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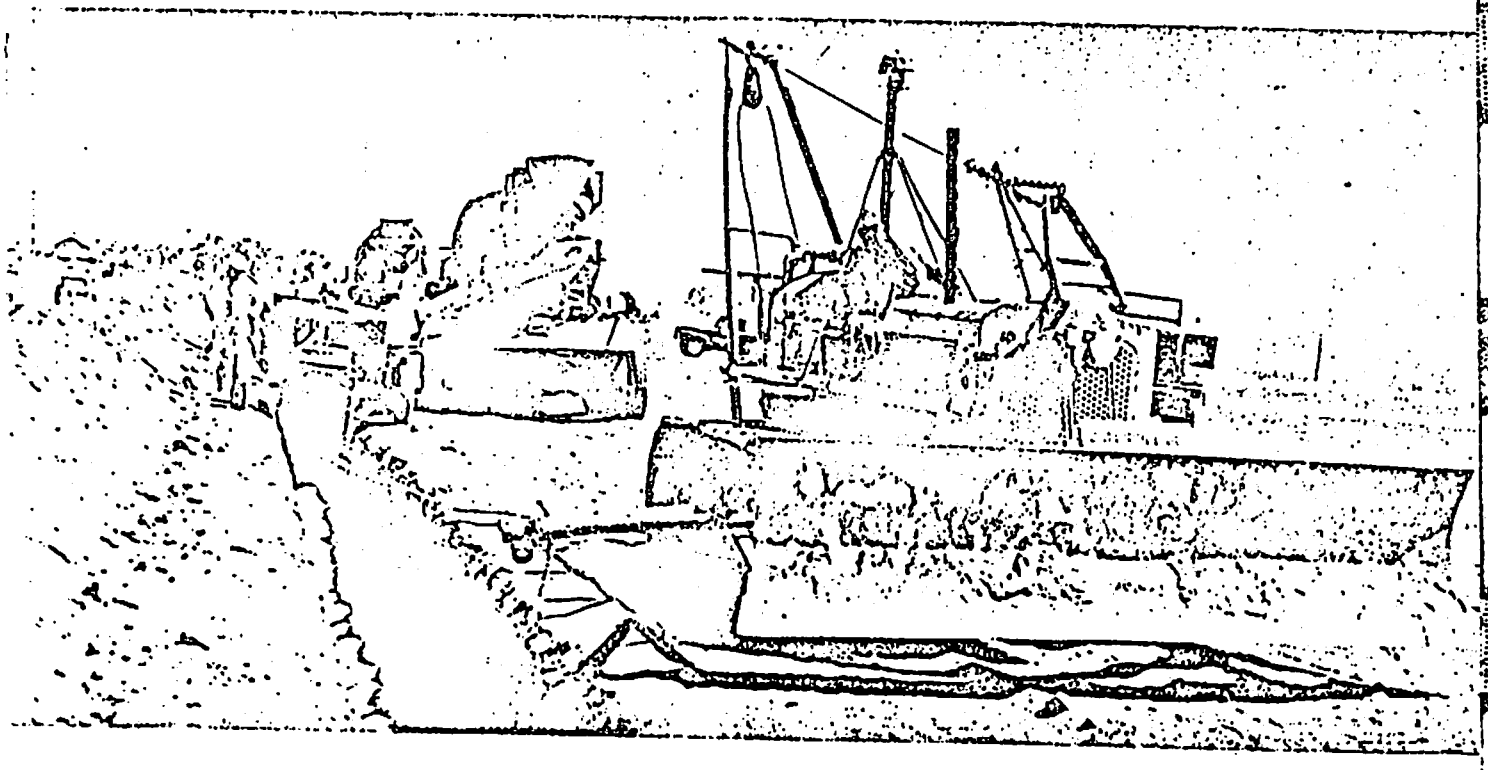
MODERN TECHNIQUES IN WATER MANAGEMENT



PROCEEDINGS

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Watershed Research On Semiarid Rangelands

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RLY HALF A MILLION SQUARE MILES in the ıwestern United States lie in the arid and semiarid .tic zones. Such lands yield only a small proportion w annual precipitation as usable water for down- ın areas, but they contribute the major part of the ıent entering irrigation reservoirs. The land is used ipally for livestock grazing. To gain an understand- f the basic hydrologic relationships existing on these ·lands, and to determine how or whether these rela- hips may be altered by range conservation and im- ement programs, the Agricultural Research Service ınducting watershed studies in Arizona and New co.

'he major activity in Arizona is centered in the Walnut h Experimental Watershed at Tombstone. (Figure 1) ıut Gulch is a westward draining, ephemeral tribu- of the San Pedro river, entering at Fairbank. Its 58- re-mile drainage area is representative of the black .a grasslands of Southern Arizona and New Mexico. ations range from 4,200 feet at the watershed outlet ,000 feet at the upper end in the foothills of the oon mountains. In addition to the gaging station at vatershed outlet, 9 subwatersheds ranging in size from o 44 square miles are gaged.

\t the outset of the studies it was felt that, in studying ıydrology of semiarid rangeland watersheds, a large gh area would be needed to insure that such things ıannel transmission losses could be adequately eval- d. Performing research on a 58-square-mile watershed ıt without its disadvantages; in order to develop the ıicture, the work must be intensive as well as exten- and adequate instrumentation becomes quite a prob- As we shall see in discussing some of the preliminary ts, however, studying an area of this size from the l subwatersheds up to the complete drainage area ıits the drawing of conclusions that could be obtained ı other way.

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Precipitation Characteristics

The annual precipitation comes in two distinct periods —July through September, and December through February—separated by periods of little or no rainfall. Storm characteristics during these two periods differ markedly: winter precipitation results from widespread Pacific frontal storms of low intensity which very seldom produce runoff; summer rain, on the other hand, result from convective activity within moist air masses originating in the Gulf of Mexico and invading the area during the July through September period, and they cause virtually all the runoff. Such convective storms are of small areal extent, short duration, and high intensity, and they account for about 70% of the total annual precipitation.

Since the convective thunderstorms comprise most of the total precipitation and produce nearly all of the runoff, a detailed knowledge of their characteristics is essential to an understanding of the hydrologic performance of rangeland watersheds. The network of recording raingages has gradually been intensified until we now have a total of 70 on the watershed area. Records from this dense raingage network have revealed several interesting results: [2]

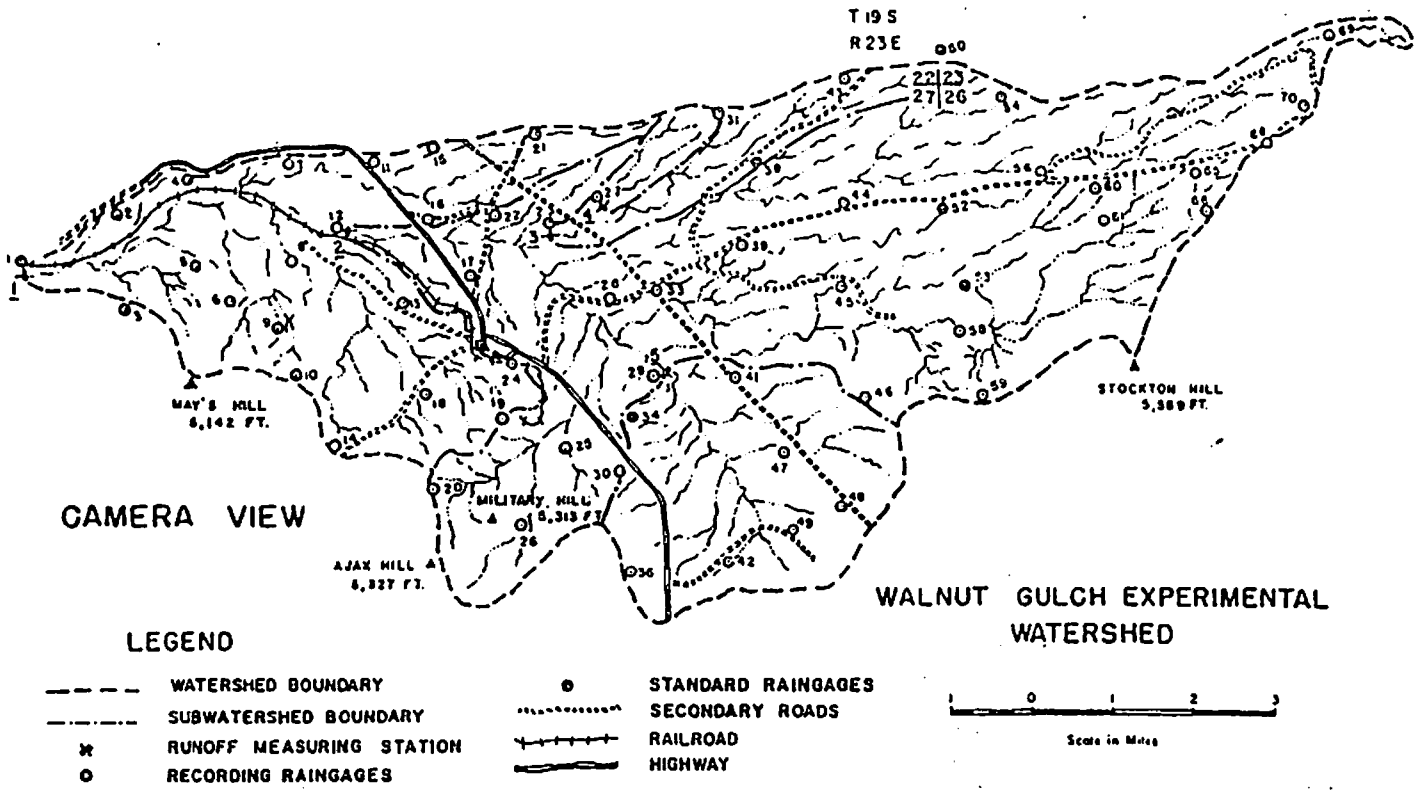
1. Eighty per cent of the convective thunderstorms cover areas smaller than 4.5 square miles, and none has covered 20 square miles.

2. Over half of the thunderstorms consist of 2 or more cells. The location of these individual cells in space and time is extremely important in relating rainfall to runoff. All major runoff events result from multi-celled storms.

3. The storms occur over the watershed in a random fashion. Frequency analysis of 3 years of record from the dense raingage network yield results comparable to those obtained by analyzing 61 years of record for the city of Tombstone.

Because of their extreme importance, thunderstorm

2 *Fletcher, J. E. Some Properties of Precipitation Associated with Runoff from Walnut Gulch Watershed, Arizona. Presented to American Geophysical Union, April 1960.*



characteristics are being studied on a continuing basis, and a radar installation will soon be added at Walnut Gulch to supplement the data obtained from the raingage network.

Unit Source Area Watersheds

The fundamental building blocks comprising a large complex drainage area are the small subwatersheds having homogeneous soils and vegetative cover—or unit source area watersheds. Techniques for sampling and surveying soils and native vegetation have been adapted for delineating these unit source areas. Seven major types are represented on Walnut Gulch Watershed, with cover ranging from good black grama to areas covered predominantly with whitethorn, creosotebush, and tarbush. Five of these types are presently being gaged, and additional installations will soon be installed. Following the initial calibration period on the brush and mixed cover watersheds, vegetative and management changes which give greater forage production will be affected, and any resulting changes in the hydrologic performance will be evaluated. During the short period of record thus far, the water yields from the brush and grass-covered unit source areas have not been significantly different, but the sediment yield from brush-covered areas has been 4 times that from the grassed areas.

Fundamental information concerning the correlation of total plant cover and that of important species with physical and chemical characteristics of the soil should help point the way toward useful and productive management and reseeding practices.

Transmission Losses

Before reaching a point of downstream use, the water yielded from individual unit-source-area watersheds must move through an extensive channel system. One of the major reasons for conducting studies on large experimental watersheds is to furnish means for evaluating the influence of channel or transmission losses on "on-site" runoff from the top to the outlet of the watershed. Our data indicate that these losses are significantly large and have a profound effect on both the water yield and the hydrograph characteristics at downstream points. In one channel reach during a single flow event transmission losses of as much as 20 acre feet per mile have been measured. The cumulative effect of these losses is a sharp reduction in water yield per unit area as watershed area increases. A convective thunderstorm covering 2 or 3 square miles of the upper reaches of the watershed may result in 30% to 50% of the rainfall's starting out as "on site" runoff; yet, because of the large transmission loss, little or no water may be yielded at the watershed outlet. Whether or not all of the water entering the channel materials is truly lost has not been fully determined; to determine the ultimate disposition of this water, additional instrumentation and study is planned. We do know that on one channel reach there are geologic barriers preventing the movement of the water downward to the regional water table, and much of the transmission loss water enters a shallow local aquifer from which it is removed by phreatophytic vegetation. On another reach, there is a fair possibility that a portion of the transmission losses may recharge the regional groundwater supply. Thus, depending on the geology and vegetation involved, transmission losses may be completely dis-

ted by evaporation and transpiration, or they may con-
ite an important recharge source. Increased attention
.t be given to ways and means of reducing the non-
eficial disposal of transmission losses.

vnstream Water Yield

The yield of usable water obtained at any point in a
ershed is an integrated value depending, first of all, on
"on-site" runoff, which is determined by the sequence
intensity of convective thunderstorm precipitation and
soil-vegetation complex on which this precipitation
s; secondly, the modifying influence of the channel
.em must be considered, and this depends on the na-
: of the channel materials, the amount and kind of
rian vegetation present, and the local and regional
logy. It should be recognized that on many semiarid
:ersheds, any effects of increasing the "on-site" runoff
vegetational or other changes may be nullified if transmission and evapotranspiration losses in the channel system are sufficiently large. The complete watershed entity, from its headwaters to the point where it delivers water to a major river system or irrigation reservoir, must be carefully considered in assessing the potential for increasing water yields. Only by understanding the hydrologic performance of our watersheds in their entirety can we hope to achieve management which will provide maximum benefits to all concerned. The possibilities for increasing water yields by vegetational changes alone appear much more limited on the semiarid watersheds than on the more humid ones lying at higher elevations. Where essentially all of the runoff results from thunderstorms, intensities of which greatly exceed infiltration capacities, it seems probable that plant cover could not influence the water yield to any great extent. Forage production and sediment delivery should be considered along with water yield in planning the management of our rangeland watersheds.

Heavy Equipment In Water Conservation

JACK W. WHITEMAN, PRESIDENT
Empire Machinery Company

:AME TO ARIZONA two years ago from Oregon. In
egon our concern for water was not, "How do we get
ore, or conserve what we have?" But rather, "What do
do with what we have?" Frankly, as an Oregonian I,
e most others, was not concerned with water problems
all. Once in a while, during a flood, or a particularly
ig dry spell that might play havoc with our forests or
.r crops, we did become aware of it. Every now and
:n we were taunted by the professionals about stream
llution, ocean pollution, or in some other similar vein.
it a concern for the supply of water certainly never
uched my awareness, nor that of nearly any other Pa-
ic Northwesterner. However, as an Arizonan, (and I
:ve truly been converted) I do have a deep concern for
ater supply, and this same concern, I am sure, is a part
the conscious awareness of all who have lived here any
ne at all. An Oregonian considers water in about the
me light as we consider air; now and then it is brought
our attention because of some pollution or storm. An
rizonan, though, considers water as he does food; either
: work for it or we won't have it.

Being a newcomer, and wanting to learn as much as I could about Arizona, I quickly found water was problem number one. However, I was shocked to see the terrible waste of water in a country so short of it. It is true that great storage projects have been built here, that a few more are planned, but in the short time I have lived here, I have seen a great flood right here in Phoenix, November 1959. During each summer the papers carry stories of floods washing away bridges, automobiles, roads and lives. For the most part, the water which causes these floods runs on unchecked and unused. For some eighteen months a project on the middle Gila River, one that would conserve nineteen thousand acre feet of water annually, has been stalled. The funds have been appropriated, but for some reason local differences have not been solved and the water continues to be wasted. I am sure something is being done and will be done about this and other water conservation problems as is evidenced here today.

A contractor customer of ours told me this story. He won his first contract in nineteen twenty-seven with a high-