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Abstract. Bi-weekly samples of wood were taken from two species of conifers and three species of dicots from September to April. From the samples water content and solute content of each tree were determined. From soil samples taken beneath each tree the soil moisture was determined. The water content in the dicots was high in winter and low in the fall and spring, and in the conifers it was high in the fall and decreased through the winter to low values in the spring. Soil water influenced the water content of the trees only in minor details. The solute content of the conifers was low compared with the dicots. High solute content in the dicots occurred in February after rising during the fall and winter. Tree trunks apparently did not fill with water because of the increased solute since increases in water content preceded increases in solute content.

Many plant scientists have been interested in the water and solute content of tree trunks. These interests range from the technical aspects of hardiness (Levitt, 1941), sap flow (Huber, 1952), sequence of growth processes (Reimer, 1949), to flotation of logs (Gibbs, 1939). This investigation was undertaken to determine the degree of hydration and the changes in solute content of various tree trunks during the "dormant" season.

Materials and Methods

The trees selected for sampling were located on the University of South Dakota campus in Vermillion. These included silver maple (*Acer saccharinum* L.), green ash (*Fraxinus pennsylvanica* var. *lanceolata* (Borkh.) Sarg.), American elm (*Ulmus americana* L.), red cedar (*Juniperus virginiana* L.), and white spruce (*Picea glauca* (Moench) Voss). Two trees each of the three dicots and one tree each of the conifers were sampled at intervals of two weeks from September to April. Samples about five inches long were removed at breast height from the trunks of these fairly large trees by means of a .25 inch diameter increment borer. The plugs were carried in petri dishes and weighed immediately upon return to the laboratory. Samples were then dried in an oven at 120°C. to a constant weight. Loss of weight was taken as an indication of the amount of water originally present, although in the conifers it probably also included some volatile non-aqueous contents. The water content was expressed in per cent of the dry weight of the sample. Each dried plug was then sliced into pieces about 2 mm thick and placed in a test tube containing 10 ml of distilled water. After 24 hours the freezing

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point depression (Loomis and Shull, 1937) was determined and used to calculate the water-soluble solute of the sample. This was expressed in millimoles per gram of sample.

The water content of the soil was determined by air drying soil samples which were taken with a soil auger near the base of each tree at a depth of approximately 4 feet. Soil water was expressed as per cent of the dry weight of the sample.

Results

The data obtained in this study are shown in Figure 1. The solute determinations were plotted at two week intervals; the water content was averaged for each month. The values for each tree are indicated separately in the figure.

In dicots the water content of the trunks was lowest in September but increased to the maximum in December after which it declined irregularly. By April the water content of the wood was near or only slightly higher than the minimum values of September. The variation in water content was greatest in maple and least in ash.

In the conifers the water content of the wood increased from September to a maximum in October, and thereafter it declined each month except in February when a slight increase occurred over the previous month. The downward trend then continued until the termination of sampling in April when the minimum values were recorded.

The water content of the soil under all trees increased during the fall to a winter high in December. January readings were less in all samples taken except under the spruce. No soil samples were taken in February nor under the juniper in January. By March the soil water had been replenished by percolation of surface water into the soil, so that the soil water was equal to or greater than in December. All April samples showed less soil water than in March. In general the graphs (Figure 1) show that the soil under the conifers was roughly 5 percent drier than under the dicots during the course of sampling.

The water-soluble solute content of the wood in the dicots was lowest in October. The solute content rose rather irregularly to maximum values in February. In maple the rise was more regular and reached near peak values all during January and February. Sharp declines in solute content occurred in all dicots in the latter part of February or in early March, which resulted in solute values almost as low in March as those of October. Some recovery was shown from the minimum spring values by late March or early April.

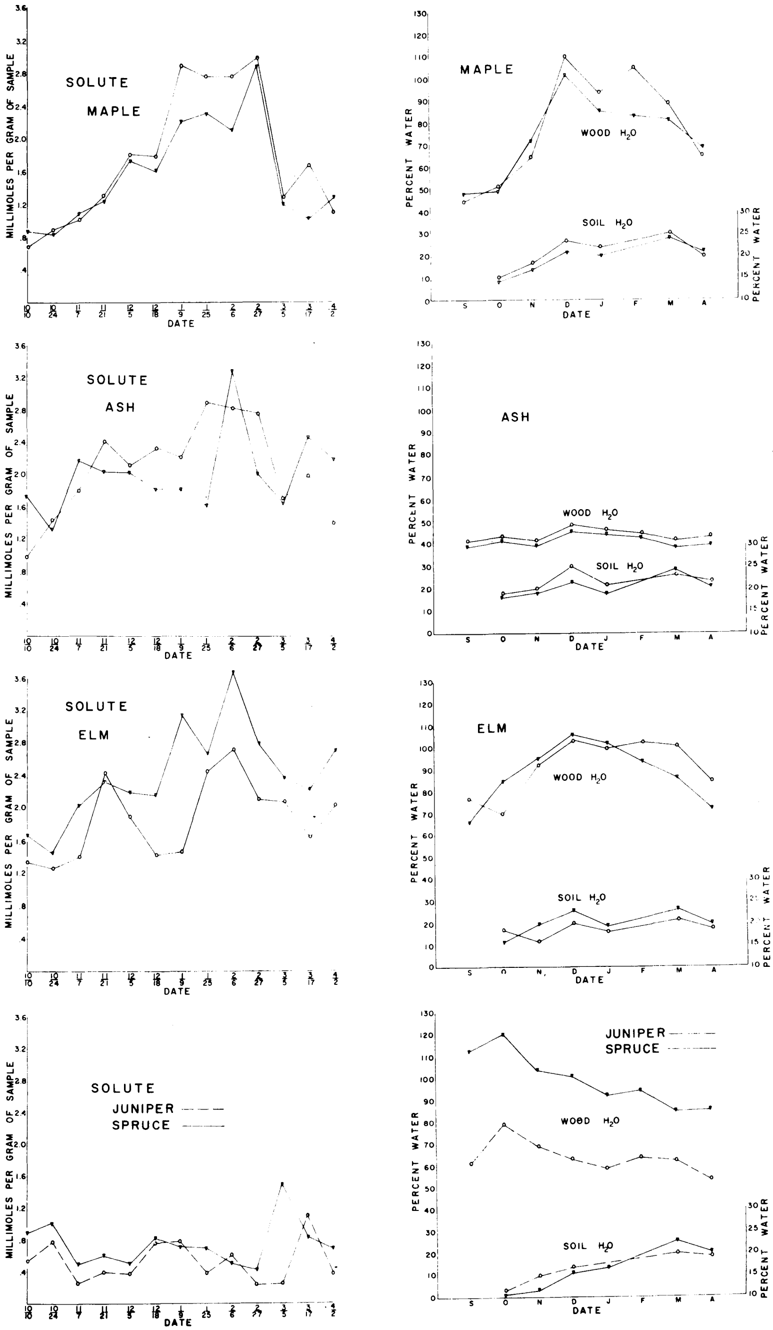

Figure 1. The concentration of water-soluble solutes and the percentage of water, on a dry weight basis, of wood and soil samples taken from the various trees and their substrata throughout the duration of the experiment.

The solute content of the wood in the conifers was low compared to the dicots. The highest solute values in conifers were found in March after overall decreases from October through February. Minimum values occurred in November and February with a slight increase during December and January. The maximum solute concentrations in the conifers compared numerically with the minimum concentrations in dicots.

Discussion

Seasonal variation in the water content of tree trunks has been studied by Gibbs (1939, 1950), who took samples at three-month intervals and generalized as to the water content for the year. The bi-weekly sampling in this study gave more adequate data on the cyclic changes as they occurred. The five-inch samples taken with the increment borer were from the most dynamic part of the tree with regard to fluctuations in water content; they extended through the sapwood and into a part of the heartwood. Parker (1954) showed that seasonal fluctuations were greater in the sapwood than in the heartwood which was always less hydrated. Although the patterns of hydration for ash and elm as given by Gibbs (1950) do not agree with the findings here, it is significant that in general the pattern of variation for all three of the dicots in this study is similar. Differences from the results of Gibbs may be due to the differences in locality and the general climatic conditions. The patterns of water content for the two conifers were remarkably similar, although quantitatively they differed in that the juniper was about 40 percent dryer than the spruce. From this study the water content of the dicot trees of southeastern South Dakota may be characterized as being high in the winter and low in the fall and spring, whereas in the conifers it is high in the fall and decreases through winter and spring.

Since most of the soil samples revealed less water present during January than in the preceding or succeeding month and five of the eight trees showed a corresponding decrease in water content at that time, it may be that soil water was one factor of the environment which affected the water content of the trees. In general, however, it must be concluded that the filling of trees with water was not directly correlated to this one factor, since the conifers showed a decrease in water while the water content of the soil in which they were growing was increasing. It is doubtful that the approximately 5 percent dryer soil found under the conifers can be attributed to their "evergeen" condition. It seems likely that drainage and soil types would be more responsible than the utilization of the moisture by the trees, but this is a point that could be profitably investigated further. Apparently soil water does not determine the pattern of water content of trees, but it may affect the pattern quantitatively to a minor extent.

In the determination of the solute content of wood, no attempt was made to assay the total food stored in the trunk but simply to determine how much material was in a water-soluble condition and thus could be related to drought resistance or hardiness. In his reviews Levitt (1941, 1956) has emphasized the importance of soluble materials in effecting hardiness. The results obtained from the dicots investigated here agreed with his results on the conversion of starch to sugar during the coldest months of the year, as indicated by the highest solute content corresponding to the coldest temperatures. The low water-soluble solute content of the conifers recorded during late fall and winter may have been an indication that the food stored in the wood, probably as a lipid, changed to a water-soluble form during March. The soluble materials then may have been translocated to the swelling buds or developing twigs. There is also a probability that the filling of trunks with water is not due to an effect similar to that of an osomometer, since in this study the water content of the wood increased before (rather than after) significant increases in solute content. In the case of ash, there seemed to be no corresponding increase in the water content of the wood compared with the extreme variations in solute content. In conifers there was an inverse relationship between high solute content and high water content. The former occurred in the spring, and the latter occurred in late fall. These relationships indicate that trees, even through the "dormant" season, are dynamic entities responding in their own characteristic fashion to the forces of their environment.

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