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VARIABILITY IN RAINFALL PRODUCING RUNOFF FROM A SEMIARID RANGELAND WATERSHED, ALAMOGORDO CREEK, NEW MEXICO*

J. C. DRISSEL and H. B. OSBORN**

Abstract: In eastern New Mexico, most of the winter precipitation occurs as low-intensity rain or snow along slow-moving cold fronts, whereas summer rains are produced by short-duration, high-intensity thunderstorms, from purely convective buildup, or from convective cells developing along weak, fast-moving cold fronts. These summer convective storms (May–October) produce about 80 percent of the annual rainfall.

Since runoff-producing precipitation on semiarid rangeland watersheds is of primary interest at the Southwest Watershed Research Center, the variability in rainfall affecting runoff has been analyzed for the Alamogordo Creek watershed. The ten-year mean, annual, seasonal, and monthly variations have been analyzed and compared with the long-term averages of nearby weather stations. The distribution and orographic effects have been discussed in detail. Variations in runoff yields were discussed and analyzed for the period of record.

Introduction

With the increased demand for information on water yields in the Southwest[1]), the USDA, Agricultural Research Service, Southwest Watershed Research Center has been studying a group of five experimental watersheds in New Mexico and Arizona (Fig. 1). The principal study areas are the 67-square-mile Alamogordo Creek watershed in northeastern New Mexico near Santa Rosa, and the 58-square-mile Walnut Gulch watershed in southeastern Arizona near Tombstone. Other study areas are 3 very small watersheds near the Rio Puerco west of Albuquerque, 3 small watersheds on the Fort Stanton Military reservation near Capitan, New Mexico, and four, widely scattered, small watersheds near Safford, Arizona. Studies on the variability of rainfall are being made concurrently from rain gage records of the Alamogordo Creek and Walnut Gulch watersheds.

* Contribution of the Soil and Water Conservation Research Division, Agricultural Research Service, USDA, in cooperation with New Mexico State University, Las Cruces, New Mexico.

** Research Agricultural Engineer and Research Hydraulic Engineer, Southwest Watershed Research Center, 442 East Seventh Street, Tucson, Arizona.

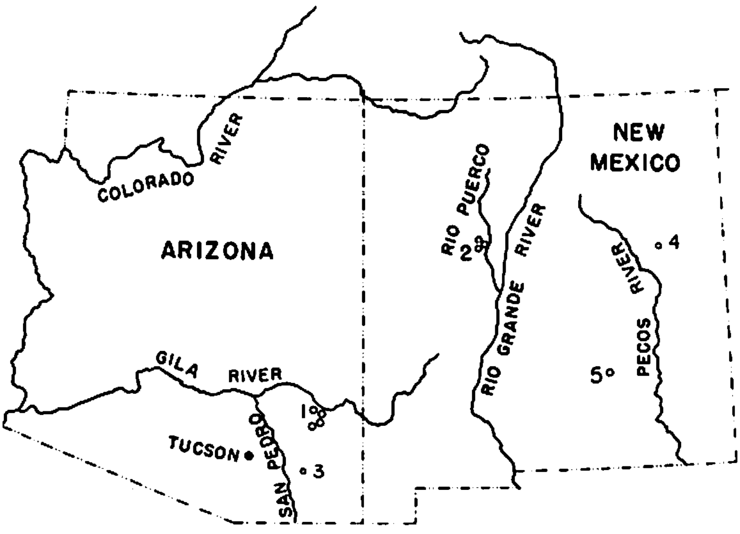

Fig. 1. Locations of experimental watersheds. 1. Safford, Arizona; 2. Albuquerque, New Mexico; 3. Walnut Gulch nr Tombstone, Arizona; 4. Alamogordo Creek nr Santa Rosa, New Mexico; 5. Fort Stanton, New Mexico.

Study area

Precipitation and runoff records have been collected from the Alamogordo Creek watershed in New Mexico since 1955. This watershed is located on the western edge of the Llano Estacado about 35 miles east of Santa Rosa, New Mexico. The 67-square-mile watershed consists primarily of a flat recessed basin, which is almost entirely surrounded by a steep escarpment (Fig. 2). The surrounding plateau is 500 to 700 feet above the basin floor. The drainage pattern on the basin floor is partially discontinuous. Grass is the dominant cover[2]).

Presently, sixty-four recording rain gages are located on the watershed, including a few along the escarpment rim. Because of their continuous records for ten years (1956 through 1965), thirty-two gages were selected from the present sixty-four for this study, with a rain gage density of approximately one gage for every 2 square miles (Fig. 2). Since 1955, a continuous record of the runoff from the 67-square-mile watershed has been recorded by a prerated, critical-depth flume located at the watershed outlet.

Data and observations

In eastern New Mexico, the precipitation is seasonal, with the greater portion falling during the growing season, from May to October. Most

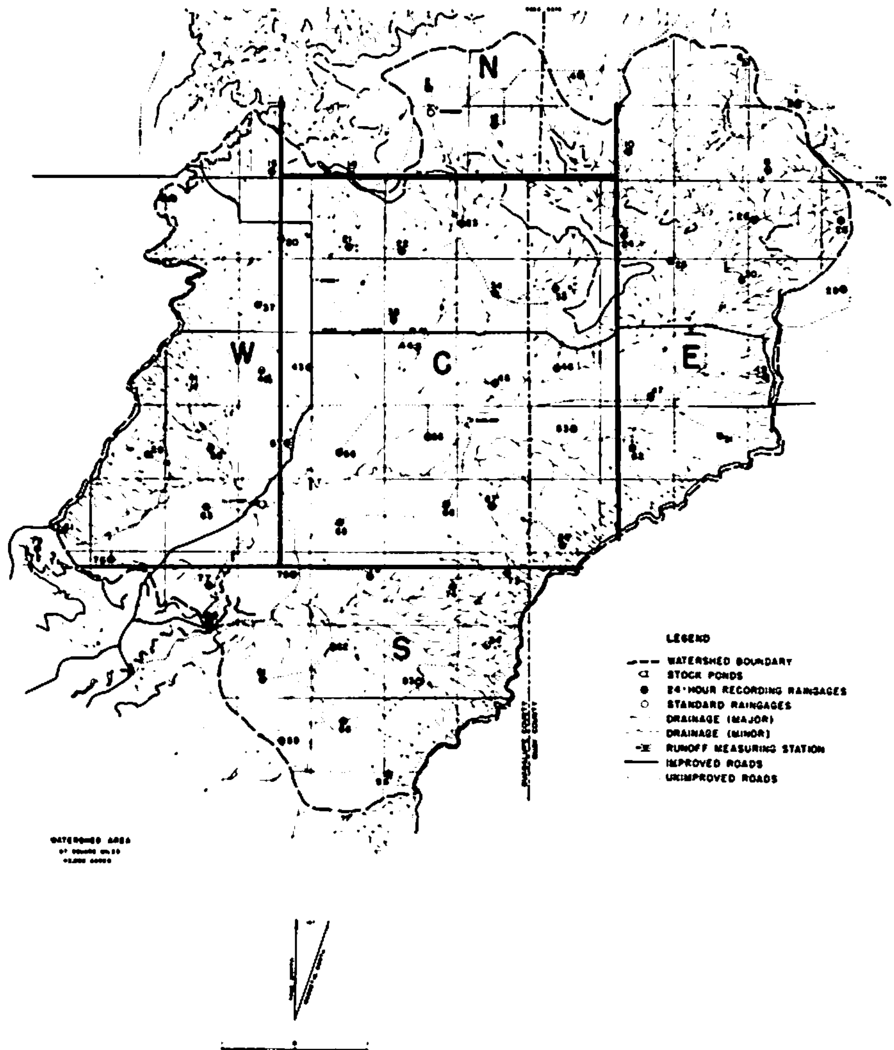

Fig. 2. Alamogordo Creek, New Mexico.

of the winter precipitation occurs as low-intensity rain or snow along slow-moving cold fronts; in contrast, summer rains are produced generally by short-duration, high-intensity thunderstorms, from purely convective buildup, or from convective cells developing along weak, fast-moving cold fronts[3]. The summer convective storms produce about 80 percent of the annual rainfall, with over 50 percent of the annual total occurring in June, July, and August (Fig. 3).

The mean annual precipitation for the period (1956–1965) was 11.18

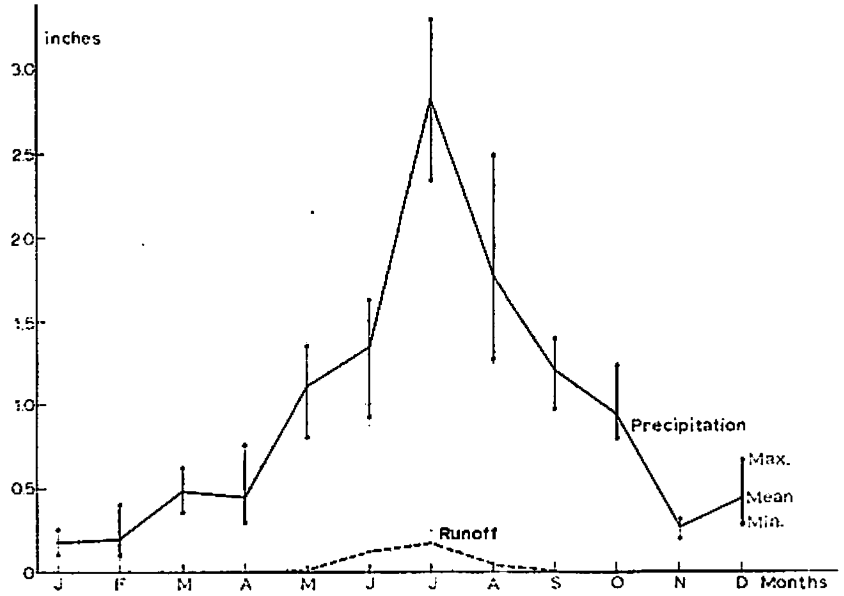

Fig. 3. Mean monthly precipitation and runoff.

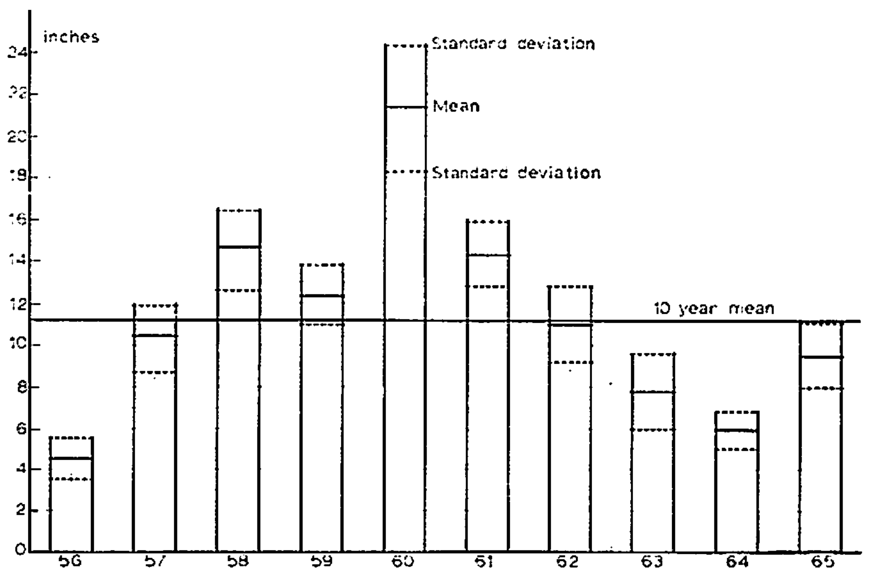

Fig. 4. Deviation of mean annual precipitation.

inches, with a standard of 4.92, and a median of 10.96 inches (Fig. 4). Such a deviation for ten years of record shows the extreme variation in annual precipitation in the Southwest. Both indices of the average are below the long-term average of 14.01 inches recorded 35 miles west in Santa Rosa, New Mexico. The average precipitation for Santa Rosa for the 10-year period of this study is also about 3 inches higher than that on the watershed.

The distribution of mean annual rainfall over the entire watershed was

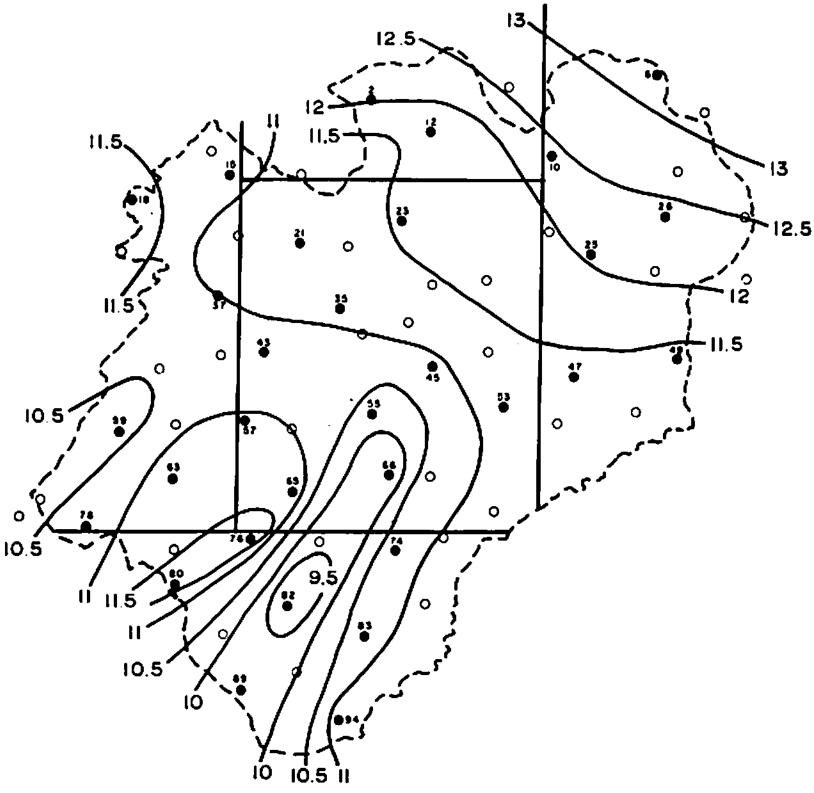

Fig. 5. Mean annual isohyetal, Alamogordo Creek watershed.

not random. The watershed was divided into 5 zones (Fig. 2), and an isohyetal map of the mean annual rainfall was drawn (Fig. 5). The isohyetal map shows, for example, that Rain Gage 6, on the rim of the escarpment, recorded about 30 percent more rainfall than Rain Gage 82 on the basin floor. Thus, a possible orographic effect is indicated. Plotting rainfall versus elevation also indicates that there is an increase in precipitation with an increase in elevation (Fig. 6). Gages 80, 76, 25, and 26 are located in

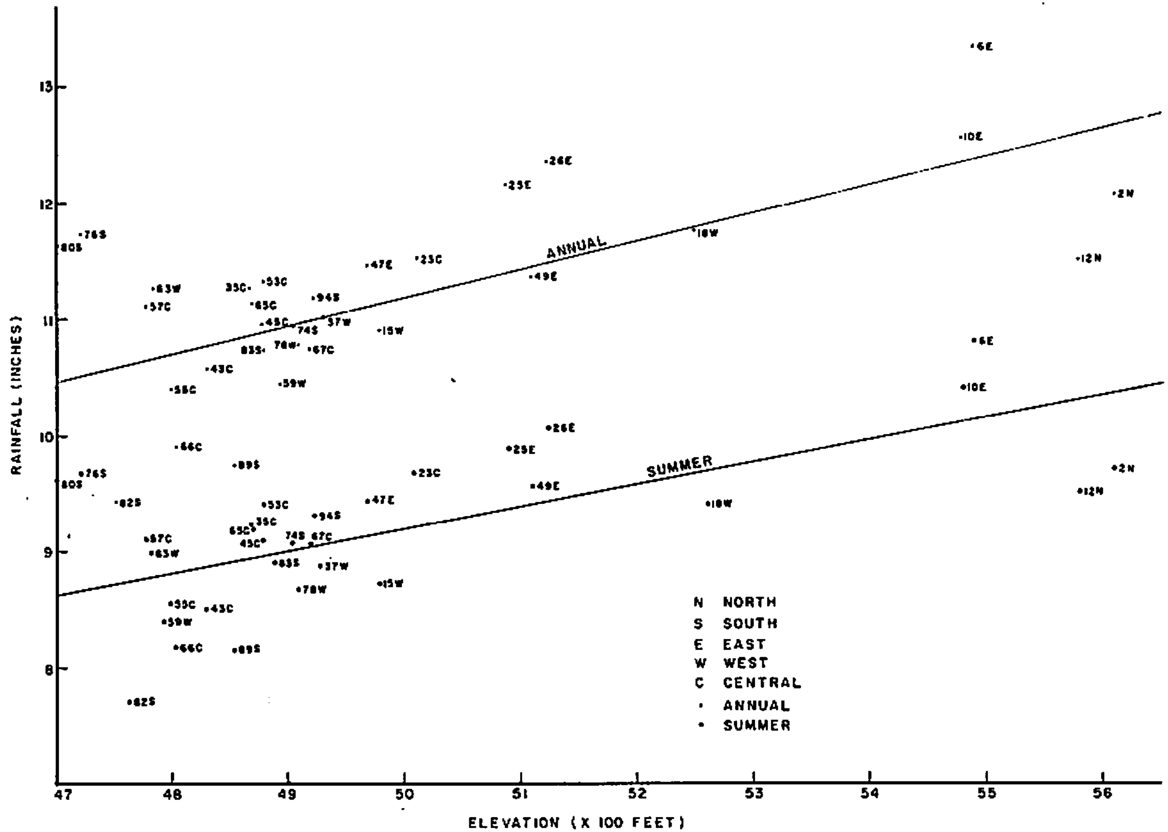

Fig. 6. Rainfall vs. elevation.

canyons surrounded by mesas 200 to 300 feet above them. Therefore, the surrounding escarpments could account for the higher rainfall at these sites. The average in each zone also indicates an orographic influence.

A possible explanation for the orographic distribution concerns the type of frontal activity that exists (when there is frontal activity) during the period of precipitation. Summer rains resulting from a combination of convective heating and weak, fast-moving cold fronts seem to produce the most intense and more random rains over the watershed, whereas summer rains connected with stronger, slow-moving or nearly stationary cold fronts produce less intense rains of much longer duration, with significantly greater amounts generally recorded on or near the rim of the watershed. An example of the latter type is the July storm in 1960[3]) where rainfall on the northeast rim was about 12 inches as compared to about 6 inches on the southern floor of the valley.

This orographic distribution, plus an east-west variation, might be explained partially from observations of the cloud formations during the summer season[3]). Warm, moist air moves into the region from the southeast during the summer when certain atmospheric conditions exist. Cumulus clouds usually form first in the late morning or early afternoon above the west and north rims of the watershed, as the moist gulf air is lifted by convective heating. By late afternoon the clouds may become mature thunderstorms. As these storms mature, they generally move slowly in an easterly direction, producing intense rainfall along their path, and a result apparently is that the eastern half of the watershed receives more rainfall than the western half (Fig. 6). With a few exceptions, the gages on the eastern side of the watershed plotted above the curve, while most of the western gages plotted below the curve, which could indicate more precipitation on the eastern half of the watershed.

The slow-moving cold fronts in the winter seem to produce little variation in rainfall distribution over the watershed. However, the average winter rainfall, about 2 inches, may be too little to determine if there is an orographic effect. The orographic effect in the summer is very pronounced.

All of the runoff was produced by the summer storms (May through October). The mean annual runoff was 0.37 inch (approximately 20 acrefeet per square mile or 1330 acre-feet), which was 3.3 percent of the mean annual precipitation.

Runoff varied even more than rainfall. In 1964, the total runoff was only 0.03 inch (107 acre-feet), while in 1960, 2.34 inches (8360 acre-feet) were recorded. Therefore, about 60 percent of the total runoff from 1956 through 1965 was produced in 1960. Ninety-three percent of the total runoff for the 10-year period occurred during the months of June, July, and August (Fig. 3).

Summary

The ten-year average annual precipitation for the Alamogordo Creek watershed was 11.18 inches with a standard deviation of 4.92 inches. Considerable variation in monthly and seasonal precipitation also would be expected with this large deviation (Fig. 4).

An orographic variation was observed (Fig. 5) and analyzed (Fig. 6). These figures showed an increase in rainfall with an increase in elevation, particularly during the growing season (May through October). It is felt that this orographic effect on the annual rainfall results primarily from rainfall produced by occasional weak, slow-moving summer cold fronts. Also, from the observed storm formations and the locations of the ranging values in Fig. 6, a less obvious east-west variation in the precipitation distribution was indicated.

All runoff was produced by summer storms (May through October), when 80% of the annual rainfall was recorded. During the 10-year period of record, 93 percent of the total runoff occurred from storms producing 50 percent of the total annual precipitation (June, July, and August). About 60 percent of the total runoff from 1956 through 1965 was recorded in 1960.

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