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PERSISTENCE OF SUMMER RAINY AND DROUGHT PERIODS ON A SEMIARID RANGELAND WATERSHED (1)

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ABSTRACT

In southeastern Arizona, almost all summer rainfall results from widely-scattered high-intensity afternoon or evening thunderstorms of limited areal extent. For eleven years of record on the Walnut Gulch Experimental Watershed, Tombstone, Arizona, about 70 percent of the annual rainfall of 11½ inches and over 95 percent of the annual runoff occurred in July, August, and early September. In contrast, about 5 percent of the rainfall occurred in the previous 3 months, and about 25 percent in the remaining 6½ months.

Therefore, summer rainfall, although highly variable, represented the most dependable source of water to the Walnut Gulch watershed. On the average, significant rainfall was recorded on some part of the watershed on 40 percent of the days in the critical July-August period. The maximum frequency was 3 out of every 4 days in 1955, and the minimum 3 out of every 10 days in 1960.

The wettest year was 1955, with a continuous rainy period of 47 days; whereas, the driest was 1960, with the longest rainy period lasting only 5 days. The longest summer drought during the period of record occurred in 1962, when no rain fell for 17 days in August, following a 14-day rainy period in late July.

As yet, there are not enough data to determine reliable expectancies for summer rainy or drought periods.

Most summer rains in the southwestern United States occur as short-duration, high-intensity thunderstorms. They result from purely convective buildup or from convective cells developed along weak, fast-moving cold fronts. Under certain atmospheric conditions which normally occur in the summer months, great masses of moist air flow into the Southwest from the Gulf of Mexico. Such flows may continue for several days or weeks, depending on the relative positions of a high pressure ridge over the central United States, and a corresponding low pressure trough over northern Mexico. Any combination of strong convective heating, orographic influences, and cooler air along a front may lift portions of the moist air, and thunderstorms result. These widely-scattered thunderstorms occur generally in the afternoon and evening, and produce nearly all of the surface runoff from small-to medium size semiarid rangeland watersheds (100 square miles or less) in the Southwest (Dorroh, 1949).

In southeastern Arizona, most of the annual rainfall occurs in July, August, and the first half of September. On the Walnut Gulch watershed, Tombstone, Arizona, about 70 percent of the annual rainfall of 11½ inches (from 11 years of record) has occurred in this 2½ month period, and almost all of this summer rainfall resulted from thunderstorms.

On the average, less than 2 percent of the annual rainfall has occurred in April and May and only about 3 percent in June. Generally, winter rains have been inadequate to provide any carryover moisture for Spring growth. Therefore, the actual growing season usually began with the first rain of the summer rainy season, which usually occurred during the first 2 weeks in July. The dominant grasses and shrubs depended mostly on the summer rains for growth, and the volumes and distribution, both in time and space, of the summer rains largely determined the condition of the vegetation on the watershed.

The growth of vegetation during the summer rainy season tends to decrease runoff volumes. On the other hand, and of greater importance, extended wet periods tend to condition the soil to higher infiltration rates because of the hydrophobic condition of the soil surface (Kincaid, 1964). Therefore, the persistence of either a wet or dry period is important in determining precipitation-runoff relationships for semiarid rangeland watersheds.

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Description of study

Precipitation records have been collected from a dense network of recording rain gages on the Walnut Gulch Experimental Watershed (58 square miles) in southeastern Arizona since 1954 (fig. 1). Periods of consecutive days with significant rainfall and without significant rainfall have been determined from records of 60 of these recording rain gages that are about evenly distributed over the watershed.

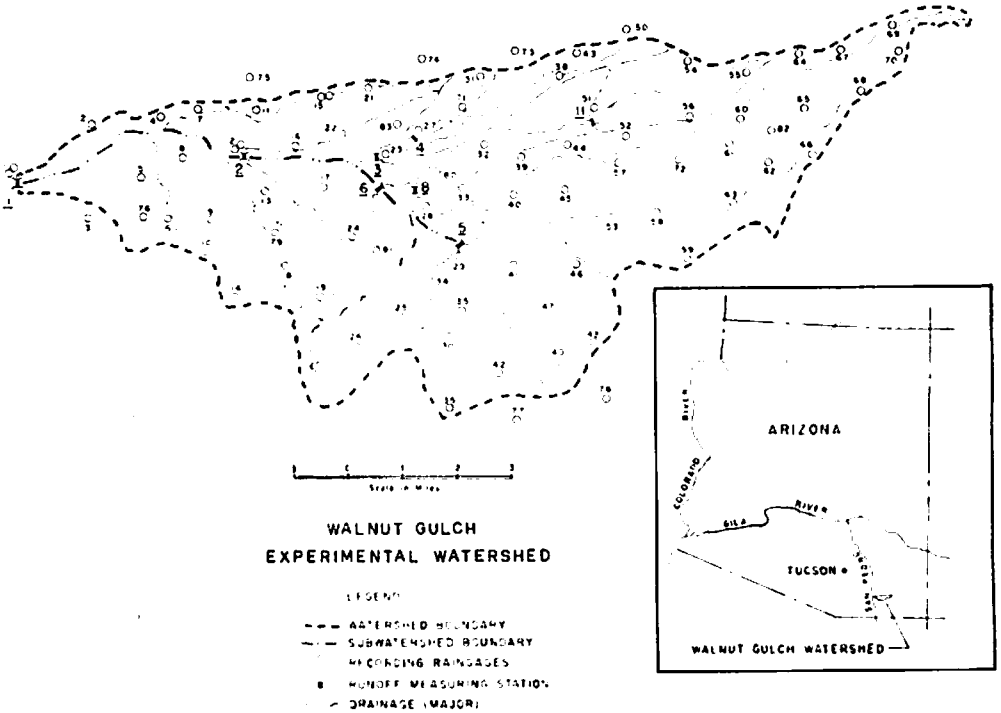

Fig. 1

If a thunderstorm began late on one day and continued into the next, this was counted as only one day with significant rainfall.

Generally, the temperatures at the ground surface are high and the vegetation and soil surfaces relatively dry prior to a thunderstorm. Evaporation losses are relatively high, and roughly one-quarter of an inch of rainfall is necessary to provide some excess moisture for plant growth and surface runoff. Therefore, a significant rain is defined as producing 0.25 inch, or more, of precipitation.

Most of the significant rains cover much less than one-half of the watershed, but the accumulation of significant rainfall during a period, although unevenly distributed over the watershed, is a good indication of the general condition of the rangeland vegetation and soil surface.

RESULTS

Variation in Summer Rainfall Distribution:

The average number of days with significant rainfall for the years 1954 through 1964 was 1½, 12, 11, and 4 for June, July, August, and September, respectively (table 1). For the same period of record, over 95 percent of the streamflow occurred in July, August, and early September. No streamflow has resulted from storms with less than significant rainfall.

TABLE 1

Days with Significant (*) Rainfall

	June	July	August	September (1-15)
1954	1	12	16	4
1955	2	19	18	1
1956	4	15	7	0
1957	2	12	13	0
1958	3	9	13	5
1959	1	15	15	1
1960	0	6	8	5
1961	3	10	10	4
1962	1	12	3	7
1963	0	13	12	6
1964	0	10	10	11
Average	1½	12	11	4

(*) Significant rainfall equals 0.25 inch or greater.

In 1955, significant rainfall was recorded on some part of the Walnut Gulch watershed about 3 out of every 4 days from July 11 through August 31 (table 2). In contrast, in the summers of 1960 and 1962, significant rainfall was recorded on an average of only one out of every 4 days in July and August. For 8 of the 11 years, significant rainfall was recorded on 30 to 50 percent of the days during July and August. The 11-year average was about 40 percent. Significant rainfall has been recorded on about 15 percent of the days in September and less than 5 percent of the days during the remainder of the year (October through June).

Although highly variable, some significant rainfall has been recorded in July and August for every year of record; the maximums were 19 and 18 days in July and August, respectively, of 1955, and the minimums were 6 and 3 days in July 1960 and August 1962, respectively. There was no significant June rainfall in 1960, 1963, and 1964, and no significant September rainfall in 1956 and 1957. In contrast, there were 4 days with significant rainfall in June 1956, and 11 days with significant rainfall in early September 1964.

Rainy and Drought Periods:

The word "rainy" refers to a persistent period of relatively moist atmospheric conditions and strong convective heating, during which thunderstorms are recorded on most afternoons or evenings on the watershed. The word "drought" refers to a persistent period with relatively

TABLE 2

Days of Significant (*) Rain from First Significant (*) Rain in July through August

Length of Period		Significant (*) Rainfall	
Year	Days	Days	Percent
1954	57	28	49
1955	52	37	71
1956	52	22	30
1957	59	25	42
1958	49	22	45
1959	62	30	48
1960	56	14	25
1961	61	20	33
1962	60	15	25
1963	55	25	45
1964	51	20	39
Average	56	23	41

(*) Significant rainfall equals 0.25 inch or greater.

TABLE 3

Longest Rainy Period during July and August

	Period of Significant (*) Rainfall (days)			
	$A = 0$	$A = 1$	$A = 2$	$A = 3$
1954	13	23	23	23
1955	14	27	47	47
1956	7	13	21	21
1957	4	6	17	17
1958	4	10	18	41
1959	6	16	18	28
1960	2	4	5	10
1961	4	5	9	16
1962	5	8	14	14
1963	7	9	16	16
1964	5	6	22	22

Note: "*A*" equals allowable consecutive dry days within the designated wet period.
(*) Significant rainfall equals 0.25 inch or greater.

dry atmospheric conditions where few or no thunderstorms occur. The critical months, as stated earlier, for both rainy and drought periods are July and August.

Annual rainy periods were determined by counting the successive days within July and August where significant rainfall was recorded on some part of the watershed, allowing for 0, 1, 2, and 3 successive dry days within the rainy period (table 3). In both 1954 and 1955, significant rainfall was recorded on some part of the watershed every day for at least one, two-week period. The longest rainy periods for both years were extended to better than 3 weeks for both years by allowing single dry days within the rainy period, and to 47 days in 1955, by allowing for up to 2-day periods without rainfall within the rainy period. The maximum rainy period in 1954 ended abruptly, whereas the rainy period in 1955 continued through most of July and August.

The second wettest summer on record was in 1958, where the rainy period was almost as long as in 1955, but not as continuous (table 3).

As yet, no firm statistical analysis can be made that would establish expectancies for the persistence of rainy periods. Past records from the U.S.W.B. rain gage at Tombstone (about 70 years of record) indicate that 1955 was probably one of the wettest summers on record, and that the 1956 and 1960 summers were among the driest. However, since the Tombstone gage represents only one point on the watershed, this record provides more qualitative than quantitative information.

Drought periods are more difficult to define than rainy periods. Obviously, a year such as 1955 had no drought period, but other years had dry periods even though July-September rainfall was average. In 1962, there was a 14-day wet period during the last two weeks in July that was followed by 17 days without rain from July 31 to August 17. This 17-day dry period during the period of main potential plant growth was critical to the condition of the watershed in late August and September, and would be expected to affect the precipitation-runoff relationship during some later period. There was no runoff between July 31 and September 4, so the pattern of runoff from the storm of September 4 might be expected to correspond more closely to an early July storm than to the usual early September event.

There is no evidence of a wet or dry cycle in the 11 years of record on the Walnut Gulch watershed; nor is there any evidence of a carryover effect on the next year's precipitation from either a wet or a dry year. The wettest year was 1955 and the driest was 1960.

Summary

On the Walnut Gulch watershed in southeastern Arizona, about 70 percent of the annual rainfall of 11½ inches for the 11-year period of record fell in July, August, and early September. Only about 5 percent of the annual rainfall for the same period was recorded in the 3-month period of April, May, and June. On the average, significant rainfall was recorded on some part of the 58-square-mile semiarid rangeland watershed on about 40 percent of the days in the July-August period. The maximum frequency was about 3 out of every 4 days in the summer of 1955, and the minimum was 3 out of every 10 days in the summers of 1960 and 1962.

Although highly variable, the July-August rainfall represented the most dependable source of water to the Walnut Gulch watershed, and rainy and drought periods within this 2-month period most influenced plant growth and surface conditions and indirectly influenced runoff.

The wettest year was 1955, with a rainy period of 47 days; whereas the driest was 1960, with the longest rainy period lasting only 5 days. The longest drought occurred in 1962 when no rain fell for 17 days in August, following a 14-day rainy period in late July. No streamflow was recorded between June 31, 1962 and September 4, 1962, which is the longest period without summer runoff during the period of record.

There was no evidence of a wet or dry cycle or a carryover effect on precipitation from one year to the next in the 11 years of record on the Walnut Gulch Experimental Watershed. The distribution and volume of rainfall for any year is independent of the previous year, but the

general atmospheric pattern is such that each year resembles the last in that most rains occur in the late evening, the significant rains generally begin during the first two weeks in July, and most of the convective rain occurs in July and August.

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