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POINT TO AREA CONVECTIVE RAINFALL SIMULATION[1/]

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Abstract.--Convective rainfall can be simulated for ungaged rangelands as input to more complex range management models developed to increase long term range productivity through more efficient water use and erosion control.

INTRODUCTION

The largest single land classification in the world is "rangeland." Thus, a small percentage increase in rangeland productivity could mean a large increase in livestock production. However, both short and long term effects of range "improvements" are uncertain, unless there are accurate estimates of both the hydrologic and forage variables. The principal hydrologic variable affecting forage production is rainfall, and the most-dependable source of moisture for much of the world's rangeland is convective rainfall. For example, for rangelands in southeastern Arizona, about 70% of the rainfall and nearly all runoff results from summer convective rains. The occurrence, or lack of occurrence, and the distribution of convective rainfall determines whether there will be water for range forage, stock ponds, ground water recharge, erosion, and sedimentation, and in the extreme, damaging flood peaks. In this paper, Natural Weather Service (NWS) raingage records in Arizona and New Mexico were used to predict rainfall occurrence. Records from dense raingage networks on two USDA, ARS experimental watersheds in Arizona and New Mexico were used to develop depth-area models for thunderstorm rainfall. The rainfall models would be an integral part of more-complex range management models developed to increase long-term range productivity through improving range forage, more-efficient water use, and erosion control.

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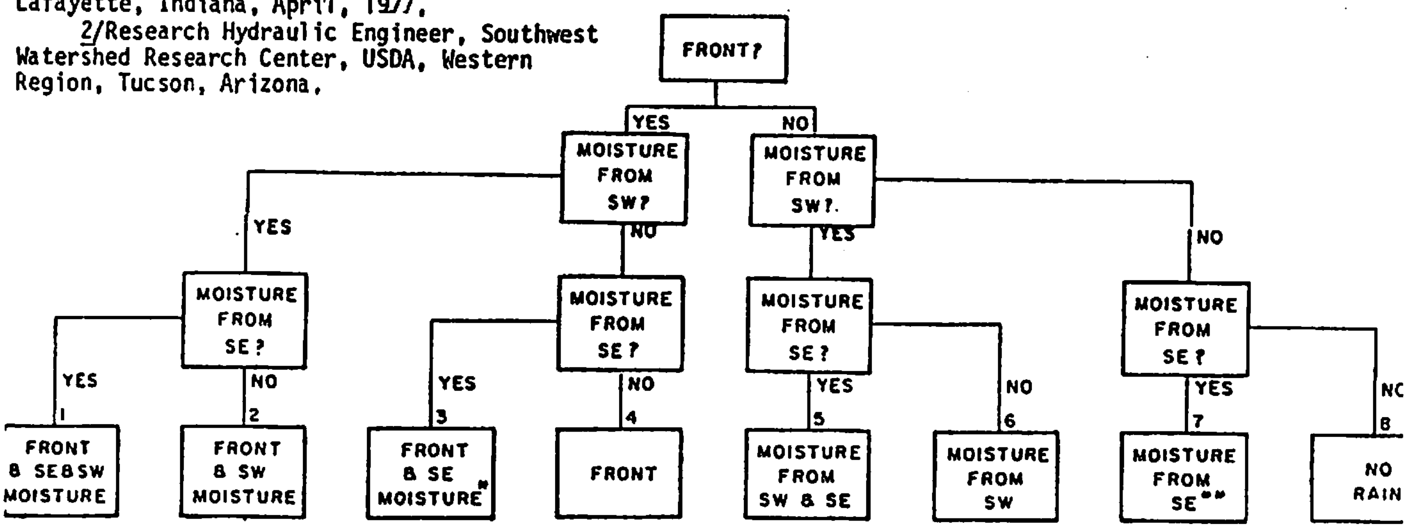
RAINFALL OCCURRENCE

There are significant differences in types and amounts of rainfall in different regions of Arizona and New Mexico, which can complicate a prediction model. For example, in southeastern Arizona most thunderstorms can be classified as airmass; whereas, in eastern New Mexico frontal activities are important considerations in estimating rainfall. In the higher mountains of northern and central Arizona and New Mexico, winter rain and snow are more important sources of precipitation than are summer thunderstorms, although thunderstorms still produce a significant amount of rainfall.



* AREAL RAINFALL GENERATED WITH ALAMAGORDO CREEK THUNDERSTORM RAINFALL MODEL.

** AREAL RAINFALL GENERATED WITH WALNUT GULCH AIR-MASS THUNDERSTORM RAINFALL MODEL.

Fig. 1. Simplified schematic diagram of summer rainfall occurrence in Arizona and New Mexico.

The rainfall-occurrence model was based primarily on NWS raingage records. The model with simplifying assumptions, is based on conditions producing rainfall in Arizona and New Mexico. A flow diagram (fig. 1) follows through the logical sequence to determine whether rainfall will occur and its form of occurrence or outcomes based on possible frontal activity, time of year, and available moisture. The terms "SE" and "SW" refer to moist air flow from the Gulf of Mexico and the Gulf of California, respectively. In practice, the two sources are indistinguishable. However, since we believe they produce different precipitation patterns, the adapted procedure accounts for the different moisture-source areas.

AIR-MASS RAINFALL SIMULATION

Once the type of storm has been predicted, a subroutine simulates rainfall over an area. For example, a model for simulating air-mass thunderstorm rainfall (outcome 7, fig 1) has been developed, based on raingage records from the USDA, ARS, Walnut Gulch Experimental Watershed in southeastern Arizona. A flow diagram (fig. 2) illustrates the simulation of rainfall over an area of 260 km^2 (100 sq. mi.). An isohyetal map of simulated rainfall (fig. 3) superimposed on Walnut Gulch compares well with similar maps of actual summer convective rainfall.

A similar model was developed for combined frontal activity and convective heating from similar records from the USDA, ARS Alamogordo Creek Watershed in eastern New Mexico (outcome 3, fig. 2). For most uses, frontal rains are fairly evenly distributed and point records can be used directly to estimate areal rainfall (outcome 4, fig. 2). At present, these 3 models (outcomes 3, 4, and 7) are used to simulate the 8 outcomes, since available data are insufficient to justify greater sophistication.

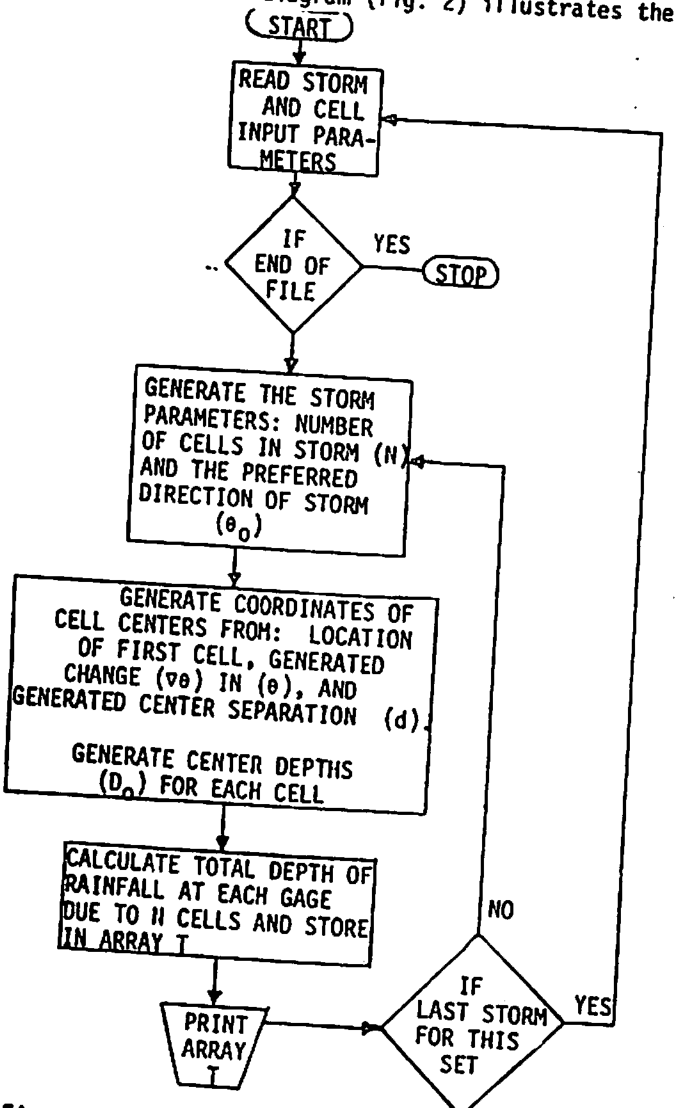


Figure 2. Flow chart for simulation of individual air-mass thunderstorm rainfalls.

APPLICABILITY TO OTHER REGIONS

Rainfall models described here have application to about 440,000 km^2 (170,000 sq. mi.) of arid rangelands in the Southwest, and probably have limited application to other U.S. regions. Several researchers have attempted to develop similar models for "universal" use without much success. There are similarities between some summer rains in the Southwest and in the Corn Belt, for example, but it may be more practical to develop regional models independently, and then possibly investigate similarities between them.

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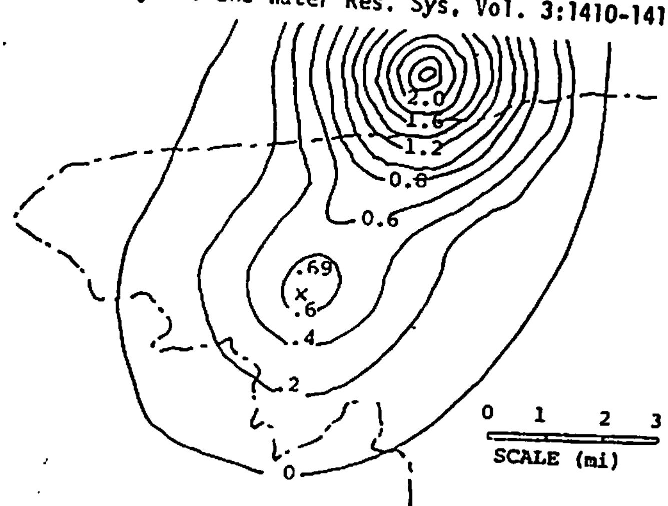

Figure 3. Isohyetal representation of a simulated rainfall for Walnut Gulch.