Effect of Various Grazing Systems on Type and Density of Cattle Trails

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Abstract

Number and kinds of cattle trails may have a dramatic impact on relative amount of bare soil and subsequently on amount and rate of soil erosion. The objective of this study was to quantify the effect of a cell-designed, rotational grazing treatment (RG) on density and kinds of cattle trails. Density of cattle trails in the RG treatment was compared to those in heavy continuous (HC), moderate continuous (MC), and deferred rotation (DR) treatments at 4 distances from water. There were no differences among the HC, MC, and DR treatments in density of trails. Trail densities ranged from 14/km near water sources to 9/km at the far end of the pastures. This compares to the RG treatment where trail densities ranged from 164/km near the cell center to 24/km at the far end of the paddock. The effect of increasing the RG treatment from 14 to 42 paddocks was also investigated. Subdivision of paddocks increased trail densities near the center from 32/km to 57/km with no increase noted at the far ends of the paddocks. It is concluded that implementation of a cell-designed, RG system will cause a significant increase in density and number of cattle trails particularly near the cell center.

The advent of intensive rotational grazing systems on rangeland may affect many aspects of the ecosystem. The importance of hoof action as one of the factors necessary for successful application of rotational grazing is a point of contention (Savory and Parsons 1980, Heitschmidt and Walker 1983); however, one indisputable consequence of hoof action is formation of cattle trails. Cattle trails generally connect favored grazing, resting, and watering areas and can be an important factor contributing to soil erosion. Trails usually form along routes of least resistance such as crest of ridges, in valleys, or parallel to contour lines (Weaver and Tomaneck 1951, Arnold and Dudzinski 1978, Oikawa et al. 1981). On heavily stocked mountain pastures, cattle trails created bare ground on 18 to 25% of the pasture when slopes were varied from 18° to 28° (Oikawa et al. 1981).

The purpose of this study was to investigate the effect of type of grazing system and distance from water on density and type of cattle trails. Our hypotheses were: (1) number of cattle trails per unit area of land would be greater in an intensive rotational grazing system than in 3 extensive grazing treatments; (2) density of cattle trails and proportion of heavily used trail types would increase close to water; and (3) number of cattle trails would increase in the rotational system as number of paddocks was increased.

Methods

Research was conducted at the Texas Experimental Range located (99° 14′W, 33° 20′N) in the eastern portion of the Rolling Plains. Two experiments were conducted. The first experiment compared the effect of 4 grazing treatments on trail density (hypothesis 1 and 2). The second experiment investigated the effect of number of paddocks in a rotational grazing system on trail density (hypothesis 3). All pastures were stocked with mature Angus × Hereford cow/calf pairs.

Methods of sampling were the same for both experiments. Each pasture was subdivided into 4 zones. Each zone was of equal width as measured along the longest side of the pasture. This procedure for stratifying pastures into zones was used because pasture shapes and water locations varied and concentric zones would not have been practical for some pastures. Zones were classified according to relative distance from water. Zone 1 encompassed the water source for a pasture and zone 4 was located farthest from the water source. Density of cattle trails in each zone was estimated by counting number of trails intersecting 3 randomly located line transects. All transects were oriented perpendicular to the longest side of a pasture. Transects ran the entire width of a pasture.

Cattle trails intersected by a transect were classified as one of 3 types (Fig. 1). Category A or primary trails were identified as extending below the adjacent soil surface and void of vegetation. Category B or secondary trails were identified as level with or extending only slightly below the adjacent soil surface and supporting intermittent vegetation. Category C or tertiary trails were identified as level with the adjacent soil surface and supporting sparse but continuous vegetation. Trail density (trails/km) for each type of trail was calculated by dividing the number of trails by the length of the transect.

Experiment 1

Cattle trail density was sampled in 4 grazing treatments. Grazing treatments included yearlong continuous grazing at heavy (HC) and moderate (MC) rates of stocking, a 4-pasture, 3-herd deferred rotation (DR) system, and a rotational grazing (RG) treatment. Pastures in the HC and MC treatments were about 243 ha each and were stocked at 5 and 6 ha/cow/yr, respectively. The DR pastures were about 111 ha each. Pastures in this treatment are alternately grazed for 12 months and rested for 4 months. The DR grazing treatment was stocked at 6 ha/cow/yr and provided a livestock density of 4.5 ha/cow. The 1-herd RG grazing treatment consisted of 14 paddocks with an average size of 33 ha. Paddocks were grazed for 2 to 5 days with corresponding rest periods of 26 to 65 days. Stocking rate in the RG treatment was 3.7 ha/cow/yr with an average stock density of 0.3 ha/cow. Paddocks were fenced in a cell design with fences radiating from a centrally located watering facility. The length of the paddocks in the RG treatment was about 1.5 km. The HC, MC, and DR pastures used in this study had been subjected to the same grazing treatment for 25 years. The RG treatment had been established for 1 year. Prior to the establishment of the RG treatment the area where the cell was located was in 4 pastures that received a variety of grazing treatments; but, antecedent to the RG treatment, this area was continuously grazed at a moderate stocking rate.

Cattle trail density was analyzed for effect of grazing treatment, relative distance from water (i.e., zone), and type of trail utilizing a 4×4×3 factorial analysis of variance model. The model included all 2 and 3-way interactions. Data were transformed with a $\log_{10}(x+1)$ transformation prior to statistical analyses because standard deviations of the means were proportional to the means, and Bartlett's test for homogeneity of variance indicated variances were not equal ($P<0.001$) among treatments. Variances of the transformed data were equal ($P>0.50$). Mean separation was performed using 48 orthogonal single degree of freedom contrasts. Grazing treatment contrasts compared RG to all other treatments; HC and MC to DR, and HC to MC. The 4 distances from water were tested for linear, quadratic, and cubic effects. Trail type was

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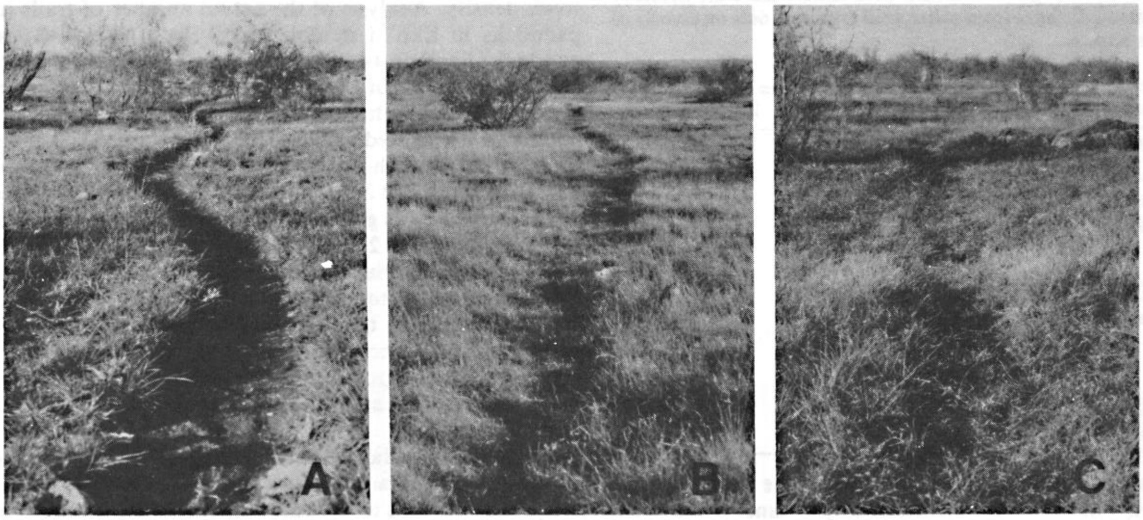

Fig. 1. *Three types of cattle trails (A, B, C) based on relative use.*

tested for linear and quadratic effects. All possible 2 and 3-way combinations of main effect contrasts were tested. Data analyses were performed using the SAS general linear models procedure (SAS Institute 1982).

Because trail density was highly dependent on shape of pasture in the cell-designed RG treatment, an additional analysis was performed on the data from this treatment using actual number of trails per transect. These data were analyzed for effect of zone and type of trail. Orthogonal single degree of freedom contrasts were used for mean separation.

Experiment 2

Experiment 2 studied the effect of dividing a 30-ha paddock in the previously described 14-paddock RG treatment (RG-14) into 3 paddocks. The three 10-ha paddocks then simulated a 42-paddock RG treatment (RG-42). Stocking rate in both RG-42 and RG-14 paddocks remained equal (i.e., 3.7 ha/cow/yr) after the subdivision; however, length of graze and stock density differed by a factor of 3 because cattle grazed the RG-42 paddock for 1/3 as long as the RG-14 paddocks and stock density was 3 times greater in the RG-42 than the RG-14 (0.1 and 0.3 ha/cow, respectively). The subdivided paddock and an adjacent paddock were sampled for density of cattle trails immediately before and 2 years after the division. The initial sample was taken after the RG treatment had been in place for 1 year. The same transects were read on both sample dates.

Data were analyzed for effects of grazing treatment, zone, trail type, and date (i.e., before vs after) using a repeated measures analysis of variance with date as the subplot. Mean variation was performed using orthogonal single degree of freedom contrasts.

Results

Experiment 1

Although there were significant contrasts at all levels (i.e., main effects, 2-way and 3-way interactions), variations in the data were primarily explained by the main effect contrasts for grazing treatment and the 3-way interaction of treatment × distance × type [i.e., specifically RG vs HC, MC, DR × distance linear × type linear (Table 1)]. Other statistically significant lower order contrasts were judged biologically meaningless because of the presence of this specific 3-way interaction.

Cattle trail density was greater in the RG treatment compared to the HC, MC, and DR treatments for all trail types and zones (Fig. 2). Mean trail density in the RG, weighted by the proportion of pasture in each zone, was about 4 times greater than in the other

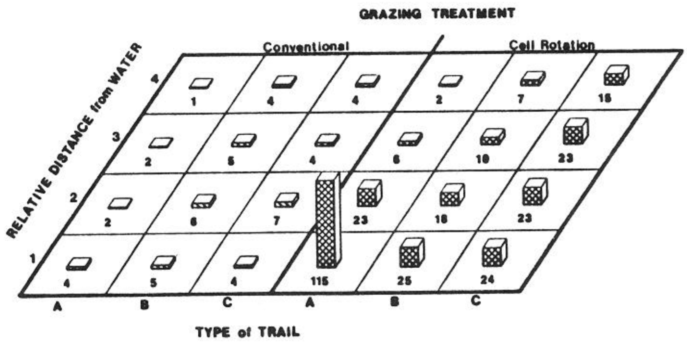

Fig. 2. *Cattle trail density (trails/km) in conventional (i.e., mean of HC, MC, and DR treatments) and RG treatment by type of trail and relative distance from water.*

treatments. The 3-way interaction contrast of RG vs HC, MC, DR × distance linear × type linear was caused by a distance linear × type linear interaction in the RG treatment compared to conventional treatments where a zone × type interaction did not exist. The distance linear × type linear interaction in the RG treatments was caused by a linear decrease in trail density from primary to tertiary types of trails in the 2 zones closest to water, and conversely, a linear increase in trail density from primary to tertiary types in the 2 zones farthermost from water in the RG treatment. Magnitude of change in trail density caused by zone and trail type in the RG treatment was much greater than in the other treatments.

Table 1. Significant orthogonal contrast used to determine the effects of grazing treatment, distance from water, and trail type on the density of cattle trails in Exp. 1.

Contrast	Probability
Main Effects	
RG vs HC, MC, DR	.0001
Distance from water, linear	.0012
Trail type, linear	0.206
2-Way Interactions	
Distance linear × type linear	.0012
RG vs HC, MC, DR × distance linear	.0099
3-Way Interactions	
RG vs HC, MC, DR × distance linear × type linear	.0013

Table 2. Significant orthogonal contrasts used to determine the effects of grazing treatment, distance from water, trail type, and date on density of cattle trails in Exp. 2.

Contrast	Probability
Main Effects	
Distance from water, linear	.0003
Trail type, linear	.0241
Trail type, quadratic	.0865
Date (before vs after)	.0266
2-Way Interactions	
Treatment $\times$ date	0.133
Distance linear $\times$ type quadratic	.0427
Distance linear $\times$ date	.0159
3-Way Interactions	
Treatment $\times$ date $\times$ distance linear	.0861

Analysis of number of trails per transect from the RG treatment indicated number of trails was not affected by distance from water or type, but distance linear $\times$ type linear interaction was significant. This interaction was caused by an increase in tertiary trails compared to a decrease in primary trails as distance from the cell center increased.

Experiment 2

Although there were several significant contrasts in experiment 2 (Table 2), the essence of this experiment was demonstrated by the treatment x date and the treatment x date x distance linear interactions. The treatment x date interaction showed that subdividing rotationally grazed padocks (i.e., RG-42, after subdivision) increased trail density compared to the control treatment [(i.e., RG-14) Fig. 3]. The treatment $\times$ date $\times$ distance linear interaction showed that increased trail density after subdividing the RG-42

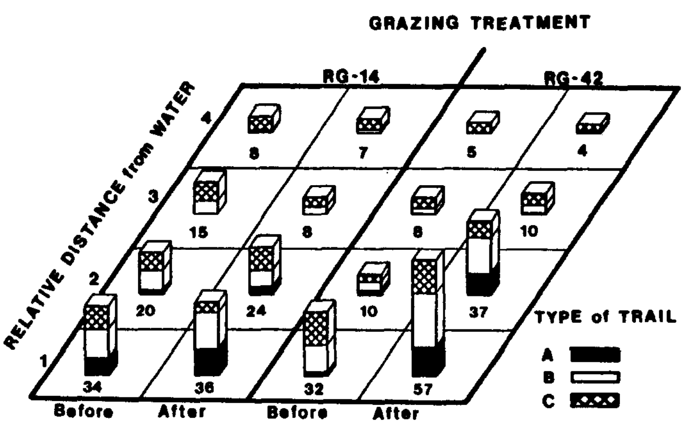

Fig. 3. *Cattle trail density (trails/km) by type of trail and relative distance from water in RG-14 and RG-42 paddock RG treatments before and 2 years after subdivision.*

treatment was caused by an increase in the number of trails in the 2 zones nearest the cell center. Trail density in the RG-14 treatment which was not subdivided did not change between dates.

Discussion

The HC, MC, and DR grazing treatments were similar in terms of cattle trail density. Formation of cattle trails was probably dependent primarily upon topography and other obstacles which hindered free movement in these grazing systems. Lange (1969) reported that density of sheep tracks on continuously grazed pastures was affected by density of bushes that were circumvented and did not vary because of distance from water. Greater density of trail in the RG treatment compared to the other treatments was presumably caused by the interaction of paddock shape and high stock density. Analysis of the actual number of trails in the RG paddocks in Exp. 1 demonstrated the effect of the triangular paddock shape on trail density and degree of use. This analysis indicated number of trails did not differ as distance from water increased. The high trail density in zones 1 and 2 of the RG paddocks was caused by their triangular shape and resultant short transect lengths. The greater number of primary and secondary trails in zones 1 and 2 indicated that in the area near the cell center either total use was greater or travel was primarily on established trails. Experiment 2 showed the effect of stock density on the density of cattle trials. Subdividing the paddock in the RG-42 treatment tripled stock density and resulted in an increase in the density of trails in this treatment. Increased trail density in the RG-42 treatment occurred in zones 1 and 2, which further supports the hypotheses proposed earlier that either more animal use occurs in these zones or travel within these zones tends to be limited to established trails.

These studies indicate that in a cell-designed, rotational grazing system, the zone nearest the cell center, which contains about 6% of the paddock, tends to become a sacrifice area because of the high density of trails. Based on the estimated density of cattle trails found in zone 1 of the rotationally grazed paddocks in these studies, 3–5% of the area in zone 1 is directly affected by trails if the width of cattle trials is assumed to be 30 cm (Oikawa et al. 1981). In certain topographical situations a cell-designed, fencing arrangement may cause livestock trails to develop on highly erodible areas such as on steep slopes and further subdivision will only aggravate this problem. Voisin (1959) warned against narrow paddocks because the constriction causes excessive trampling of narrow parts. He also showed that rectangular paddocks require less fence than cell-designed paddocks. If the grazing cell used in the present study had been divided into rectangular paddocks with a 15-m-wide corridor in the middle it would have required 17% less fence than the cell-designed paddock and the corridor would contain less than 1% of the pasture. Depending on the amount of area affected by trail formation at the gates leading to the corridor, the total area lost to cattle trails may be reduced by rectangular paddocks.

Finally, the results of this study contradict the belief that cattle trails will not develop on range that is rotationally grazed. Trail formation is essentially an edaphic manifestation of livestock behavior. Cattle tend to move between locations in a pasture in a single file along the route of least resistance (Weaver and Tomanek 1951, Arnold and Dudzinski 1979). This innate behavioral characteristic eventually destroys the vegetation on the route and creates a trail. Under rotational grazing, trail formation is determined by the extent of vegetation destruction during the grazing period versus the extent of revegetation during the rest period. The results of this study showed that under the management system imposed on our rotationally grazed treatment the extent of vegetation destruction along routes of cattle movement were greater than the extent of revegetation during the rest periods. We believe this will normally be the case under any type of rotational grazing because vegetation destruction along cattle routes occurs rapidly when stock density is high, but plant establishment on bare soil in most grassland ecosystems is an extremely slow process.

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