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Hydrologic Effects of Rangeland Renovation

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Highlight

Ripping significantly decreased runoff from a 227-ha semiarid watershed. A ten-fold decrease in runoff was experienced following the ripping treatment, which appeared to be effective for 5 years. The ripping treatment had very little effect on the watershed's vegetative composition or percent crown cover.

Root-plowing and seeding significantly decreased runoff from a 40-ha semiarid watershed. However, this runoff reduction was not noticed until 4 years after treatment. The treatment was also effective in changing the watershed's vegetative composition from predominantly brush to grass. Measured sediment yields per millimeter of runoff were reduced 60 percent after treatment as compared with the pre-treatment sediment yields.

The western United States, excluding Alaska and Hawaii, contains 40% of the total U.S. land area (USDA 1976). Of this, 110 million ha are pasture or rangeland, of which only 23 million ha are classified as good or better condition rangeland. Methods available to improve grazing output in the form of forage include mechanical treatments, vegetation conversion, fertilization, and improved grazing and cattle management practices.

Mechanical treatment and/or vegetation conversion are probably the quickest and most economical methods of improving and increasing forage production. Soil ripping and root-plowing are two common mechanical treatments that have been used on thousands of hectares in the western United States.

Soil ripping effectively reduced surface runoff and erosion during a 3-year study in New Mexico (Dortignac and Hickey 1963). However, Branson et al. (1966) found that ripping decreased perennial grass production and did not significantly decrease runoff from six sites in the western United States.

Root-plowing and seeding were very effective in revegetating deteriorated rangeland (Jordan and Maynard 1970, Allison and Rechenthin 1956, and Herbel et al. 1973). However, limited watershed data are available on the hydrologic effect of root-plowing and seeding. Tromble (1976) reported that on 1.8 × 3.7 m plots in southeastern Arizona, runoff was less from root-plowed plots than from nontreated plots.

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The effectiveness of these two treatments in renovating or revegetating deteriorated rangelands is well documented but we know little about hydrologic consequences. This paper reports and discusses the hydrologic changes measured from two semiarid watersheds — one that was ripped on the contour and the other that was root-plowed and seeded. Data analyses included changes in rainfall-runoff relationships, sediment yields, and vegetation composition.

Description of Experimental Areas

The watersheds studied are located in southeastern Arizona, near Tombstone, and are part of the Walnut Gulch Experimental Watershed operated by the Agricultural Research Service. Before treatment, the watersheds were typical of thousands of hectares of deteriorated semiarid rangeland found throughout southern Arizona, New Mexico, Texas, and northern Mexico. Desert shrub was the dominant vegetation, and consisted primarily of whitethorn (*Acacia constricta*), creosotebush (*Larrea divaricata*), and tarbush (*Flourensia cernua*) (Table 1). Soils of the watersheds are gravelly loams formed in calcareous old alluvium (Gelderman 1970). Annual precipitation averages about 330 mm with about two-thirds occurring from June through September. About 7 percent of the annual precipitation is runoff, and usually occurs only during the summer thunderstorm season.

Ripped Watershed

The objectives of the ripping treatment were to determine the effect of ripping on runoff and to evaluate changes in watershed vegetative cover. A 227-ha predominately grass covered watershed with an average slope of 9 percent was contour ripped in June, 1965. A Jayhawk Soil Saver[1], a chisel with a 15-cm diameter vaned spinner that fractures the subsoil behind the chisel point, was used at 45-cm contour intervals to rip 80 percent of the watershed. The remaining area near the main drainage channels was not ripped because of terrain roughness.

Runoff from the watershed was measured by a Walnut Gulch critical depth flume. Rainfall was measured by three recording raingages evenly spaced across the watershed.

Root-Plowed Watershed

The objectives of the root-plowing and seeding treatment were to determine the hydrologic, erosive, and vegetative changes produced by

[1]The mention of commercially manufactured equipment does not imply endorsement by the U.S. Department of Agriculture over similar equipment not mentioned.

Table 1. Change in vegetation crown cover and composition due to watershed treatment.

Watershed treatment	Vegetation		% Crown cover			% Composition		
			Before	After	Change	Before	After	Change
Ripped	Shrub		36.8	39.8	+ 3.0	86.8	75.4	−11.4
	Grass		5.5	10.3	+ 4.8	13.0	19.5	+ 6.5
	Forb		.1	2.6	+ 2.5	.2	5.1	+ 4.9
		Total	42.4	52.7		100.0	100.0	
Root-plowed, seeded	Shrub		70.0	5.3	−64.7	97.1	14.4	−82.7
	Grass		2.0	31.2	+29.2	2.9	84.0	+81.1
	Forb		0	0.6	+ 0.6	0	1.6	+ 1.6
		Total	72.0	37.1		100.0	100.0	

this treatment. A 40-ha watershed was fenced to exclude grazing, then root-plowed on the contour in June, 1971. The watershed was rangeland drilled to side-oats grama (*Bouteloua curtipendula*) in July, 1972. Although optimum seeding time is usually immediately after brush removal because of the eliminated moisture competition from other vegetation, the 1 year's delay before seeding, caused by seed unavailability, did not seem to hinder grass establishment. The seeding was successful, and grass now dominated the watershed vegetative cover (Table 1). Watershed runoff was estimated from recorded water level changes in a stock pond at the watershed outlet. Stock pond depth-volume curves were developed from annual topographic survey data, which were also used to determine sediment accumulation. Rainfall was measured with two recording raingages within 1 km of the watershed.

Results and Discussion

Figure 1 shows accumulated summer rainfall versus runoff for the ripped and root-plowed and seeded watersheds. Figs. 2a, 2b and 3a, 3b illustrate changes in runoff for a given precipitation event from the ripped and root-plowed watersheds, respectively. The curve number (CN) method for relating runoff to precipitation was developed from the Soil Conservation Service National Engineering Handbook (SCS 1971). The modified linear regression technique (Diskin 1970) was developed specifically to treat rainfall-runoff data, when some of the independent data (precipitation) produced zero dependent (runoff) data.

The rainfall-runoff relationship for the ripped watershed changed significantly after treatment. Figs. 2a and 2b show this change in terms of CN and regression analyses. The CN's were 85 before treatment and 73 for the first 5 years after treatment. In terms of runoff, this means that for 25-mm rainfall the before-treatment runoff was 4 mm, and the after-treatment runoff was 0.4 mm — a 10-fold decrease. The modified linear regression analysis (Fig. 2b) indicated that for a 25-mm rainfall, runoff before and after treatment was 6 and 0.1 mm, respectively. The rainfall-threshold values for runoff initiation increased from 9 mm before treatment to 19 mm after treatment. These significant changes in runoff and surface storage were apparent for the first 5 years after treatment (Table 2). When we analyzed the 12 years of post-treatment data (1965-1976), the changes in the rainfall-runoff relationships are still significant, but not as large.

For the CN analysis (Fig. 3a) of the root-plowed and seeded watershed data, there was no significant difference in runoff between the pre- and post-treatment, but there was a significant difference when we used the modified linear regression (Fig. 3b). The curves of Fig. 3b also indicated that the rainfall threshold for runoff initiation was about 20 percent greater during the transition period than during the pre- and post-treatment periods. These threshold changes indicated that the watershed surface storage and drainage network, disturbed by root-plowing, held water during the smaller rainfall events. However, this

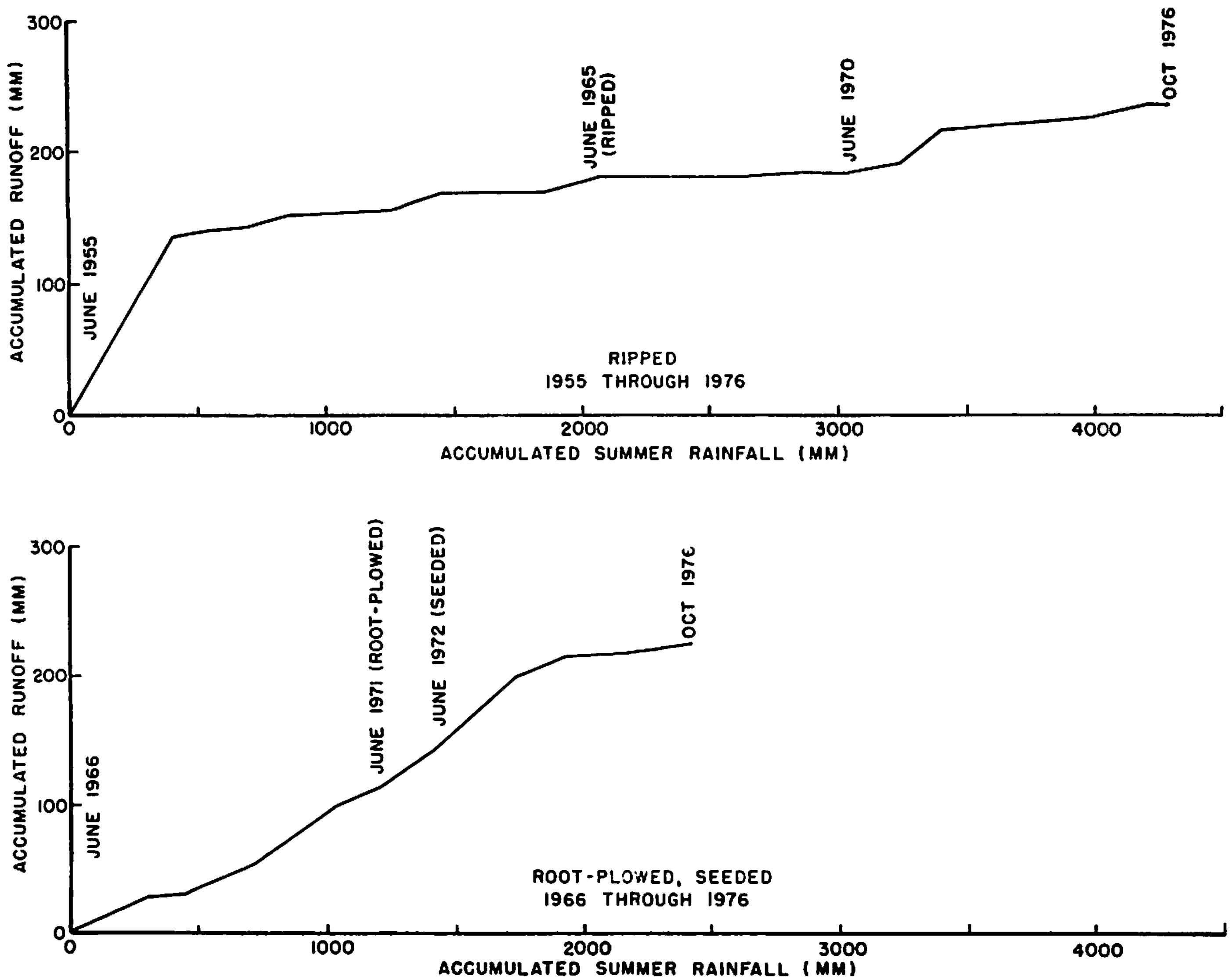

Fig. 1. Accumulated summer (July → Oct) rainfall vs. accumulated runoff.

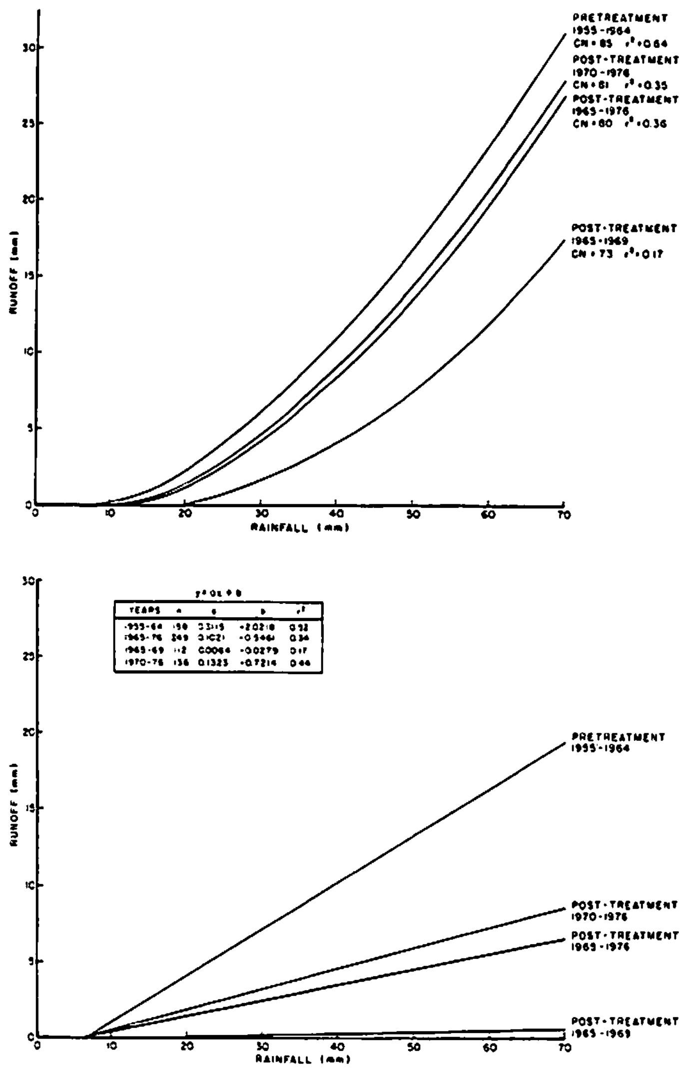

Fig. (2a.) Rainfall-runoff Curve Numbers of different periods of watershed change of a contour ripped watershed. (2b.) Modified linear regression method relating runoff to rainfall for different periods of watershed change of a contour ripped watershed.

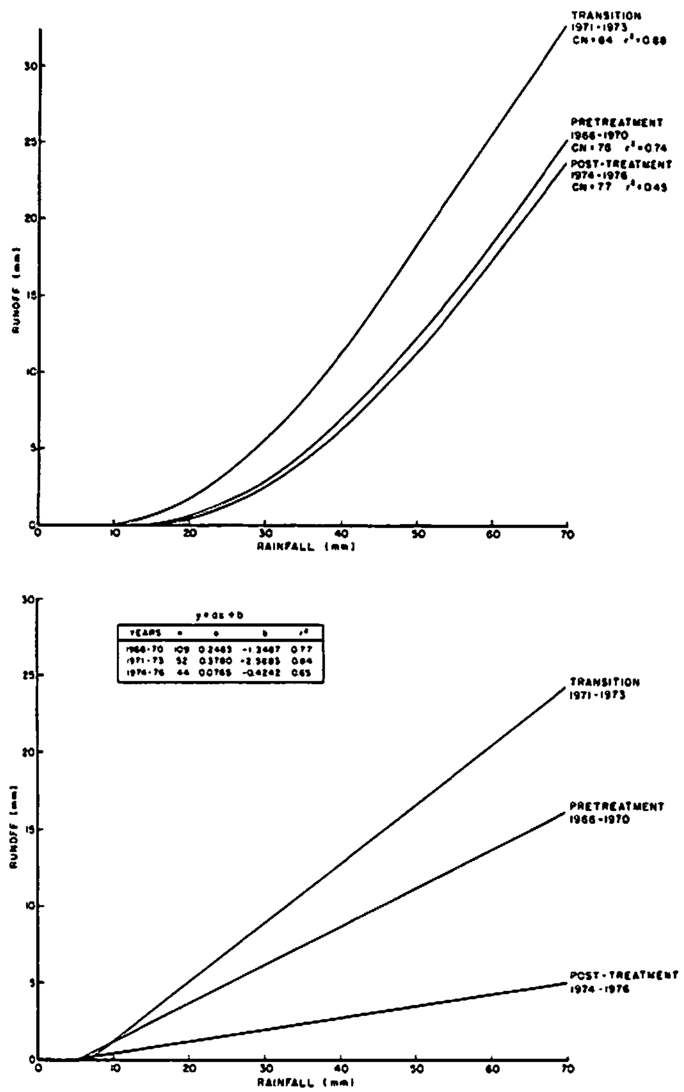

Fig. (3a.) Rainfall-runoff Curve Numbers for different periods of watershed change of a root-plowed and seeded watershed. (3b.) Modified linear regression method relating runoff to rainfall for different periods of watershed change of a root-plowed and seeded watershed.

Table 2. Average summer precipitation, runoff, and sediment yields before and after treatment.

Period	Average summer precip (mm)	Average summer runoff (mm)	Sediment yield (tonnes/ha/yr)
Ripped			
Pretreatment (1955-1964)	205	18	Not measured
Post-treatment (1965-1976)	185	4.7	" "
Post-treatment (1965-1959)	191	.5	" "
Post-treatment (1970-1976)	180	7.8	" "
Root-plowed, seeded			
Pretreatment (Brush vegetation) (1966-1970)	240	23	3.7
Transition (1971-1973)	237	34	2.6
Post-treatment (Grass vegetation) (1974-1976)	174	3	0.3

disturbance was not enough to compensate for the loss of vegetation cover, which caused the runoff to increase from the larger events. Average summer precipitation, runoff, and sediment yields from the root-plowed, seeded watershed are shown in Table 2. Time related changes in watershed roughness, drainage patterns, erosion pavement, and vegetation all made the sediment yield analyses difficult.

Conclusions

Ripping as a rangeland renovation treatment effectively reduced runoff for 5 years after treatment. However, the treatment had little effect on the existing brush vegetative cover so that the only watershed change was in the contour dikes and furrows produced. These dikes were slowly leveled and the furrows were filled by the erosive force of precipitation, so that after 5 years the treatment had lost its effectiveness. This leveling of the dikes and filling of the furrows might have been reduced if grass had been seeded on the watershed after treatment.

Root-plowing and seeding did not reduce runoff until 4 years after treatment, when there began a slow but significant reduction in runoff per millimeter of precipitation. Associated with the reduction in runoff after treatment was a 60 percent reduction in sediment per millimeter of runoff. The treatment was also very effective in converting the watershed's vegetation composition from brush to grass.

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