WATER USE BY WESTERN JUNIPER

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Western juniper (*Juniperus occidentalis*) is located throughout eastern Oregon, southcentral Washington, southwestern Idaho, northern Nevada, and northeastern California. This species has more than doubled the land area it occupied before the late 1800s. Dense stands are found on approximately 1,772,500 acres, with at least an equal amount of additional land area being occupied by scattered or invading stands of juniper. Range condition appears to have little effect on the establishment of juniper seedlings. Seedlings establish readily on areas supporting well developed herbaceous and woody vegetation.

We have little information on the ecology and physiology of this species. Because of limited knowledge, the ability to manipulate plant communities and predict community response in juniper occupied areas is extremely limited. This paper will report results and preliminary conclusions from ongoing research evaluating patterns of water use by western juniper throughout the year. Specific objectives of this research are to estimate the amount of water utilized by western juniper throughout the year and to determine what environmental factors influence their levels of water use.

METHODS AND PROCEDURES

Water and growth measurements on western juniper have been taken from September 1982 to the present on the Squaw Butte Experimental Range. The two study sites (one-half mile apart) are classified as a mountain big sagebrush - Idaho fescue (*Artemisia tridentata* subsp. *vaseyana* - *Festuca idahoensis*) habitat type, approximately 5,100 feet in elevation. Soils are rocky and average 60 inches in depth. Herbage production is 600 pounds per acre with a shrub canopy of 13 percent. Average annual precipitation is 12 inches, however, precipitation has exceeded the average during this study.

Environmental factors measured are air and soil temperature, humidity, soil water, precipitation, and photosynthetic active radiation. Tree measurements included internal plant water level (a measure of the internal water status of the plant), stomatal resistance, transpiration, leaf growth, and reproductive development. Plant measurements were taken periodically throughout the year on six mature trees on each site.

RESULTS AND DISCUSSION

The amount of water transpired into the air by juniper is primarily influenced by soil temperature, air temperature, and vapor pressure deficit, a measure of the air water content (as temperature increases, so does the air's capacity to hold water; as humidity decreases, the amount of water the air actually contains as compared to what it can hold at saturation also decreases, thus the dryness or vapor pressure deficit increases). Each of these three parameters play a major role in determining water loss by juniper at different times of the year. The amount of water lost through juniper in the winter is minimal, limited by frozen soils, subfreezing air temperatures, and low vapor pressure deficit (Figure 1). As long as soils remain frozen, transpiration will be minimal regardless of air temperature and air dryness (vapor pressure deficit). This is because of the inability of juniper roots to conduct water at sub-freezing soil temperatures. As soils thaw in March (as was the case at Squaw Butte in 1983 and 1984), the amount of water lost is influenced by air temperature and air dryness. In early spring, junipers transpire water as soon as leaf temperature rises above freezing and water thaws in the foliage. This may be for only a few hours during the day. As soon as leaf temperatures drop below 32°F, transpiration essentially ceases.

As the growing season progresses and freezing temperatures become less frequent, air dryness becomes the primary factor determining the rate of water lost by western juniper. At sunrise, solar radiation stimulates stomatal opening. As the day progresses, and temperatures increase and relative humidity decreases, water is transpired at an increasing rate. Stomates close about sundown. During the summer of 1983, lack of soil water did not appear to limit juniper transpiration by causing the stomates to close.

It is likely that soil water depletion does not have a gradual effect on juniper water consumption. It is more likely that transpiration will not be limited until a threshold in internal plant water, caused by droughty conditions, is reached. Soil moisture conditions since September 1982 apparently have not reached this threshold. Early morning internal plant water levels have been found to decline under two different conditions (Figure 1). During the winters of 1983 and 1984, internal plant water levels were at their lowest. Although the amount of water lost through plant leaves is very small at this time, water absorption through the roots is even slower because of frozen soils. Also in May, plants were not able to replenish early morning internal water content from the previous day's transpiration. This was a time when above normal air temperatures and low moisture content in the air caused relatively large amounts of water loss by transpiration. Although soils contained large amounts of water, it is likely that cool soil temperatures and/or limited root absorbing surface (root growth probably occurring at this time) limited the ability of juniper to compensate for high levels of moisture loss this early in the growing season. Juniper appears to not be able to compensate for high levels of water loss early in the growing season as compared to later.

CONCLUSIONS

In summary, frozen soils and freezing air temperatures limit transpiration of juniper through much of the year. In above freezing conditions, the rate of water lost through juniper is primariy determined by the dryness of air. In areas where soils remain unfrozen or are frozen for short periods of time, juniper can transpire water and produce sugars for a longer period of the year, thus making it more competitive with associated vegetation. This may be one of the reasons why its occurrence in central Oregon is greater than on the high desert where soils are frequently frozen throughout most of the winter. As its opportunity to grow in the winter and early spring increases, so does its ability to compete with dormant herbaceous vegetation and deciduous shrubs. Even though some shrubs are evergreen, their leaf areas in winter are usually greatly reduced (i.e., big sagebrush maintains approximately 50% of its leaf area in winter) and the capacity of winter leaves to produce sugars and transpire water is generally low. So sagebrush, with its winter persistent leaves, is capable of growing and producing sugars earlier in the spring than such associate species as rabbitbrush and various perennial grasses. However, it is probably less efficient at using soil water and nutrients than juniper in the winter and early spring.

On a warm summer day, on a site receiving 12 inches of precipitation annually, a stand of juniper trees (167/acre, averaging 12 inches in diameter) can potentially transpire, in one day, 1 percent of total moisture received on the site for the entire year. Since we know a significant proportion of the precipitation will be lost to runoff and evaporation from the soil surface and plant canopies, the percentage of total soil moisture transpired would be much greater.

As stated earlier, some of the above conclusions are preliminary. Additional work needed to verify some of these statements include: (1) to better determine the influence of soil temperature on photosynthesis and transpiration, (2) determine if the relationships between water use by juniper and environmental factors are constant across the western juniper zone, (3) determine if these principles change with tree age, (4) determine the level of soil water or internal plant water that will shut down transpiration, and (5) determine when and where in the soil profile juniper is withdrawing soil moisture.

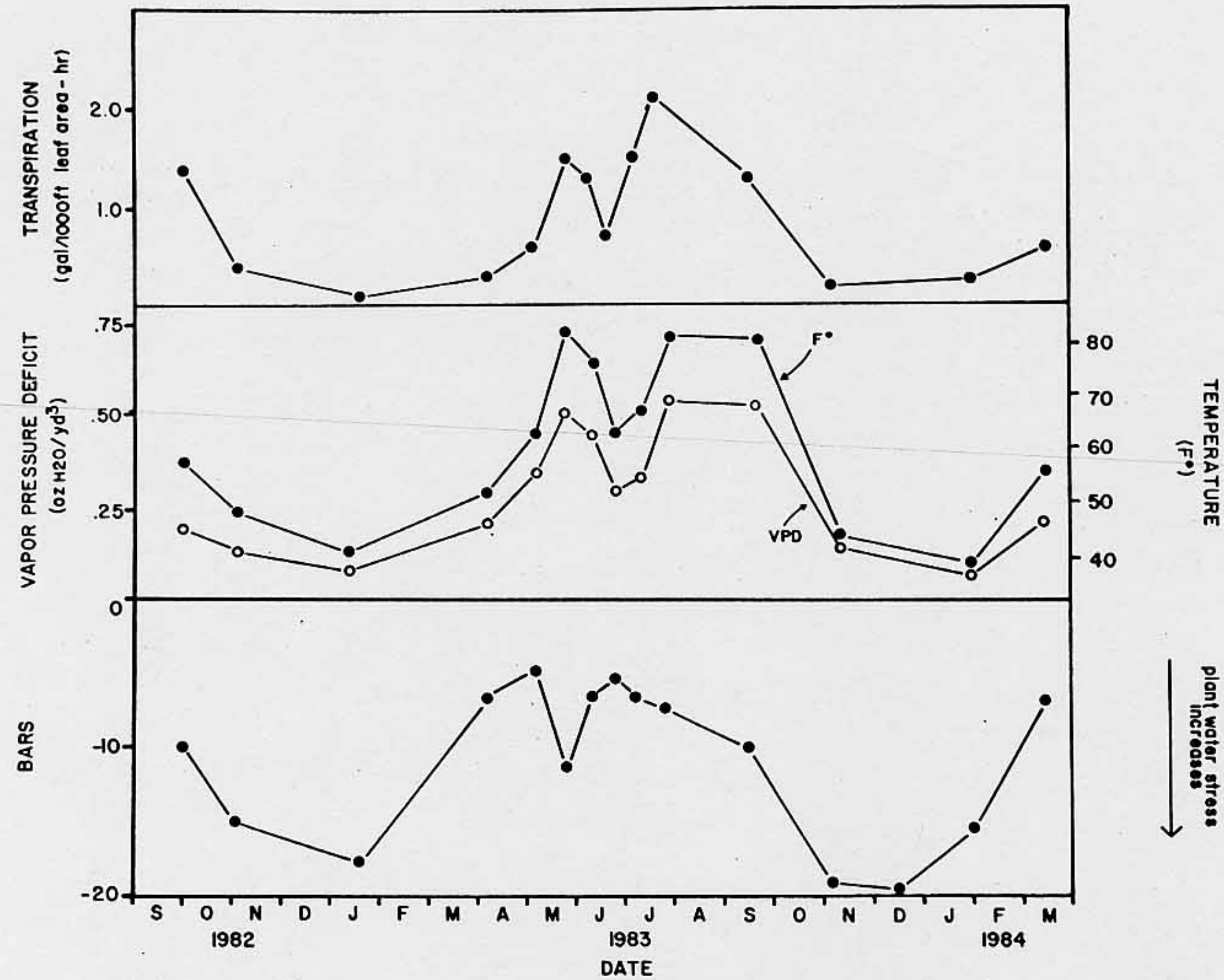

Figure 1. Seasonal transpiration, vapor pressure deficit and temperature (all three taken at midday) and internal plant water (measured just before sunrise). Transpiration and internal plant water were measured on 12 mature trees on two locations. One tree 14.5 inches in diameter, or two trees 9.5 inches in diameter would contain approximately 1,000 ft^2 of leaf area. Both transpiration points for 1984 are estimated since measurements have not yet been corrected for actual leaf area.