Semiarid Rangeland Treatment and Surface Runoff

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Highlight: *Effects of pitting and rootplowing on surface runoff were determined on a desert shrub range in southeastern Arizona, and the time-dependent changes in the soil surface characteristics resulting from these practices were studied. Additional detention storage was provided by increased roughness in microtopography, thereby decreasing surface runoff when compared to the control. Rock and gravel were negatively correlated with surface runoff. Combining the two parameters showed a significant reduction in surface runoff. Increases in runoff were associated with exposed soil. Crown cover significantly reduced runoff. Litter was not significant in the reduction of runoff. Regulation of surface runoff is important for on-site rangeland improvements as well as reducing sediment yields.*

In arid and semiarid regions, rainfall is insufficient and distribution uncertain for maintaining vegetation that adequately protects the soil. Ranchers often try to convert the sparse vegetation, often not suited for grazing, to a more desirable plant species. To manage these critical rangelands for maximum productivity, it is important to know which factors control water yield.

Many factors affect soil water yield, like storm intensity, watershed size, and soil surface characteristics. Rowe and Reimann (1961) also listed as important factors soil depth and water storage capacity, rainfall amount and distribution, and the type of vegetation, before and after site conversion.

Soil surface conditions are important in the infiltration ratio because of vegetation sparsity (Duley and Kelly, 1939; Horton, 1940; Dixon, 1966; and Kincaid and Williams, 1966). Simple correlations between infiltration rates during the second 30-minute period of 1-hour infiltration runs showed that the soil structure of the first horizon was highly correlated with water intake. Texture of the second horizon was second in importance, followed by the nature of the boundary of the first horizon (Rauzi and Fly, 1968).

Kincaid et al. (1964) indicated a strong relationship between infiltration and plot cover, with most cover variation associated with differences in crown spread of shrubs and half-shrubs. Rauzi and Fly (1968) found the amount of vegetation, both old and new, had the greatest general correlation with water intake rate for midcontinental rangelands.

Schreiber and Kincaid (1967) reported that average runoff for any location year increased as precipitation volume increased, decreased as vegetation crown cover increased, and increased as antecedent soil moisture increased. Kincaid and Williams (1966), after brush clearing, pitting, and grass-seeding runoff plots, found little correlation between these treatments and surface runoff. However, as the amounts of crown cover increased, runoff significantly decreased.

Dortignac and Hickey (1963) reported on approximately 30,000 acres on the Rio Puerco drainage in New Mexico treated by ripping and seeding to grass and browse species. Surface runoff was reduced 97 and 83% the first and third years after treatment. Erosion was also reduced, amounting to

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86 and 30% for the first and third years after the ripping operation.

Branson et al. (1966) tested seven different mechanical treatments. The two most effective were contour furrowing at 3- and 5-foot intervals and broadbase furrowing consisting of low dikes about 1.5 feet in height.

In southern Arizona, Brown and Everson (1952) determined the longevity of contour furrows to be about 15 years, with grass production 2.5 times greater on the treated than on adjacent untreated areas 10 years after treatments. However, treatment effects on runoff were not determined.

On-site forage productivity of semiarid, shrub-covered watersheds can sometimes be increased when they are converted to grass. Pitting and rootplowing with seeding are two methods used in southwestern United States to improve semiarid rangeland. Both methods disturb the soil surface, enhance water storage, and provide seedbed preparation. Hydrologic information concerning the effects of rangeland conversion treatments on surface runoff is lacking. Therefore, the purpose of this study was to evaluate the effects of rootplowing and pitting treatments on surface runoff and study the time-dependent changes in the soil surface characteristics resulting from these practices.

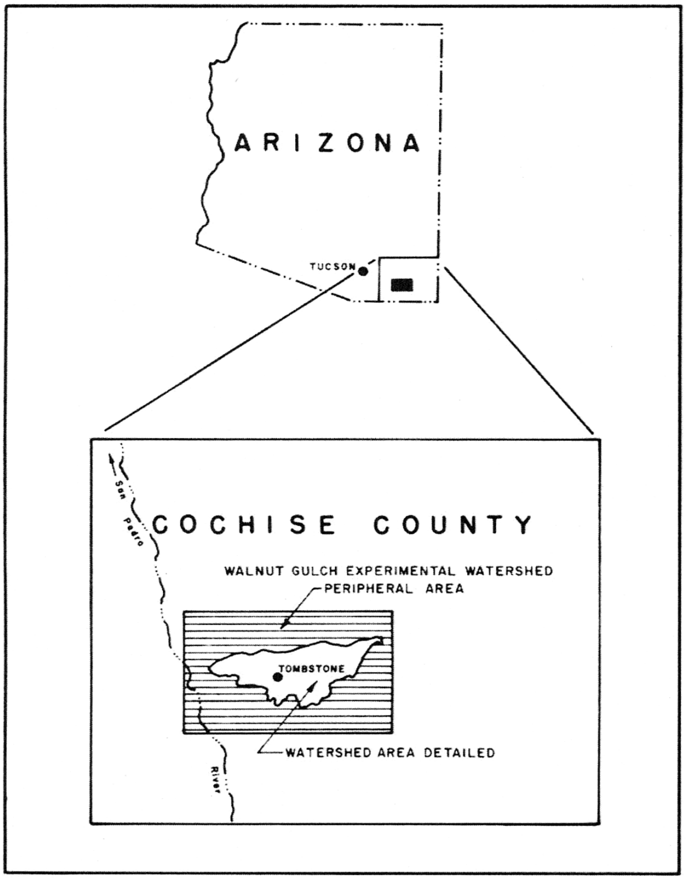

Fig. 1. *Location of the Walnut Gulch Experimental Watershed.*

Study Area

The experimental site (Fig. 1) is within the Walnut Gulch Experimental Watershed, a 150-km^2 rangeland watershed on which the Agricultural Research Service is conducting hydrologic research.

Vegetation on the experimental site was mainly shrubs; whitethorn (*Acacia constricta* var. *vernicosa* L. Benson), creosotebush (*Larrea tridentata* (D.C.) Coville), tarbush (*Flourensia cernua* D. C.), and other scattered shrub species. Grasses, which were sparse, consisted of black grama (*Bouteloua eriopoda* (Torr.) Torr.), bush muhly (*Muhlenbergia porteri* Scribn.), and fluffgrass (*Tridens pulchellus* (H.B.K.) Hitchc.).

The soils are a Rillito-Karro gravelly loam, consisting of deep, well-drained medium and moderately coarse-textured gravelly soils formed in calcareous old alluvium. They are found on gently to strongly sloping sides and tops of hills formed by the dissection of old valley plains and alluvial fans (Gelderman, 1970).

Approximately 60% (Kincaid and Williams, 1966) of the 36.07-cm annual precipitation and 95% of the surface runoff comes from summer convective thunderstorms.

Methods

Rootplowing and pitting treatments were imposed in the summer of 1968 on a 32-ha site. Rootplowing was accomplished by pulling a blade behind a tractor and severing the brush roots about 30 cm below the soil surface (Fig. 2). A rangeland disk with a portion of each disk cut off was used for pitting. The completed pits were about 70 cm long and 10 to 15 cm deep (Fig. 3). The rootplowed area was seeded to a mixture of equal parts of Lehmann lovegrass (*Eragrostis lehmanniana* Nees), and Boer lovegrass (*Eragrostis chloromelas* Steud.).

Twelve 1.83- by 3.66-m plots were established in equal

Fig. 2. *Rootplowing the experimental area.*

Fig. 3. *Experimental area after the pitting treatment.*

numbers in the winter of 1969 on the three range treatments—rootplow, pit, and control, and were measured in 1970, 1971, and 1972. Plot locations were selected for uniformity in aspect, slope, and soils. Each treatment was replicated four times with each plot bordered by a partially buried metal frame along two sides and the upper end. A metal trough across the lower end of each plot collected runoff after each storm and transported it into two 208-liter barrels. Rainfall was measured with a recording rain gage located at the site and also with a volumetric rain gage located near the center of each group of four plots.

Soil surface characteristics and plant cover were measured with a microrelief meter (Fig. 4) each June for the 3-year study period, as described by Kincaid and Williams (1966). Characteristics recorded were: (a) microtopography (surface roughness), (b) erosion pavement (divided into two size fractions, gravel (2 mm to 1 cm) and rock (larger than 1 cm), (c) exposed soil, (d) litter, (e) crown cover, and (f) basal area.

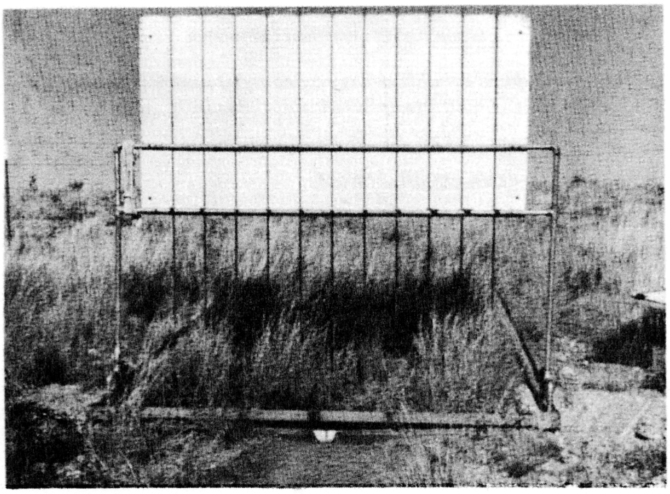

Fig. 4. *Microrelief meter in place over a runoff plot.*

Microtopography, soil surface, and vegetation characteristics were determined from 253 point measurements on each plot. Surface roughness as determined at the pin-soil surface intersection using the microrelief meter is reported as the variance from a plane parallel to the soil surface.

Results and Discussion

After combining data for all treatments and all years, a regression analysis (Table 1) was used to examine effects of plot surface variables on runoff after treatment. Total crown cover (Fig. 5) significantly reduced runoff (r value = 0.80). Total crown cover correlated significantly with litter, but litter was not correlated significantly with reduction in runoff. Garcia and Pase (1967) reported that in Arizona chaparral more abundant litter cover increased infiltration capacity and reduced soil erosion.

Table 1. Correlations of runoff vs plot surface characteristics.

Characteristic	r*	Equation
Crown cover	−0.80	y = −0.064x + 2.96
Litter	−0.29	y = −0.027x + 1.76
Soil	0.92	y = 0.014x − 0.62
Gravel	−0.64	y = −0.086x + 3.75
Rock	−0.69	y = −0.071x + 2.25
Rock + gravel	−0.93	y = −0.070x + 4.52

*r must be .632 for significance at .05 level.

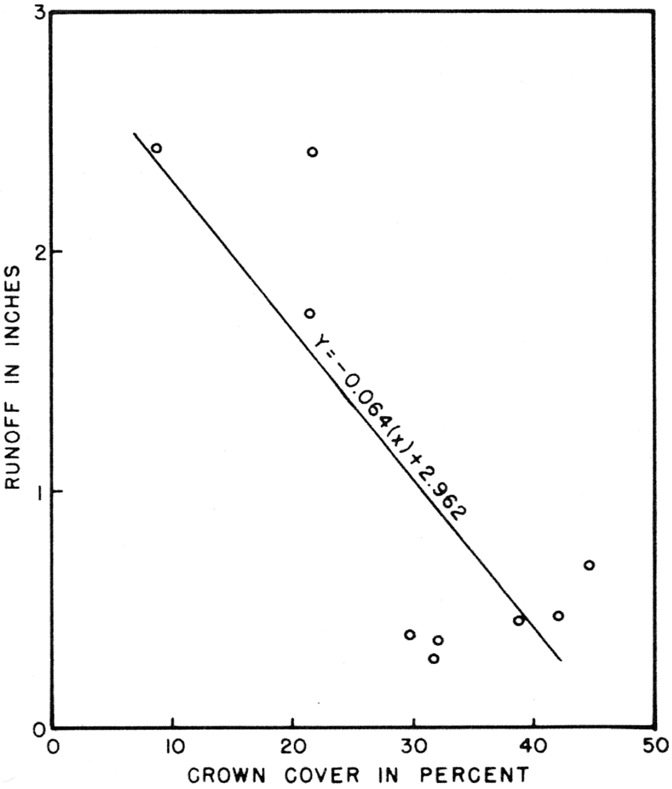

Fig. 5. *Runoff versus crown cover for the Lamb's Draw Plots.*

As expected, runoff was significantly correlated with percent bare soil at the 1% level. Rock and gravel were negatively correlated with runoff at the 1 to 5% levels, respectively. When the two parameters were combined (Fig. 6) and tested for significance, they were highly significant and negatively correlated with runoff.

The percentage averaged total plant basal area and grass basal area for the 12 plots were 3.03 and 2.06. These parameters were not correlated with runoff.

Since the semiarid rangeland is sparsely covered with vegetation, its influence on runoff may be minimal. Harrold

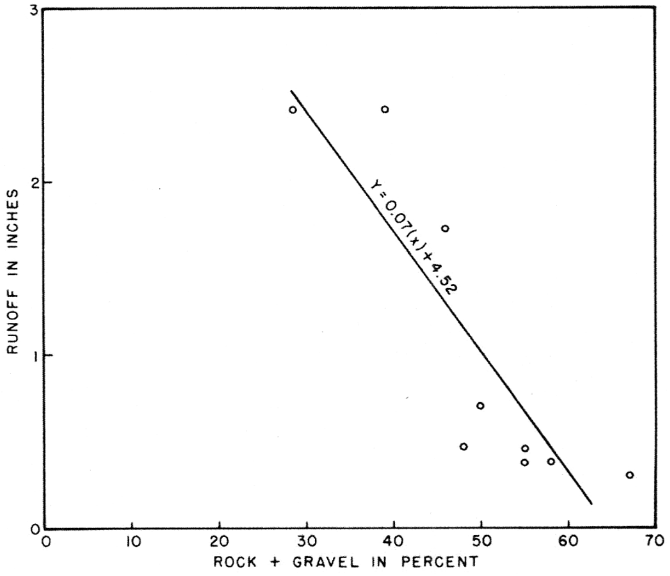

Fig. 6. *Runoff versus rock and gravel combined for the Lamb's Draw Plots.*

(1951) reported that in tests on sparsely covered desert grassland range, effects of soil texture overshadowed those of cover. Kincaid et al. (1964) reported that the best correlation was obtained when the time to infiltrate the first 0.5 inch was compared with the sum of litter, erosion pavement, basal area of grasses, and overstory of shrubs and half-shrubs.

To evaluate the effectiveness of the treatments in altering the volume of runoff with time, differences among treatment means for each year were tested for significance with Duncan's multiple range test. This test suggested that runoff volume was related to the length of time after treatment.

Surface roughness of the control plots remained relatively constant for the study period while the roughness of the pitted and rootplowed plots decreased (Table 2). However, surface roughness of the rootplowed and the pitted plots was still greater than the control and provided additional detention storage as compared with the control plots. Smoothing of the soil surface with time was very apparent on both the rootplow and pitting treatments.

Table 2. Variance* as an indicator of plot surface roughness.

	Date		
Treatments	1970	1971	1972
Control	60	68	67
Pit	92	93	75
Rootplow	129	107	102

*Variance from a plane parallel to the plot surface obtained from 253 point measurements per plot.

Comparison of treatment vs runoff for all study years using the Snedecor (1956) *"t"* test indicated that pitting significantly reduced runoff as compared with the control treatment. No significant difference was manifested between pitting and rootplowing or between rootplowing and the control treatment. Although these treatments were compared by the *"t"* test, caution should be exercised in interpreting results since the rootplowed plots were grazed much more heavily than other plots in 1971 and 1972. Observations of the area and support data (Fig. 7) showed a corresponding increase in runoff from the rootplowed treatment during this grazing period as compared with the pitted treatment. Crown cover on the rootplowed plots was reduced from 23 to 9%. Possibly surface runoff from the rootplow treatment would have been significantly reduced if the area had not been overgrazed.

Range renovation can leave treated portions of watersheds largely denuded of vegetation until replacement vegetation is established. During this vulnerable period, annual forbs may give the soil surface minimal protection. Decreased vegetation cover greatly reduces rainfall interception and generally reduces water infiltration. Vegetation cover between the rootplow (17.5%), pitted (30.9%), and control (41.7%) area were noticeably different. This cover may have broken up the raindrops, reduced raindrop impact energy on the soil surface, and thus prevented soil surface sealing on the pitted and control plots as compared with the sparsely vegetated rootplowed plots.

Plant cover was less on the pitted than on the control plots because of plant thinning by the eccentric disk. Although rootplowed plots initially had less cover than the other two treatments, crown cover increased tenfold with an associated increase in basal area from 1970 to 1972. This increase was attributable to grass establishment.

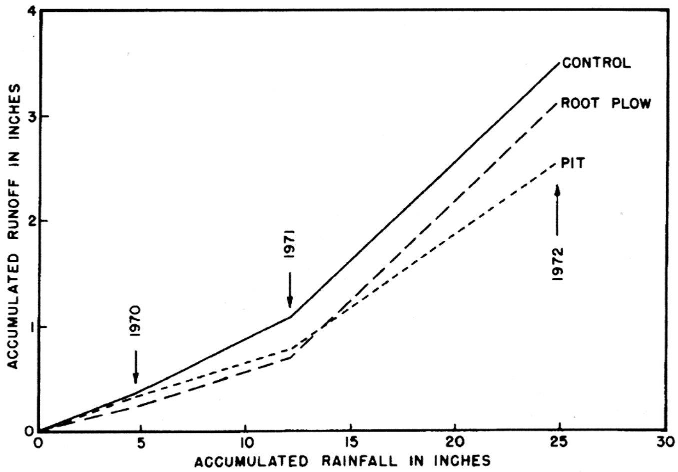

Fig. 7. *Accumulated rainfall versus accumulated runoff from storms of greater than 1.27 cm of precipitation for 1970, 1971, and 1972.*

Conclusions

Erosion pavement (rock + gravel) and crown cover were significantly and negatively correlated with surface runoff. Litter was not significantly correlated with reduced runoff.

Surface roughness of the rootplowed and pitted plots provided detention storage for average-size storms. Conservation treatments decreased surface runoff as compared with nontreated areas. The pitting treatment significantly decreased runoff as compared with the control. The rootplow treatment had the lowest water yield of all treatments for 1970 and 1971; however, in 1972 overgrazing increased runoff. When vegetative cover was reduced by heavy grazing or immediately after rangeland conversion, rainfall interception by vegetation was reduced. This increase in raindrop impact energy contributed to sealing of the soil surface.

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