AN ABSTRACT OF THE THESIS OF

Jeffrey E. Clawson for the degree of Master of Science in Rangeland Resources presented on June 2, 1993

Title: The Use of Off-stream Water Developments and Various Water Gap Configurations to Modify the Watering Behavior of Grazing Cattle.

Signature redacted for privacy.

Abstract approved: ______________________
John C. Buckhouse

Two case studies were designed to study the effects of using off-stream water developments and water gap configurations to modify watering behavior of cattle. There were two objectives: 1) to evaluate an off-stream water source to reduce water quality impacts of grazing cattle on a mountain riparian zone during summer months; and 2) to evaluate water gaps to reduce the amount of manure being deposited in or within one meter of a stream.

Installation of a water trough had a significant impact on cattle use of riparian areas. Use of a mountain stream and bottom area (spring) decreased after a watering trough adjacent to these areas was installed. Use of the stream dropped from 4.7 to 0.9 minutes per cow per day, and use of the bottom area dropped from 8.3 to 3.9 minutes per cow per day after the trough was installed. The watering trough offered a convenient and preferred water source over

the traditional sources. In this case study, cattle watered at the trough 73.5% of the time, the bottom area 23.5%, and the stream 3% of the time.

Cattle spent an average of 3.4 minutes per cow per day watering. While in the riparian zone, cattle spent an average of 47 minutes per cow per day loafing, and 1 minute per cow per day foraging. The cattle exhibited a daily pattern of use in the riparian zone, with 97.4% of the use falling between 12:00 noon and 6:00 pm.

In the case study designed to evaluate water gap designs, cattle exhibited no preference between gaps 0.9 or 1.8 meters wide. No significant reduction in watering time or time spent waiting to water was observed with the different designs. Fecal depositions into the water were completely eliminated with all designs tested at both Soap creek and Berry Creek.

The Use of Off-stream Water Developments and Various Water Gap Configurations to Modify the Watering Behavior of Grazing Cattle

by

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I. INTRODUCTION

A majority of the land mass in the United States is classified as rangeland (Platts 1991). Although these semi-arid regions are not well suited for cultivation, in the Western United States, they are often grazed by domestic livestock (Darling and Coltharp 1973). The presence of water in the form of streams, stock ponds, or stock troughs is a necessity for livestock production.

Land in close proximity and directly effected by water is sometimes referred to as a riparian area (Platts 1991, Kauffman and Krueger 1984, Elmore and Beschta 1987, Oregon Department of Forestry 1987). Riparian areas are often a focal point for wildlife, fisheries, livestock, and humans (in the form of recreationalists), because of the availability of water, forage, shade, habitat, favorable microclimate, and aesthetics. This heavy use is sometimes a detriment to the over-all quality of water within these riparian areas.

There has been an increasing environmental awareness of water quality issues within government agencies, as well as the general public. Increasing recreational use of riparian areas in rangelands will spawn more public awareness of the uses and misuses of these sites. Livestock grazing and watering in riparian zones, with respect to nonpoint source pollution, is a current source of conflict among many groups (landowners, government agencies, environmental organizations, and a wide array of other interested parties).

Grazing around rangeland streams can impact water quality. Livestock influence surface water quality through vegetation removal, trampling, soil compaction, and chiseling, thus reducing infiltration, shade, streambank stability, and increasing erosion potential. Water quality can also be influenced by fecal deposition into or near streams. Enteropathogens can be transmitted via water from feces of domestic livestock to humans. As recreational uses of rangeland waters increase, the risk of bacterial infection from water borne pathogens also increases.

During summer months, cattle spend a disproportionate amount of time in riparian zones as compared to upland areas (Bryant 1982). When cattle concentrate around riparian areas, it would stand to reason that more fecal material would be deposited in or near streams and ultimately enter the water either through direct deposition or through overland transport during a storm event.

Various management practices such as range riders, trailing, salting, fencing, and water developments have been moderately successful in reducing the time spent in riparian areas (Kauffman et al. 1983). The search for better management practices continues, as a reduction in time cattle spend in or near the water equates to a reduction in fecal matter in the water; and ultimately a reduction in bacterial diseases from waterborne pathogens.

The objectives of this study were:

1. to evaluate the use of an off-stream water source to reduce the water quality impact of grazing cattle having access to a mountain riparian zone during summer months.
2. to evaluate the use of water gaps to reduce the amount of cattle manure being deposited in or within one meter of the stream.

II. LITERATURE REVIEW

Riparian Areas and Animal Behavior

The wet soil areas next to streams, lakes, estuaries and wetlands are known as riparian areas (Oregon Department of Forestry 1987). Riparian areas are normally limited in size but are often highly utilized by cattle. Roath and Krueger (1982) observed that 81% of the forage removed by livestock on a mountain allotment came from the riparian zone which made up 1.9% of the total area and produced approximately 21% of available forage.

Streams impacted by cattle overuse are generally wider, shallower, warmer, have less overhead cover, and have more fine sediment than unimpacted streams (Platts 1981). These impacts are usually a compound result of vegetation removal and the physical effects of the cattle's presence (chiseling, trampling, and compaction). Damage to vegetation induced by livestock grazing are the result of compaction of soil, which results in increased runoff, lower plant vigor, higher soil temperatures, increased evaporation, and physical damage to the vegetation by browsing, trampling,and rubbing (Severson and Boldt 1978). Lowrance et al. (1985) suggested that riparian zone vegetation reduced sediment and nutrient transport and also increase hydraulic resistance to flow, thereby lowering flow velocities and causing sediment deposition.

Vegetation in riparian zones is an important component of the stream ecosystem in that it provides the detrital substrate on which much of the instream system is based. It cycles nutrients and it modifies the aquatic environment (Jahn 1978).

Streamside vegetation provides shade (preventing adverse water temperature fluctuations), and acts as a "filter" to prevent sediment and debris from man's activities from entering the stream. The roots of trees, shrubs and herbaceous vegetation stabilize streambanks providing cover in the form of overhanging banks (Meehan et. al. 1977). Riparian vegetation also provides organic detritus and insects for the stream organisms (Cummins 1974, Meehan et. al. 1977).

Vegetative cover has been shown to affect the susceptibility of a soil to compaction on rangelands in the United States (Wood and Blackburn 1984). Alderfer and Robinson (1949), Bryant et al. (1972), and Orr (1960) all found soil compaction increased linearly with increases in grazing intensity.

The degree of soil compaction is dependent upon the grazing intensity, soil texture, soil moisture and organic matter. Compaction is higher, and to a greater depth on coarse-textured soils, but there is often no effect on fine-textured soils (Van Haveren 1983). Infiltration capacity is generally reduced with increased grazing intensity and reduced range condition, mainly through vegetation and litter removal, soil structure deterioration, and compaction (Naeth et al. 1990b).

Living plant material and associated litter are more significantly correlated with infiltration than any other measured variable (Meeuwig 1970). They increase infiltration rates by decreasing the impact of raindrops, improving soil structure through formation of larger soil aggregates, and creating a rougher microtopography that increases infiltration opportunity (Naeth et al. 1990b).

Naeth et al. (1990b) showed that infiltration rates were consistently higher on ungrazed lands verses any grazing treatments on mixed prairie and fescue rangelands in Alberta. During their tests they found that water infiltrated the ungrazed land at almost twice the rate of very heavily grazed land.

In most studies, grazing effects on soil bulk density were manifested in the top 6 cm. Studying compaction in range ecosystems has been complex because factors other than trampling, such as vegetation mass and type, plant rooting depth, freeze-thaw and wetting-drying cycles, affect soil structure, and soil water holding capacity, affect soil bulk density and penetration resistance (Naeth et al. 1990a).

In a riparian zone continuously grazed season long, Orr (1960) found bulk density and macropore space to be significantly greater in grazed areas over exclosures. Naeth et al. (1990a) found heavy intensity and/or early season grazing had greater impacts on compaction than light intensity and/or late season grazing on grasslands in Alberta.

When soil compaction occurs it decreases the porosity and drainage of the soil reducing the infiltration capacity. This limits the supply of air, nutrients, and water that roots need for growth. This also decreases the infiltration rates during precipitation or run-off events, thus increasing the likelihood of overland flow and erosion.

To combat the processes of decreased infiltration and erosion, grazing strategies have been developed and tested. Holechek (1983) pointed out that grazing strategies have become a major focus of range research and management. Grazing management strategies discussed for riparian zone rehabilitation and/ or maintenance include exclusion of livestock, alternative grazing strategies, changes in the kind and class of animals, managing riparian zones as special use pastures, and several basic range practices (e.g. salting, artificial reestablishment of riparian vegetation, upland water developments, and herders) (Kauffman et al. 1983).

Management practices should create a soil surface conducive to absorbing precipitation. Such practices should maintain high levels of soil organic matter, litter, and vegetative cover thereby minimizing factors detrimental to infiltration and improving hydrologic conditions (Naeth et al. 1990b). Light intensity and/ or late season grazing may provide the least impact on soils as shown in the Naeth et al. (1990a) study on a Alberta grassland.

Kauffman et al. (1983) showed there was a significant increase in streambank erosion on grazed verses ungrazed pastures. Marlow et al. (1987) suggested that a combination of high flow, moist streambanks, and cattle use lead to major streambank alteration. However, Buckhouse et al. (1981) in a study in the Blue Mountains of Eastern Oregon, found no significant increase of streambank erosion with different managed grazing patterns as compared to ungrazed areas, but that season-long unmanaged grazing had higher erosion rates than did ungrazed or managed pastures.

The differences in these studies may be attributed to the fact that individual streams respond differently to perturbations and that some streams are more susceptible to disturbance than others. Also indicative is the duration and intensity as well as the time of year of the perturbation.

Cattle prefer areas in which palatable plants make up large proportions of vegetative composition (Cook 1966, Miller & Krueger 1976). Reid and Pickford (1946) postulated that preference for riparian zones were due to high herbage production, dominated by grasses and grass-like plants and the riparian communities maintain green palatable herbage for a longer period than adjacent upland communities. Gillen et al. (1985), in a study of the use of riparian meadows in the Blue Mountains of Eastern Oregon, found that cattle continued to use riparian meadows even as the herbage levels decreased to the physical limits of grazing.

Bryant (1982) postulated that conditions of temperature and relative humidity in late season produced less comfortable environments in canyon bottom riparian zones and more comfortable environments on the up-slopes; but found that when temperatures are high, cattle will seek the cooler microclimate of the riparian area. Thus, as slope increases, frequency of livestock use decreases (Bryant 1982, Mueggler 1965). Cattle normally graze heavily on valley bottoms and more level land near water before moving on to rougher terrain (Cook 1966).

Percent slope and distance of slope from water accounted for 81% of the variation in use of the slope (Mueggler 1965). Bryant found that alternative sources for water separated from riparian zones by steep slopes were not utilized (1982). Roath and Krueger (1982), in their study of cattle grazing in the Blue Mountains of Eastern

Oregon, theorize that slope and turning cattle onto a pasture at a certain point contributed to concentrating the cattle on the riparian zone early in the grazing season.

A major tool for improving cattle distribution is water developments, such as stock-ponds or watering troughs (Skovlin 1965. Cook 1967). Fencing carries a high cost, but is also effective in re-distributing cattle (Skovlin 1965). Skovlin also found that salt placed at least 400 meters from water achieved a positive effect in cattle distribution.

Some of the more recent studies have pointed out a few of the draw-backs of some distribution practices. Gillen et. al. (1985) found that cattle preferred the quality of free-flowing water to that held in an impoundment (ponds and troughs). Ames (1977) postulated that cattle stay in the riparian areas due to the quality and variety of forage, the shade and thermal cover, and the availability of water. Bryant (1982) also noted that concentrated use of the riparian zone by cattle can be attributed to energy conservation, availability of succulent vegetation, microclimate, or a combination of these factors.

The frequency of drinking will depend on temperature, condition of feed, and the distribution of water (Arnold and Dudzinski 1978). Beef cattle grazing rangelands in the U.S.A. in the summer, drink between one and four times a day. (Dwyer 1961. Sneva 1970. Wagnon 1963. McInnis 1985).

Sneva (1970) found that yearling cattle, during the summer months on sage-brush range in Eastern Oregon, had varied drinking times; 30% occurred between 6:00 a.m. and 12:00 noon, 53% from noon to 4:00 p.m., and the remaining times between 4:00 p.m. and 8:00 p.m. Wagnon (1963) found that cattle on the California range spent three minutes watering per day, with an average of two minutes per visit, but when water levels were low or water was muddy this would increase to five or six minutes. Sneva (1970), however, observed cattle drinking on an Eastern Oregon range for an average of seventeen minutes per day; and McInnis (1985) observed a mean drinking time of 26.6 minutes per day, in Eastern Oregon. Even when not drinking, cattle may loaf around water for several hours (Dwyer 1961. McInnis 1985).

Miner et.al. (1992) found that under wintering feeding conditions, the amount of time cattle spent drinking or loafing in the area of the stream was reduced by more than 90% by the presence of a watering tank. A portion of this reduction is speculated to the water in the tank being warmer.

Water Quality

Documented cases of infectious, bacterial diseases of animal origin, in man and animals have been associated with water transmission. These include salmonellosis, leptospirosis, anthrax, tularemia, brucellosis, erysipelas, tuberculosis, tetanus, and colibacillosis (Diesch 1970). Two important diseases transmitted to humans via water from cattle are salmonellosis and leptospirosis (Atlas 1984. Diesch 1970).

Darling and Coltharp (1973) found that significant increases in bacterial counts were noted during the grazing of cattle and sheep at stream locations immediately downstream of grazing activity, in northern Utah.
A positive correlation between livestock grazing intensity and coliform counts has been shown in studies by Buckhouse and Gifford (1976) and Johnson et. al. (1978). Bacteria in fecal material can enter a stream either through direct deposition or by overland flow during a runoff event. Buckhouse and Gifford (1976) determined on a semiarid watershed in Southeastern Utah that unless feces was deposited within one meter of the stream, there was little danger of fecal bacteria entering the stream. However, feces concentration were most often higher around watering locations, gates, fence lines and bedding areas (Hafez and Schein 1962).

Larsen (1989) in a study of free ranging cattle on the semi-arid environment of Central Oregon, found that feces concentrations were greater in the riparian zones than the uplands during the spring time. Larsen also found that the average defecation rate directly in to a stream was 0.41 per animal per day during the summer. Bacteria within dry fecal material may remain viable for at least a year (Buckhouse and Gifford 1976).

Stephenson and Street (1978) in a study on a Southwest Idaho rangeland watershed found that occurrence of fecal coliform was directly related to the presence of cattle and that fecal coliform counts were found to increase in adjacent streams soon after cattle were turned in and remained high for several months after cattle were removed. Sherer (1991) found that bacteria in contaminated water died-off at a significantly higher rate than indicator bacteria that were bound in sediment.

To routinely monitor water for enteropathogens, such as salmonella, is difficult and uncertain. Therefore, the test most commonly used to determine the degree of fecal contamination is one for indicator organisms.

Atlas (1984) stated that the ideal indicator organism should: (1) be present whenever the pathogens concerned are present; (2) be present only when there is a real danger of pathogens being present; (3) occur in greater numbers than the pathogens to provide a safety margin; (4) survive in the environment as long as the potential pathogens; and (5) be easy to detect with a high degree of reliability of correctly identifying the indicator organism, regardless of what other organisms are present in the sample.

Fecal coliform and fecal streptococci are generally used as indicator organisms for water pollution from livestock due to the ease and standardization of measurement. Bohn and Buckhouse (1985) point out some of the shortcomings of using only fecal coliform as indicators of water quality in wildland streams. These include: daily and annual population cycling, not a satisfactory indicator for *Giardia* (a protozoa), behavior of die-off rates of other pathogens in bottom sediments may not follow fecal coliform, and most monitoring studies using fecal coliform were designed for point-source not nonpoint-source pollution.

Geldreich (1970) advocates the use of fecal coliform to fecal streptococcus ratios to better quantify the species of origin of the contaminates. It can be assumed that, as livestock density increases in riparian zones, there is an increased risk of humans contracting bacterial diseases of animal origin.

III. METHODS

Experiment 1: Livestock Use of Riparian Area Before and After Installation of a Watering Trough

The research question asked during this study was: can a watering trough placed adjacent to a riparian zone reduce the amount of time cattle spend in or around the stream or bottom area?

Study Site

The Hall Ranch was used as the study site for both Experiment 1 and 2. The Hall Ranch is a unit of the Eastern Oregon Agriculture Research Center located at Township 5 South, Range 41 East approximately 19 km (11.8 miles) southeast of Union, Oregon (Figure 1). Pasture "B" of the Hall Ranch is located on the east side of State Highway 203 and consists of approximately 118.7 hectares (293 acres) of coniferous forest and native grass pastures (Figure 2).

The stream used for this study was a perennial stream located on the north side of a 118.7 hectare (293 acre) pasture (Pasture "B" of the Hall Ranch Union County Experimental Station). Alternative access to water was

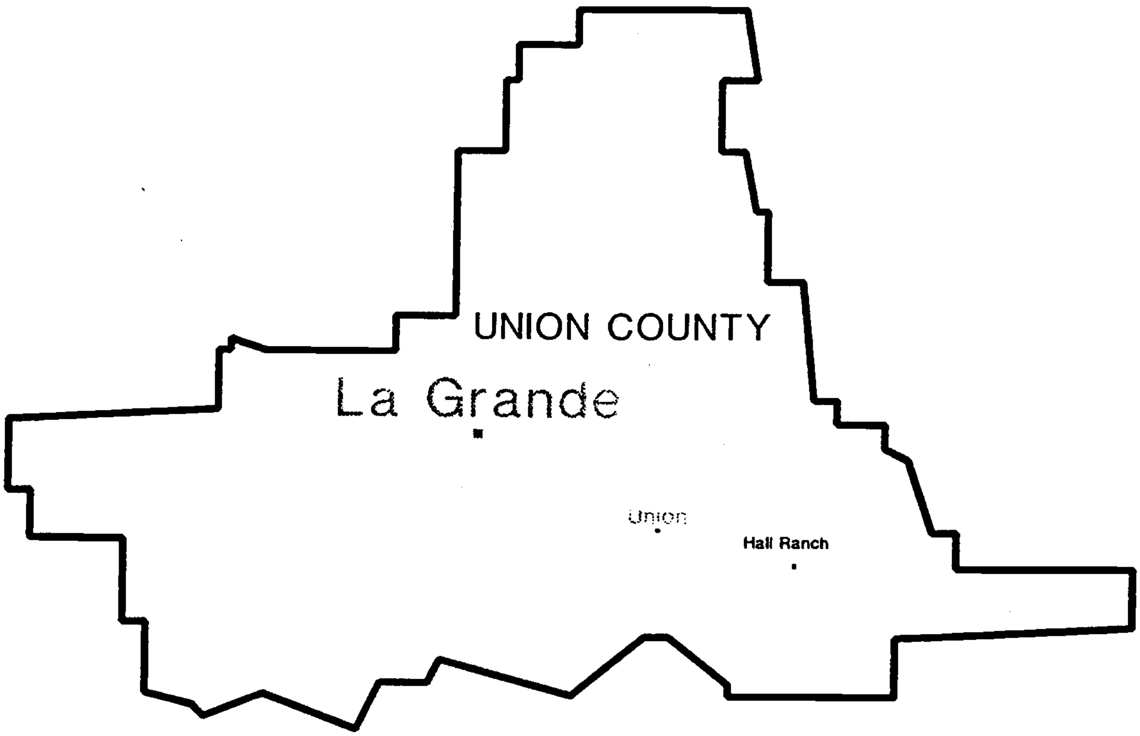


Figure 1. Map of Union county, Oregon with location of the Hall Ranch.

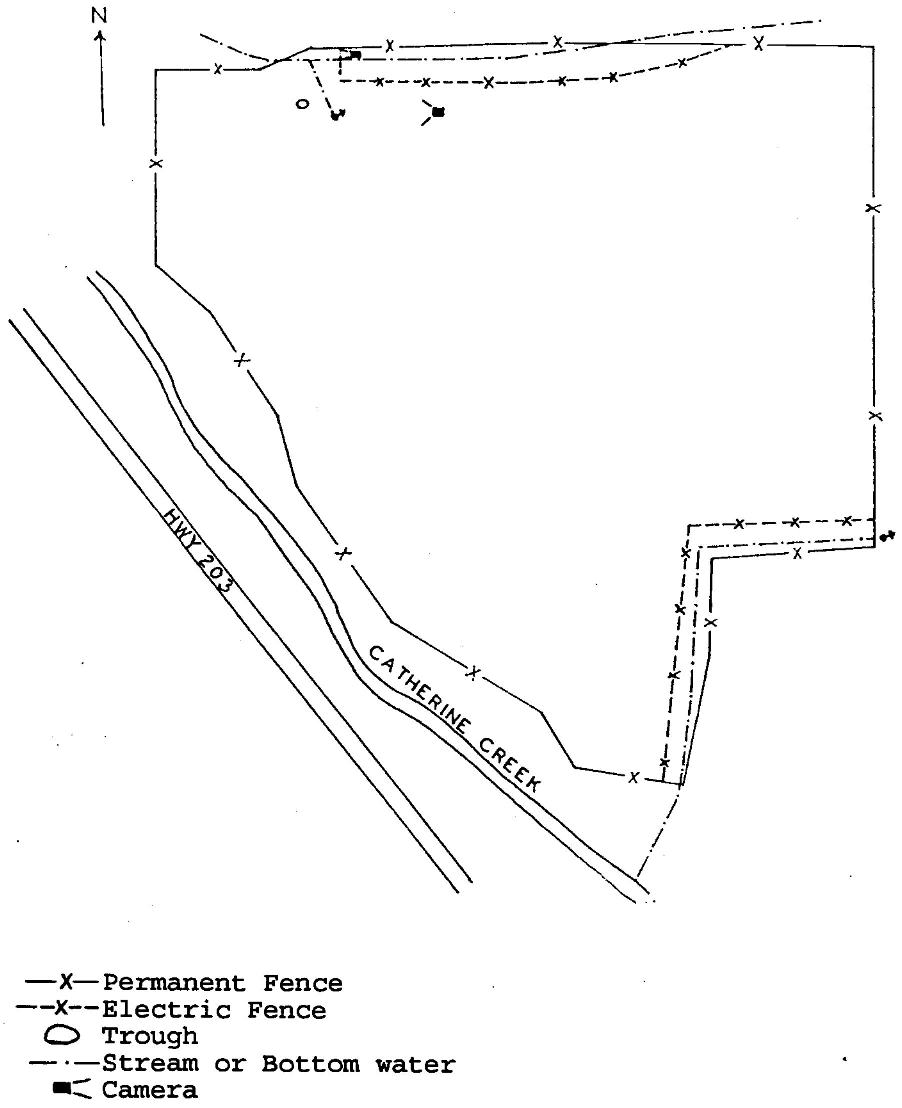


Figure 2. Map of Pasture B of the Hall Ranch with watering sites and camera locations.

supplied by a 0.6 x 0.6 x 2.4 meter (2x2x8 foot) galvanized steel watering trough that was gravity fed by the stream through 213 meters (700 feet) of 1" diameter black, poly vinyl pipe. Drinking water was available at the stream, trough, and a spring (referred to as bottom area), which flowed for about 91.4 meters (300 ft.) into the stream. The trough was located approximately 61 meters (200 ft.) south and uphill of the stream and 30.5 meters (100 ft.) west of the bottom area. The watering area sat in a natural bowl, so from any accessible direction cattle had to walk downhill to get to the water. The approximately 0.8 hectares (2 acres) surrounding the trough, stream or bottom is referred to as the riparian area (Figure 2). The riparian zone around the stream and the bottom area are classified as Tolo silt loam soils which have moderate to high water erosion potential and can be very dusty during the dry season.

The major vegetation around the stream was Douglas Fir (*Pseudotsuga menziesii*) with patches of Cheatgrass (*Bromus tectorum*). The uplands of the pasture are classified as Hall Ranch stony loam of 2-35% slopes. Bluebunch Wheatgrass (*Agropyron spicatum*) and Idaho Fescue (*Festuca idahoensis*) are the major plants found on this site (Soil Conservation Service and The Oregon Agricultural Experiment Station 1978).

The stream and its adjacent banks provided little to no vegetation but plenty of shade and cool water. The bottom area was lush with phreataphytes and other very palatable plants. Approximately 91.4 meters (300 ft.) of the stream was available for watering and about 91.4 meters (300 ft.) of the spring water was also available.

The cattle at the Hall Ranch consisted of three bulls, seventy heifers, and forty cow-calf pairs. The calves were treated as individual units as it was difficult to discern them from the adults in the film and from the observation location, therefore there were one hundred and fifty three head being observed.

Time spent watering at the trough, stream, and bottom area were observed every one minute by use of two SanKyo Em-60XL super eight movie cameras and by personal observation. All observations were done during daylight hours only. Observation by camera was begun as soon as cattle were released into the pasture. The trough was made available to the cattle fourteen days into the study. The data from the camera overlooking the trough and bottom area was analyzed on a proportional and weighted average basis due to blocks of over-exposed film. There were no over exposed frames of film for the stream. The camera was set in the trees and did not have a view of the whole reach of the stream. The position of the camera was never altered so the data provides a consistent sample of the stream use over time.

<u>Experiment 2</u>: Livestock Use Patterns Around Riparian Area and Trough

The cattle were observed continuously (sun up to sundown) for seven days after the trough was installed. The continuous observations were done from a small trailer located uphill (south) from the watering areas. The observation post yielded a view of all watering locations and activities of the cattle were observed using binoculars. Cattle were counted if they were present within one and a half meters of either bank of the stream or the bottom area and if they were within a 12.1 meter square around the trough.

The continuous observations were recorded at one minute intervals under the location categories of trough, stream, and bottom (Figure 2). Activities of the cattle were also recorded along with location, the three categories were; drinking, loafing, or foraging. Cattle standing or laying down (ruminating) were counted as loafing. Cattle with their heads down to water were counted as drinking and cattle with their heads down to land were counted as foraging.

Continuous data from the three drinking areas (stream, trough, and bottom area) and the activities (drinking, loafing, and foraging) in each were analyzed by t-tests to determine associations between locations and activities, testing the null hypothesis that offering a off-stream watering source will not significantly reduce the amount of time cattle spend in a given activity in the riparian zone.

Experiment 3: Water Gap Configurations

The research question asked during this study was: can a water gap be designed to facilitate drinking from a stream, but reduce the input of fecal material into water?

Study Site

The two Benton County locations, Soap Creek and the South Fork of Berry Creek, are both located in Township 10 South, Range 5 West, on the west side of Tampico road. The Soap Creek Experimental Ranch is about 15 km (9.3 miles) north of Corvallis, Oregon (Figure 3). Soil at the Soap Creek site was a silty clay loam of the Waldo Series (Soil Conservation Service and The Oregon Agricultural Experiment Station 1970). There was virtually no vegetation at the watering site due to the intense use by

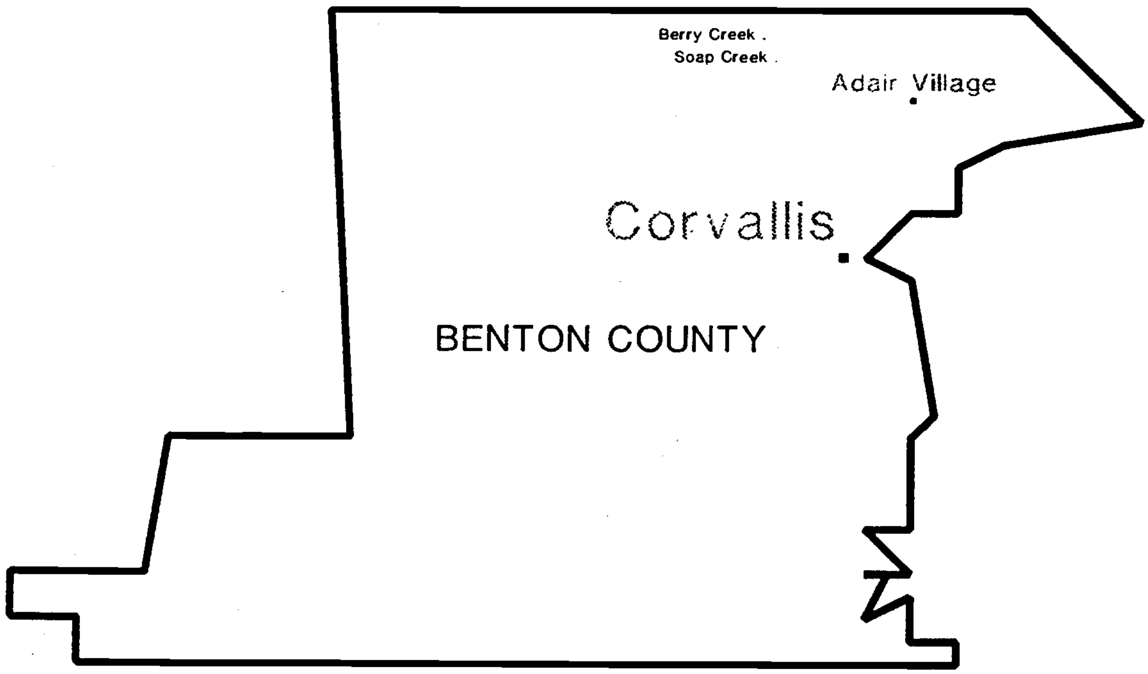


Figure 3. Map of Benton County showing locations of Berry Creek and Soap Creek.

cattle. Soils on Berry Creek are Briedwell gravelly loam with slopes of 0-7% (Soil Conservation Service and The Oregon Agricultural Experiment Station 1970).

Restricted Use Area

One hundred and twenty-four cows were allowed access to water at the south end of a pasture located on Soap Creek (Figure 4) during May 9-14 of 1992. Two, 0.9 meters (3 ft.) wide by 1.8 meters (6 ft.) deep water gaps were constructed at the watering location for the first three days. One chute was paneled off for the last three days leaving only one 0.9 meter (3 ft.) wide by 1.8 meter (6 ft.) deep watering gap in which the cattle could water. The water gap was constructed of 1.2 meter (4 ft.) high by 3.6 meter (12 ft) long aluminum panels along with 1.2 meter (4 ft.) high by 1.8 meter (6 ft.) half panels. The two chutes were placed adjacent to each other. The cattle were monitored by both personal observation and by the use of two SanKyo Em-60XL super eight time-laps movie cameras set to take one frame per minute. The water gap design was placed within an existing larger water gap on the south end of haying pasture.

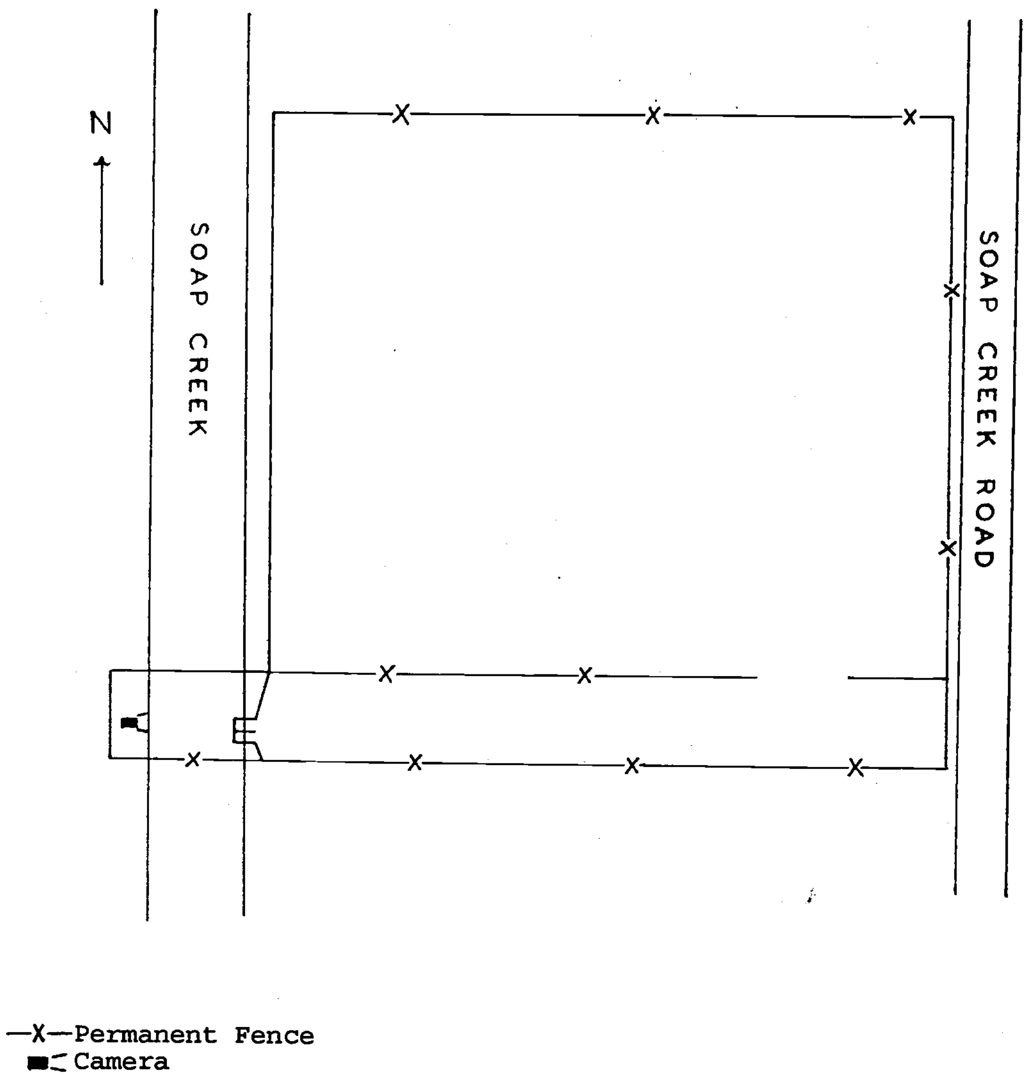


Figure 4. Map of the pasture used at Soap Creek with location and configuration of the water gap used.

Chute Length Considerations

Twenty-four cows (past breeding age) were winter fed daily on a 9.3 hectare (23 acre) pasture of the South Fork of Berry Creek (Figure 5) during the months of January, February, March, and April of 1992. The only access to water was at the water-gap location, all other access was denied by use of a electric fence (Figure 5). The weather consisted of mostly overcast or rainy days during the first three months with increasing sunny days for April.

To test the size and design of a water-gap that would limit the ability of cattle to defecate in or immediately around a stream (one meter), six 3.6 meter (12 ft.) and four 1.8 meter (6 ft.) aluminum panels were used along with 1.8 meter (6 ft.) t-posts to secure the panels. The panels were placed in a "comb" configuration (Figure 6) with five chutes, each approximately 0.9 meters (3 ft.) wide. The center chute was 1.8 meters (6 ft.) deep and the other four were 0.9 meters (3 ft.) deep.

About every seven days one chute was removed from use until only one chute remained. Cattle watering time and behavior were recorded during each of these settings to determine if there was adequate access to water. If the cattle broke through the fence it would be assumed that the minimum number of access spaces had been breached.

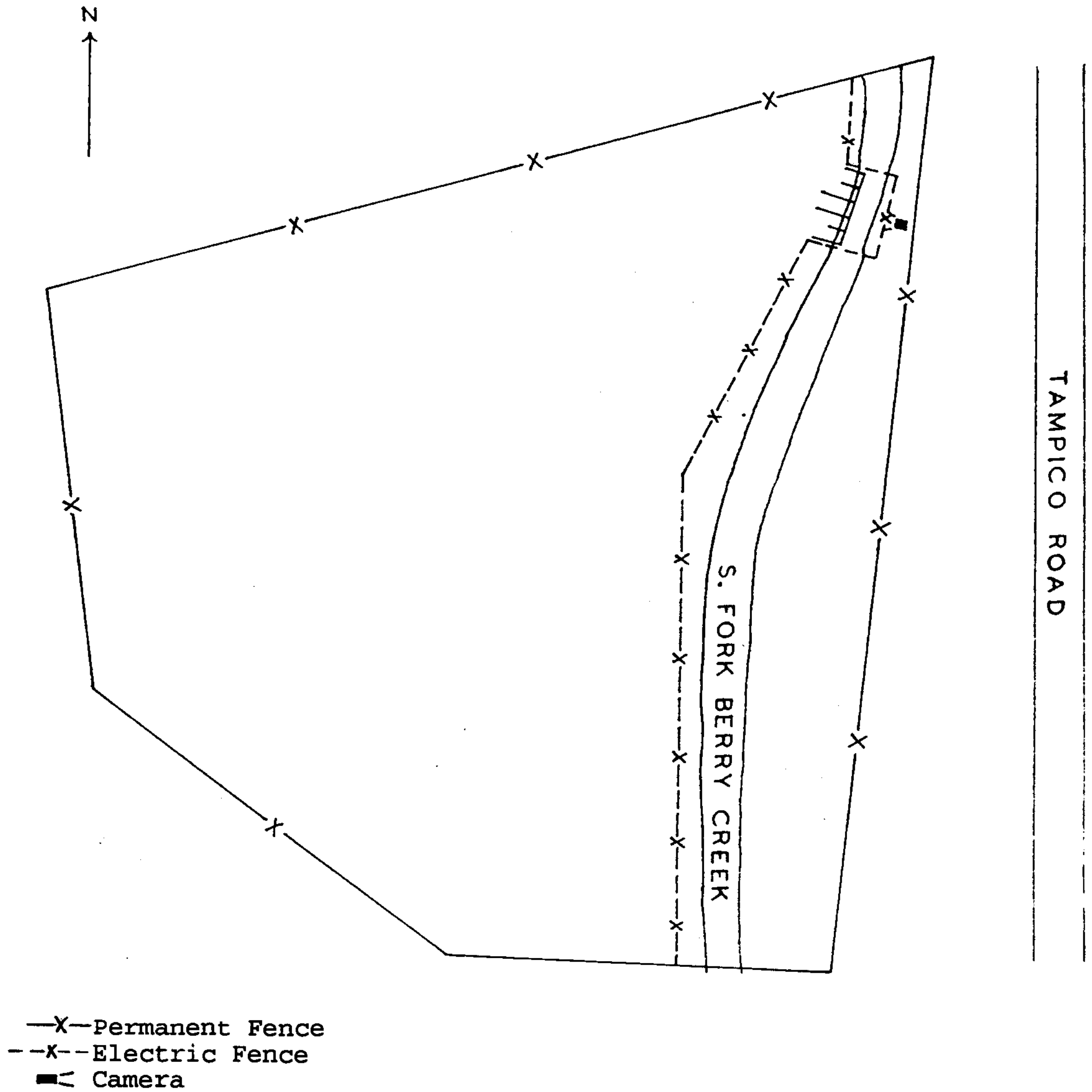
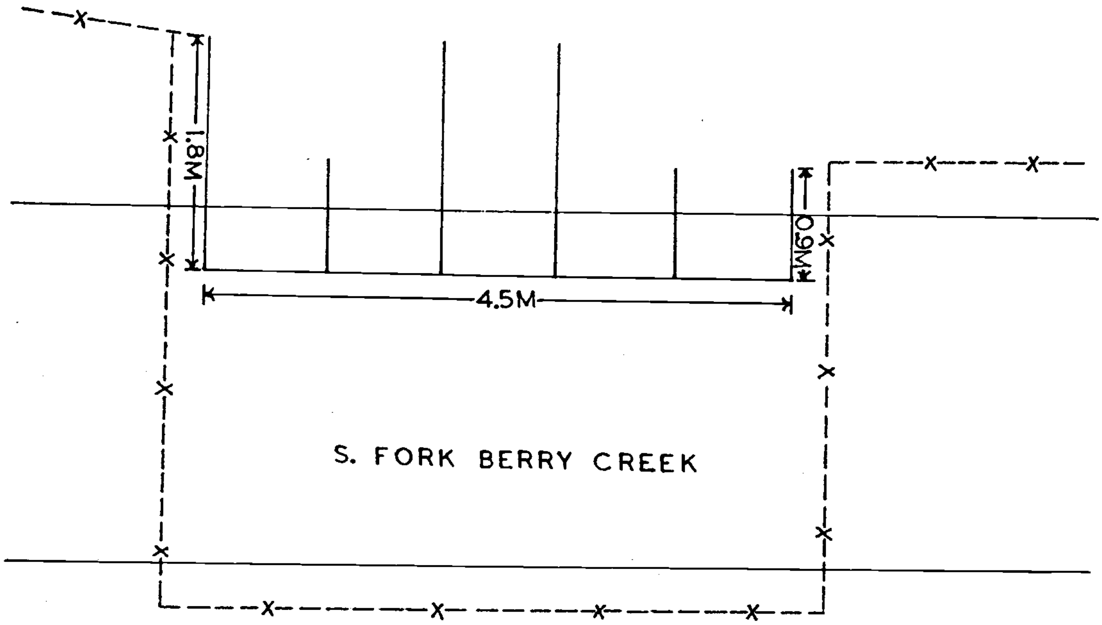


Figure 5. Map of Berry Creek, 1992, showing location of water gap and electric fence.



Electric Fence

Figure 6. Water gap configuration used at Berry Creek, 1992.

The cattle were monitored by both personal observation and by the use of a SanKyo Em-60XL super eight time-laps movie camera set to take one frame every one minute. The camera was equipped with a light sensor so as to take pictures only during day light hours. Pictures were taken four days after a new design was implemented to allow for acclimation to the new design.

IV. RESULTS

Experiment 1: Livestock Use of Riparian Area Before and After Installation of a Watering Trough

Stream

During Experiment 1 (June 24 - July 15), the amount of time the cattle spent in the stream decreased immediately when the water trough was installed (Table 1, Figure 7). The average number of minutes per cow per day before the implementation of the trough was 4.7, this dropped to 0.7 after the trough was installed. The day the trough was installed, (7-8-92) the photographed portion of the stream received a total of only fifteen minutes of use (0.1 minutes per cow per day).

A two sample t-test was run on the stream data using the information gathered before and after the trough was installed (testing the null hypothesis that the two samples were the same) to insure that the difference between the two data sets were valid. The t-test showed a difference with a P value <0.05.

Table 1. A summary of the stream use before and after the installation of the trough, Hall Ranch June 24 - July 15, 1992.

TIME	Average Minutes Per Hour of Use Before Trough Installation	Average Minutes Per Hour of Use After Trough Installation
5-6am	4	0
6-7am	20	0
7-8am	80	0
8-9am	57	0
9-10am	29	0
10-11am	62	0
11-12noon	62	1
12-1pm	50	15
1-2pm	81	25
2-3pm	74	23
3-4pm	76	12
4-5pm	55	21
5-6pm	50	10
6-7pm	19	0
7-8pm	0	0
8-9pm	0	0
Total	716.8	106.1
Minutes Per Cow Per Day	4.7 a	0.7 b

Different letters indicate significant differences ($P<0.05$).

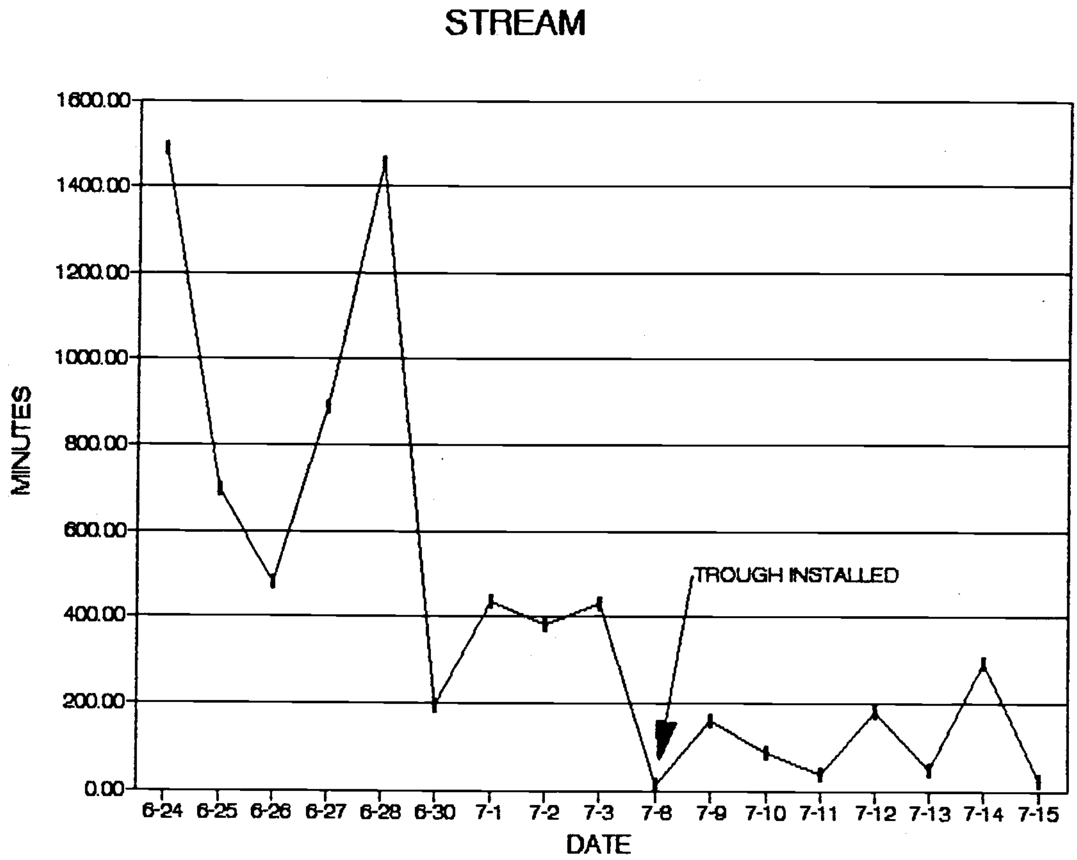


Figure 7. Summary of the stream use before and after installation of the watering trough on Pasture B of the Hall Ranch, June - July,1992.

Bottom Area

The data show a significant drop in the over-all use of the bottom area and an increase of use of the trough after installation (Table 2, Figure 8). The cattle spent a weighted average of 8.3 minutes per cow per day in the bottom area before the trough was installed. The bottom area received 3.9 minutes per cow per day after the trough was installed and the trough received 3.8 minutes per cow per day.

The daily data show that the majority of the use at the bottom area was between the hours of 12:00pm and 6:00pm both before the trough was installed and after (87% and 96% respectively). The trough received 93% of its use during the 12:00 noon to 7:00pm hours with 7% before noon and no significant use was observed after 7:00pm.

Table 2. A summary of weighted average daily minutes of cattle use of the bottom area and trough before and after trough installation, Hall Ranch June 24 - July 15, 1992.

Date	Minutes Per Day at Bottom Area Before Trough	Date	Minutes Per Day at Bottom Area After Trough	Minutes Per Day at Trough
6-24	2622	7-10	619	648
6-25	1091	7-11	521	682
6-26	1446	7-12	577	658
6-27	696	7-13	516	545
6-28	1220	7-14	683	506
6-30	154	7-15	660	451
7-2	1687			
Total	8,916.0		3,576.0	3,490.0
Average /Day	1,273.7		596.0	581.6
Minutes Per Cow Per Day	8.3 a		3.9 b	3.8 b

Different letters indicate significant differences ($P<0.05$).

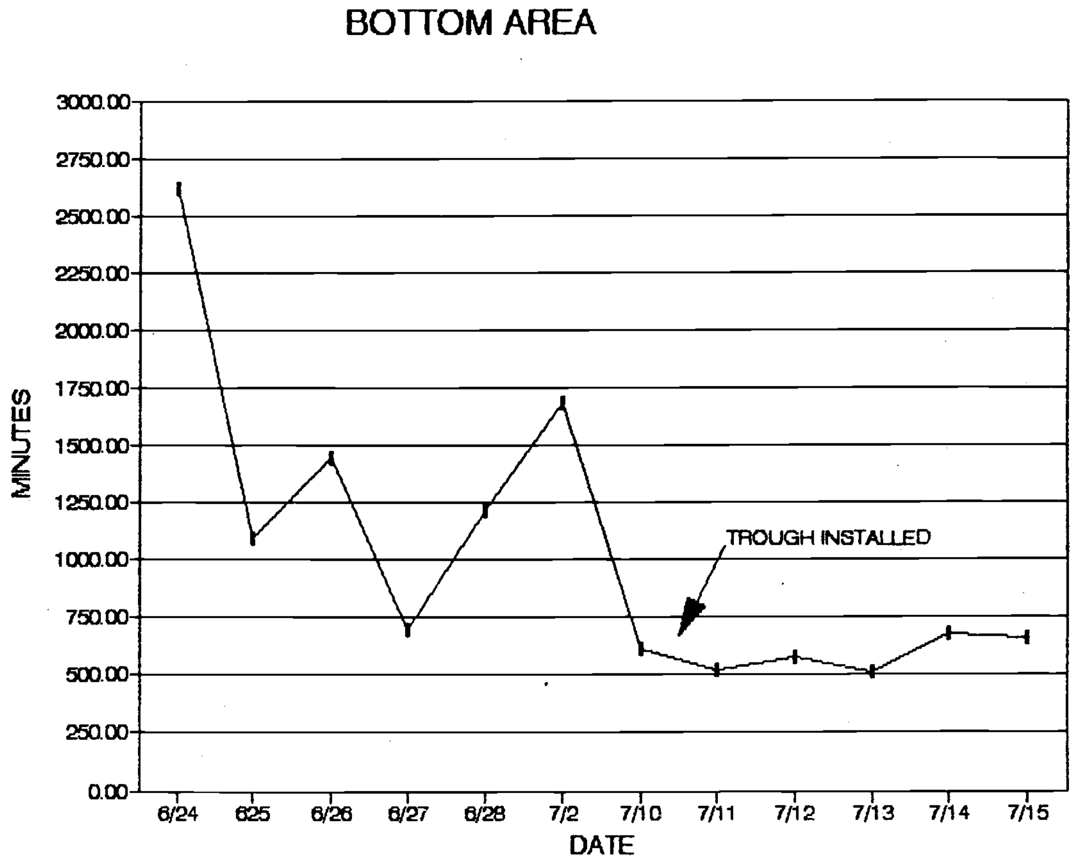


Figure 8. Summary of the bottom area use before and after installation of the watering trough on Pasture B of the Hall Ranch June - July, 1992.

<u>Experiment 2</u>: Livestock Use Patterns Around Riparian Area and Trough

During the period covering Experiment 2 (July 8, 9, 11, 12, 13, 14, and 15), cattle spent an average of 51.5 minutes per cow per day present in the riparian area and/or in the vicinity of the trough. Of these 51.5 minutes per cow per day, 3.4 minutes per cow per day (6.6% of the time present in the area) were spent drinking (Table 3,). Of the time spent drinking, the cattle drank from the trough 73.5% of the time (2.5 minutes per cow per day), from the bottom area 23.5% of the time (0.8 minutes per cow per day), and from the stream 3% (<0.1 minutes per cow per day [Figure 9]).

The greatest amount of drinking occurred between noon and 2:00pm (51% or 1.7 minutes per cow per day) with the 1:00pm to 2:00pm (29% or 1.0 minutes per cow per day) hour being the peak (Table 3, Figure 9). Very little drinking occurred before 12:00 noon (8.2% or 0.3 minutes per cow per day) or after 7:00pm (3% or <0.1 minutes per cow per day).

The maximum depth of the water in either the stream or the meadow bottom was 17.8cm (7in.) while the trough offered a depth of 53.3cm (21in.). The flow of water into the trough was substantial enough to keep the water depth at least 35.6cm (14in.).

Table 3. A summary of hourly drinking use by cattle at all available watering sites, Hall Ranch July 8 - 15, 1992.

TIME OF	TROUGH	BOTTOM	STREAM	TOTAL
5-6am	0	0	0	0.00
6-7am	0	0	0	0.00
7-8am	28	0	0	28.00
8-9am	7	0	0	7.00
9-10am	73	5	2	80.00
10-11am	13	0	4	17.00
11-12noon	127	37	1	165.00
12-1pm	600	168	28	796.00
1-2pm	654	364	22	1,040.00
2-3pm	331	75	4	410.00
3-4pm	264	77	0	341.00
4-5pm	259	59	0	318.00
5-6pm	186	72	2	260.00
6-7pm	27	6	0	33.00
7-8pm	94	3	0	97.00
8-9pm	13	0	0	13.00
TOTAL	2,676.0	866.0	63.0	3,592.0
Minutes Per Day	380.4	123.7	9.0	513.1
Minutes Per Cow Per Day	2.5 a	0.8 b	<0.1 c	3.4

Different letters indicate significant differences ($P<0.05$).

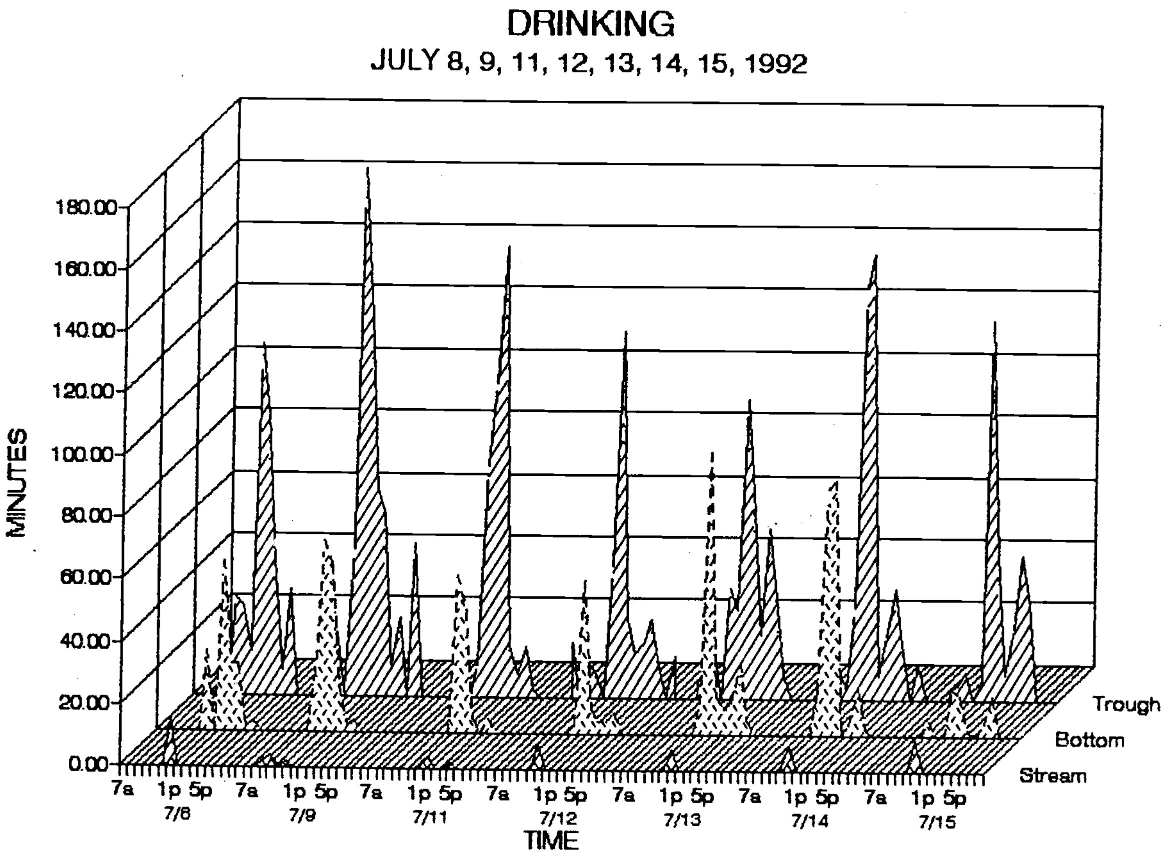


Figure 9. Summary of the cows daily watering times at the three watering locations of Pasture B on the Hall Ranch, July 1992.

The cattle spent 91.2% (47 minutes per cow per day) of the total 51.5 minutes per cow per day in the riparian area loafing. The majority (97.5% or 45.8 minutes per cow per day) of the loafing time occurred between 12:00 noon and 6:00pm as with drinking, but the peak times for loafing occurred between 2:00pm and 4:00pm (Table 4, Figure 10). One percent (or 0.4 minutes per cow per day) of the loafing time occurred before 12:00 noon and 1.5% (0.7 minutes per day per cow) occurred after 6:00pm.

The cattle spent more time loafing around the trough (26% or 12.2 minutes per cow per day) than they did loafing in the bottom area (13.4% or 6.3 minutes per cow per day [Table 4]), but spent the most time loafing at the stream (60.6% or 28.1 minutes per cow per day [Figure 10]).

Loafing time at the trough was spent standing; loafing time spent in the riparian zone was spent laying down. Each cow spent an average of one minute per day foraging in the riparian area, this accounted for 2.1% (1.1 minutes per cow per day) of the total time spent in the riparian area for all activities. The riparian area received the majority of its use from 12:00 noon to 6:00pm (90.1% or 1 minute per cow per day) with 3:00pm to 5:00pm being the peak hours(61.5% or 0.7 minutes per cow per day).

Table 4. A summary of hourly loafing use by cattle at all watering sites, Hall Ranch July 8 - 15, 1992.

TIME OF	TROUGH	BOTTOM	STREAM	TOTAL
5-6am	0	0	0	0
6-7am	0	0	0	0
7-8am	41	0	0	41
8-9am	5	0	0	5
9-10am	70	4	8	82
10-11am	7	0	45	52
11-12noon	216	33	26	275
12-1pm	1308	438	1552	3,298
1-2pm	3057	1472	4285	8,814
2-3pm	2458	1355	8252	12,065
3-4pm	1984	1274	8444	11,702
4-5pm	1775	1180	6164	9,119
5-6pm	1524	832	1305	3,661
6-7pm	348	157	0	505
7-8pm	229	2	0	231
8-9pm	41	0	0	41
TOTAL	13,063.0	6,747.0	30,081.0	49,891
Minutes Per Day	1,866.1	963.9	4,297.3	7,127
Minutes Per Cow Per Day	12.2 a	6.3 b	28.1 a	47

Different letters indicate significant differences (P<0.05).

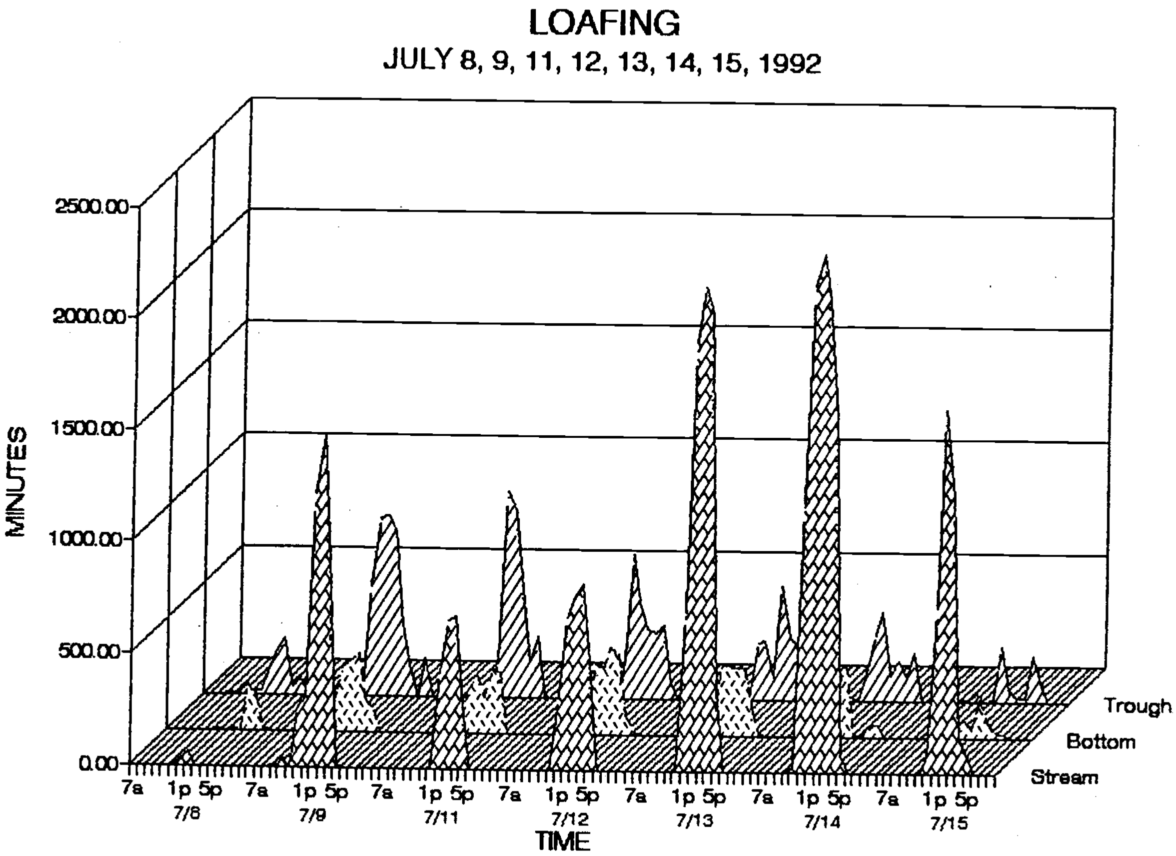


Figure 10. Summary of the cows loafing times at the three watering locations on Pasture B of the Hall Ranch, July, 1992.

The bottom area surrounding the spring was by far the most heavily utilized, receiving 90.9% (1 minute per cow per day) of the foraging use (Table 5, Figure 11). The trough received only 9.1% (<0.1 minutes per cow per day) of the foraging time, with the most use from 9:00am to 10:00am when small groups of cattle would trail in to water then leave. The stream received no significant foraging use. During an average day, with all activities combined, the stream area received the most use (55.3% or 28.2 minutes per day per cow) followed by the trough (28.8% or 14.7 minutes per day per cow), then the bottom area with 15.9% (8.1 minutes per day per cow) of use (Table 6, Figure 12).

Table 5. A summary of hourly foraging use by cattle at all watering sites, Hall Ranch July 8 - 15, 1992.

TIME OF	TROUGH	BOTTOM	STREAM	TOTAL
5-6am	0	0	0	0.0
6-7am	0	0	0	0.0
7-8am	0	0	0	0.0
8-9am	0	0	0	0.0
9-10am	14	0	0	14.0
10-11am	2	0	0	2.0
11-12noon	0	8	0	8.0
12-1pm	3	60	0	63.0
1-2pm	2	157	0	159.0
2-3pm	0	111	0	111.0
3-4pm	0	241	0	241.0
4-5pm	0	418	0	418.0
5-6pm	0	60	0	60.0
6-7pm	0	8	0	8.0
7-8pm	0	4	0	4.0
8-9pm	0	0	0	0.0
TOTAL	21.0	1,067.0	0.00	1,088.0
Minutes Per Day	3.0	152.4	0.0	155.4
Minutes Per Cow Per Day	<0.1 a	1.0 b	0.0 a	1.1

Different letters indicate significant differences ($P<0.05$).

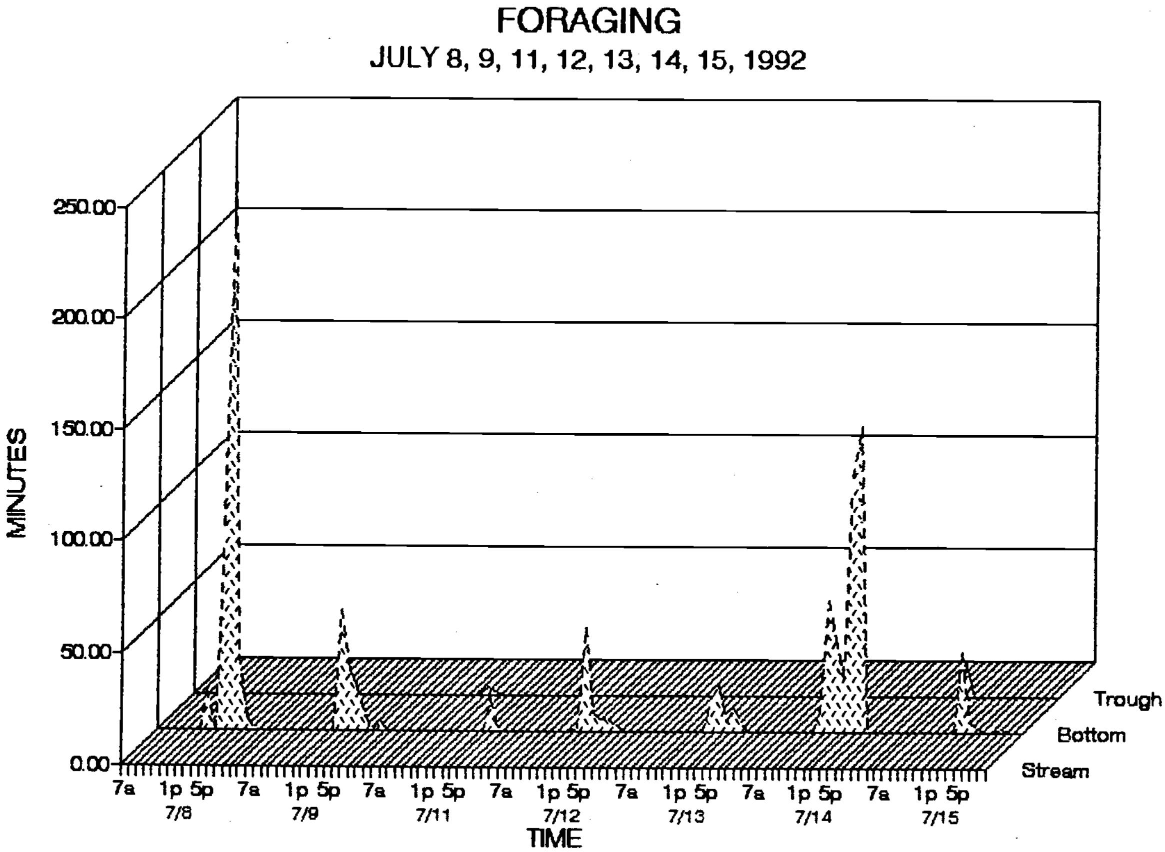


Figure 11. Summary of the cows foraging times at the three watering locations on Pasture B of the Hall Ranch, July, 1992.

Table 6. A summary of hourly use of all activities during an average day, Hall Ranch July 1992.

TIME OF DAY	TROUGH	BOTTOM	STREAM	VICINITY OF RIPARIAN AREA	UPLANDS
5-6am	0	0	0	0	9180
6-7am	0	0	0	0	9180
7-8am	9.9	0	0	1.2	9168.9
8-9am	1.7	0	0	0	9178.3
9-10am	22.4	1.3	1.4	1.7	9153.1
10-11am	3.2	0	7.1	0	9169.8
11-12pm	49.0	11.1	3.9	26.3	9089.7
12-1pm	272.6	108.0	226.4	511.3	8061.7
1-2pm	530.1	281.9	615.8	1425.2	6327.0
2-3pm	398.4	215.2	1179.6	2086.2	5300.6
3-4pm	321.1	213.3	1206.3	2411.7	5027.6
4-5pm	290.6	201.5	880.6	2271.7	5535.6
5-6pm	244.3	161.3	186.7	845.2	7742.5
6-7pm	53.6	44.4	0	17.2	9064.9
7-8pm	48.8	1.6	0	0	9129.5
8-9pm	7.8	0	0	0	9172.2
TOTAL	2,253.5	1,239.6	4,307.8	9,597.7	129,481
Minutes Per Day Per Cow	14.7 a	8.1 b	28.2 a	62.7	846.3

Different letters indicate significant differences ($P<0.05$).

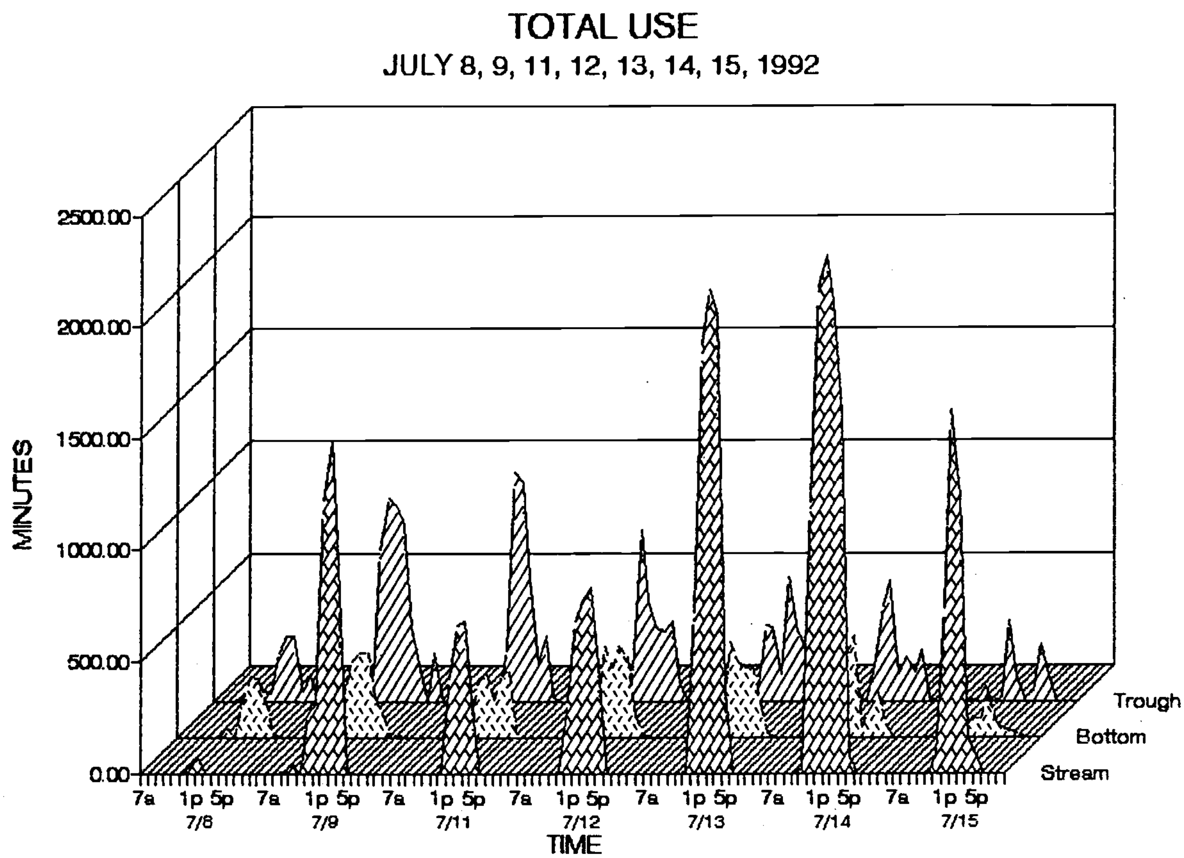


Figure 12. Summary of the cows use pattern at the three watering sites with all three activities (drinking, loafing, and foraging) combined. Hall Ranch, July, 1992.

Experiment 3: Water Gap Configurations

Restricted Use Area

The case study at Soap Creek (May 9, 10, 11, 12, 13, 14) showed a 14.3% decrease in the time cattle spent watering when the south chute was closed off. Time spent watering averaged 2.1 minutes per cow per day when two watering chutes were open and 1.8 minutes per cow per day when only one chute was open (Table 7).

With only one chute open the 124 cows used the water gap more heavily between noon - 1:00pm, 2:00 - 4:00pm, and 7:00 - 8:00pm. Interestingly, they used it less at other times of the day (Table 8).

The cattle spent an average of 4.8% more time adjacent to the watering area after the south chute was closed. When two chutes were open, 6.0 minutes per cow per day was spent in the adjacent area, this increased to 6.3 minutes per cow per day after the south chute was closed.

Table 7. A summary of daily minutes of use for two chutes open then one chute open, Soap Creek May 1992.

DATE	TWO CHUTES	WAITING AREA	DATE	ONE CHUTE	WAITING AREA
5-9	253	710	5-12	265	855
5/10	202	329	5-13	255	711
5/11	360	1196	5-14	174	776
Total	815.0	2,235.0		694.0	2,342.0
Average /Day	271.4	745.0		231.3	780.6
Minutes Per Cow Per Day	2.1 a	6.0 c		1.8 a	6.3 c

Different letters indicate significant differences ($P<0.05$).

Table 8. An average hourly summary of minutes of cattle use for two chutes open then one chute open, Soap Creek May 1992.

TIME OF DAY	BOTH CHUTES 5/9, 10, 11	ONE CHUTE 5/12, 13,14	STAGING AREA 5/9, 10, 11	STAGING AREA 5/12, 13, 14
6-7am	15.3	9.3	9.3	43.3
7-8am	12.6	23.7	35.3	80.8
8-9am	3.3	18.3	44.3	90.3
9-10am	15	13.3	26.3	51.7
10-11am	9.3	2.7	24.3	0.4
11-12noon	60.3	43.3	332.7	241.7
12-1pm	7.7	19	12.7	55.0
1-2pm	31.3	9.3	70.3	31.3
2-3pm	3.7	2.3	13.7	1.6
3-4pm	14.3	16.7	21.3	64.8
4-5pm	10.7	8.7	14.7	26.2
5-6pm	57.3	32.3	101.7	46.9
6-7pm	30.3	27.7	38.0	45.5
7-8pm	0.3	4.7	0.3	1.1
TOTAL	271.4	231.3	744.9	780.6
Minutes Per Cow Per Day	2.1 a	1.8 a	6.0 c	6.3 c

Different letters indicate significant differences ($P<0.05$).

Chute Length Considerations

The cattle spent an average of 1.4 minutes per cow per day watering over the course of the study and 13.3 minutes per cow per day in the watering area. The most time spent drinking or waiting occurred when two chutes were available for watering (3.1 and 25.4 minutes per cow per day respectively).

During the time from five to three chutes were open (January 3 - february 10, 1992), the cattle drank from the one 1.8 meter (6 ft.) deep chute 40% of the time and the other two to four 0.9 meter (3 ft.) deep chutes the other 60% of the time. The cattle showed no significant preference between the 1.8 meter (6 ft.) deep chute and the 0.9 meter (3 ft.) deep chutes.

Table 9. A summary of cattle use with variable numbers of chutes open, South Fork of Berry Creek January - April 1992.

# OF CHUTES OPEN	AVERAGE DAILY USE DRINKING	MINUTES PER COW PER DAY DRINKING	AVERAGE DAILY TIME IN AREA	MINUTES PER COW PER DAY IN AREA
5	2.6 a	0.1	65.6 a	2.8
4	24.5 b	1.0	235.8 b	9.8
3	13.7 bc	0.6	39 c	16
2	44.0 d	3.1	356.0 d	25.4
1	32.3 be	2.3	176.0 e	12.6
TOTALS		1.4		13.3

Different letters indicate significant differences ($P<0.05$).

Table 10. A summary of cattle use on various chutes depths, South Fork of Berry Creek January 23 - February 3, 1992.

CHUTE LENGTH AND PLACEMENT	3 FEET SOUTH	3 FEET SOUTH CENTER	6 FEET CENTER	3 FEET NORTH CENTER	3 FEET NORTH
TOTAL MINUTES OF USE	0 a	1 a	42 b	23 b	40 ab
% OF USE	0	1%	40%	22%	38%

Different letters indicate significant differences ($P<0.05$).

V. DISCUSSION

Experiment 1: Livestock Use of Riparian Area Before and After Installation of a Watering Trough

Before the trough was made available, the cattle had developed a fairly consistent pattern for watering. Small groups (seven head or fewer) of cattle would come to water in the morning hours and stay for a short duration (ten minutes or less). Over next three hours, from 11:00am till 2:00pm, large numbers of cattle (50-120 head) would trail in and remain till early evening hours (5:00-6:00pm). Usually the first activity the cattle would engage in after social greetings was watering. Before the trough was in place, most cattle would water first at the bottom area, then move off to the stream or begin foraging around in the bottom area. The stream and its adjacent banks provided little to no vegetation but plenty of shade and cool water. The bottom area was lush with phreataphytes and other very palatable plants.

After the trough was put in, the majority of the cattle would stop and drink (or at least socialize) before moving on to the stream or the bottom area. The trees adjacent to the trough started to become a popular place to loaf because of the shade and the closeness to the water.

Many times, as cows trailed into the area in large numbers, the trough was too crowded and many would move on to the bottom area or the stream to drink. A larger trough or another trough may have provided preferable watering over the stream or bottom area.

Stream

The amount of time the cattle spent in the area of the stream decreased 85% when the trough was installed. The cattle spent 4.7 minutes per cow per day at the stream before the implementation of the trough, this dropped 0.7 minutes per cow per day after the trough was installed. The daily variability of the use of the stream before the trough was installed may be attributed to climatic change as there was precipitation during the last days of June and the first days of July.

The photographed portion of the stream served as a representative sample. The day the trough was installed (7-8-92), the stream received a total of only fifteen minutes (<0.1 minutes per cow per day) compared to an average of 716.8 minutes per day (4.7 minutes per cow per day) prior to that. The continued low levels (0.7 minutes per cow per day) of use of the stream area indicates that the trough displaced the stream as a watering facility.

The two sample t-test run on the stream data supports the results of the effect the trough had on the stream use.

Bottom Area

The data shows a noticeable drop in the over-all use of the bottom area and an increase of use at the trough after installation (Table 2). The amount of time the cattle spent at the bottom area before the trough was installed (8.3 minutes per cow per day) is statistically equal to the combined use of the bottom area and the trough (3.9 minutes per cow per day and 3.8 minutes per cow per day respectively) after the trough was installed (Table 2). This would indicate that the trough did in fact reduce the amount of time spent in the bottom area and did not just offer another location for the cattle to visit above and beyond their normal use of the other areas.

The average daily data shows that the majority of the use at the bottom area was between the hours of 12:00pm and 6:00pm both before the trough was implemented and after (87% and 96% respectively). The trough received 93% of its use during the 12:00 noon to 7:00pm hours with 7% before noon and no significant use after 7:00pm. The timing of use corresponds closely to the continuous observation data from Experiment 2.

The data gathered from the stream and the bottom area indicate that the implementation of the watering trough altered the daily habits of the cattle - not only their drinking habits but also their loafing and to some extent their foraging habits. The most important observation from the data is the reduction of watering time at both the stream and the bottom area. As time spent near the stream is reduced, a corresponding reduction in fecal material deposited directly into the water occurs. With reduced fecal contamination, bacterial levels in the stream would probably be correspondingly reduced.

<u>Experiment 2</u>: Livestock Use Patterns Around Riparian Area and Trough

During this experiment (July 8, 9, 11, 12, 13, 14, and 15) the cattle drank for an average of 3.4 minutes per cow per day (Table 1) out of 51.5 minutes per cow per day spent in the riparian area. This corresponds closely to what Wagnon (1963) found in the annual grasslands of California (3 minutes) but differs from Sneva's (1970) and McInnis's (1985) findings in Eastern Oregon (17 and 26.6 minutes respectively).

The time spent drinking in each location indicates that the cattle preferred drinking from the trough over drinking from the stream or the bottom area (Figure 9). Of the 3.4 minutes per cow per day spent watering, the cattle drank from the trough 73.5% of the time, the bottom area 23.5% of the time, and the stream only 3% of the time.

The maximum depth of the water in either the stream or the meadow bottom was 17.8cm (7in.) while the trough offered a depth of 53.3cm (21in.). The flow of water into the trough was substantial enough to maintain a water depth of at least 35.6cm (14in.). The trough also elevated the surface of the water so the cattle did not have to stretch for a drink. The temperature in the stream was 11°C (52°F) while the trough was 13°C (56°F) and the bottom water was 16°C (60°F).

The cattle watered in both the stream and the bottom regularly before the trough was installed and then utilized the trough as well when it was installed, so water temperature probably did not seem to play a significant role in their choice of watering location.

The greatest number of cow minutes spent drinking, observed at all locations, occurred between 12:00 noon and 2:00pm with the 1:00pm to 2:00pm hour being the highest (Table 3). Very little drinking occurred before 12:00 noon (8.2% or 0.3 minutes per cow per day) and after 6:00pm (3.9% or <0.1 minutes per cow per day). 88% or 3 minutes per cow per day of drinking occurred between 12:00 noon and 6:00pm (Table 3).

During the time before 12:00 noon and after 6:00pm only small groups of cattle would trail in for a drink then leave, very little time was spent loafing or foraging. Between 12:00 noon and 6:00pm, large groups of cattle (up to 130 head) would trail in and spend long periods of time in the riparian areas involved in all three activities (drinking, loafing, and foraging).

Loafing was the predominant activity observed at all locations. The stream area received by far the most use. The cattle spent an average of 47 minutes per cow per day loafing (Table 6) in the riparian area.

As with drinking, the majority (97.4% or 45.8 minutes per cow per day) of the loafing time occurred between 12:00 noon and 6:00pm. However, the peak times for loafing occurred between 2:00pm and 4:00pm (Table 4). One percent (or 0.4 minutes per cow per day) of the loafing time occurred before 12:00 noon and 1.5% (0.7 minutes per cow per day) occurred after 6:00pm. From the observed daily pattern, the majority of the cattle tended to trail in around 12:00 noon, drink from either the trough or the bottom area and forage some, retire to the shade of the trees by the stream and spend two to three hours loafing (mostly laying down), then start to forage as they worked their way out of the riparian area.

The cattle spent more time loafing around the trough (26% or 12.2 minutes per cow per day) than they did loafing in the bottom area (13.4% or 6.3 minutes per cow per day [Table 4]), but spent the most time loafing at the stream (60.6% or 28.1 minutes per cow per day). Most of the loafing time at the trough was spent standing up whereas the loafing time spent in the riparian areas was spent laying down. This may be due to the shade provided by the trees around the stream, giving the cattle a cooler place to chew their cud.

Time spent foraging in the riparian areas was minimal (Table 5) as most of the forage had been removed during the three weeks prior to the trough being installed. The cattle spent an average of one minute per day foraging in the riparian area (Table 5). The riparian area received the majority of its use from 12:00 noon to 6:00pm (90.1% or 1 minute per cow per day) with 3:00pm to 5:00pm being the peak hours(61.5% or 0.7 minutes per cow per day). The bottom area surrounding the spring was by far the most heavily utilized, receiving 90.9% (1 minute per cow per day) of the foraging use (Table 5). The trough received only 9.1% (<0.1 minutes per cow per day) of the foraging time, with the most use from 9:00am to 10:00am when small groups of cattle would trail in to water then leave. The stream received no significant foraging use. The vegetation around the stream was minimal and in poor health due to the heavy utilization from cattle in the past, also, it was predominantly Cheatgrass (*Bromus tectorum*) which was dry and wolfy at that time of year.

During an average day, with all activities combined (Table 6), the stream area received the most use (55.3% or 28.2 minutes per cow per day) followed by the trough (28.8% or 14.7 minutes per cow per day), then the bottom area with 15.9% (8.1 minutes per cow per day) of use. It's important to note that the greatest use of the stream was for loafing (all but <0.1 minutes per cow per day for drinking) as this was the least impacting activity recorded in the sense that they were not removing vegetation or standing in the water drinking.

The data gathered from Experiments 1 and 2 seem to indicate that the installation of the watering trough altered the daily habits of the cattle - not only their drinking habits but also their loafing and to some extent their foraging habits.

The most important observation from the data is the reduction of watering time at both the stream and the bottom area. As time spent near the stream is reduced, a corresponding reduction in fecal material deposited directly into the water occurs. As fecal contamination is reduced, bacterial levels in the stream are also reduced.

Experiment 3: Water Gap Configurations

Restricted Use Area

One hundred and twenty-eight cows were used in the study at Soap Creek during May, 1992. Two, 0.9 meters (3 ft.) wide and 1.8 meters (6 ft.) deep watering chutes were the only available water for the cattle during the first part of the experiment. After three days, one chute was closed off.

The cattle watered an average of 2.1 minutes a day per cow with two chutes open and 1.8 minutes a day per cow with one chute open (Table 7). Time spent adjacent to the watering facilities (staging area) did not change statistically when availability changed. The reason the increase is small may be due to the fact that the cattle were never stressed for water. The cattle may have watered when the camera was not operating (night time), perhaps they found alternative sources of water (in puddles or small depressions), or it may be that their rain-soaked forage reduced their need to crowd around the open watering chute. The variation in total daily minutes in the adjacent waiting area was greater when two chutes were open (329 - 1196 minutes) vs one chute being open (711 - 855 minutes). The low number occurred on the second day (May 10, 1992) of the study. The low number of minutes at the waiting area corresponds with the low number of minutes at the chutes. The weather, which was cool and rainy on the low day and mostly sunny the following day, may account for the low use. Often, the cattle would trail into the watering area then loaf around, some would not even drink before leaving.

Cattle would frequently come to water in small groups (1-10 animals) but occasionally larger groups of fifty or more would arrive. With only 1.8 meters (6 ft.) of drinking area available, dominant cows and bulls would keep others from drinking (this occurred even with small groups watering). Sometimes the other cows would wait to drink and sometimes they would leave the area to come back another time.

When the two chutes were open and large groups were watering, the cattle would sometimes forcibly crowd in and enlarge the chutes to allow three cows to water at once. When access was reduced to one chute, 0.9 meters (3 ft.) wide, this occurred more often though only two cows could water instead of three.

Having at least two chutes open but not adjacent to each other would be a logical step to help alleviate the dominance problems. During times when more than one cow is watering, there might still be problems with cattle rough-housing around the facilities and trying to force their way into water. Structures must be built strongly enough to withstand this abuse or more area should be allocated for watering.

Chute Length Considerations

The study at Berry Creek consisted of 14-25 cows at one time with access to water starting at 4.6 meters (15 ft.) wide then going down to 0.9 meters (3 ft.) wide. Most of the days during the beginning of the study were overcast or rainy. This had an affect on the watering habits of the cattle as some days they would not even come to water; perhaps they were getting enough moisture from the forage in the pasture or were watering from puddles or small depressions. The cattle only watered for an average of 0.53 minutes per cow per day when up to three chutes were open, this average increased to 2.4 minutes per day when two and one chutes were open. This is most likely explained by the cool, wet days when five to three chutes were open and the warmer, dryer days when two and then one chutes were open. There is no significant data to support that having fewer chutes open caused the cattle to water longer or more frequently.

Very seldom would more than two cows come to water at once, and when two or more showed up, they would wait patiently until a chute was open. The cattle at Berry

Creek were older than the cows studied at Soap Creek and seemed to have their social structure solidly in place.

The cattle preferred using the middle chute which was 1.8 meters (6 ft.) deep, and one of the end chutes (to the far north) which was 0.9 meters (3 ft.) deep. The end chute had the gentlest slope leading into it (about 2%) as compared to the far south chute which had the steepest slope (about 12%) leading in. The far south chute received no use. The predominant use of the 1.8 meter (6 ft.) deep chute is interesting since 0.9 meter (3 ft.) deep chutes were available. This indicated that 1.8 meter (6 ft.) depth was not inconvenient for the cattle, even though it required them to take an extra two steps backwards to exit the chute. With this modest number of cattle, the number of chutes open did not seem to affect the time spent watering or waiting to water.

At neither Berry Creek and Soap Creek were there defecations which landed directly into the water, since the chutes prevented the cows from turning around once they had watered. The only exception to this was from calves suckling while their mothers were in the chute watering. The calves were small enough to get backwards in the chutes while nursing. This only occurred once, and in that instance the calf did not defecate into the water.

VI. CONCLUSIONS

The installation of the watering trough had a significant impact on cattle use of the riparian areas. The stream data shows a significant drop in cattle use of the stream after the trough was installed. The daily use per cow was 4.7 minutes before the trough was installed and 0.9 minutes after the trough was installed. The bottom area also had a significant drop in use after the trough was installed. Use dropped from 8.3 minutes per cow per day before the installation of the trough to 3.9 minutes per cow per day after the trough was installed.

Cattle preferred to drink from the watering trough over other sources of water available to them. Cattle watered 73.5% of the time at the watering trough compared to 23.5% at the bottom area and 3% at the stream. Cattle drank for an average of 3.4 minutes per day per cow, this accounted for 6.6% of the total time the cattle spent in the riparian area. The watering trough placed adjacent to the traditional watering places offered a convenient and preferred watering source which reduced the time the cattle spent in the riparian area.

Data from Experiment 2 indicated that the cattle have a daily pattern of use in the riparian area. The majority tended to trail in around 12:00 noon, drink and forage some while spending the afternoon loafing in shaded areas close to water.

Cattle spent little time foraging (1 minute per cow per day) at any of these watering locations. This activity accounted for only 2.1% of the time spent in the riparian area. This late in the growing season, the cattle were spending their foraging time in the uplands. Loafing was the predominant activity for the cattle at the sites. Each cow spent an average of 47 minutes per day loafing, this accounted for 91.2% of the time the cattle spent in the riparian area. Cattle preferred to loaf at the stream, spending 60.6% of their loafing time there.

Of the 51.4 minutes that each cow spent in the riparian area, 97.4% of the use fell between the hours of 12:00 noon to 6:00pm. During the morning and evening hours, the cattle used the riparian area mainly for watering purposes. This accounted for only 2.6% of the observed time.

In Experiment 3, there was no significant increase or reduction in watering time or time spent waiting to water, but water gaps, using the panels arranged in a comb configuration to form chutes, at both Soap Creek and Berry Creek completely eliminated fecal depositions into the water. Cattle showed no preference for the 0.9 meter verses the 1.8 meter deep chute.

VII. MANAGEMENT IMPLICATIONS AND FUTURE RESEARCH

Reducing cattle use of riparian areas by installing a watering trough adjacent to a stream can have a positive impact on the water quality. Most benefits are realized by reducing the amount of fecal material deposited in or around the stream. This study indicates that the cattle favored the trough over the stream or bottom area for drinking. Thus reducing the amount of time cattle would have otherwise spent drinking in the riparian area.

Future research should examine the role of riparian vegetation and its impact in trying to "draw" cattle away from riparian areas by using a watering trough. Experiment 2 was conducted after a majority of the riparian vegetation was removed by the cattle which may account for the low foraging use of the riparian areas.

Movement of the watering trough further away from the riparian area to test its effectiveness should also be considered as well as temperature and rate of flow of the water in the trough. The watering trough in experiments 1 and 2 was located on a major path to better "intercept" the cattle on their way to the riparian area.

Water rights and permit requirements may be required by individual state policies. Before implementing any off-site watering device, check local and state ordinances dealing with in-stream water removal.

Using a water gap to reduce the amount of fecal material entering a stream was very effective in this study. More research needs to include the effects of various widths and numbers of gaps to evaluate cattle responses and find optimal settings to use as a standard. Research on finding the optimal number of chutes to provide per number of cattle would also be good.

The case study at the Hall Ranch has applicability in mountainous, forested rangelands similar to the Blue Mountain sites where the study was conducted. I anticipate that a broader applicability exists, but further research is necessary before one could comfortably transfer these results to other ecosystems.

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APPENDICES

IX. APPENDICES

Appendix A. Additional Data for Experiment 1

Table A-1. Daily data for the stream before trough installation. Presented in minutes. Hall Ranch, Oregon June 24 - July 2, 1992.

DATE

	June						July		
TIME	24	25	26	27	28	30	1	2	3
5 am	0	32	0	0	0	0	0	0	0
6 am	0	109	16	4	21	32	0	0	0
7 am	286	128	0	50	235	12	0	7	0
8 am	268	0	0	0	138	94	0	13	0
9 am	97	6	0	5	137	0	0	8	7
10 am	280	115	0	3	85	10	11	7	51
11 am	122	16	14	147	147	36	0	10	63
12 pm	75	28	33	129	110	0	8	35	29
1 pm	42	0	0	153	203	0	40	173	115
2 pm	80	52	66	94	134	0	61	112	69
3 pm	125	4	8	176	142	13	10 0	17	97
4 pm	73	71	153	89	70	0	27	8	0
5 pm	17	110	79	34	22	0	18 4	0	0
6 pm	24	28	110	4	0	0	3	0	0
7 pm	0	0	0	0	0	0	0	0	0
8 pm	0	0	0	0	0	0	0	0	0

Table A-2. Daily data for the stream after trough installation. Presented in minutes. Hall Ranch, Oregon July 8 - July 15, 1992.

DATE

July

TIME	8	9	10	11	12	13	14	15
5 am	0	0	0	0	0	0	0	0
6 am	0	0	0	0	0	0	0	0
7 am	0	0	0	0	0	0	0	0
8 am	0	0	0	0	0	0	0	0
9 am	0	0	0	0	0	0	0	0
10 am	0	0	0	0	0	0	0	0
11 am	0	0	2	0	0	0	4	0
12 pm	0	30	24	0	0	0	66	0
1 pm	5	22	0	3	57	0	112	0
2 pm	10	42	25	0	28	13	66	0
3 pm	0	38	31	0	0	0	23	6
4 pm	0	27	7	0	97	18	13	4
5 pm	0	0	0	35	2	15	10	14
6 pm	0	0	0	0	0	0	0	0
7 pm	0	0	0	0	0	0	0	0
8 pm	0	0	0	0	0	0	0	0

Appendix B. Additional Data for Experiment 2.

Table B-1. Daily drinking data from continuous, personal data. Presented in minutes. Hall ranch July 8- 15, 1992.

DATE 7-8-92	TROUGH	BOTTOM	STREAM
7:00-8:00 AM	0	0	0
8:00-9:00 AM	0	0	0
9:00-10:00 AM	0	0	0
10:00-11:00 A	1	0	0
11:00-12:00 P	0	0	0
12:00-1:00 PM	31	0	0
1:00-2:00 PM	28	26	15
2:00-3:00 PM	14	0	0
3:00-4:00 PM	113	55	0
4:00-5:00 PM	90	22	0
5:00-6:00 PM	43	22	0
6:00-7:00 PM	8	1	0
7:00-8:00 PM	34	3	0
8:00-9:00 PM	0	0	0

7-9-92	TROUGH	BOTTOM	STREAM
7:00-8:00 AM	4	0	0
8:00-9:00 AM	3	0	0
9:00-10:00 AM	20	0	2
10:00-11:00 A	1	0	4
11:00-12:00 P	47	23	0
12:00-1:00 PM	170	61	2
1:00-2:00 PM	122	53	0
2:00-3:00 PM	66	15	0
3:00-4:00 PM	58	2	0
4:00-5:00 PM	10	4	0
5:00-6:00 PM	25	0	0
6:00-7:00 PM	0	0	0
7:00-8:00 PM	49	0	0
8:00-9:00 PM	0	0	0

7-11-92	TROUGH	BOTTOM	STREAM
7:00-8:00 AM	0	0	0
8:00-9:00 AM	0	0	0
9:00-10:00 AM	9	0	0
10:00-11:00 A	0	0	0
11:00-12:00 P	10	0	0
12:00-1:00 PM	74	0	0
1:00-2:00 PM	101	50	0
2:00-3:00 PM	145	39	4
3:00-4:00 PM	16	5	0
4:00-5:00 PM	7	0	0
5:00-6:00 PM	16	5	2
6:00-7:00 PM	2	0	0
7:00-8:00 PM	0	0	0
8:00-9:00 PM	0	0	0

7-12-92	TROUGH	BOTTOM	STREAM
7:00-8:00 AM	17	0	0
8:00-9:00 AM	0	0	0
9:00-10:00 AM	11	0	0
10:00-11:00 A	8	0	0
11:00-12:00 P	0	0	0
12:00-1:00 PM	42	3	8
1:00-2:00 PM	118	49	0
2:00-3:00 PM	25	8	0
3:00-4:00 PM	14	4	0
4:00-5:00 PM	17	4	0
5:00-6:00 PM	25	7	0
6:00-7:00 PM	10	0	0
7:00-8:00 PM	0	0	0
8:00-9:00 PM	13	0	0

Table B-1 continued: Daily drinking data from continuous, personal data. Presented in minutes. Hall ranch July 8- 15, 1992.

DATE

7-13-92	TROUGH	BOTTOM	STREAM
7:00-8:00 AM	5	0	0
8:00-9:00 AM	0	0	0
9:00-10:00 AM	15	0	0
10:00-11:00 A	0	0	0
11:00-12:00 P	35	0	0
12:00-1:00 PM	28	10	0
1:00-2:00 PM	96	91	7
2:00-3:00 PM	66	12	0
3:00-4:00 PM	20	8	0
4:00-5:00 PM	54	10	0
5:00-6:00 PM	29	23	0
6:00-7:00 PM	7	5	0
7:00-8:00 PM	0	0	0
8:00-9:00 PM	0	0	0

7-14-92	TROUGH	BOTTOM	STREAM
7:00-8:00 AM	0	0	0
8:00-9:00 AM	0	0	0
9:00-10:00 AM	9	0	0
10:00-11:00 A	3	0	0
11:00-12:00 P	29	14	1
12:00-1:00 PM	133	79	8
1:00-2:00 PM	143	82	0
2:00-3:00 PM	7	0	0
3:00-4:00 PM	20	3	0
4:00-5:00 PM	35	15	0
5:00-6:00 PM	17	2	0
6:00-7:00 PM	0	0	0
7:00-8:00 PM	11	0	0
8:00-9:00 PM	0	0	0

7-15-92	TROUGH	BOTTOM	STREAM
7:00-8:00 AM	2	0	0
8:00-9:00 AM	4	0	0
9:00-10:00 AM	9	5	0
10:00-11:00 A	0	0	0
11:00-12:00 P	6	0	0
12:00-1:00 PM	122	15	10
1:00-2:00 PM	46	13	0
2:00-3:00 PM	8	1	0
3:00-4:00 PM	23	0	0
4:00-5:00 PM	46	4	0
5:00-6:00 PM	31	13	0
6:00-7:00 PM	0	0	0
7:00-8:00 PM	0	0	0
8:00-9:00 PM	0	0	0

Table B-2. Daily loafing data from continuous, personal data. Presented in minutes. Hall ranch July 8-15, 1992.

DATE 7-8-92	TROUGH	BOTTOM	STREAM
7am	0	0	0
8am	0	0	0
9am	0	0	0
10am	1	0	0
11am	0	0	0
12pm	29	0	0
1pm	17	4	29
2pm	14	0	64
3pm	104	7	0
4pm	199	4	2
5pm	248	209	0
6pm	35	148	0
7pm	72	2	0
8pm	0	0	0

DATE 7-9-92	TROUGH	BOTTOM	STREAM
7am	0	0	0
8am	3	0	0
9am	2	0	6
10am	1	0	45
11am	74	8	0
12pm	502	114	269
1pm	789	287	315
2pm	804	310	1226
3pm	738	347	1490
4pm	315	152	812
5pm	107	90	11
6pm	0	0	0
7pm	167	0	0
8pm	0	0	0

DATE 7-11-92	TROUGH	BOTTOM	STREAM
7am	0	0	0
8am	0	0	0
9am	4	0	0
10am	0	0	0
11am	0	0	0
12pm	149	0	0
1pm	917	191	1
2pm	832	252	421
3pm	536	161	668
4pm	160	284	682
5pm	269	275	284
6pm	10	0	0
7pm	0	0	0
8pm	0	0	0

DATE 7-12-92	TROUGH	BOTTOM	STREAM
7am	37	0	0
8am	0	0	0
9am	7	0	0
10am	5	0	0
11am	0	0	0
12pm	96	15	0
1pm	644	307	323
2pm	426	290	685
3pm	311	392	776
4pm	292	355	835
5pm	329	80	482
6pm	59	2	0
7pm	0	0	0
8pm	41	0	0

Table B-2 continued: Daily loafing data from continuous, personal data. Presented in minutes. Hall Ranch July 8-15, 1992.

DATE	TROUGH	BOTTOM	STREAM
7-13-92			
7am	3	0	0
8am	0	0	0
9am	13	1	2
10am	0	0	0
11am	17	0	0
12pm	9	2	0
1pm	247	321	710
2pm	261	310	1919
3pm	103	301	2160
4pm	507	300	2060
5pm	280	107	376
6pm	244	7	0
7pm	0	0	0
8pm	0	0	0

DATE	TROUGH	BOTTOM	STREAM
7-14-92			
7am	0	0	0
8am	0	0	0
9am	12	0	0
10am	0	0	0
11am	120	25	26
12pm	288	229	1207
1pm	389	324	2168
2pm	110	19	2317
3pm	176	0	2106
4pm	96	48	1612
5pm	208	53	81
6pm	0	0	0
7pm	0	0	0
8pm	0	0	0

DATE	TROUGH	BOTTOM	STREAM
7-15-92			
7am	1	0	0
8am	2	0	0
9am	32	3	0
10am	0	0	0
11am	5	0	0
12pm	235	78	76
1pm	54	38	739
2pm	11	174	1620
3pm	16	66	1244
4pm	206	31	161
5pm	83	18	71
6pm	0	0	0
7pm	0	0	0
8pm	0	0	0

Table B-3. Daily foraging data from continuous, personal data. Presented in minutes. Hall Ranch, Oregon. July 8-15, 1992.

DATE	TROUGH	BOTTOM	STREAM	DATE	TROUGH	BOTTOM	STREAM
7-8-92				7-9-92			
7AM	0	0	0	7AM	0	0	0
8AM	0	0	0	8AM	0	0	0
9AM	0	0	0	9AM	0	0	0
10AM	1	0	0	10AM	1	0	0
11AM	0	0	0	11AM	0	0	0
12PM	0	0	0	12PM	0	54	0
1PM	0	4	0	1PM	0	26	0
2PM	0	0	0	2PM	0	21	0
3PM	0	7	0	3PM	0	13	0
4PM	0	4	0	4PM	0	21	0
5PM	0	209	0	5PM	0	7	0
6PM	0	148	0	6PM	0	0	0
7PM	9	2	0	7PM	0	4	0
8PM	0	0	0	8PM	0	0	0

DATE	TROUGH	BOTTOM	STREAM	DATE	TROUGH	BOTTOM	STREAM
7-11-92				7-12-92			
7AM	0	0	0	7AM	0	0	0
8AM	0	0	0	8AM	0	0	0
9AM	0	0	0	9AM	0	0	0
10AM	0	0	0	10AM	0	0	0
11AM	0	0	0	11AM	0	0	0
12PM	0	0	0	12PM	0	2	0
1PM	0	0	0	1PM	0	46	0
2PM	0	0	0	2PM	0	8	0
3PM	0	0	0	3PM	0	5	0
4PM	0	0	0	4PM	0	6	0
5PM	0	0	0	5PM	0	3	0
6PM	0	0	0	6PM	0	0	0
7PM	0	0	0	7PM	0	0	0
8PM	0	0	0	8PM	0	0	0

Table B-3 continued: Daily foraging data from continuous, personal data. Presented in minutes. Hall Ranch, Oregon. July 8-15, 1992.

DATE	TROUGH	BOTTOM	STREAM
7-13-92	0	0	0
7AM	0	0	0
8AM	0	0	0
9AM	0	0	0
10AM	0	0	0
11AM	0	0	0
12PM	0	0	0
1PM	0	15	0
2PM	0	21	0
3PM	0	4	0
4PM	0	10	0
5PM	0	3	0
6PM	0	0	0
7PM	0	0	0
8PM	0	0	0

DATE	TROUGH	BOTTOM	STREAM
7-14-92			
7AM	0	0	0
8AM	0	0	0
9AM	0	0	0
10AM	0	0	0
11AM	0	8	0
12PM	0	58	0
1PM	0	42	0
2PM	0	24	0
3PM	0	113	0
4PM	0	137	0
5PM	0	1	0
6PM	0	0	0
7PM	0	0	0
8PM	0	0	0

DATE	TROUGH	BOTTOM	STREAM
7-15-92			
7AM	0	0	0
8AM	0	0	0
9AM	14	0	0
10AM	0	0	0
11AM	0	0	0
12PM	0	36	0
1PM	0	4	0
2PM	0	2	0
3PM	0	0	0
4PM	0	0	0
5PM	0	2	0
6PM	0	0	0
7PM	0	0	0
8PM	0	0	0

Appendix C. Additional Data for Experiment 3.

Table C-1. Daily use of water gap and staging area with two chutes open. Soap Creek, Oregon. May 9-11, 1992.

	5/9		5/10		5/11	
TIME	chute	stage	chute	stage	chute	stage
6 am	18	0	20	20	8	8
7 am	31	99	2	7	5	0
8 am	10	133	0	0	0	0
9 am	16	57	19	16	10	6
10 am	20	48	3	9	5	16
11 am	18	76	0	0	173	922
12 pm	0	0	23	38	0	0
1 pm	45	112	30	72	19	27
2 pm	0	0	0	0	11	41
3 pm	3	6	37	58	3	0
4 pm	0	0	0	0	32	44
5 pm	89	178	22	47	61	80
6 pm	2	1	46	62	43	52
7 pm	1	0	0	0	0	0

Table C-2. Daily use of water gap and staging area with one chute open. Soap Creek, Oregon. May 12-14, 1992

	5/12		5/13		5/14	
TIME	chute	stage	chute	stage	chute	stage
6 am	17	107	11	23	0	0
7 am	21	66	50	174	0	0
8 am	0	0	55	271	0	0
9 am	19	38	21	117	0	0
10 am	8	1	0	0	0	0
11 am	9	34	29	31	92	663
12 pm	30	133	4	0	23	29
1 pm	25	91	0	0	3	2
2 pm	0	0	0	0	7	4
3 pm	50	193	0	0	0	0
4 pm	16	68	10	10	0	0
5 pm	19	24	36	41	42	75
6 pm	49	101	31	33	3	1
7 pm	10	2	0	0	4	1