WINTER COURSE OF TRANSPIRATION IN ARIZONA PONDEROSA PINE TREES

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Measures of sap movement in tree stems obtained with a heat pulse velocity meter (Swanson 1962, Skau and Swanson 1963) have been correlated with water vapor production in the trees (Decker and Skau 1964, Swanson and Lee 1966, Swanson 1972). This heat pulse velocity meter, therefore, was used to determine whether transpiration, as indicated by sap movement in tree stems, takes place in ponderosa pine trees during the winter months. Because a large portion of the annual water yield from upland watersheds in Arizona ponderosa pine forests originates in the winter, knowledge of the course of transpiration at this time might be helpful in evaluating the effects of vegetative modifications on water yields.

Description of Study

The study was carried out in a large pole, small sawtimber stand of ponderosa pine trees located approximately 25 kilometers south of Flagstaff, Arizona. Average volume of the stand was 87.5 cubic meters per hectare. Soils are classified into the Brolliar soil management area (Williams and Anderson 1967). Annual precipitation averages 610 millimeters, one-half of which comes during the November 15 to April 15 period.

Ten trees of similar characteristics were selected as the sample basis (Table 1). It was thought that a small, homogeneous sample would better provide the source data necessary to satisfy the study objective than a more heterogeneous sample confounded by interactions among individual tree characteristics.

Sap velocities were measured by the heat pulse technique specified by Swanson (1962). Three probes were inserted into the tree stems in a vertical row; the middle probe was a miniature electrical heater and the other two probes contained small thermistors coupled as two legs of a bridge circuit. To operate, the bridge was balanced and the heater turned on for 1 second. The upper thermistor changed in electrical resistance as warmed sap can into contact with it, resulting in the bridge being thrown out of balance. Time required for the balance to be restored was measured and taken as an index of sap movement and, in this study, transpiration. No attempt was made to estimate absolute quantities of water vapor involved, however.

Sampling points, 1 set per sample tree, were located 1 meter above the ground and at a depth of 1.5 centimeters into the xylem. Points were selected randomly with respect to direction. Measurements were taken at weekly intervals in the study period of November 15 to May 15. All measurements were made near solar noon on clear to partly cloudy days.

Table 1. Characteristics of sample trees.

Characteristics	Mean	Maximum	Minimum
Dbh (centimeters)	28.4	31	24
Height (meters)	15.4	17	14
Crown			
Length (meters)	7.5	9	6
Width (meters)	3.8	4	3
Age (years at dbh)	56.5	63	53

Daily air temperatures were available from a nearby weather station. Soil moisture data and moisture content of the xylem were not obtained, however, and precipitation was not measured on the study area.

Results

An assumption made in this study was that transpiration must result in sap movement in a tree stem (Swanson 1966). The converse, though, is not necessarily true. It is possible that sap movement can lag behind transpiration, resulting in sap movement continuing for a period of time after transpiration has ceased. However, sap movement in the tree stem must represent water loss from the soil and, therefore, was labeled transpiration for study purposes.

Average velocity of sap movement in the sample trees and air temperature at the time of measurement were correlation closely throughout the study period. Velocities of sap movement ranged from less than 2.7 centimeters per hour on December 26, when the air temperature was the lowest, -20°C., to over 14.1 centimeters per hour near the end of the study period, when the air temperature exceeded 15°C.

Sap movement was detected in all of the 10 sample trees on every measurement date with the exception of December 26, when there was no deflection in the heat pulse velocity meter for 3 sample trees; it was assumed that these trees were frozen at the sampling points. A distinct increase in sap movement was observed on February 6, an unseasonably warm period. Starting on February 26 and for the balance of the study period, a gradual increase in sap movement was measured in all sample trees.

Discussion

Swanson (1966) listed likely reasons for observing winter sap velocities, including falsely indicated movement as the result of heat flow in response to temperature gradients across sampling points, movement of water into the tree stem to replace stem storage depleted during the previous summer, and movement in response to water loss by leaves or needles. Unfortunately, it was not possible to evaluate these reasons individually in this study. It is conceivable, therefore, that all of the reasons contributed to detection of sap movement.

That sap movement was observed in most of the sample trees throughout the study period suggests that transpiration possibly occurred, to some degree, during the winter months. Consequently, it seems possible that a reduction in the number of trees in a stand might decrease the amount of water vapor lost. Once again, absolute quantities of water vapor involved were not measured in this study; it was not possible, therefore, to quantify the magnitude of this potential decrease. Swanson (1967) described how measurements of sap movement can be used to estimate transpiration. However, the difficulty in determining the cross-sectional area through which sap is flowing restricts obtainment of estimates of actual fluxes of transpiration through time. This estimate was not made in this study due to a lack of necessary input information.

References Cited

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