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RAINFALL INTERCEPTION IN A DENSE UTAH ASPEN CLONE

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ABSTRACT

Interception by high-elevation aspen and herbaceous vegetation averaged 10.3 percent of gross summer rainfall, but totaled only 1.43 inches for four summers. Stemflow from aspen averaged 1.4 percent of gross rainfall. Removal of aspen or structural changes in aspen clones would not greatly benefit water yield by reducing rainfall interception losses.

Interception and the redistribution of precipitation by vegetation can be an important part of the water budget and could significantly affect water yield. It can account for reductions to 35 percent in gross precipitation or--as in the case of single, small storms--all precipitation could be intercepted and evaporated back to the atmosphere (Ven Te Chow 1964; Zinke 1967). Interception is influenced by a number of precipitation and vegetation characteristics (i.e., storm size and intensity, form of precipitation, and wind movement, and the species, structure, form, and canopy density of vegetation).

Numerous reports concerning interception have led at least one author (Patric 1966) to conclude that interception studies "...probably outnumber those of any other aspect of hydrology." Despite this, few studies have been made of interception by communities of western aspen, an important vegetation type in the Rocky Mountain and Intermountain regions.

STUDY AREA AND METHODS

This study of rainfall interception by aspen and related herbaceous understory vegetation was conducted on the Davis County Experimental Watershed during the summers of 1962 through 1965. It was part of a seasonal water budget investigation on the Parrish Plots, an intensively studied area at an elevation of 8,400 feet, a short distance below the crest of the Wasatch Range

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near Bountiful, Utah. The study was conducted on a 1/10-acre plot characterized by a stand of scrubby aspen and a lush herbaceous understory. The aspen had a basal area of 100 square feet per acre and an average height of 17 feet. Stem diameters at breast height varied from 1.4 to 4.9 inches and ages ranged from 28 to 46 years. Ground cover was 73 percent vegetation (exclusive of aspen) and 12 percent litter. The remaining area was bare ground.

Annual precipitation there frequently exceeds 50 inches and most of that occurs as snow. Analysis of 22 years of data shows that total summer rainfall is quite variable, ranging from 0.93 inch to 15.38 inches. This rainfall usually occurs as high-intensity, convective storms of short duration.

For this study, interception was considered to be the difference between gross precipitation measured in the open and net precipitation, or throughfall, measured in the trough gages beneath the aspen-herbaceous canopy. Rainfall was measured for each storm during the 1962 through 1965 summer seasons. Eight trough gages, each 66.6 inches long, 1.5 inches wide, and 3 inches deep, were randomly located under the aspen-herbaceous canopy and two gages were placed in an adjacent opening. The gages were placed on ground that had an average slope of 23 percent. A recording intensity gage, located in the opening, was mounted in the customary manner (i.e., the orifice was level).

Stemflow was collected from eight aspen trees on the plot during the 1964 and 1965 seasons. Collars were attached to the trees about 4 feet above the ground. All stemflow was diverted into collecting tanks and measured after each storm. An estimate of average stemflow per unit area was derived by converting the volume of stemflow to inches per projected crown area of the average tree and multiplying this figure by the canopy density. No attempt was made to measure stemflow from the herbaceous vegetation.

RESULTS

Interception was calculated for 33 storms that produced a total of 14.91 inches of rain during the study. Precipitation from individual storms varied from 0.02 inch to 2.30 inches. Nearly a third of the storms produced less than one-tenth inch of rain; only four storms produced more than 1 inch.

The average catch in the trough gages in the open was highly correlated with the catch in the recording gage (R^2=0.99). In most instances, the trough gage caught more rain than did the recording gage.

Throughfall was quite variable between storms, reflecting differences in canopy structure, in time, and in space, as well as in storm characteristics. Throughfall (Pn) averaged 89.2 percent of gross rainfall and could be estimated from measured gross rainfall (Pg) by the equation:

$$Pn = 0.9346 Pg - 0.019$$

Standard error for the regression is 0.134 for these 33 observations.

If stemflow was neglected, interception per season averaged 10.3 percent of gross rainfall, but totaled only 1.43 inches for the four summers. The percent interception by storm size varied from 3 percent for a storm that produced 2 inches of rain to 50 percent for several storms that produced 0.1 inch or less. As expected, the percent intercepted generally varied inversely with storm size; however, there was considerable variation in the amount intercepted from a storm of given size, too. Stemflow was only 0.065 inch (1.43 percent) for the 11 storms measured in 1964 and 1965; total rainfall for these storms was 4.55 inches.

DISCUSSION

Interception by an aspen community appears to be quite variable both for a storm of given size and for different measurement periods, as is shown by the variability of these data and by their comparison with data reported by other authors. Dunford and Niederhof (1944), Monninger (1951), and Croft and Monninger (1953) reported average aspen-herbaceous interception to be 15.7 percent, 36 percent, and 15.8 percent, respectively, compared to 10.3 percent reported in this study. It is particularly interesting to note that Monninger's figures are more than double those reported by Croft and Monninger for the same area. Monninger's analysis was based on only 2 of the 4 years of data later reported by Croft and Monninger. These variations reflect the influence of storm intensity, storm size, and seasonal rainfall totals on interception.

Aspen stemflow measurements in this study compare well with those recorded in Colorado by Dunford and Niederhof. Net stemflow was 1.43 percent of gross precipitation during this study and 1.04 percent for the Colorado study. Analysis of the data from this study indicates that 18 gages would be sufficient to provide an estimated throughfall with a confidence interval of ±10 percent at the 95-percent probability level for storms greater than 0.15 inch.

Aspen are not efficient interceptors of rainfall. A waxy cuticle on the upper surface of aspen leaves makes them difficult to wet. Water applied to the surface forms large droplets, which are easily shaken from the leaf by the slightest breeze. Also, the smooth bark of aspen has a much smaller surface storage potential than rough-barked trees. By contrast, the dense grass and forb understory in western aspen communities has a high interception potential due to the large leaf-to-ground surface area ratio. Croft and Monninger reported that this herbaceous canopy without an aspen overstory intercepted two-thirds as much rainfall (10.5 percent) as did an adjacent undisturbed aspen community. Stemflow and possible reduced transpiration during the period that intercepted water is evaporated from the leaf surface tend to reduce the estimate of gross interception loss from herbaceous vegetation.

Soil moisture measurements on the Parrish plots indicate that summer rainfall seldom contributes to the recharge of soil moisture beyond the surface few inches. This moisture is quickly lost by evapotranspiration (Johnston 1970). Hence, from the standpoint of water yield alone, it makes little difference whether summer rainfall is lost by evaporation from the leaf surface, the ground surface or withdrawn from the root zone and transpired by the plants. However, summer rainfall plays an important role in the water relations of shallow-rooted grasses and other herbaceous vegetation. Even though summer rainfall is meager, it contributes to the growth and survival of many plant species that otherwise would be subjected to severe summer drought conditions.

Recent evidence supports the theory that evaporation of intercepted water tends to reduce transpiration loss (Goodell 1963; Thorud 1967; and Rutter 1968). The resultant net water loss from a site is less than the calculated interception loss. This evidence lends further support to the contention already presented in this paper that interception loss by aspen-herbaceous communities does not account for a very significant amount of summer rainfall.

Summer rainfall on the Parrish Plots averaged 4.54 inches over 31 years. Results of this study indicate that average interception would be less than 0.5 inch per season and that this amount would not be greatly reduced by altering stand characteristics or removing the aspen overstory. Although interception in the aspen-herbaceous community may be important in detailed water balance analysis, this study indicates that interception by this vegetation type does not significantly affect water yield.

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