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Sediment Yields of Rangeland Watersheds

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Highlight

Sediment yields from small watersheds in the Southwest varied significantly, primarily because of differences in channel and cover types. Sediment yields were several times greater from gullied than from ungullied watersheds, and as much as 10-times greater from brush-covered than from grass-covered watersheds.

The rangelands of the Southwestern United States have deteriorated in this century primarily because of climatic pressure and misuse by man. Rangelands have become more exposed and gullied, with brush replacing grass in many areas. The region also experiences intense convective rains, with thunderstorms producing over one half of the annual rainfall and almost all runoff in many areas. Sparse cover and intense rain combine to produce relatively high sediment yield rates. At the USDA Southwest Rangeland Watershed Research Center, Tucson, Arizona, emphasis has been placed on measuring sediment movement and developing methods for estimating rangeland erosion and sedimentation.

Review of Recent Literature

Most recent literature on erosion and sediment yields from small watersheds in the Southwest has concerned the possible or practical use of the Universal Soil Loss Equation (USLE). Wischmeier and Smith (1965) used records from small cropland plots and watersheds in the East and Midwest to develop the USLE.

The USLE is given as:

$$A = RKLSCP$$

where

- A = estimated soil loss (tons/acre/year)
- R = rainfall factor
- K = soil-erodibility factor
- L = slope length factor
- S = slope gradient factor
- C = cover and management factor
- P = erosion control practice factor

Wischmeier (1976) cautioned against using the USLE beyond its intended area and design capabilities. Nevertheless, several investigators, including scientists at the Southwest Watershed Research Center, have investigated the possible use of the USLE in the western United States, and particularly in the Southwest. Investigations have centered on R, the rainfall factor, C, the cover, and P, the management factor.

Ateshian (1974) estimated R for the western U.S. using 2-yr, 6-hr rainfall data from the National Weather Service, but Renard and Simanton (1975a) pointed out that because of the extreme temporal and spatial variability of short-duration thunderstorms in the Southwest, 2-yr, 6-hr rainfall was probably not a good measure of R. Furthermore, Renard and Simanton (1975b) showed that point estimates of R should be used only in the immediate area near the raingage for which the R is computed. For very small watersheds (less than 5 ha), R values based on point rainfall measurements within the watershed probably vary less than 10%, and can be confidently used (Osborn, Simanton, and Renard 1977), so that differences in sediment production are not attributed to rainfall variability.

In the Southwest, the greatest uncertainty is using the USLE is probably C, the cover and management factor. If only rangeland vegetation is considered, ground cover is relatively low, and C is relatively high. However, measurements of sediment production from very small watersheds do not support such high sediment yields. The most likely explanation for lower than expected sediment yields is the protective erosion pavement, which is fairly common in many areas of the Southwest (Osborn, Simanton, and Renard 1977). The erosion pavement's role in sediment yield is an area that needs more research.

Renard, Simanton, and Osborn (1974) found much greater apparent sediment yields from a watershed with a sharply incised channel than from one without an incised channel. They suggested a possible sixth parameter, E_c, to explain possible channel contribution to sediment yields. It is uncertain as to whether the relatively straight incised channels increase the efficiency of sediment movement or whether the channel banks provide the additional sediment (Osborn, Simanton, and Renard 1977).

Experimental Watersheds

Sediment data have been collected for 4 years from four very small (less than 5 ha) watersheds within the 15,000 ha USDA Walnut Gulch Experimental Watershed in southeastern Arizona (Fig. 1). Three of the four very small watersheds (Nos. 103, 104, and 105) are primarily brush covered, whereas one (No. 112) located several kilometers away is primarily grass covered (Table 1). Runoff is estimated from continuous stage records at broad-crested V-notch weirs on three watersheds, and from a 1-m H-flume on the fourth. Storm bedload yields were

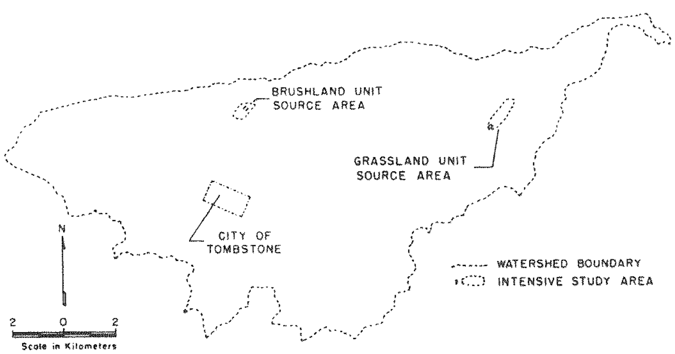

Fig. 1. Intensive study areas on Walnut Gulch Experimental Watershed.

Table 1. Small experimental watersheds within the Walnut Gulch Experimental Watershed.

Watershed designation	Area (ha)	Principal watershed cover	Years of record
103	3.7	brush	4
104	4.5	brush	4
105	0.2	brush	2
112	1.8	grass	4

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estimated for the small watersheds from accumulations in sediment traps. Accumulations were surveyed after each event, and the traps cleaned when necessary. Suspended loads for individual events were estimated with bottom-pivot, slot-type Chickasha pump samplers, modified for use in ephemeral stream channels.

A relatively simple and descriptive way to show differences in sediment yields from these four small watersheds is to compare summer rainfall with sediment yields. Sediment yields from a non-gullied grass-covered watershed (No. 112), non-gullied brush-covered watershed (No. 104), and a gullied brush-covered watershed (No. 103) were plotted versus summer rainfall (Figs. 2 and 3). Sediment yields from No. 103 were about 2 to 3 times greater than that from No. 104; sediment loads from No. 104 were about 10 times greater than that from No. 112 (Fig. 2). Sediment yields for just 2 years of data from No. 105, a much smaller, steeper sloped watershed adjacent to No. 103 were about the same as those from No. 103. Unfortunately, sediment yields for the largest storm in the 4-year record are partially estimated. Since we suspected that the rainfall-sediment yield relationship was non-linear, we did not attempt to fit a curve through the four points for No. 103.

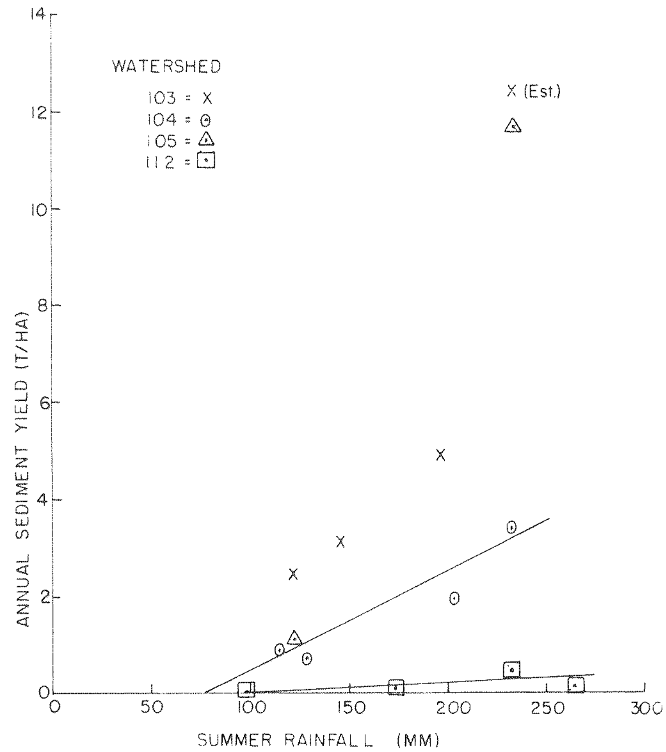

Fig. 2. Total annual sediment yield versus summer rainfall for several very small rangeland watersheds in southeastern Arizona.

In general, we expected these results, although we did not expect their relative magnitudes. Again, the relative roles of grass and brush seemed apparent, but the gullied versus ungullied did not. We must still answer the question of how or why the gullied watersheds produce greater sediment yields.

Suspended sediment loads from the brush-covered watersheds showed that this area produced appreciably less sediment than that from the grass-covered watershed (Fig. 3). The major differences among the watersheds were in the production or movement of coarser sediment. Annual suspended and total sediment yields are summarized in Table 2.

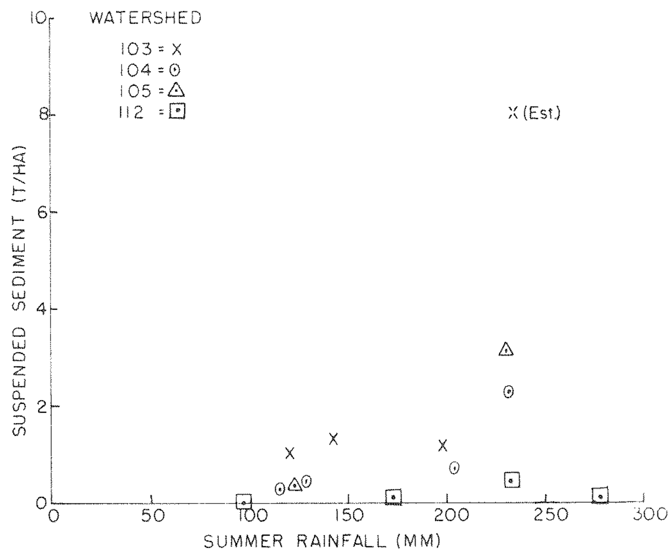

Fig. 3. Suspended sediment loads versus summer rainfall for several very small rangeland watersheds in southeastern Arizona.

Summary

Sediment yields from small watersheds in the Southwest varied significantly primarily because of differences in channel and cover types. Sediment yields were several times greater from gullied than from ungullied watersheds, and can be as much as 10 times greater from brush-covered than from grass-covered watersheds.

Table 2. Average annual sediment yields (tonnes/hectare) from 4 very small watersheds on Walnut Gulch.

Year	103		104		105		112	
	Suspended	Total	Suspended	Total (Tonnes/ha)	Suspended	Total	Suspended	Total
1973	1.3	3.2	0.4	0.9	—	—	0	0
1974	1.2	5.0	0.7	2.0	—	—	.02	.03
1975	8.3	12.5	2.2	3.4	3.1	11.7	.07	.10
1976	1.0	2.4	0.3	0.7	0.3	1.1	.40	.44
Avg.	3.0	5.8	0.9	1.8	1.7	6.4	.12	.14

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