W. H. Rickard

and

J. L. Warren

Battelle Pacific Northwest Laboratories
Richland, Washington 99352

Response of Steppe Shrubs to the 1977 Drought[1]

Abstract

Litterfall collecting is a non-destructive and efficient way to monitor the leaf growth of steppe shrubs over extended periods of time. During the 1977 growing season, the shrub steppe region experienced severe drought. Shrubs responded by producing few leaves, resulting in less litterfall. In some areas, spiny hopsage did not produce leaves at all. The drought was broken in 1978: sagebrush, bitterbrush, spiny hopsage, and greasewood produced as much or more litterfall as they did in the 1976 growing season.

Introduction

Although drought is an annual experience for plants growing on the Hanford Site in southcentral Washington, it was especially prolonged during the 1976-77 plant growing season. Herbaceous productivity was reduced in 1977 as compared to previous years and shrubs were also affected. This paper reports monthly collections of shrub litterfall in the years before, during, and after the 1977 drought. Litterfall has been used as a way to estimate productivity of forest communities; however, it has seldom been used to estimate shrub production in semi-arid regions (Mack, 1977). In forest regions, the trees are of economic concern because of the value of wood. In shrub-steppe regions, grasses are usually the subjects of concern because shrubs (e.g., sagebrush) are poor livestock forage as compared to grasses (Daubenmire, 1970). This study presents a way to monitor temporal and spatial differences in chemical composition of shrub leaves in a non-destructive fashion through litterfall collections. The data also indicate that leaf fall collecting is an efficient way to obtain information concerning the impact of drought upon the leaf growth of steppe shrubs.

Methods

Collectors made of short lengths of plastic irrigation pipe (polyvinyl chloride, PVC) were used to collect litterfall from individual shrubs. Each collector consisted of a one decimeter length of 15.6 cm diameter pipe and a 0.5 dm length of the same pipe. The two pieces were cemented together after putting in place a piece of nylon mesh screen to serve as a floor to the collector. The mesh permitted rainfall to pass through the collector, but leaves and other plant parts were retained. One collector was placed under the canopy spread of each shrub with the tall section above the short section. Each collector was emptied of its accumulated contents at the beginning of each month. These devices were heavy enough to remain in place under the most windy conditions

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and also deep enough to keep leaves from blowing away once they were in the collector. The collected plant material was hand-sorted in the laboratory to exclude any large twigs or animal debris; the remainder was air dried before weighing.

Four species of shrubs were selected for study, greasewood (*Sarcobatus vermiculatus*), spiny hopsage (*Atriplex spinosa*), butterbrush (*Purshia tridentata*), and sagebrush (*Artemisia tridentata*). At each site, four individual shrubs of each species were provided with collectors. The shrubs were all located on the Arid Lands Ecology Reserve at the locations shown below.

Taxa	Location	Elevation (ft.)
Hopsage and greasewood	Rattlesnake Spring	690
Bitterbrush	Southeast ALE	440
Sagebrush	ALE Headquarters	1080
Sagebrush	Rattlesnake Mountain	3130

Rain gauges were maintained at three of these sites and were read monthly.

Results and Discussion

The results of litterfall collections are summarized in Figure 1. Hopsage averaged 2.12 g of dry litter during the first season, 1976. No measurable litter was collected in 1977 because hopsage failed to produce a crop of leaves that year. However, in 1978 hopsage averaged 3.65 g of litter per collecting device. The 1978 litterfall collections were marked by an abundance of winged fruits. July was the month of peak litterfall collection in 1976 and 1978.

Bitterbrush produced on the average 2.95 g of litter in 1976, 0.77 g in 1977, and 3.70 g in 1978. August was the peak month of litterfall collection. The duration of litterfall in 1978 extended later into the autumn than it did in 1976 and 1977 (Fig. 1).

Greasewood produced more litterfall than other shrub species, partly because of larger plants. Litterfall averaged 5.33 g in 1976 and only 1.29 g in 1977. Clearly, greasewood litterfall was influenced by the 1977 drought even though greasewood has deep root systems and is regarded as a phreatophyte (Harr and Price, 1972). The peak month of litterfall in 1976 was November (Fig. 1). In 1978 litterfall averaged 8.87 g; unlike the previous years, the peak month of litterfall was September (Fig. 1).

Sagebrush is by far the most abundant shrub species on the Arid Lands Ecology Reserve; two sites were studied, a low elevation site and a high elevation site (Fig. 1). The low elevation site in 1976 yielded 2.69 g of litterfall but only 1.46 g in 1977. As were the other shrub species, sagebrush was affected by the 1977 drought. In 1978 sagebrush recovered from the drought and produced 3.99 g of litterfall. There was no definitive peak month of litterfall in 1977, but July was the peak month for litterfall in 1978 (Fig. 1).

Sagebrush at the high elevation site produced 2.14 g of litter in 1976 and 2.88 g in 1977. The effect of drought on sagebrush at the higher elevation was not so apparent. In 1978 litterfall amounted to 5.09 g. July was the peak month of litterfall during all three years, but August 1978 was also a heavy producer (Fig. 1).

The monthly precipitation measured at three of the study sites is summarized in Figure 2. As expected, precipitation was greatest at the high elevation. The October to May precipitation corresponds to the most active portion of the plant growing sea-

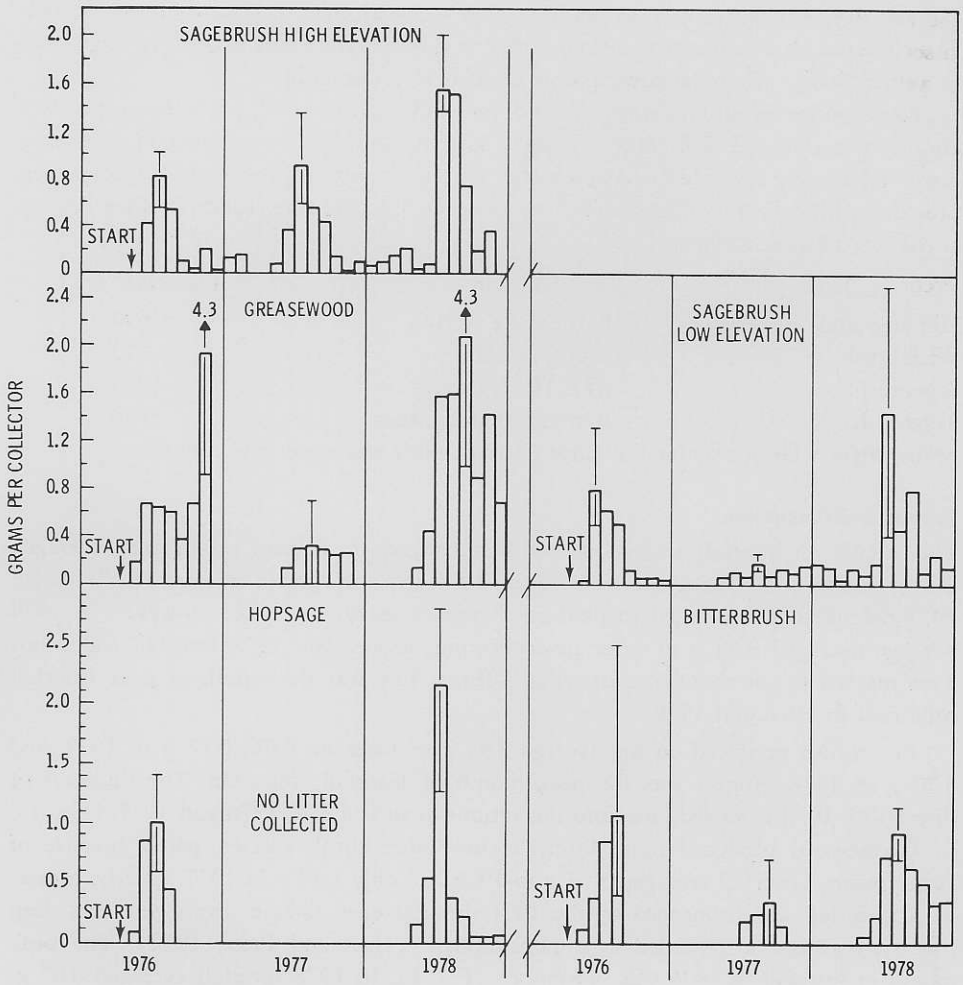

Figure 1. Monthly collection of shrub litterfall on the Arid Lands Ecology Reserve in the growing seasons of 1976, 1977, and 1978. The values are means (n = 4) and the vertical bars are extremes of the month of peak litterfall.

son in the shrub steppe region and clearly shows that 1977 was extremely dry (Fig. 2). Only 5 cm of precipitation was recorded at the two lower elevation sites and 7.3 cm at the high elevation site. The 1978 growing season was much wetter than the 1976 season, with 25.4 cm of precipitation recorded at the high elevation site, 18.8 cm at the low elevation sagebrush site, and 15.3 cm at the greasewood-hopsage site (Fig. 2).

These data show that monthly collections of shrub litterfall is a way to monitor the leaf growth of steppe shrubs. Growth of shrubs as measured by the amount of collected litterfall was relatively small in the drought year of 1977 at all sites except the high elevation sagebrush site. Hopsage failed to produce leaves in 1977. However, leaf growth for all plants was restored in the 1978 season when precipitation was more normal. The moderate response of the high elevation sagebrush plants to the 1977

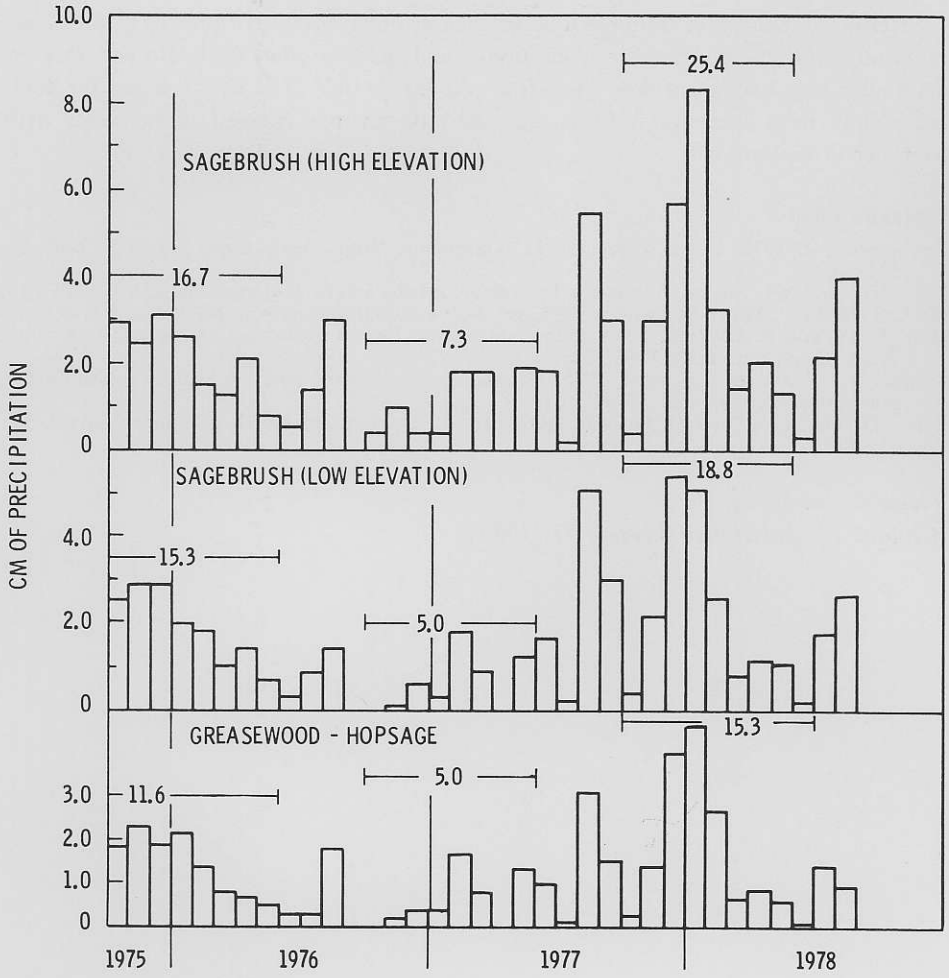

Figure 2. Monthly precipitation (cm) measured at three litterfall collection sites during the growing seasons of 1976, 1977, and 1978. The numerical values show the amount of growing season precipitation October through May.

drought is unexpected. Snow drifts are deposited at this site and the soil water regime may be more mesic than the rain gauge indicates.

There are factors other than weather that can influence litterfall collections. Insects can defoliate shrubs. The moth, *Aroga websterii*, has been known to defoliate and kill *Artemisia* shrubs (Gates, 1964). Grasshoppers also forage upon shrub leaves (Sheldon and Rogers, 1978). Mule deer, *Odocoileus hemionus*, browse upon steppe shrubs, especially bitterbrush. However, mule deer are scarce at the bitterbrush site studied, and there was no evidence that bitterbrush plants were being utilized by deer. Jackrabbits are widespread throughout the shrub steppe vegetation, and they also eat shrub leaves (Uresk, 1978). There was no indication that insects or vertebrate animal foraging were important factors in limiting litterfall collections during the period of this study.

Herbicide damage to shrubs can occur even at great distances from the point of application from leakage en route from airport and field; so, too, small droplets may remain aloft long enough to drift away from the target field. The sites selected for study are remote from agricultural fields and are probably not exposed to herbicide drift from aerial applications.

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