Short Duration Grazing in Central New Mexico: Effects on Infiltration Rates

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Abstract

The objectives of this study were to determine the influence of short duration grazing, continuous grazing, and grazing exclusion on infiltration rates on 2 range sites in southcentral and eastcentral New Mexico.

Short duration grazing had no beneficial effect on the hydrology of 2 different range sites. The terminal infiltration rates of both short duration grazing systems, after the cattle had grazed the area, were about one-half the terminal infiltration rate of the same area before the cattle grazed the area. Cattle distribution within the different grazing treatments had no effect on infiltration rates at 0.4, 0.8, and 1.2 km away from water for a moderate continuous, heavy continuous, and a short duration grazing system. Moderate continuous grazing was superior to heavy continuous grazing and short duration grazing, based on the hydrologic variables evaluated.

Grazing systems impact range watersheds by altering vegetation and soil variables. The objectives of most grazing systems are to increase forage production while, at the same time, increasing livestock and wildlife production. In the past several years, researchers have studied several different grazing systems and their effect on surface water runoff and sediment production. However, little is known about the effect of short duration grazing on rangeland watersheds. A short duration grazing system is defined here as having a stocking density index greater than 2 (Kothmann 1974), but is distinguished from a high intensity, low frequency grazing system by grazing periods of less than 2 weeks.

Aldon and Garcia (1973) studied the effects of changing from heavy continuous to moderate continuous grazing with summer deferment on a 190-ha watershed. They reported sediment yields decreased 71% over a 4-year period. Smith (1980), working at the Ft. Stanton Experimental Ranch in southcentral New Mexico, noted moderate continuous grazing was superior to either heavy continuous grazing or a 4-pasture 1-herd rotation grazing system. Smith (1980) concluded that reduced vegetal cover on the heavy continuous and 4-pasture 1-herd systems was the predominate reason for decreased infiltration rates and increased sediment production.

Wood and Blackburn (1981), in the Rolling Plains of Texas, reported a 4-pasture 3-herd grazing system (Merrill system) approached the optimum infiltration rate of a 20-year old exclosure. On the basis of analyzing infiltration rates, Wood and Blackburn concluded the deferred-rotation system was superior to moderate continuous; high intensity, low frequency (HILF); or heavy continuous grazing. McGinty et al. (1979), working in Sonora, Texas, reported infiltration rates of midgrass interspace areas were highest in a livestock exclosure and a deferred-rotation pasture. The heavy continuous grazing treatment significantly reduced terminal infiltration rates.

McCalla et al. (1984) initiated another study at the Sonora Research Station to evaluate the influence of mixed livestock grazing on the hydrologic variables in moderate continuous; heavy continuous; and a high-intensity, low frequency grazing system stocked at a moderate level. The pastures were 5 ha each and were grazed at a ratio of approximately 50:25:25% for cattle, goats, and sheep, respectively. In general, he concluded there was no significant difference in infiltration rates between the HILF and the moderate continuous grazed pastures. Infiltration rates on the heavy continuous grazed pastures were significantly lower than the other 2 treatments in all but 1 month. McCalla et al. (1984) noted accumulated sediment production, standing grass crop, and surface roughness to be significantly lower on the heavy continuous pasture. There were no major differences in the mulch content, surface soil aggregate stability, or organic matter content in any of the treatments at the conclusion of the 17-month experiment.

This study determined the influence of short duration grazing, continuous grazing, and exclusion from grazing on infiltration rates on 2 range sites in southcentral and eastcentral New Mexico.

Study Area

Two similar studies were conducted on the impacts of short duration grazing systems on hydrologic variables in New Mexico. One study area was at the Ft. Stanton Experimental Ranch in southcentral New Mexico, 10 km east of Capitan, New Mexico. The study was conducted on a mesa top. Soils across all treatments were members of the Dioxice series. The Dioxice series is classified as a mixed, mesic, loamy-skeletal, Aridic Calciustoll. Slopes on the study area ranged from 0–3%. In general, the mesa tops were dominated by blue grama (*Bouteloua gracilis* [H.B.K.] Steud.) grasslands, with the slopes and rocky ridges dominated by pinyon-juniper and oak associations. Other important grasses included wolftail (*Lycurus phleoides* H.B.K.), sand dropseed (*Sporobolus cryptandrus* [Torr.] Gray), mat muhly (*Muhlenbergia richardsonis* [Trin.] Rydb.), and ring muhly (*M. torreyi* [Kunth] Hitchc. & Chase). Common forbs include carruth sagewort (*Artemesia carruthii* Wood) and scarlet globemallow (*Sphaeralcea coccinea* [Pursh] Rydb.). Important woody species included pinyon pine (*Pinus edulis* Engelm.), single-seeded juniper (*Juniperus monosperma* [Engelm.] Sarg.), walkingstick cholla (*Opuntia imbricata* Haw.), and wavy-leaf oak (*Quercus undulata* Torr.) (Tober 1978).

The second study area was 25 km southwest of Ft. Sumner, New Mexico in the Canadian-Pecos plains area. Soils across all sites were in the Berwolf series and classified as a fine-loamy, mixed, thermic, Ustollic Haplargid. Slope in the area ranged from 0–3%. Vegetation was characterized by blue grama, hairy grama (*B. hirsuta* Lag.), red three-awn grass (*Aristida longiseta* Steud.), tumble lovegrass (*Schedonnardus paniculatus* [Nutt.] Trel.), and sand dropseed. Important forbs and woody species included sand sagebrush (*Artemesia filifolia* Torr.), broom snakeweed (*Gutierrezia sarothrae* [Pursh] Skinners), and yucca (*Yucca glauca* Nutt.).

Treatments studied at Ft. Stanton during June 1982 represented: (a) a heavily stocked, continuously grazed pasture (337 ha) (13.5 ha/A.U.); (b) a moderately stocked, continuously grazed pasture (168 ha) (18.0 ha/A.U.); (c) one paddock of a short duration grazing system before grazing took place (95 ha) (14.0 ha/A.U.); (d) the same short duration paddock after the cell had been grazed for 4 days; (3) and a livestock exclosure (7.5 ha) protected from grazing since 1952. The 2 continuously grazed treatments were initiated in 1964. Before initiation of the short duration grazing system in 1980 the area was used seasonally at a moderate rate. A paddock was chosen in the short duration grazing system that was similar to the soil series and vegetation communities of the other grazing systems. The other paddocks in the short duration grazing system were not sampled due to differences in soil properties. Within each grazing treatment, infiltration rates were determined

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This article is published as journal article 1090, Agricultural Experiment Station, New Mexico State University, Las Cruces 88003.

Manuscript accepted 4 November 1985.

at 0.4, 0.8, and 1.2 km distances (zone 1, zone 2, and zone 3, respectively) away from water. These distances were selected to determine if the different grazing systems affected the way cattle distributed themselves throughout a grazing system, thus affecting infiltration rates. Within each zone, 6 plots were randomly located for a total of 18 plots per treatment.

Treatments evaluated at Ft. Sumner during July 1982 represented: (a) a moderately stocked, continuously grazed pasture (260 ha) (26.6 ha/A.U.); (b) 1 paddock of a short duration grazing system (65 ha) (13.3 ha/A.U.) before the cattle had grazed the area; (c) the same short duration paddock 1 day after the cattle had grazed the cell for a 3-day period; (d) and a livestock exclosure (4 ha) which had been protected from grazing since the turn of the century. The short duration grazing system was initiated in 1979. Before 1979, the area was grazed as part of the moderate continuous treatment. Within each grazing treatment or exclusion from grazing, 6 randomly located plots were evaluated.

Methods

A modified Purdue infiltrometer (Bertrand and Parr 1961) was used to determine infiltration rates on 1 × 1-meter plots. Eighty-five percent of the raindrops were from 0.15 and 3.33 mm diameter with the largest percentage between 1.65 and 2.36 mm. Nozzle pressure was 62.1×10^3 PA, which assured velocities similar or equal to natural rainfall. Water used for rainfall was obtained from a well and was filtered to remove suspended solids. The runoff plots were prewet with the infiltrometer to remove antecedent soil-water content differences. Plots were prewet with 7.62 cm of water and allowed to drain for 24 hr. The simulated rainfall rate of 7.62 cm/hr (one standard deviation of 0.36 cm/hr) for one hour was chosen to ensure runoff from all treatments. The amount of runoff was determined at 5-minute intervals. Time to ponding was not recorded. Terminal infiltration rate refers to the rate at the end of 60 minutes.

Foliar cover of grasses, forbs, and percentage of ground cover by litter and rock (>1 cm diam.) were determined by using a 20-point point frame. Five lines were read horizonally across the plot for a total of 100 points. Foliar cover was determined by the number of hits out of 100 possible points. Plant biomass (standing dead and live, and litter) was determined on each plot by clipping vegetation to ground height, raking-up all litter, oven drying the material at 60° C for 1 week and weighing.

Soil moisture by the gravimetric method (Gardner 1965) was determined for areas adjacent to each runoff plot at 0-5 cm before each simulated rainfall event. Soil was collected to a 4 cm depth within each plot after the final simulated rainfall event. Particle size distribution of the soil was measured by the hydrometer method (Bouyoucos 1962), and organic carbon content by the Walkley-Black method (Allison 1965). Microrelief within each plot was measured after the final run along 5 different lines with a relief meter consisting of 20 pins spaced 4.5 cm apart (Kincaid and Williams 1966). Soil moisture and texture data were collected to assure similarity between treatment so that differences in infiltration rates could be attributed to management changes.

A completely randomized design with the treatments arranged in a factorial arrangement was used to analyze the experimental data at Ft. Stanton. Data were tested for normality and no transformations were needed. Analysis of variance was performed on all variables. The type four sum of squares was used to determine if a significant difference existed between the different grazing systems at the 0.10 level. Within treatment variation (variation among subplots) was allocated to the residual for testing differences among treatments (Kothmann et al. 1982). A Protected Fisher's Least Significant Difference (L.S.D.) Test was used to separate means which were significantly different. At Ft. Sumner, experimental data were analyzed similar to the Ft. Stanton data. An analysis of variance across treatments was used in place of factorial arrangement.

Results and Discussion

Because the 2 study areas represented different soils and vegetative communities, the comparisons among treatments are restricted to those within study sites.

Ft. Stanton

The exclosure terminal infiltration rates were significantly greater than any of the grazing treatments (Table 1). These rates nearly equaled the application rate. Mean terminal infiltration rate of the moderate continuously grazed pasture was higher than the rested and grazed short duration and the heavy continuously grazed pastures. The rested short duration treatment infiltration rates were significantly higher than the heavy continuous and the grazed short duration treatment. There was no statistical difference between the heavy continuous and grazed short duration pasture's terminal infiltration rates.

Table 1. Mean values for treatment vegetation characteristics and hydrologic variables, Ft. Stanton, New Mexico.

	Treatments[1,2]				
Variable (units)	EX	MC	HC	SR	SG
Terminal Infiltration Rate (cm/hr)	7.4a	4.9b	2.6d	3.9c	2.3d
Grass standing crop (kg/ha)	175a	168a	156a	127ab	91b
Forb standing crop (kg/ha)	61a	46ab	22c	31bc	36bc
Litter accumulation (kg/ha)	143a	74bc	40c	96b	65bc
Total above ground biomass (kg/ha)	380a	288b	218bc	254bc	192c
Bare ground (%)	46a	34b	49a	47a	53a
Organic carbon (%)	4.0c	4.6b	4.9b	5.5a	4.8b

[1]Ex = Exclosure, MC = moderate continuous, HC = heavy continuous, SR = rested short duration, SG = grazed short duration.
[2]Means in the same row followed by the same letter are not significantly different ($P \leq .10$) according to Fisher's least significant difference (L.S.D.) Test.

The exclosure's mean infiltration rate remained nearly constant for the duration of the simulated rainfall event (Fig. 1). The mod-

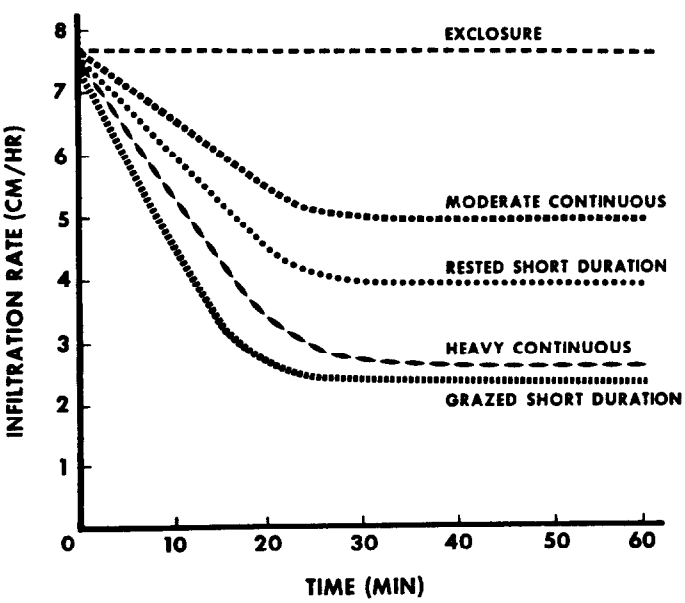

Fig. 1. *Mean infiltration rates for the various grazing treatments at Fort Stanton, New Mexico.*

erate continuous treatment reached mean terminal infiltration at 28 min, and the heavy continuous and short duration treatments reached mean terminal infiltration at 30 min.

Distance away from water (zone) was not statistically important in any of the grazing treatments at Ft. Stanton for any given plant community. If treatment-by-zone interactions are compared, the only difference is at zone 2 of any treatment. The heavy continuous treatment had a blue grama community and a mat muhly community in zone 2 and the terminal infiltration rate at zone 2 was twice the terminal infiltration rate of either zone 1 or zone 3. Thomas and Young (1954) found tobosa grass sites had higher infiltration rates than did either buffalograss or curly mesquite sites. Wood and Blackburn (1981) determined areas dominated by bunchgrasses have higher infiltration rates than sodgrass areas. It was concluded that the large differences in terminal infiltration rates in zone 2 in the heavy continuously grazed pasture were a result of the change in vegetation communities, and not related to grazing.

The livestock exclosure, moderate continuously grazed, heavy continuously grazed, and rested short duration pastures had statistically similar amounts of standing grass crop. The grazed short duration pasture had the least amount of grass of any of the grazing treatments, although it was statistically similar to the rested short duration treatment (Table 1). The exclosure had the highest amounts of above-ground biomass of any of the treatments. Total above-ground biomass in the moderate continuously grazed, heavy continuously grazed, and rested short duration pastures were statistically similar, although the rested short duration was the lowest. The grazed short duration treatment had less above-ground biomass than the exclosure, moderate continuously grazed, and heavy continuously grazed pastures, and was statistically similar to the rested short duration treatment. Percentage of bare ground was highest in the grazed short duration pasture but was statistically similar to the livestock exclosure, rested short duration, and the heavy continuously grazed pastures. The moderate continuously grazed pasture had the lowest percentage of bare ground of any of the treatments.

The livestock exclosures and moderate continuously grazed pasture had similar amounts of forbs. Likewise, forbs in the heavy continuously grazed, rested, and grazed short duration pastures were significantly less than the livestock exclosure. The heavy continuously grazed pasture had less forb standing crop than the moderate continuous. Litter accumulation (kg/ha) in the exclosure was significantly higher than any of the other treatments. The moderate continuously grazed, rested and grazed short duration pastures produced intermediate litter accumulation. The heavy continuously grazed pasture had the least litter accumulation, although it was statistically similar to the moderate continuously grazed and heavy continuously grazed pastures. Organic carbon was significantly lowest in the exclosure and highest in the rested short duration treatments. This agrees with findings in other similar studies by Wood and Blackburn (1981) and Pluhar (1984).

Total above-ground biomass had the highest correlation (r=0.77) with terminal infiltration rates followed by grass standing crop (0.67) and litter accumulation (0.66). All other variables had r-values less than 0.40.

Ft. Sumner

Mean terminal infiltration rates were higher in the rested short duration pasture than in the other grazing treatments, although not statistically different from the livestock exclosure (Table 2). The exclosure and moderate continuous grazing treatment had statistically similar terminal infiltration rates. The grazed short duration treatment had a significantly lower terminal infiltration rate than any of the other grazing treatments.

The rested short duration and the exclosure treatments reached mean terminal infiltration at 30 min (Fig. 2). The grazed short duration treatment reached mean terminal infiltration rate at 35 min, and the moderate continuous treatment reached mean terminal infiltration at 40 min.

Table 2. Mean values for treatment vegetation characteristics and hydrologic variables, Ft. Sumner, New Mexico.

Variable (units)	Treatments[1,2] Ex	MC	SR	SG
Terminal Infiltration Rate (cm/hr)	6.3ab	5.5b	7.0a	3.8c
Grass standing crop (kg/ha)	128a	113a	146a	116a
Forb standing crop (kg/ha)	34a	22a	40a	20a
Litter accumulation (kg/ha)	466a	206b	137b	108b
Total above ground biomass (kg/ha)	628a	341b	323b	244c
Bare ground (%)	47b	50b	59a	64a
Organic carbon (%)	2.15ab	1.23b	2.19ab	3.00a

[1]Ex = Exclosure, MC = moderate continuous, SR = rested short duration, SG = grazed short duration.
[2]Means in the same row followed by the same letter are not significantly different ($P \leq .10$) according to Fisher's least significant difference (L.S.D.) Test.

Grass standing crop and forb standing crop (kg/ha) were statistically similar for all grazing treatments. Litter accumulation in the livestock exclosure was significantly greater and ranged from 2 to 4 times higher than in the other grazing treatments. Total above-ground biomass (kg/ha) in the exclosure was about 2 times more than any of the other treatments. The moderate continuous and rested short duration treatments produced statistically similar amounts of biomass, and both were significantly higher than the grazed short duration treatment. The exclosure and moderate continuous treatments had significantly less bare ground than either of the short duration treatments.

Total ground cover had the highest correlation (r = 0.74) with infiltration rates followed by grass standing crop (0.63) and forb standing crop (0.48). All other variables had r-values less than 0.36.

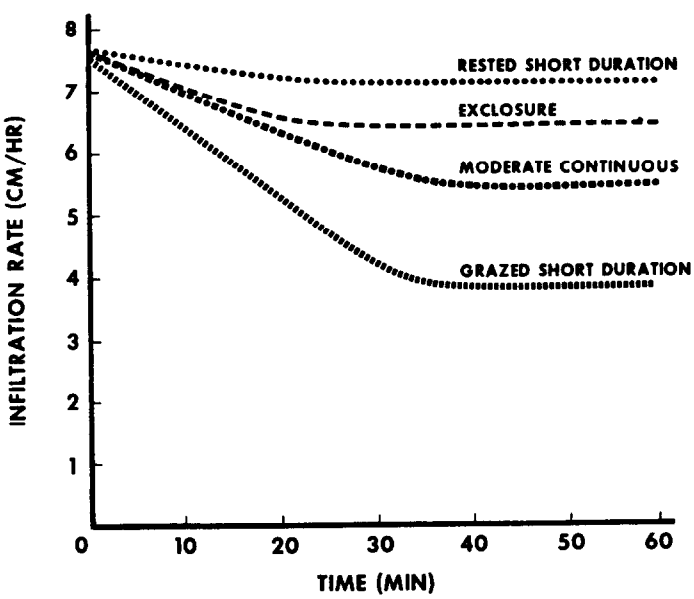

Fig. 2. *Mean infiltration rates for various grazing treatments near Fort Sumner, New Mexico.*

Conclusions

Results from this research indicated short duration grazing at both sites had no beneficial impact on the hydrologic condition of

the range over continuous grazing at similar or different stocking rates after 2 and 3 years. It is not known how long it will take to increase infiltration rates after implementation of a short duration system or if they will increase at all.

The reduction in grass standing crop and litter load, and the correlated increase in the percentage of bare ground on the short duration system after grazing, was the reason attributed to the significantly reduced infiltration rates of both grazed short duration systems. Rauzi (1960), Dunford (1954), and Johnston (1962) reported that, as litter is removed and the percentage of bare ground is increased, a corresponding increase in surface runoff can be expected. Results of this research at Ft. Stanton indicated moderate continuous grazing had higher infiltration rates compared to short duration grazing, and heavy continuous grazing and short duration grazing respond similarly. Exclusion from grazing resulted in higher infiltration rates than any of the grazing treatments even though the rest period at Ft. Sumner was adequate to restore infiltration rates similar to that of the livestock exclosure. Stocking rate seems to be a more important influence on infiltration rates than the type of grazing system. The low infiltration rates after the short duration grazing period are alarming. At Ft. Sumner, the rest period was adequate for the site to recover and have high infiltration rates. The dangerous time period is immediately following a grazing period. One of the pastures is in the vulnerable state at any given time.

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