Apparent Sap Velocities in Big Sagebrush as Related to Nearby Environment[1]

GERALD F. GIFFORD[2]

Lecturer, Watershed Management, Renewable Resources Center, Reno, Nevada.

Highlight

Peak daily sap velocities were rather consistent throughout the year, and were always less than five cm/hr (average of five plants). A 30-variable multiple regression equation involving environmental parameters measured near plants accounted for only 54.05% of variability associated with apparent sap velocity measurements. Big sagebrush plants must, therefore, exert considerable physiological control of transpirational water losses.

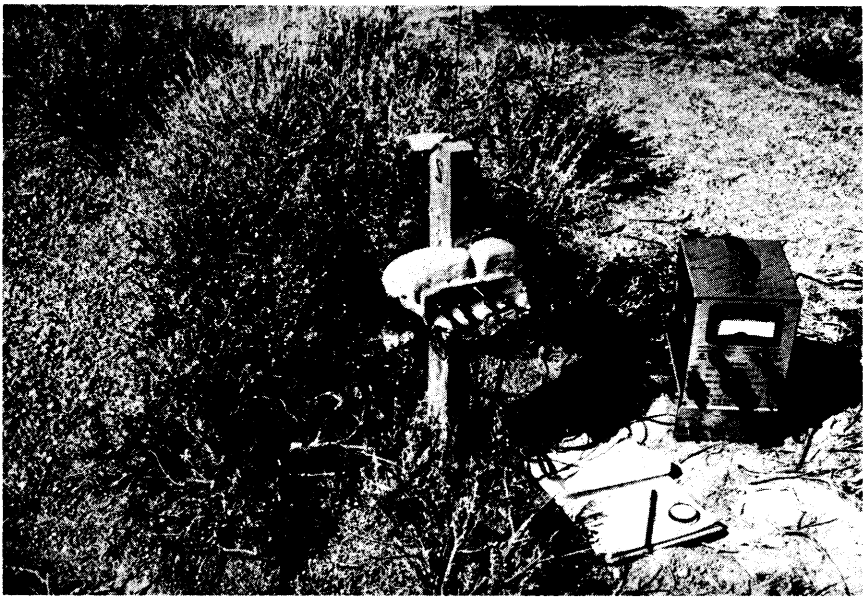

FIG. 1. Big sagebrush plant equipped for measuring sap flow velocities.

Ecology of semiarid plant species is probably influenced more by water relations than by anything else. The passive and physiological aspects of plant response to available moisture have not been studied extensively in the West, and especially with respect to big sagebrush (*Artemisia tridentata* Nutt.). Yet this particular plant occupies millions of acres of western rangeland and is used by many as an indicator plant for potential range rehabilitation measures, for estimating annual rainfall amounts, for visual determination of particular soil properties, etc. Certainly an understanding of the water relations of this species would greatly enhance our present knowledge of the niche this species occupies.

Transpiration is of interest in plant–water relationship studies. Not only total quantities, but also seasonal and daily losses are important and how these losses are modified through plant response to the environment.

One indicator that transpiration is occurring is velocity of the sap stream. In this paper, velocity of a heat pulse within a sagebrush as influenced by flow of sap was used to approximate apparent sap velocities. Heat pulse velocity, the technically correct term, is used interchangeably throughout this paper with sap velocity.

Study Area and Procedures

The study was undertaken in Eastgate Basin, located 120 miles east of Reno, Nevada. The Basin constitutes an area of about 220 mi^2 and is generally quite dry. Elevation varies from about 4,500 ft at the mouth of the basin to nearly 10,000 ft in the nearby Desatoya Mountains. Greasewood (*Sarcobatus vermiculatus* Hook.), shadscale (*Atriplex confertifolia* Torr. & Frem.), big sagebrush, pinyon–juniper (*Pinus monophylla* Torr. & Frem.–*Juniperus osteosperma* Torr.), and low sagebrush (*Artemisia arbuscula* Nutt.)—dominated communities are found in the basin. Average annual precipitation at 5,500 ft, the elevation of the study site, is 10 to 12 inches.

Soils on the sagebrush site were alluvial derived, with little or no profile development. Soil texture was sandy loam down to at least 36 inches, with gravel and some boulders present.

The study site is part of the *Artemisia tridentata/Bromus tectorum* L. community in the Basin as delineated by Heinze et al. (1965). Live shrub canopy coverage was about 25% and the slope a gentle 2 to 3%.

All sap velocities were measured by the heat-pulse technique of Marshall (1958), as modified by Swanson (1962, 1965). Marshall's theory was developed for non-porous woods (no vessels) and sagebrush wood is diffuse porous.

A 3-0-8 mm probe spacing was used, and probes were installed near the base of each sagebrush, one set per plant. Ferguson (1964) has discussed stem anatomy of big sagebrush, and probes were installed where reliable sap velocity readings were most likely to occur. A Medistor Model A-60C microvoltmeter was used as a null detector for temperature measurements. Five plants were measured each hour on 13 selected days during a year from before sunrise to after sunset (Fig. 1). Minimum detectable apparent sap velocity was 3 cm/hr.

Several environmental parameters were measured near the plants. Net radiation was measured with a Fritschen-type (Fritschen, 1963) net radiometer coupled to a Rustrak Model 88 6v battery-powered recorder. Wind was measured with a Stewart anemometer coupled to a Rustrak Model 88 24v battery-powered recorder. Temperatures were measured with Rustrak Model 1443 shielded nickle-wire sensors coupled to a multiple-input Rustrak Model 133 24v battery-powered recorder. Some canopy temperatures were measured with Weston Model 2261 thermometers. Soil moisture was measured with a Troxler Model 105 A Depth Moisture Probe to a depth of 4.5 ft.

The following parameters (in linear

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[2] Presently Assistant Professor, Range Watershed Science, Utah State University, Logan.

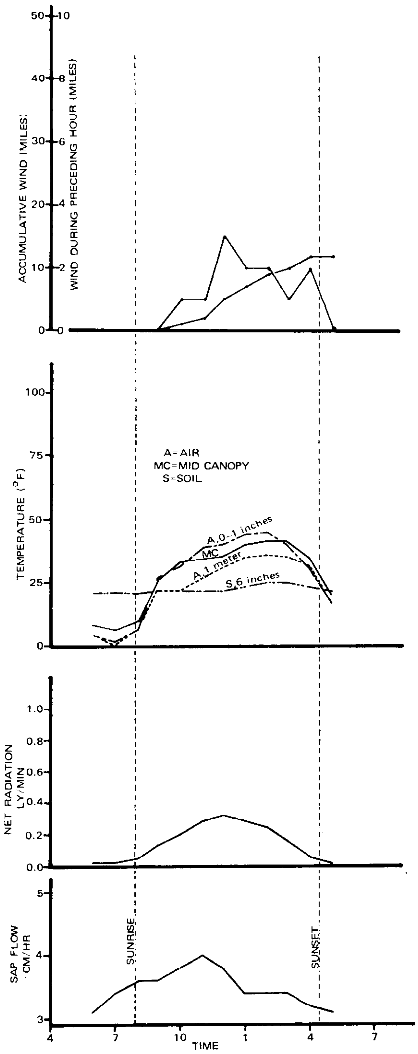

FIG. 2. Sap velocities (average of 5 plants) and selected environmental parameters on 1–17–67.

and quadratic form) were examined in a step-wise multiple regression analysis for their influence on sap movement:

- X_1 Temperature, top of sagebrush canopy
- X_2 Temperature, mid sagebrush canopy
- X_3 Temperature, bottom sagebrush canopy
- X_4 Temperature, 3-inch soil depth directly beneath sagebrush
- X_5 Temperature, air at 39.37-inch height in opening between plants
- X_6 Temperature, air at 6-inch height in opening between plants
- X_7 Temperature, air at 0 to 1-inch height in opening between plants

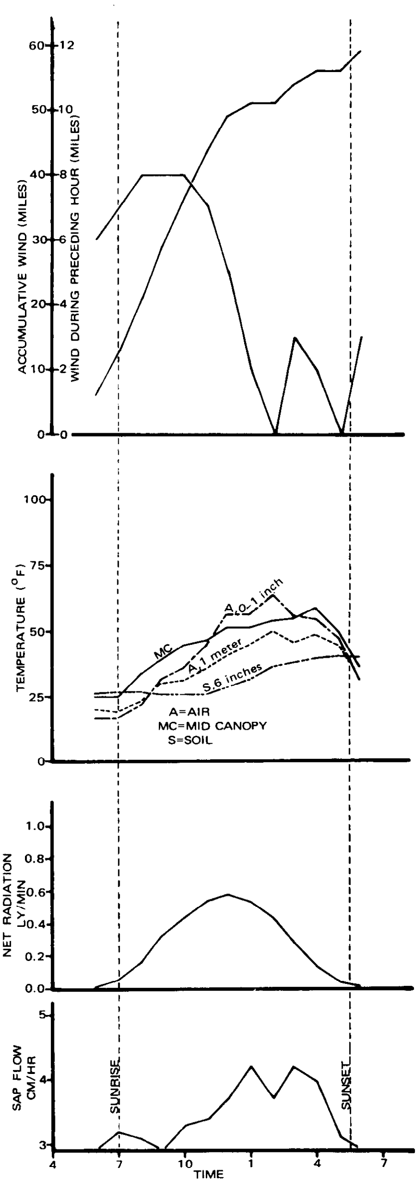

FIG. 3. Sap velocities (average of 5 plants) and selected environmental parameters on 3–7–67.

- X_8 Net Radiation, ly/min at 39.37-inch height
- X_9 Temperature, soil in opening between plants at 2-inch depth
- X_{10} Temperature, soil in opening between plants at 6-inch depth
- X_{11} Temperature, soil in opening between plants at 24-inch depth
- X_{12} Wind (miles) during preceding hour at 39.37-inch height
- X_{13} Accumulative wind (miles) at 39.37-inch height
- X_{14} Relative humidity at 12-inch

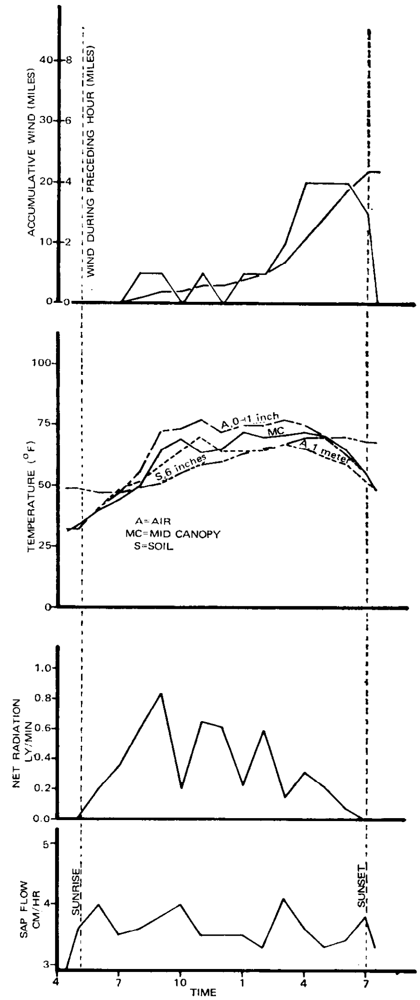

FIG. 4. Sap velocities (average of 5 plants) and selected environmental parameters on 6–14–67.

height in opening between plants

- X_{15} Relative humidity at 39.37-inch height in opening between plants

Soil moisture distribution in a four-foot soil profile on each sampling date is shown in Table 1. The more uniform the moisture distribution, the drier the profile. Moisture seldom penetrated greater than 30 inches on the study site.

Results and Discussion

Big sagebrush apparently exercises considerable physiological control of water loss. The 30-variable multiple regression equation explained only 54.05% of the variation associated with apparent sap velocities, and only 14 variables explained more than 1% each of measured variability. These vari-

Table 1. Soil moisture distribution (percent of total water by one foot increments) in four-foot soil profile on days when sap velocities were measured.

Date	Foot increments			
	0–1	1–2	2–3	3–4
9-21-66	29.1	23.4	24.1	23.4
10-5-66	26.3	24.6	24.6	24.5
10-19-66	25.2	25.2	25.2	24.4
10-25-66	25.4	24.6	25.4	24.6
11-23-66	25.7	24.8	24.8	24.7
12-15-66	35.0	21.9	21.9	21.2
1-17-67	35.0	21.9	21.9	21.2
2-8-67	44.3	22.7	16.5	16.5
2-28-67	37.0	24.6	20.0	18.4
3-7-67	37.0	24.5	20.0	18.5
3-21-67	42.1	23.1	17.4	17.4
4-8-67	44.7	22.9	16.2	16.2
6-13-67	24.5	28.2	24.5	22.8

ables, and their relative importance, are given below:

Variable	Variance Explained (Percent)
$(X_5)^2$	17.1
$(X_1)^2$	5.6
$(X_{14})^2$	5.3
X_9	4.3
$(X_{10})^2$	3.8
X_{13}	3.4
X_2	2.3
$(X_2)^2$	2.2
X_{14}	1.8
$(X_{11})^2$	1.5
X_{12}	1.4
$(X_2)^2$	1.2
X_8	1.2
$(X_9)^2$	1.1

The resulting empirical relationship is as follows:

$$\hat{Y} \cong f\left[\frac{(X_{11})^2 + (X_1)^2 + X_2 + (X_9)^2 + X_8 + X_{12} + X_{13} + X_{14}}{(X_2)^2 + (X_{14})^2 + (X_5)^2 + (X_{12})^2 + X_9 + (X_{10})^2}\right]$$

where $\hat{Y}$ is sap velocity.

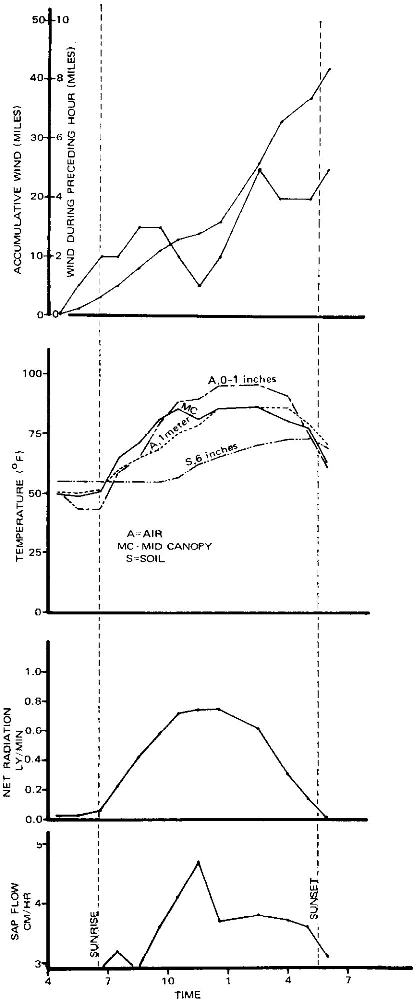

FIG. 5. Sap velocities (average of 5 plants) and selected environmental parameters on 9-21-67.

As previously noted, the analysis represents data from all seasons of the year. If data were analyzed on a seasonal basis, then above relationships could vary somewhat. Soil moisture, an important factor, would also influence the equation, if included.

Peak daily sap velocities were approximately the same, regardless of season (Fig. 2, 3, 4, 5). Average sap velocity for five plants never exceeded 5.0 cm/hr.

Similar sap-flow velocity patterns throughout the year should not infer equal volumes of water being transpired. Late in the summer when moisture is highly limiting, only a small portion of the stem is probably transporting water. However, during the spring soil moisture is readily available, and a greater cross-sectional area of the stem may be conducting water. Therefore, volume of water being transpired cannot be inferred from sap velocity, only time when transpiration is taking place. This study indicates that sagebrush may transpire at any time during the year, but variance associated with sap-velocity measurements could be only partially explained by surrounding measured environmental conditions. Physiological control is, therefore, at least one probable important unmeasured parameter in this study.

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