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Interception of Rainfall by Creosotebush (*Larrea tridentata*)

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Summary

The objective of this study was to examine interception by creosotebush (*Larrea tridentata* [DC.] Cov.) of artificially applied rainfall for improved understanding of this phenomenon in hydrologic processes. This research was conducted near Las Cruces in southern New Mexico. Forty-four creosotebush shrubs were collected to obtain a representative sample of shrub size classes. Simulated rainfall was applied at the rate of 6 cm/hr. Measurements taken for each shrub were: (1) shrub height, (2) canopy area, (3) shrub volume, (4) number of stems, (5) leaf area, (6) green weight of stems, (7) oven-dry weight of stems, (8) green weight of leaves, (9) oven-dry weight of leaves, and (10) shrub green weight. Shrub height and the maximum and minimum diameter of the crown canopy were measured for determining canopy cover and shrub volume. The shrubs were severed at the base of the stem, weighed, and placed in a metal holding device. Shrub weight was again taken after 30 minutes of simulated rainfall, and the difference in weight was recorded as the amount of rainfall that was intercepted. Canopy cover of the creosotebush community was determined from 10 line transects 30.48 m (100 ft.) long. A stepwise regression analysis was performed on the data to determine from the collection of independent variables which have the best relationship to the dependent response variable. It was determined that leaf area was most highly correlated with rainfall interception, followed by number of stems, crown canopy area, and weight of oven-dry leaves. The average interception capacity of the 44 creosotebush shrubs was 1.2 g/cm², expressed in g of water held/unit area of crown canopy. Expressing the amount of water intercepted as a function of leaf area shows 0.54 g/cm². The annual rainfall in the southwestern U.S.A. is produced from storms of small amounts. Thus, interception by desert shrubs is of significant importance, since a high percentage of precipitation from these storms is "lost" from interception and subsequent evaporation back into the atmosphere. Twenty percent of the artificially applied rainfall was intercepted by creosotebush. For the native stands of creosotebush that had 30% crown cover, the loss of rainfall by interception would equal 22%. These data clearly demonstrate that light showers (< 5 mm) do little to replenish soil water.

KEY WORDS: interception, creosotebush, *Larrea tridentata* (D.C.) Cov.

INTRODUCTION

The hydrologic cycle has been the subject of a large number of experiments because of its extreme importance in dryland ecosystems, and it is probably the best known of the abiotic cycles. Interception, a process affecting the disposition of water in the hydrologic cycle, can be defined as the process of aerial redistribution of precipitation by vegetation (Collins 1970). Although some information is available (Zinke 1966, Helvey 1967, Helvey and Patric 1965) concerning interception by trees, there is a general paucity of information on interception by arid and semi-arid rangeland shrubs. Reasons for this lack of information may be the small, inconspicuous stature of shrubs compared to trees, and the limited total vegetation cover of shrubs, often less than 50%, giving the appearance of individual plants rather than of a solid block such as is presented by a dense stand of trees. Also, arid rangelands, characterized by low amounts of precipitation, have not been the focal point for hydrologic investigations that forested lands have been.

The few available studies dealing with interception indicated that saltbush (*Atriplex argentea* Nutt.) 46 cm high and in full bloom occurring in dense pure stands intercepted 50% of a 15-cm rain applied in 30 minutes, while burning bush (*Kochia scoparia* [L] Schad.) 76 cm high in a pure stand intercepted 44% (Collins 1970). Hull (1972) and Hull and Klomp (1974) studied big sagebrush (*Artemisia tridentata* Nutt.), using 10-cm-diameter gauges in dense stands at two locations in Idaho. Comparing gauges in heavy brush and brush-free areas, they indicated that the heavy brush intercepted about 30% of the rainfall between 1 April and 30 October. By spraying 10 individual plants with water they determined the potential interception/rainfall event to be 0.11 cm.

West and Gifford (1976) determined mean interception rates of individual plants of big sagebrush and shadescale (*Atriplex confertifolia* [Torr. and Frem.] Watts) to be 0.15 cm for both species, averaged over three sampling dates and two intensities. Utilizing this information and the average rainfall for 1 April to 30 November for north-

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ern Utah, but ignoring storm events less than 0.15 cm, they determined that an average of 0.59 cm of rainfall was intercepted by big sagebrush and shadescale communities. This amount was about 4% of the total precipitation that fell as rain.

The objective of this study was to examine interception by creosotebush (*Larrea tridentata* [DC.] Cov.) of artifically applied rainfall for elucidating and improving the understanding of this phenomenon in hydrologic processes.

METHODS

The interception studies were performed near Las Cruces in southern New Mexico. Forty-four individual plants representing various volume classes were subjected to simulated rainfall from a Purdue-type rainfall simulator. Rainfall intensity was 6 cm/hr. This high intensity was selected to insure that water loss by evaporation would be minimized, since we were interested in actual rainfall interception and storage on the canopy. Parameters determined for each shrub included (1) crown cover, (2) shrub height, (3) shrub green weight, (4) green weight of stems, (5) oven-dry weight of stems, (6) green weight of leaves, (7) oven-dry weight of leaves, (8) number of stems, (9) leaf area, and (10) shrub volume. As the shrub crowns were elliptical rather than circular in shape, both maximum and minimum diameters were measured for determining crown area. Each shrub was then severed at the soil surface, weighed, and subjected to simulated rainfall. At the end of 30 minutes the shrub was reweighed, and the difference in weight was recorded as intercepted rainfall. Leaves were stripped from the stems, and the leaf area was determined. Green weight of leaves and stems was measured, and the leaves and stems were oven-dried at 60°C for 24 and 48 hours, respectively, and reweighed. Crown cover for each shrub was calculated, using the formula for an ellipse. Shrub volume was calculated by multiplying crown area by shrub height.

The average crown cover of the creosotebush community was determined from 10 line transects 30.48 m long. Utilizing the interception storage data determined from individual shrubs and data from the line transects, rainfall interception was calculated for the creosotebush community.

RESULTS AND DISCUSSION

The average rainfall interception by the 44 individual shrubs was 0.12 cm, as determined from the crown cover.

Linear regression analysis (Table 1) was used to examine the effects of plant parameters on interception. Nine of the 10 parameters were highly significant with respect to the amount of water intercepted. Shrub height was the only parameter not correlated with the amount of water intercepted. Green weight of leaves (r = 0.52) and leaf area (r = 0.52) were the two most highly correlated parameters, closely followed by oven-dry weight of leaves (r = 0.51). The total shrub green weight had a correlation coefficient of 0.67, followed in descending order by oven-dry weight of stems (0.60), number of stems (0.50), crown cover (0.49), green weight of stems (0.45), and the volume of the shrubs (0.44).

Table 1. Correlations of interception vs. plant parameters for creosotebush.

Plant parameter	r^2	*Equation*
Crown cover	0.24	y = 1.25(x) + 88.5
Stem-green wt.	0.20	y = 8.99(x) + 1796.0
Stem-oven-dry wt.	0.36	y = 13.38(x) + 1421.4
Leaf-green wt.	0.52	y = 39.41(x) + 331.5
Leaf-oven-dry wt.	0.51	y = 58.00(x) + 257.9
Number of stems	0.25	y = 293.30(x) + 2242.6
Leaf area	0.52	y = 1.11(x) + 333.7
Shrub volume	0.19	y = 0.01(x) + 1691.7
Shrub-green wt.	0.43	y = 0.50(x) + 110.4

Note: Shrub height was not correlated with interception using a linear regression analysis.

Stepwise regression analysis for maximum r^2 improvement was also used to analyze these data further. This method determines the best 1-variable model, the best 2-variable model, and so forth for describing the influences of the measured variables on the water intercepted. Utilizing this technique, the best 1-variable model was leaf area, which accounted for 46% of the variability of the intercepted rainfall. A further example is the 4-variable model, which would account for 61% of the variability. This model includes crown cover, shrub height, oven-dry weight of leaves, and shrub volume.

The most important parameter in the interception process is the canopy storage capacity (Aston 1979). Leonard (1965) stated that storage capacity is a function of leaf area, leaf-area index, storm intensity, and surface-tension forces resulting from leaf surface configuration, liquid viscosity, and mechanical activity. Canopy storage is usually expressed as mm of water/crown projection area on the soil surface or as depth of water/unit area of the representative plant community.

The change in water detained on the canopy, assuming no evaporation, has been described by Aston (1979) as:

$$\frac{C}{t} = (1 - p)R - \exp(a + bC) \qquad (1)$$

where a = empirically determined constant, b = empirically determined constant, C = quantity of water detained on the canopy, R = rainfall intensity, p = proportion of rainfall passing through the canopy, and t = time.

It was considered that the leaves were the major tissues intercepting water and that it would be the depth of water on the leaf surface that determines the rate of water loss. Interception storage capacity is a function of the amount and nature of the intercepting leaf surfaces, and the storage is linearly related to leaf area. Under field conditions and natural rainfall the amount of intercepted water would be influenced by wind, and this influence would need to be assessed. The impact of raindrops may influence water flow across the leaf surface and so may the leaf angle. These factors, plus others that may influence the balance of leaf surface-tension forces with gravitational forces, will all affect water storage on the leaves.