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STOCKWATER RESTRICTION AND TRAILING EFFECTS ON ANIMAL GAIN, WATER DRUNK, AND MINERAL CONSUMPTION 1/

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HIGHLIGHT

Yearlings restricted to drinking water once a day or once every 2 days reduced their intake of water by 13 and 35%, respectively, of that of controls with ad libitum water. ADG was significantly reduced by the most stringent treatment for the 80-day trial period, but in a 30-day recovery period these animals compensated for losses during treatment. Similarly the reduction in water drunk was significant for yearlings trailing about 1 mile between feed and water during the summer months of May through September, with little or no effect on weight gain. Gains from suckling calves 2 1/2 months of age, totally restricted from water for 60 days, were significantly reduced, and weight gains were only partly compensated for in the recovery period. In one year, lactating cows drinking once every other day drank significantly less water, but they gained significantly more than the control animals, while their calves lost weight. Compensatory gains of the calves during the recovery period nullified any treatment effect. Trailing and water stress treatments both reduced consumption of offered minerals.

Cattle, grass, and water are 3 basic ingredients of ranching. Judging from the quantity of literature published, these parts have been researched in that same order. Considerable effort has been expended in discerning the physiological effects of water stress on the animal over short periods of time, somewhat less in studying the influence of water quality on feed intake and subsequent metabolism, and still less effort in evaluating the relationship of feed and water intake. A few studies have considered the importance of water on the uniformity of forage use by the grazing animal, but no studies have been found that emphasize the effect of water stress on animal performance as measured by changes in body weight.

This paper is concerned with results of studies conducted at the Squaw Butte Experiment Station in the years 1969-1972 to answer the following questions: (1) how much does water restriction influence body weight of grazing animals; (2) how much does distance of trailing to water restrict the amount of water drunk and animal gain; and (3) what is the effect of total water restriction on the suckling calf while on summer range?

1/ Contribution from the Squaw Butte Experiment Station, Burns, Oregon 97720. This station is jointly operated by the Oregon Agricultural Experiment Station, Oregon State University and Agricultural Research Service, United States Department of Agriculture.

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STUDY AREA

The Squaw Butte Experiment Station lies at an elevation of approximately 4,500 feet on the cold, high desert of southeastern Oregon. The landscape is typified by closed basins covered with various shrub canopies, mainly *Artemisia* spp. with a bunchgrass understory. On slopes and tops of rim-rocked mesas, a juniper overstory of varying density intermingles with the brush and grass. Elevation differences within some of the station pastures are great; however, differences in elevation within pastures used for these studies did not exceed 50 feet.

The eastern Oregon ranges are grazed by cattle from April through October, with mean monthly temperatures varying from 43 in April to 65 F in July. The mean maximum temperature in July is 85, with daily temperature extreme reaching above 100 F. About 12 inches of precipitation is received annually. Most of this is in the form of snow or rain during the winter. Less than 10 percent of the annual total is received in July, August, and September, collectively.

MATERIALS AND METHODS

Weather and Related Parameters

Temperature and precipitation were recorded daily at the Station's headquarters, 1/2 to 2 miles from the study pastures. In 1969, air temperature and humidity was continuously recorded at the study site. Beginning in 1971, daily insolation (I) was monitored with a Mark XIV Sol-A-Meter 3/. Water loss by evaporation from watering tanks was estimated by direct measurement from a tank of the same size located near the study. All data reported have been corrected for evaporation loss.

Animal Allotment to Treatments and Weighing Procedure

Cattle were randomly allotted to treatments after stratification by (1) weight for yearlings and, (2) weight, sex, and birth date of calves for trials with cows and their calves. Weights at beginning, end of treatment, and final recovery period were recorded after an overnight shrink off feed and water. Weights during the treatment period were recorded after an overnight shrink off water only. In the frequency-of-watering studies, all cattle were weighed on the morning of the day that the animals on the least frequent watering treatment would be given access to water.

Measurements of Water Drunk

Water tanks 4 feet in diameter by 2 feet high provided water to animals in all studies. The initial water level in the tank was measured with a hook gauge. The daily or period amounts drunk were determined by measuring the

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3/ Talley Industries, Mesa, Arizona. Use of a trade name does not constitute endorsement of the product by the U. S. Department of Agriculture over other products with similar capabilities.

water required to refill to that level. In 1969 water was measured with a calibrated "jerry can", but in other years a low-gravity head direct-reading water-flow meter coupled to a truck-mounted supply tank was used. Measurement was to the nearest 0.1 gallon. The water in all tanks was filled to a high level to give the calves access to it. All readings were measured before 10 a.m.

Mineral Supplements

Crushed salt and a 50-50 crushed salt and ground bonemeal mix were available at all times in all pastures. The two-compartment mineral boxes were placed close to water. Consumption was determined by adding an additional 2 pounds as the supply was depleted and weighing the amount left at the close of the trial.

Study of Watering Frequency (1969)

Uniform yearling heifers weighing about 560 pounds were placed on twelve 7 1/2 acre crested wheatgrass pastures, one animal per pasture. Treatments were water *ad libitum* (∞/1), water *ad libitum* for two hours once a day (1/1), and water *ad libitum* for two hours once every other day (1/2). The study was conducted as a randomized block with 4 replications.

The animals were weighed at the beginning on July 8, again August 7, and September 4, and at the end of the trial September 25. They were then trucked 45 miles and allowed to graze meadow aftermath with *ad libitum* water. Recovery weights were obtained November 7. Frequency of drinking was controlled by removing plywood covers at 1 p.m., then replacing them at 3 p.m. on the scheduled drinking day. Nitrogen and dry-matter concentrations of the herbage were determined at periodic intervals. Fecal samples were obtained from the first defecation of the day for each animal on six consecutive days for the determination of lignin, nitrogen, fiber, and other nutritional constituents. Herbage samples for the same chemical determinations were also obtained in the same time period. Chemical analyses followed methods recommended by A.O.A.C. (1955), except that of lignin, which followed the method of Van Soest & Wine (1968) as modified by Rittenhouse (1969).

Study of Watering Frequency (1972)

Two lactating cows and their calves, weighing about 960 and 123 pounds, respectively, were placed as pairs in each of four 160-acre fields of native range and two 7.5-acre crested wheatgrass pastures on April 14. Two yearling heifers, averaging 512 pounds, were turned into each pasture on May 4th. Treatments were *ad libitum* water and water for 2 hours every other day. The cows and calves were intitially weighed April 12, and yearlings were weighed on May 11. They were weighed again on July 6 and at the end of the study September 3. The cattle were then returned to their pasture and allowed *ad libitum* water. Final recovery weight was measured September 10. The data were analyzed as a randomized block with 3 replications.

Water drunk by pasture groups was measured during May 1-17 and July 11-17. Herbage-moisture concentrations were assessed during the May 1-17 period only.

Trailing Studies (1970 and 1971)

Two cows with their spring-born calves and 2 yearling heifers were placed into each of six, 160-acre native-range pastures. For one treatment, water was centrally located in the pasture. For the other, water was placed at a distance of about 1 mile from the pasture. Each treatment was replicated 3 times (Figure 1). The study was conducted as a randomized block. In 1970, initial weights were measured May 19, intermediate weights July 3, and end-of-study weights August 17. Cows and calves were weighed 4 days later, after corral feeding of hay and *ad libitum* water. Initial weights in 1971 were taken April 16 for cows and calves and May 11 for yearlings. Intermediate weights were recorded on June 6 and July 7, and end-of-study weights on August 30. Initial cow, calf, and yearling weights in 1970 were 953, 162, and 706 pounds, respectively; in 1971 they were 1,035, 101, and 497 pounds. Ten of the cows used in 1970 were also used in 1971, and each pasture in 1971 had at least 1 animal that was conditioned to that pasture and treatment. Water drunk by pasture groups was measured during August 11-19, 1970 in 2 replications and in all pastures May 26-30, June 28 - July 2, July 26-30, and August 16-20, 1971. Visual observations of cattle movement on 2 replications were made from dawn to dusk July 7 through 10, 1971.

Calf Water Study (1971)

A single cow and her 2 1/2-month-old calf, averaging 950 and 190 pounds, respectively, were placed into each of sixteen, 7 1/2-acre crested wheatgrass pastures June 2, 1971. Treatments were *ad libitum* water for the cow only and *ad libitum* water for both cow and calf. The calf was restricted from the water by elevating the tank beyond its reach. Animals were weighed again June 30, and the end-of-study weight was obtained August 2. The cows and calves were subsequently placed with the main herd on crested wheatgrass pasture, and final recovery weights were obtained August 31. The study was conducted as a randomized block with 8 replications. Water drunk was measured over a 4-day period at 4 times during the study.

RESULTS

Effects of Watering Frequency

Table 1 presents some characteristics of the crested wheatgrass available to these animals in 1969. At no time during the 80 days was available forage limiting their intake. Crude-protein concentrations were low; levels beginning in August were below the minimum NRC requirement of 560-pound animals. Herbage dry-matter concentrations shown are typical for grass during the summer grazing period.

The average daily gains (ADG) in 1969 were 1.22, 1.38, and 0.88 pounds, respectively, for water frequenciew of $\infty/1$, 1/1, and 1/2. The ADG for only the 1/2 watering frequency differed significantly ($P < 0.10$) from that for the other two frequencies. In the subsequent 42 days of grazing meadow aftermath, the mean weight change per animal was 3, -8, and 22 pounds for $\infty/1$, 1/1, and 1/2 watering frequencies, respectively.

Table 1. Herbage characteristics in 1969

Sample date	Yield/acre	Crude protein	Herbage dry-matter
	lb.	%	%
7/8	992	5.4	55
8/7	---	3.1	73
9/4	---	2.6	79
9/24	646	2.5	79

Mean daily water consumption significantly decreased with each decrease in water frequency and averaged 9.4, 8.2, and 6.4 gal/hd/day. The reductions in water drunk for 1/1 and 1/2 watering frequencies respresent 13 and 35 percent reduction from ad libitum consumption.

Daily salt consumption averaged 99,70, and 46 gms, respectively, for animals on decreasing watering frequencies, with bonemeal consumption having a similar trend; 21, 14, and 8 gms/hd/day. Extreme variation in mineral intake occurred in this trial, the highest salt intake, 178 gms/day, was 6 times the lowest. Mean daily water intake was significantly ($P < 0.05$) correlated with mean daily salt intake and with bonemeal intake, $r = 0.791$ and 0.871, respectively.

Dry-matter digestibility coefficients in 1969, determined by the lignin-ratio technique, were 54.4, 55.6, and 57.1 percent, respectively, for ∞/1, 1/1 and 1/2 watering-frequency treatments, but were not statistically different ($P > 0.10$).

In 1972, weight changes of cows and calves during the months of April and May varied and ADG for treatments were not significantly different (Table 2). In the subsequent 2 months, cows restricted to watering every other day gained significantly ($P < 0.10$) more than cows on ad libitum water, but the ADG of their calves was significantly ($P < 0.10$) reduced. During the 7-day recovery period, cows and calves previously restricted from water gained large amounts. Thus, significant differences ($P < 0.10$) in ADG of cows was retained, but that of calves became nonsignificant ($P > 0.10$).

Yearling ADG varied significantly between treatments in May and in the June-July period, but differences were not consistent between periods, (Table 2). ADG differences for yearlings during the recovery period were not significant by treatments. Over the total trial period, ADG were similar, 1.65 and 1.73 pounds, for groups with water ad libitum and with water every other day, respectively.

Table 2. ADG for lactating cows, their calves, and yearlings by periods for *ad libitum* (∞/1) and every-other-day (1/2) watering treatment

Class	Period	Treatment ∞/1	Treatment 1/2	Significance (P = 0.10)
		lb.	lb.	
Cows	4/12-5/11	0.62	1.37	N.S.
	5/11-6/6	1.09	-0.80	N.S.
	6/6-8/3	0.40	1.12	*
	4/12-8/3	0.47	0.75	*
	8/3-8/10	0.95	3.45	*
	4/12-8/10	0.64	0.91	*
Calves	4/12-5/11	2.50	1.88	N.S.
	5/11-6/6	1.92	1.73	N.S.
	6/6-8/3	1.95	1.54	*
	4/12-8/3	2.08	1.67	*
	8/3-8/10	1.43	2.14	*
	4/12-8/10	2.04	1.69	N.S.
Yearlings	5/11-6/6	1.96	0.96	*
	6/6-8/3	1.49	1.97	*
	5/11-8/3	1.64	1.66	N.S.
	8/3-8/10	1.79	2.62	N.S.
	5/11-8/10	1.65	1.73	N.S.

During the period of May 1-17 when water intake was measured, the mean air temperature was 51 F, with 6 nights below freezing, and 0.22 inches of precipitation was recorded over 3 consecutive days. Herbage-moisture concentration of new growth was 61 percent, and that of old growth was 32 percent. Animals restricted to the 1/2 watering frequency drank 36 percent less ($P < 0.05$) water than animals with free access to water.

Mean air temperature during the July water-intake period was 67 F, and no precipitation was received. The amount of water drunk per group in July was nearly twice that in May. Cattle on the restricted-water treatment drank about 32 percent ($P < 0.05$) less water than those on control treatments.

Trailing Effects

In 1970, when cows trailed about 1 mile between the forage supply and water, the calves gained significantly less than calves in pastures with water close by (Table 3). Average daily gain of cows and yearlings in 1970 were biased by very poor performance of the cattle in one pasture. The trailing lane and water were next to this pasture, and the cattle did not adapt well to the trailing arrangement. In 1971, a fence was constructed inside this pasture next to the watering point to deter the cattle from collecting where the water was near but inaccessible. This was partly successful. Nevertheless, mean daily gains during treatment in 1971 did not differ significantly ($P > 0.10$).

Table 3. Average daily gain as affected by trailing treatments

Period	Treatment: No trailing	Treatment: Trailing
	lb.	lb.
1970 (May 20 - Aug. 17)		
Cows	1.32	1.11
Calves	2.05	1.68*
Yearlings	1.37	1.10
1971 (April 16 - Aug. 3)		
Cows	0.41	0.48
Calves	1.80	1.70
Yearlings	1.86	1.32

* $P < 0.10$.

In 1970, 27% less water was consumed August 11-15 by cattle trailing to water than by cattle with water close by. Salt and bonemeal consumption was similarly affected, the reductions being 47 and 64%, respectively.

Reductions of water drunk in 1971 by trailing animals was similar to that in 1970 (Table 4). Differences in the amount drunk for treatments were signiicant in 3 of the 4 test periods, with reductions ranging from 5 to 40% and averaging 26%. In 1971 water drunk per animal-unit-day (AUD) increased as the season progressed. Water drunk was more closely related to a combined temperature and insolation index (modified solar thermal unit (Caprio, 1971) than to either alone (Tables 4 and 5). Fifty-three and 47% less salt and bonemeal was consumed by trailing animals than by animals with water close by.

Table 4. Water drunk (gal/AUD) as influenced by trailing treatments, 1971

Period	Water drunk: No trailing	Water drunk: Trailing
May 26-30	8.5	6.4*
June 28 - July 2	11.0	10.4
July 26-30	17.4	10.5*
August 16-20	15.5	11.5*
Mean	13.1	9.7*

* $P < 0.10$.

Table 5. Mean temperature (F), insolation (I) (langleys/day), and modified solar thermal unit (MSTU) for water intake periods, 1971

Period	Temperature	I	MSTU 1/
May 26-30	58	498	28,884
June 28 -- July 2	50	619	30,950
July 26-30	66	651	42,966
August 17-20	69	603	41,607

1/ $MSTU = \frac{\text{Max tp} + \text{Min tp}}{2} \cdot I$

Observations of cattle movement for 4 days in 1970 suggest that all grazing cattle are not similarly motivated; however, some characteristics were common to animals in each treatment. Cattle with water close by generally drank twice a day and stayed close to water for 2-3 hours each time. Cattle trailing to water drank only once a day. They walked rapidly to water, drank quickly, and returned quickly to their pasture. The total sequence seldom took more than 1 hour, with 20 minutes being the maximum time spent in drinking. This sequence of watering by trailing animals was altered only once, when all animals in one pasture remained at water for 10 hours. On that day the maximum temperature was 92° F, compared with 90, 86, and 85° F for the other 3 days the cattle were observed. Calves did not always trail with their dams to water, but lay down at various distances from water, sometimes inside the pasture, to await their dams' return.

Effects of Water Restriction on Calves

Average daily gain of 2 1/2-month-old calves totally restricted from water for 60 days was 78% of that of calves having free access to water (Table 6). In the subsequent 30 days, with free access to water, the ADG of calves previously restricted from water was still less than that of control animals. Dams of calves restricted from water gained 0.3 pound per day more than cows whose calves had free access to water, but this difference in gain was not significant. Mineral consumption was greater for control animals than for animals on restricted treatment, but differences were not significant.

Mean daily water consumption increased in each succeeding measurement period (Table 7). Water consumption was more closely related to mean temperature than to insolation or to MSTU. The mean difference between the two treatments was 1.1 gal/day. The data suggest that the 1.1 gal/day is a measure of the calf's intake, providing that the dams of those calves did not increase their water intake compensatorily.

Table 6. ADG of cows and calves, as influenced by water restriction and the subsequent 30-day recovery period

Period	Ad libitum water	No water 1/
	lb.	
Calf		
6/2-8/2	1.8	1.4*
8/2-8/30	0.8	0.5
6/2-8/30	1.4	1.2
Cow		
6/2-8/2	1.2	1.5

1/ Only calf restricted from water.

* Treatment differences significant (P 0.10).

Table 7. Water drunk (gal/day) by cows alone and the cow-calf pairs, with mean temperature (F), insolation (I), and modified solar thermal units (MSTU)

Period	Water drunk: Cow	Water drunk: Cow-calf	Temperature	I	MSTU
June 7-11	12.4	12.2	52	550	28,600
June 21-25	13.3	14.1	60	628	37,680
July 5-9	14.1	16.7	58	668	38,744
July 19-23	16.7	18.0	71	508	36,068

DISCUSSION

It was difficult to accept the fact that, over these summer-grazing trials, reductions of 20-25% in water drunk created no strong or lasting effect on the body weight of the mature cattle. The results seem to refute the close association of feed intake with water intake, first reported by Ritzman and Benedict in 1924 and confirmed in later years by too many to cite here. At this point we can only agree with Sykes (1955), "We have relatively little data on the actual needs of animals for water under range or pasture conditions and the effect of restricted water intake on growth."

Every-other-day watering and forcing animals to trail about 1 mile caused similar reductions in the amount of water consumed. Animals that trailed such a distance to water normally did so only once per day; yet animals that were grazing close to water but allowed to drink only once per day reduced their water intake by 10-15% of normal. Lack of pasture and animal numbers did not permit a direct evaluation of that comparison. It is inferred from the data that trailing about 1 mile to water has a direct influence on water intake. Many ranchers in arid areas have indicated that cattle come in to water every other day. It would appear that it is now necessary to evaluate the combined effect of every-other-day watering and a trailing effect. Certainly water intake cannot be reduced much more without having significant impact on animal performance.

Weight losses of the mature animals while on restricted or restricting water regimes were nearly always compensated for in the recovery periods. The only exception to this was with cows that gained weight when restricted to 1/2 watering. This weight gain may have resulted from reduced milk production, which lessened the total nutrient demand on the cow, allowing her to gain weight at the expense of the calf, which lost weight.

Calves about 2 1/2 months of age during the 1st 30 days of total water restriction did not show any great desire for water. However, in the 2nd 30 days, visible evidence of thirst was evidenced by their standing near water, nervousness about water, a noticeable gauntness, and their physical attempts to reach water. The loss of weight by these small calves when totally restricted from water was not made up in the recovery period. The small stomach capacity of calves is, perhaps, one factor causing calves to be more susceptible to restriction of drinking water.

Increased dry-matter digestibility of forage by animals on restricted water regimes has been reported by Thornton and Yates, 1968. The explanation for this increase has generally been believed to be a slower rate of passage through the gut. More recently Asplund and Pfander, 1972, inferred that this increase in dry-matter digestibility with decreasing water intake is an artifact. If a reduced forage intake was brought about in these studies by water stress, an increased digestibility of the forage in the animal could explain the lack of weight loss in stressed animals.

Water consumed by the animals increased as (1) forage became drier, (2) mean temperature increased, (3) animal size increased, and (4) relative humidity decreased. These observations agree with those of others who have studied water-stress effects on animals in more confined conditions (Roubicek, 1969).

As early as May 1, when new growth contained at least 61% water concentration, animals were drinking regularly. Assuming a 25 lb/day intake (oven dry) of only new growth by lactating cows, about 8 gallons of water was ingested with it. This was evidently insufficient for their demands.

The cattle trained very quickly to their scheduled drinking days. Upon reaching water, restricted animals drank very quickly and immediately returned to grazing. Usually a 1/2 hour <u>ad libitum</u> water-intake period would have sufficed.

Only in 1969 for yearlings and in 1970 for cows and calves were per-head water consumption per day recorded. In those years ad libitum water drunk averaged 9.4 and 15.2 gal/hd/day for yearlings weighing 560 and mature cows of 950 pounds, respectively, with grazing confined to 7 1/2 acres. Stanley (1945) reported water consumed by cows in June and July in Arizona to range from 8-11 gal/hd/day. This estimate appears low, because mean temperatures for the two locations are similar. The primary cause of differences is that the cows in Stanley's study had a mean body weight of about 660 pounds, only slightly more than yearlings in this study. Furthermore, Stanley indicated that cattle traveled no farther than 1 1/2 miles to water. On the basis of our findings, those cattle may have been under a water stress at certain times of the year. His observations did show that cattle came to water twice daily, but that watering frequency of the calf was less frequent.

Test animals were frequently observed on the far side of the native-range pastures in the trailing studies: thus, the distance from water approached 2 miles. Use estimates of the forage were not made, as the work of Talbot (1926), Valentine (1947), Glendenning (1944), Cully (1949), Smoliak and Peters, (1952), and Holscher and Woolfolk (1953) have adequately shown that forage use decreases almost linearly with increasing distance from the watering source. In particular, Valentine reported that on black grama range in New Mexico, use of the grass by cattle was 30% or less beyond 1 mile from water, while at the same time at distances less than 0.4 miles the grass was overgrazed (proper use was set at 50%).

IMPLICATIONS

A primary reason for these studies was to determine the benefits that might accrue in animal gain by providing closely available water, benefits that could be used to offset the cost of water development. On the basis of these studies it is concluded that, for yearlings, providing water closer than 1 mile will not return increased benefits except those resulting from a greater uniformity in use of the forage. It is likely that the same would apply to the dry cows. Indeed, if the reduced water intake associated with trailing is accompanied by a decrease in forage intake, then an increase in carrying capacity could be justified.

The impact of water stress on the growth and performance of the calf is more serious. These studies showed that after 2 1/2 months of age, the suckling calf desires water and performs poorly without it. Similarly, its dam needs daily access to water, or the calf's performance will be hindered. It is inferred from these results that the calf that drinks infrequently with its dam because of trailing distances is stressed for water, and its gain is likely to be reduced. Yet, in 2 years no reductions in calf gains were found where the distance between water and forage supply was about 1 mile.

The results of these studies may apply directly to ranchers who are hauling water or who have quick access to and complete control of their stockwater. Watering every other day could reduce the amount hauled or the amount drunk, thereby saving considerable hauling expenses or extending the duration of use of a nonreplaceable bulk supply. However, if such is placed into operation, the daily opening and closing of gates to water should be regular. Watering every other day would be best applied to cows without calves and to yearlings.

The overuse of range near water, the subsequent decline in range condition of that area, and its enlargement as the years rolled by was recognized by Talbot in 1926. The rehabilitation of these areas is critical to the future use of range by domestic stock. The use of fences and trailing lanes to control animal movement and location of grazing may have application in the rehabilitation of these sacrifice areas.

Finally these studies suggest that the relation of feed intake to water drunk, as defined by controlled and confined studies, as well as the impact of water, needs further clarification as it affects grazing animals on semi-arid and arid ranges. This information is of vital concern now, when the impact of use on rangeland by any means has strong environmental overtones. The role of stockwater is also of significance when the federal agencies who control the majority of the public lands estimate from their own surveys that as many additional water developments are now needed as we presently have (Cliff, 1967) and that from 30 to 64% of the Bureau of Land Management ranges in Nevada, Idaho, and Oregon are presently inadequately watered (Personal communication, 1968).[1/]

1/ Bureau of Land Management response at the District level to a form questionnaire directed to State Offices in Oregon, Idaho, and Nevada.

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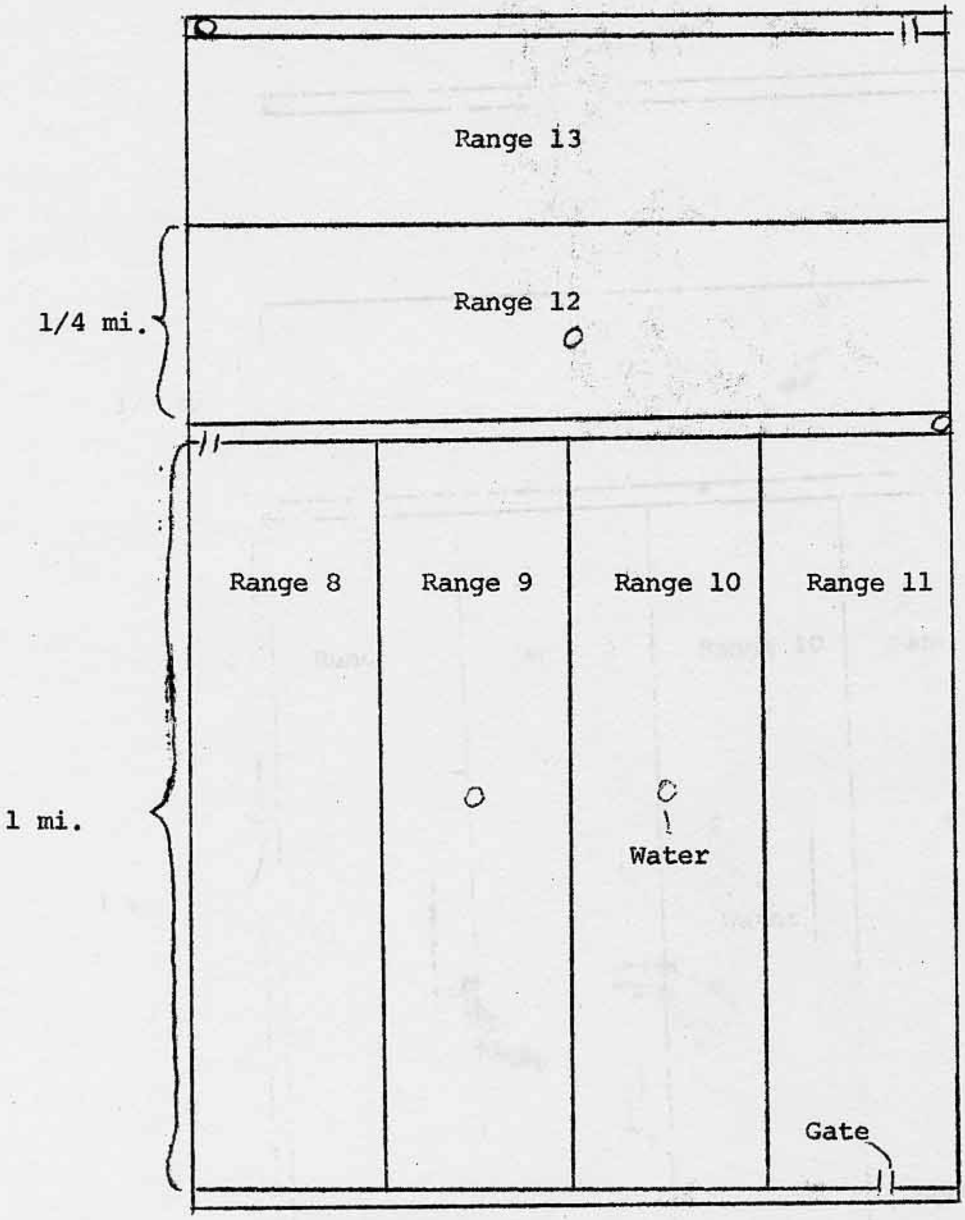

Figure 1. Trailing-pasture layout.