow, open shrub-grass, and open grassland vegetation types are in higher stages of succession and better range condition under rest-rotation than under season-long grazing.

Nutrient status of soils and leaf tissues–Soil and plant nutrient studies were made, but were not included in the point ratings. Results from soil analyses indicate that rest-rotation grazing at Harvey Valley has had little effect on soil nutrient status. Phosphorus was the only nutrient for which a significant difference was found. Higher phosphorus content on the Harvey Valley plots occurred in the second soil horizon of timber bunchgrass plots.

There was more calcium (0.01 percent) and more magnesium (0.01 percent) in leaf tissue from the timber-bunchgrass plots under rest-rotation. However, under both grazing programs, the content of calcium and magnesium was above the livestock requirements given by Morrison (1957). Hence, it is unlikely that such differences could affect cattle gains. No differences were found for phosphorus, sodium, or potassium.

Table 9–*Difference between paired plots in average percent composition of annual plants, by major vegetation type*

Major vegetation type	Average percent composition: Rest-rotation	Season-long	Differences RR-SL
Wet meadow	8.9	12.2	-3.3*
Open shrub-grass	22.3	29.2	-6.9*
Open grassland	14.6	23.3	-8.7*
Timber bunchgrass	11.6	13.0	-1.4

*Statistically significant at 5 percent level of probability by chi-square test.

Effects of Cultural Improvement Work

Range seeding and sagebrush control at Harvey Valley were planned to complement the effects of management in improving the resource. Sagebrush was controlled on 3,655 acres, and 497 acres were reseeded. This work was accomplished without requiring periods of nonuse, and the seedings have been maintained without special fencing.

The actual extent to which this cultural work has contributed to improvement of areas of native range cannot be determined. However, the seeded areas are highly preferred (Ratliff 1962), and tend to lessen the grazing pressure on native range areas during the early part of the grazing period.

Discussion

Rest-rotation grazing is doing much of what was expected at Harvey Valley. It seems clear that rest-rotation grazing is ecologically superior to season-long grazing; and that range health at Harvey Valley relative to nearby allotments is better, and range condition trend upward, because of rest-rotation grazing.

The response to rest-rotation has not been as dramatic at Harvey Valley as in some other areas of the West. For example, Kirk[5] reported a 10-percent increase in the allowable number of cattle after only

[5]Kirk, P. A. 1968. *Rest-rotation grazing in southwestern New Mexico.* Paper presented at annual meeting, American Society of Range Management, Albuquerque, New Mexico, Feb. 1968.

1 year of rest-rotation grazing. This was on a range grazed yearlong and with only 9 inches of precipitation annually.

There are at least two possible reasons for what appears to be a slow response at Harvey Valley. First, there was drought in 5 of the first 9 years of rest-rotation. To provide forage for the cattle this necessitated grazing units which were scheduled to be rested. Using "rested" units for this purpose is an accepted practice under rest-rotation grazing (Hormay 1970). Second, seedlings must become established if there is to be a rapid increase in basal area of perennial bunchgrass plants (Hormay and Talbot 1961). As in much of California, the summers at Harvey Valley are usually hot and dry. This, along with frequent spring drought, means few favorable years for seedling establishment.

In view of the conditions working against improvement, rest-rotation grazing has performed well on Harvey Valley during the first decade of its use. More favorable weather should bring greater and more rapid improvement in the future.

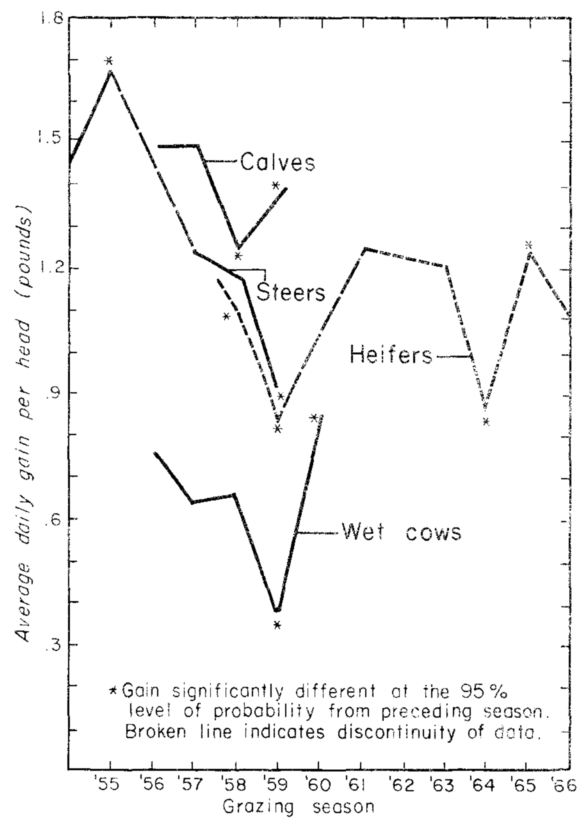
CATTLE WEIGHT GAINS

To the resource manager, improvement in range health indicates the worth of a particular system of grazing management, but to ranchers the amount and quality of beef produced is the final proof. As has been shown, rest-rotation grazing is good for the resource. The program has also produced acceptable cattle weight gains at Harvey Valley.

In the collection of data on cattle gains presented here, except where noted, cattle were weighed individually. Weights were obtained on an unshrunk basis from 1954 through 1959, but starting in 1960 animals were held overnight in the corrals without food or water. Tests made with steers in 1954 indicated that shrinkage overnight would result in about 4 percent reduction in weight, and early data were adjusted by this percentage to make them more comparable to recent data. Cattle showing weight losses for a full season were assumed to have been sick and were therefore excluded from computations.

Broad Trends

Over the period of rest-rotation grazing (1954-1966, inclusive) individual animal weight gains on the Harvey Valley allotment have shown no long-term tendency either to increase nor decrease. Gains were often significantly higher or lower from 1 year to the next *(fig. 4).* The depression of heifer gains in 1964 resulted from markedly lower gains than usual after midseason—they just held their own. Lower heifer gains in 1966 are probably the result of drought that year. Drought was probably the major factor also in the drop in steer and heifer gains in 1959 as compared with 1958. The sharp increase in cow gains in 1960 over 1959 reflects the sale of the calves at midseason, resulting in greater cow gains than usual during the second half of the season. The lowest (465 lbs.) and highest (703 lbs.) average starting weights of steers were noted in 1957 and 1959, respectively. Hence, although starting weight was probably a factor, age and condition of the steers at the start of the season probably determined the change evident in yearly differences for 1954-55 as compared to 1957-59.



Large differences in the quantity of forage available from year to year may be expected. Hormay and Talbot (1961) found the yield per acre to be 37 percent above average in 1948 and 40 percent below average the following year. Such differences in yield, with a constant stocking rate, results in different utilization, which may in turn affect weight gains from year to year.

Daily Gains Compared

In two comparisons, gains made by yearling replacement heifers on the Harvey Valley allotment in 1965 equaled and in 1966 exceeded the gains of their herd mates on neighboring allotments grazed season-long *(table 10).* In 1965 heifers were divided into three groups. One group grazed season-long on the Gray's Valley allotment. A second group was left in one range unit season-long, while the third group was moved to a fresh unit at midseason on Harvey Valley. In 1966 two groups of heifers were used. One group grazed in two range units (one of which was scheduled for rest) on Harvey Valley; the other group grazed season-long on the Lower Pine Creek allotment. The results shown in the table suggest that over a series of years the cattle-weight-gain balance sheet will look better for Harvey Valley than for its neighboring allotments. While two units of the Harvey Valley allotment were rested from grazing in 1965, forage quality and quantity in the remaining portion of the allotment were good enough to give weight gains equal to those of heifers grazing free choice over the entire Gray's Valley allotment. In addition, Harvey Valley heifer gains were only 12 percent less in the 1966 drought year than they were the year before, suggesting that the additional emergency feed available in rested units in Harvey Valley will improve gains over those on season-long ranges in poor forage years.

Table 10—*Starting weights and daily gains of replacement heifers on the Harvey Valley and two neighboring allotments (1965 and 1966)*

Allotment	Grazing regime	Head	Average starting weight	Average daily gain
		No.	*Pounds*	
1965:				
Gray's Valley	Season-long	27	649 ± 17[1]	1.27 ± 0.09
Harvey Valley	One unit	28	642 ± 18	1.29 ± .08
Harvey Valley	Two units	24	677 ± 22	1.18 ± .08
1966:				
Lower Pine Creek	Season-long	25	696 ± 27	.61 ± .10*
Harvey Valley	Two units	28	671 ± 21	1.09 ± .09

[1]Confidence interval 95 percent.

*Significantly different at 5 percent level of probability from the 1966 Harvey Valley group.

Full- and Half-Season Gains

If year-to-year variations in gains continue about as in the past–given similar age and conditions of cattle–we can expect seasonal gains to be similar to those presented in *table 11.* The acceptability of these gains for the area around Harvey Valley has been noted earlier. Also, when regional climatic and vegetational differences are taken into account, cattle gains at Harvey Valley compare reasonably well with those from the Starkey Experimental Range in northeastern Oregon (Forest Serv. 1957, 1958; Harris and Driscoll 1954) and the Manitou Experimental Forest in Colorado (Currie 1966; Smith 1967).

Table 11–*Average starting weights and daily gains of cattle on the Harvey Valley allotment, and expected weight gain for a June 1-September 30 (120-day) season*

Class	Head	Years of data	Average starting weight	Average daily gain	Expected seasonal gain
	No.	*No.*	*Pounds*		
Steers	365	5	561 ± 10.4[1]	1.20 ± 0.03	145
Heifers	588	8	623 ± 9.6	1.12 ± .02	135
Wet cows	490	5	820 ± 10.8	.66 ± .03	80
Dry cows	120	1	664 ± 23.2	1.54 ± .05	185
Calves	469	4	214 ± 8.1	1.39 ± .03	170

[1]Confidence interval 95 percent.

During the 4-month season in 1961 and 1962, yearling heifers at Harvey Valley made 73 percent of their gain before August 1 *(table 12).* They had 81 percent of their gain before August 15 during the 5-month seasons of 1962-65. It is no surprise that the rate of gain was much less during the second half of the season. Hormay and Talbot (1961) stated herbage was most nutritious just before flowering in early July. Thus, in late June and early July cattle on Harvey Valley and neighboring allotments can be expected to make their most rapid weight gains. As herbage matures, or is hit by late season frosts, gains slow to the extent that in some years weight losses occur in September and October.

Table 12 shows a slowing of rate of gain in the latter part of the season. This has also been reported from both the Starkey Experimental Range (Forest Service 1957) and the Manitou Experimental Forest (Johnson 1953). The implications of such information for ranchers will be evident from an example.

Table 12–*Gains of replacement heifers*[1] *the first and second half of the grazing season. Harvey Valley Allotment*

Grazing season	First half Days	First half Average daily gain (lb.)	Second half Days	Second half Average daily gain(lb.)
1961	51	1.71	65	0.85
	51	1.94	65	.74
1962	56	1.82	57	.74
	56	2.00	57	.24
	56	1.99	57	.57
1963	68	1.62	78	.85
	68	1.83	78	.65
1964	70	1.68	74	.08
	70	1.69	74	.04
1965	73	1.91	60	.50
	73	1.90	60	.31
Average	63	1.83	66	.51

[1]Data for each group for each year are presented because groups grazed different units or represent breed differences.

The permittee on Harvey Valley arrived each year, 1963-1965, in early June with steers weighing about 550 pounds average *(table 13).* The steers gained just over 140 pounds by an early to mid-August date when they were sold. These steers were weighed, five head at a time, on an unshrunk basis when they entered the allotment and as they went on the trucks. Also, in 1963 a group of market-type yearling heifers gained 1.9 pounds per head per day. Their average starting weight was 541 pounds, and they averaged 671 pounds 68 days later.

Table 13–*Average weights*[1] *and gains of yearling steers planned for market on August 15. Harvey Valley Allotment*

Grazing season	Days on allotment	Starting weight	Final weight	Weight gain	Gain per day
		Pounds			
1963	69	532	673	141	2.04
1964	68	545	687	142	2.08
1965	75	586	728	142	1.88
Average	71	554	696	142	2.00

[1]Weights on an unshrunk basis.

It will be noted that both these steers and heifer gains are much higher than average seasonal gains. Keeping the animals on the range past mid-August to add additional pounds at a lower rate of gain might have resulted in a lower selling price. After midseason the permittee used the allotment for nonmarket classes such as dry cows and replacement heifers.

Moving Cattle at Midseason

The management plan for Harvey Valley required that most of the cattle be moved at midseason. We compared gains made by animals thus moved with those of animals remaining season-long in one range unit.

In four out of 14 comparisons cattle moved between range units gained significantly less than those not moved *(table 14).* In no case did cattle grazed season-long in one range unit gain significantly less than those that were moved. Assuming this pattern continues at Harvey Valley about one-third of the time, 7 to 20 percent greater gains can be expected for cattle not moved.

Rigid rotation of cattle to fresh units is now considered unnecessary. Rather, Hormay (1970) recommends opening gates at the appropriate times and letting the cattle drift into the fresh units. Doing so will eliminate weight loss from forced moving and also the expense of gathering at midseason.

Table 14–*Starting weights and daily gains of cattle grazed in one range unit and cattle grazed in two or more range units, Harvey Valley Allotment*

Class and grazing season	One range unit: Average starting weight	One range unit: Average daily gain	Two or more range units: Average starting weight	Two or more range units: Average daily gain
	Pounds		*Pounds*	
Steers:				
1958	538	1.21	549	1.17
Heifers				
1957	446	1.41	471	1.20*
1959	514	.86	547	.83
1961	528	1.22	529	1.27
1965	642	1.28	677	1.18
Wet Cows:				
1956	721	.86	735	.71*
1957	839	.73	903	.53
1958	894	.55	924	.67
1959	803	.38	796	.34
Dry Cows:				
1956	664	1.56	664	1.53
Calves:				
1956	145	1.57	144	1.46*
1957	257	1.52	292	1.44
1958	236	1.39	269	1.22*
1959	258	1.35	237	1.39

*Statistically significant at 5 percent level of probability.

Livestock Production and Value Per Acre

The pounds of gain per usable acre *(table 15),* produced on the Harvey Valley allotment were estimated using the average daily gain *(table 11)* for each class of cattle. Except for calves, which were included with wet cows, the assumption was made that only one class of cattle was on the allotment and used its entire grazing capacity. Calves gained 3.8 pounds per acre of the 5.6 pounds for cows and calves (*table 15).*

Table 15–*Estimated allotment capacity and livestock production by class of cattle. Harvey Allotment*

Class of cattle	Animal unit rating	Animal days to use capacity[1]	Estimated pounds gain per acre[2]
Cows and calves[3]	1.25	49,440	5.6
Steers	.75	82,400	5.5
Heifers	.80	77,250	4.8
Dry cows	.90	68,667	5.9

[1]Capacity of the Harvey Valley allotment was 61,800 A.U.D.
[2]17,956 acres were usable for grazing on the Harvey Valley allotment in 1960.
[3]Cows = 1.00 A.U.; calves = .25 A.U.

On the animal unit basis the value produced for cows and calves–at 15 cents and 25 cents per pound for cows and calves respectively–was $1.23 per acre. The largest part, 96 cents, came from the calf gains. The value of the gain for steers–at 24 cents per pound–was $1.32 per acre. For heifers, at the same price per pound, it was $1.15. Under these conditions (dry cows excluded) there appears to be some advantage to grazing steers rather than other classes of cattle at Harvey Valley.

Discussion

We consider one of the primary advantages of rest-rotation over season-long grazing to be the availability of forage in rested units. That having this reserve of forage may improve weight gains in poor forage years was indicated by the greater gains made by yearling heifers on Harvey Valley versus the gains of those on the Lower Pine Creek allotment in 1966. Also, cattle were removed well before the end of the grazing season from some neighboring season-long allotments (because of lack of forage) during the drought years of 1959-61. The Harvey Valley permittee never took his cattle home early. Rather, the cattle were moved to units scheduled for rest during these and other poor forage years.

A second advantage is that rest-rotation provides for cultural as well as ecological improvement. Standard Forest Service practice would require a period of nonuse following cultural improvement work such as seeding or sagebrush control. At Harvey Valley, such work could be fitted into the rest-rotation pattern without nonuse periods being required.

Rest-rotation grazing at Harvey Valley has produced acceptable cattle weight gains and has probably resulted in greater beef production than would have been achieved under continued season-long grazing. At the same time, range conditions have improved relative to neighboring allotments grazed season-long. In view of these achievements, we recommended a 10-percent increase in the permitted animal unit months of grazing for the Harvey Valley allotment. This increase was granted in 1967.

ECONOMIC CONSIDERATIONS

Rest-rotation grazing produced better relative range conditions and acceptable cattle weight gains, but the question remains: Was the prescription for Harvey Valley economically practical? The following discussion aims to answer this question from the standpoints of the Forest Service and of the livestock permittee.

The test at Harvey Valley, the first Forest Service allotment to be placed under rest-rotation grazing, was intended to demonstrate the grazing principles developed by Hormay and Talbot (1961). Therefore, it included some practices, such as the use of five-wire fences and strict control of cattle, which are usually not in present programs. Hence, the costs at Harvey Valley may not be representative of costs of programs elsewhere. The figures used in this analysis are based on costs that were incurred. An economic analysis comparing rest-rotation and season-long grazing was not planned. Therefore since no actual records were available, Forest Service and permittee costs and returns for a season-long program were estimated.

To protect resources it is sometimes necessary to reduce grazing use on an allotment. A rancher may, however, be given the choice of taking a cut or of accepting a program of intensive management, such as rest-rotation grazing. Avoiding reductions can benefit both ranchers and ranch communities (U.S. Forest Service 1972). The last reduction at Harvey Valley was in 1948, and no further reduction was anticipated at the time rest-rotation grazing was being planned.

Had season-long grazing been continued at Harvey Valley, some additional reduction in permitted use would probably have been necessary eventually to gain improvement in relative condition–even with intensive cultural treatment and moderate stocking. McLean and Tisdale (1972) estimated that 20 to 40 years of complete rest are required for overgrazed ranges in southern British Columbia to recover to a productive condition. Therefore, the fact that improvement without further reductions occurred must be considered a benefit of rest-rotation grazing. But moderate season-long grazing also can benefit range condition, through controlling less desirable plants and covering seed, and cultural improvements would likely delay the time when a reduction was needed. We could not say with certainty how great an additional reduction would have been necessary nor when or for how long it would have had to be in effect. Therefore, we could not assign this benefit a monetary value.

Increases in permitted use, which result from improved range condition, are also positive benefits of rest-rotation. Although the season of use was extended 1 month in 1963, the permitted use (2060 A.U.M.'s) was held constant. The increase given in 1967 is, however, accounted for in our consideration of permittee costs.

Emergency forage available in rested units is a primary advantage of rest-rotation grazing. We know cattle were sometimes removed from neighboring allotments, but not from Harvey Valley, because of a lack of forage; and we know that in 1 drought year heifers on Harvey Valley gained more than those on an allotment grazed season-long. But we could not place a monetary value on the emergency forage. We lacked sound documentation of the facts regarding other permittees taking their cattle home early. Furthermore, 1 year's results is not enough to justify using a value for extra weight gained during drought.

Another advantage given for rest-rotation grazing is that cultural improvements can be applied without requiring periods of nonuse. Nonuse was not required at Harvey Valley, and therefore not recorded. Consequently, we could not place a monetary value on this advantage. We did, however, estimate the amount of fence required to protect the seedings had Harvey Valley remained under season-long grazing. These fence costs were included in calculating costs of season-long grazing.

Returns from range improvement such as better plant vigor and species composition, more litter cover and less bare soil, more cover of primary value plants, and more rapid absorption of water cannot be assigned realistic dollar values. Therefore, they cannot be included in a cost/return analysis.

The Harvey Valley permittee estimated that his cattle lost 50 pounds per head during late September and October. Hormay and Talbot (1961) reported that weight losses can be expected starting about October 1. The permittee ascribed 30 pounds of the weight loss to dry forage lacking protein and 20 pounds to the "forced feeding" (periods of full grazing) used in the rest-rotation program at Harvey Valley. However, we have no data to support the contention of added weight loss due to "forced feeding." Also, our data show that rest-rotation has produced acceptable cattle weight gains. Because of differences in opinion, we did not include a value for the 20 pounds per head in figuring the costs of rest-rotation.

In addition, the permittee gave $658 as the cost for extra riding under rest-rotation grazing. This is 78 percent of his regular costs for riding with season-long grazing. Normally when an allotment is crossfenced, thereby restricting the movements of cattle, we consider that the amount of riding required is reduced rather than increased. But based upon our knowledge of the amount of riding actually done–not what should be done–on season-long allotments in our area, we concluded that the increased riding charged to rest-rotation was justified. Therefore, extra riding was included as a cost to the permittee.

Cost for Forest Service

Methods of Analysis

The Forest Service received no monetary benefits for rest-rotation grazing (other than regular grazing fees, which we assumed would have also been received under season-long grazing) that we could include in our analysis. On a strictly monetary cost/return basis, rest-rotation grazing at Harvey Valley did not pay its way through 1965–the costs simply exceeded the dollar returns. Therefore, we decided to compare costs of rest-rotation with costs of season-long grazing at a similar intensity of cultural development and to determine what would have been required to pay the added Forest Service costs incurred by rest-rotation. We assumed that no return on the value of the Forest Service grazing land was required.

The original study plan for Harvey Valley called for cultural range improvement practices, development of additional water, additional fencing, and cattle handling facilities. Not all of the expenditures were chargeable to Harvey Valley alone, or to rest-rotation grazing specifically. Because of this, a break-

Table 16–*National Forest System budget expenditures related to the Harvey Valley program 1951-196*5 *inclusive*

Expenditures	Costs chargeable to: Associated costs	Costs chargeable to: Rest-rotation grazing	Estimated costs under season-long grazing
Improvements and treatments	–	–	–
Seeding (497 acres)	–	87,075	$7,075
Brush control (3,655 acres)	–	13,108	13,108
Grasshopper control (100 acres)	–	500	500
Drainage improvement (300 acres)	–	600	600
Erosion control (1 mile)	–	130	130
Boundary fence (11.54 miles)	$5,695	5,695	5,695
interior fence (16.17 miles)	3,000	13,670	–
Fence for seedings (7.8 miles)	–	–	7,800
Metal gates (11)	120	364	120
Cattleguards (12)	12,057	332	175
Spring development (1)	–	1,200	–
Extra troughs (2)	–	881	–
Water pits (II)	–	1,669	1,269
Corral and scales	5,269	–	–
Other Costs	–	–	–
Maintenance of improvements	4,892	13,328	6,785
Planning costs	2,260	3,909	2,478
Range rider costs	7,680	–	–
	$40,973	$62,461	$45,735

down of actual costs *(table 16)* was necessary, as follows: (a) costs associated with the program but rightly charged to research requirements, demonstration activities, adjacent allotments, and other uses (these costs were not included in the analysis); (b) costs incurred to develop and manage the allotment under rest-rotation grazing; and (c) costs of standard Forest Service grazing management practices, which we estimated would have been incurred had the allotment been equally developed but remained under season-long grazing. Costs on record for improvements made before 1951 were broken down in the same way, and those applicable were included in the analysis.

The decisions as to allocation of costs in the three categories were reached through discussions with the District Ranger, Fred J. Alberico. Estimates of the life expectancies of improvements and cultural treatments used to calculate depreciated values were agreed upon with him and Philip B. Lord, formerly grazing staff officer for the Lassen National Forest. The Forest staff provided cost figures for the maintenance of the improvements and treatments and all original investment values. The depreciated values at the start of 1951 were used as the values for investments made before that year.

We treated the costs for each year as the sum of the costs for improvements and treatments, planning, and maintenance for that year. The costs for each year which could not be repaid were accumulated to determine the total investment cost for the Forest Service.

Total planning costs related to the Harvey Valley program ($6,169–*table 16)* amounted to 8.6 percent of the total cost of improvements and treatments for 1951 to 1965 inclusive. Thus, planning costs for each year were estimated by multiplying total costs for improvements and treatments by 8.6 percent. These estimated planning costs were accepted as reasonable by the people involved in the planning activities.

Costs through 1965 were calculated four ways *(table 17).* The basic amount method used the basic dollar amounts summed for the 15-year period. Unpaid costs at the end of 1965 were simply determined by subtracting the net grazing fee paid during the period based on 2060 A.U.M.'s. This method of cost calculation most closely represents the bookkeeping procedures of the Forest Service.

Net grazing fees–the total fees the permittee paid less 25 percent–were used because 25 percent of Forest Service revenues must be returned to the county regardless of costs. In effect, this is an off-the-top cost to the Forest Service paid in lieu of taxes.

The add-on loan method follows the principle of add-on loans at an interest rate of 5 percent compounded annually. Unless stated otherwise, all in-

Table 17–*Actual costs and costs for 15- and 30-year pay off through 1965 for rest-rotation and season-long grazing at Harvey Valley*

Method of calculating costs	Costs under rest-rotation grazing					Estimated costs under season-long grazing			
	Total	Payments	1965 unpaid costs	Average annual/	Extra costs	Total	Payments	1965 unpaid costs	Average annual
	Dollars				*Percent*	*Dollars*			
Basic amount	70,029	13,720	56,309	4,668	26	55,424	13,720	41,704	3,695
Add-on loan	115,637	13,720	101,917	7,709	28	90,672	13,720	76,952	6,045
15-year pay off	93,001	93,001	–	6,200	26	73,815	73,815	–	4,921
30-year pay off	104,116	52,892	51,224	6,941	26	82,763	42,454	40,309	5,518

Based on total costs.

[2] Percent by which average annual costs of rest-rotation exceed average annual costs of season-long grazing; i.e., ($4,668 - $3,695/$3,695) x 100 = 26 percent.

terest costs were calculated as if all funds were loaned on the first day of the year. The value of the add-on loan was calculated as follows: The total cost for year one (1951), plus an interest charge on that total cost, less the net grazing fees paid in 1951 is equal to the value of the add-on loan on the last day of year one. The value of the add-on loan on the last day of year one, plus the total cost for year two (1952), plus an interest charge on both the previous amounts, less the net grazing fees paid in 1952 is equal to the value of the add-on loan for the last day of year two (1952). The procedure was repeated through 1965. The value of the add-on loan remaining at the end of 1965 was thus the unpaid cost, plus the total interest charges through 1965. These calculations assumed that grazing fees would not be available for use until the end of the year.

The other two ways of calculating costs were as follows: For a commercial type operation to retire the final value of the add-on loan, the required annual revenues were calculated on the basis of both a 15-year pay off period (ending in 1965), and a 30-year pay off period (ending in 1980); these are hereafter referred to as the 15-year and 30-year pay off methods, respectively. In place of the net grazing fees actually paid, we used the annual revenue required to amortize the face amount of the loan outstanding by the end of 1965 and 1980. For the 15-year pay off, the payment required for year one was figured by using the amortization factor for 15 years and for year two, the amortization factor for 14 years, etc. The total payments required, through 1965, to eliminate all unpaid costs at the end of the 15-year period is the total cost of the program *(table 17)*. Total cost for the 30-year pay off method is the sum of the required payments through 1965 and the unpaid costs remaining at the end of 1965. Because of the method of amortizing costs and because cost incurred varied from year to year, the required annual revenues were not the same for each year.

Results

Regardless of which of the four methods of calculating costs is used, average annual costs for rest-rotation grazing at Harvey Valley through 1965 were greater than they would have been had the allotment remained under season-long grazing, with improvements and treatments carried on at the same intensity. The extra costs of rest-rotation amounted to 26 percent of the costs for season-long grazing for all methods, except for the add-on loan method. And for that method the extra cost was 28 percent of the cost for season-long grazing.

More will have to be paid in the future to cover unpaid costs, regardless of the grazing program, than would have been necessary had grazing fee income originally been geared for pay off. Unpaid costs *(table 17)* were naturally zero for the 15-year pay off method. For both rest-rotation and season-long grazing, the unpaid costs for the 30-year pay off method were 49 percent of the total cost. But unpaid costs for the add-on loan method were 88 and 85 percent and for the basic amount method, 80 and 75 percent of the total costs for rest-rotation and season-long grazing respectively.

In the discussion below, care should be taken to distinguish between grazing fee per A.U.M. and net grazing fee per A.U.M. For example, the average grazing fee per A.U.M. paid from 1951 to 1965 inclusive at Harvey Valley was 59 cents. After paying the county 25 percent of grazing fees in lieu of taxes, the average net grazing fee per A.U.M was 44 cents.

Two types of comment based on *table 18* should be included. The first is based on the differences be-

Table 18–*Unpaid costs through 1965, expressed as costs per A.U.M*[1]. *for basic and add-on loan amounts, and the net grazing fees required to break even with a 15- and a 30-year pay off period for rest-rotation and season-long grazing at Harvey Valley*

Method of calculation	Rest-rotation grazing			Season-long grazing		
	Unpaid cost per AUM[2]	Fees required to break even		Unpaid cost per AUM	Fees required to break even	
		15-year[3]	30-year		15-year	30-year
Basic amount	$1.83	2.27	[4]1.13	1.35	1.79	0.90
Add-on loan	3.30	3.01	[5]1.71	2.49	2.39	L37

[1] Total A.U.M.'s of grazing, 1951-65 inclusive (based on a 2,060-A.U.M. capacity) were 30,900.

[2] Unpaid costs in 1965 *(table 17)*/30,900 A.U.M. = unpaid costs per A.U.M.

[3] Total costs *(table 17)*/30,900 A.U.M. = fees required to break even at end of 1965, eg., $70,029/30,900 = $2.27 and 93,001/30,900 = $3.01.

[4] Total costs *(table 17)*/61,800 A.U.M. = fees required to break even at end of 1980, eg., $70,029/61,800 = $1.13.

[5] Payments through 1965 *(table 17)*/30,900 A.U.M. = fees required to break even at end of 1980, eg., $52,892/30,900 = $1.71.

tween the costs per A.U.M. for rest-rotation and season-long grazing. The second involves the level of net grazing fees required if the Forest Service were to incur no unpaid costs at Harvey Valley.

Rest-rotation at Harvey Valley cost more per A.U.M. than season-long grazing would have, at least during the period covered by this analysis. Using the basic amount method *(table 18),* net grazing fees per A.U.M. for rest-rotation would have had to be 48 cents ($2.27-$1.79) greater than for season-long grazing for unpaid costs under rest-rotation to be equal to those under season-long grazing in 1965. For the unpaid costs to be equal in 1980, net grazing fees per A.U.M. for rest-rotation would had to have been 23 cents ($1.13-$.90) greater than for season-long grazing. Using the add-on loan method, net grazing fees per A.U.M. for rest-rotation would have had to be 62 cents ($3.01-$2.39) greater than for season-long grazing for unpaid costs under rest-rotation to be equal to unpaid costs under season-long grazing in 1965. For the unpaid costs to be equal in 1980, net grazing fees per A.U.M. for rest-rotation would have had to be 34 cents ($1.71-$1.37) greater than for season-long grazing.

If no unpaid costs are to be incurred by the Forest Service, the break even net grazing fees *(table 18)* represent the kind of net fees that must be considered. For example, assume that the basic amount method (which assumes that the Forest Service need not consider interest charges on the capital it uses) is considered the appropriate method and that all costs incurred should have been paid off by 1965. In that case, the net grazing fee should have been $2.27 per A.U.M. The grazing fee charged the permittee would be $3.03 per A.U.M. This amount is considerably higher than the 59 cents per A.U.M. actually charged. However, using the same assumptions for season-long grazing, the net grazing fee should have been $1.79 per A.U.M., and the permittee should have been charged $2.39 per A.U.M. Obviously, not all of the unpaid costs under rest-rotation at Harvey Valley can be attributed solely to rest-rotation grazing. Part of these unpaid costs are the result of a grazing fee structure that would have failed to cover even the costs of normal Forest Service operations.

It seems clear, using 1951-65 grazing fee schedules, that increases in permitted use can never cover the costs to the Forest Service for rest-rotation grazing at Harvey Valley. Using the basic amount method and a 100 percent increase in grazing capacity, it would take 31 more years at 1951-65 fee levels to pay off the unpaid costs remaining at the end of 1965. This conclusion assumes that the Forest Service incurs no cost after 1965. But fences and other improvements must be maintained or replaced over the years. Therefore, higher grazing fees must be charged for grazing the Harvey Valley allotment under rest-rotation grazing, if the bill is to be paid from grazing fees.

Using the basic amount method and the 30-year pay off period (the most favorable comparison of rest-rotation with season-long grazing in *table 18*) the net grazing fee under rest-rotation at Harvey Valley would have had to be 23 cents ($1.13-.90) greater than for season-long grazing. To provide the county its 25 percent share of the grazing fees collected, the grazing fee paid by the permittee would have had to be 31 cents per A.U.M. greater than paid under season-long grazing. Had firm values for benefits from range condition improvement been available, however, the extra fee required to pay the cost of rest-rotation grazing would have been lower.

Cost for Livestock Permittee

Method of Analysis

The permittee did not accrue any added monetary benefits from rest-rotation grazing until after 1965. He continued to receive the returns from cattle weight gains that we estimated would have been received under season-long grazing. Therefore, during the period from 1954, when rest-rotation became fully operational, through 1965, the extra costs the permittee incurred were not covered by added income from rest-rotation grazing. Costs not offset by added income must be considered an investment by the permittee. Increased benefits after 1965 and those through 1965 to which we could assign no monetary value must be considered by the permittee in deciding if his investment was justified.

For the purposes of this report, however, permittee costs were analyzed on the assumption that the permittee must cover all his costs and pay interest on all money used each year. During the study period, the permittee paid 6.5 percent interest on the funds used for this part of his operation. This figure was used in computing all interest charges. To simplify calculations, we assumed that interest would be charged for an entire year. Although this procedure tends to overestimate interest costs, they would be reduced only slightly by a more detailed breakdown of actual time when interest was paid.

Permittee costs were separated into three parts: (a) regular costs to operate the allotment without rest-rotation; (b) extra costs incurred because of rest-rotation grazing; and (c) extra costs incurred because of research activities. The breakdown of costs was discussed with and agreed upon by the permittee. No interest was charged to what the permittee had invested in land, cattle, and equipment.

Results

Yearly costs to the permittee averaged $10,168 *(table 19).* Of this amount, regular costs, which would be incurred under season-long grazing, accounted for 89.1 percent. His costs for extra maintenance and riding, chargeable to rest-rotation, accounted for 8.8 percent. The remaining 2.1 percent was the cost of aiding our research (these costs were not included in the analysis).

Table 19–*Average yearly costs to permittee for rest-rotation grazing at Harvey Valley-1954-1965*

Expenditure	Average yearly net cost *(dollars)*	Interest charged at 6.5 percent *(dollars)*	Average yearly cost *(dollars)*	Total cost *(percent)*
Regular costs				
Maintenance	208	14	222	2.2
Riding	880	57	937	9.2
Grazing fees	1,236	80	1,316	12.9
Livestock overhead	4,120	268	4,388	43.2
Livestock transportation	2,060	134	2,194	21.6
Total	8,504	553	9,057	89.1
Added costs because of rest-rotation				
Maintenance	185	12	197	1.9
Riding	658	43	701	6.9
Total	843	55	898	8.8
Added costs because of research				
Riding	130	8	138	1.4
Weighing cattle	70	5	75	.7
Total	200	13	213	2.1
Grand total	9,547	621	10,168	100.0

Included under "regular costs" were grazing fees, overhead, and transportation. Potentially, these costs could vary if the grazing capacity were to change. An increase in the total grazing fees resulting from an increase in permitted numbers as the result of a rest-rotation program, for example, would be chargeable to rest-rotation grazing rather than to regular costs.

With a 515-head permit, what return per head was necessary for the permittee to cover his costs? To pay all annual costs, excluding those attributable to research activities, the return per head from Harvey Valley would have to be $19.33 or $4.83 per animal-unit month. The return per head needed to pay his costs, had the allotment been under season-long grazing, was $17.59. Therefore, his extra costs due directly to rest-rotation grazing was $1.74 per head. Results from our studies show that no additional return was generated up to 1965. Therefore, it cost the permittee 9.4 percent more annually to operate under rest-rotation grazing.

The permittee had to be willing and able to accept such extra costs if a plan of rest-rotation was to be successful. His extra costs should, therefore, be considered as an investment in range health aimed at either preventing future cuts in permitted use or providing increased future income, rather than simply a cost. Since no grazing cuts were planned at Harvey Valley, the question becomes: "Was the permittee's investment at Harvey Valley economically sound?"

The permittee's extra annual costs, not including interest charges, for rest-rotation grazing were $843. The permittee could have invested this $843 each year. This amount invested annually at 6.5 percent, compounded quarterly, would be worth $17,715 at the end of 13 years (1954-66 inclusive). That period is used here because the recommendation for a 10 percent increase was not implemented until after the 1966 grazing season. Therefore, by then, the permittee had, in effect, invested $17,715 in rest-rotation grazing at Harvey Valley.

What sort of increased income would be required to pay off this investment of $17,715? To return this investment in 20 years at 6.5 percent interest, the permittee's increased income from increased permitted use would have to be $1,608 per year. This income could be generated by the permittee because he could use the increased permitted use resulting from rest-rotation to (a) substitute the Forest Service grazing for more expensive feed and thereby decrease his costs or (b) increase the size of his herd and with this increase, increase his net income.

After 1966, the permitted use was increased by 206 A.U.M.'s. Additional livestock could be added or the regular livestock could be grazed for a longer period. The permittee selected the second alternative. We were not able to obtain information on the costs to the permittee of alternative sources of feed. If a Forest Service grazing fee of 59 cents per A.U.M. (the average paid between 1951 and 1965) is used, the feed alternative to be replaced by the increased permitted use of 206 A.U.M. would have to cost $1,608/(206 A.U.M.)+59(/ = $8.40 per A.U.M. before the investment in rest-rotation would be at the break even point. However, feed may not be available on a

Table *20–Increases in permitted use required if permittee's investment is to break even within 20 years (1985)*

Item	No increase in overhead and transportation costs				Proportionate increases in overhead and transportation costs			
	Average value per pound for all cattle in herd *(cents)* . . .				Average value per pound for all cattle in herd *(cents)* . . .			
	20	25	30	35	20	25	30	35
	Dollars							
Increased value per A.U.M.	10.00	12.50	15.00	17.50	10.00	12.50	15.00	17.50
Grazing cost[1]	.64	.64	.64	.64	.64	.64	.64	.64
Interest cost[2]	1.08	1.35	1.63	1.90	1.08	1.35	1.63	1.90
Overhead and transportation costs	–	–	–	–	3.20	3.20	3.20	3.20
Total increase in cost	1.72	1.99	2.27	2.54	4.92	5.19	5.47	5.74
Gross profit per A.U.M.	8.28	10.51	12.73	14.96	5.08	7.31	9.53	11.76
Required A.U.M. increase in permitted use[4]	303	238	197	168	493	343	263	213

[1] Grazing fee of $.64 included interest charge but fees do not reflect the normal adjustment that takes place as cattle prices vary.
[2] (1000 lbs.) (price per lb.) (.065)/12 = interest charge per A.U.M. *(table 19).*
[3] ($6,583)/(2,060 A.U.M.) = overhead and transportation cost.
[4] Cost of continuing rest-rotation $897.80 per year (see *table 19*) $1,608 + $897.80 = $2,505.80 = total cost per year except for costs presented above ($2,505.80)/(gross profit per A.U.M.) = required increase in permitted use.

rental basis. The permittee may face the choice of either depleting reserve feed on his own range land or decreasing herd size unless permitted use can be increased. If, for example, grazing were available at $3.60 per A.U.M., rest-rotation would have to result in an increase in permitted use of 534 A.U.M. or an increase in permitted use of 26 percent before the investment in rest-rotation would be at the break-even point.

If the increase in permitted use were used to expand herd size, the impact on both permittee costs and revenues must be considered. The permittee's herd averaged about 50 pounds of gain for each A.U.M. of grazing *(table 11). Table 20* presents the increase in permitted use required if the permittee is to increase his profits by $1,608 per year for alternative combinations of prices and costs.

By inspecting the last row of *table 20,* it can be seen that the permittee must expect a favorable combination of both prices and costs for his investment in rest-rotation to pay off. If there were a permanent increase in permitted grazing of 206 A.U.M and this resulted in an expanded herd size, the gross profit per added A.U.M. would have to be at least $12.16.

It is not possible to state categorically whether a permittee's investment in rest-rotation grazing will pay off. But at Harvey Valley, the permittee's investment could be economically sound–given a favorable price, cost combination after 1966. The questionable nature of a permittee's investment in rest-rotation may no longer exist where cuts in use are anticipated if the present grazing program is continued and he would suffer a loss in income, and where installation of a rest-rotation program would nullify the cuts.

Discussion

A house properly maintained will last for many years, but uncared for it will soon deteriorate. In the end, it may cost the owner less to properly maintain the house than to permit it to deteriorate and then decide to restore it. So with our range resources. For many rangelands, including Harvey Valley, we are faced with a restoration rather than a maintenance problem. Man's economic time scale is not the same as nature's ecologic time scale. And the public must expect restoration to cost more than maintenance of range health.

As shown above, for both the permittee and the Forest Service, monetary costs exceeded monetary returns during the first years of rest-rotation grazing on the Harvey Valley allotment. However, considered as an investment, the extra costs incurred by the permittee during 13 years–given a favorable combination of both prices and costs–can be recovered as a result of improved range condition and greater grazing capacity.

Monetary returns from grazing, i.e., grazing fees and cattle sales, are important, but long-term returns resulting from improvement of the resource (including esthetic values) must not be ignored. On 17,956 acres of usable range, the added cost to the Forest Service of rest-rotation grazing was about 9 cents per acre per year, using the add-on loan method. For this the public received the return of a better range condition on Harvey Valley as compared to nearby allotments and, with the resulting increase in permitted use, an increase in payments to the county.

Still, the bill for rest-rotation grazing at Harvey Valley will eventually have to be paid. But who should pay it? The rancher? The "public" through the Forest Service? Or someone else? The rancher earns income from the resource–and so perhaps he should pay. But the "public" demands that the Forest Service improve the range environment–and so perhaps the "public" should pay. Or perhaps ranchers on season-long allotments should pay for not participating in grazing management practices which would improve the range environment.

One point is, however, in order. On the basis of the 30-year pay off method for calculating the cost of rest-rotation grazing *(table 18),* the public in effect has subsidized grazing to the amount of $1.27 ($1.71-.44) per A.U.M. Had Harvey Valley remained under season-long grazing, however, the subsidy would still have been 93 cents ($1.37-.44) per A.U.M.

Rest-rotation grazing has improved the range environment at Harvey Valley. The magnitude of this improvement may well justify the additional 34-cent subsidy per A.U.M. But whether it does and as to who should pay the bill for rest-rotation grazing–these are issues that must be settled by those responsible for making social, political, and administrative decisions.

SUMMARY

Ratliff, Raymond D., Jack N. Reppert, and Richard J. McConnen
1972. **Rest-rotation grazing at Harvey Valley...range health, cattle gains, costs.** Berkeley, Calif., Pacific SW. Forest & Range Exp. Sta. 24 p., illus. (USDA Forest Serv. Res. Paper PSW-77)

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Retrieval Terms: range management; rest-rotation grazing; environmental impact; economic evaluation; Harvey Valley, California.

Since 1954, a trial of rest-rotation grazing has been underway on the Harvey Valley allotment on the Lassen National Forest, northeastern California. The grazing prescription calls for a 5-year rotation of full use, full rest, early-season rest with late-season use, full rest, and early-season use with late-season rest. Nearby allotments have continued to be grazed season-long.

This paper reports an evaluation of progress observed at Harvey Valley to 1966. It summarizes findings in comparative range health and apparent condition trends; in cattle weight gains, and in cost/return analysis from the standpoint of both the Forest Service, which owns the land, and the permittee, whose livestock are grazing on the land.

Studies of relative range conditions on Harvey Valley and nearby allotments were begun 10 years after the start of rest-rotation grazing. Although the response to the grazing program was undoubtedly slowed by drought, results showed that range condition had improved and apparent condition trend was upward on Harvey Valley. Therefore, compared with season-long grazing, rest-rotation grazing is ecologically sound. At Harvey Valley, compared to nearby allotments, there was (1) improved vigor of the key forage species, Idaho fescue; (2) greater basal cover of the better plants; (3) a higher successional stage as indicated by a better species composition; (4) more grass seedlings; (5) more litter cover and less exposed soil; (6) greater herbage yield; and (7) less soil compaction, with faster water absorption.

Cattle weight gains at Harvey Valley were as good as could be expected in the vicinity. From 1954 through 1966, individual cattle gains neither increased nor decreased on Harvey Valley. In some years, cattle that were moved from one to another of the five range units at midseason made lower gains than cattle allowed to graze one of the range units for the entire season.

In one of two comparisons with nearby allotments, heifers on Harvey Valley gained one-half pound per day more than those grazed season-long. In the other test, however, gains were the same. These results indicate that over a series of years, cattle gains would prove better under rest-rotation grazing.

Other studies showed that a rancher can get a 2-pound gain per day from yearling stockers the first half of the grazing season. Keeping them past mid-August adds pounds but at a much lower rate.

During the first years at Harvey Valley, the monetary costs of rest-rotation grazing exceeded the monetary returns to both the Forest Service and the livestock permittee. There were, however, several benefits and some costs upon which we could place no firm monetary values. The analyses, therefore, dealt only with those costs and returns for which we could fix firm values.

A five-unit rest-rotation prescription with a given level of cultural improvement cost the Forest Service 28 percent more (by the add-on loan method of calculation) than season-long grazing on the same area with the same level of cultural improvement would have cost. The unpaid costs for rest-rotation grazing at Harvey Valley at the end of 1965 amounted to 88 percent of the total costs from 1951 through 1965. For an even break, the net grazing fee per A.U.M. would have had to be 62 cents more for a 1 5-year pay off or 34 cents more for a 30-year pay off than what was charged for season-long grazing. But just to have had a break-even arrangement with season-long grazing, either $1.95 (for 15-year pay off) or $0.93 (for 30-year pay off) more than actual net grazing fees (44 cents/A.U.M) would have been required. And it is unlikely that the relative condition would have improved.

Rest-rotation cost the livestock permittee 9 percent more annually than season-long grazing would have. But considered as an investment, with the 10 percent increase and a favorable combination of both prices and costs, his extra costs can be recovered. Therefore, given a gross profit of $12.16 per A.U.M. the permittee's investment would be economically sound.

Rest-rotation grazing is primarily a procedure for restoring range health and restoration can be expected to cost more than maintenance. Rest-rotation grazing is not a panacea for all ranges and all range

problems. Now, however, it is the best approach to grazing management available for many western ranges.

At Harvey Valley, rest-rotation grazing is doing much of what was expected. But one should not expect that just over one decade of rest-rotation would restore the loss in range condition and grazing capacity that occurred from 1870 to 1948. With the improvement in relative range condition which has occurred, we can expect greater and more rapid improvement in the future.

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