SOIL-PLANT RELATIONSHIPS AMONG THREE BIG SAGEBRUSH SUBSPECIES

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Big sagebrush (Artemisia tridentata) dominates 90 million acres in the western United States. This species in its various forms is the most abundant and widespread of the woody species which characterize the extensive sagebrush-grass region. Numerous subspecies of big sagebrush have been reported by Beetle, Tisdale, Winward and Young. Subspecies of big sagebrush not only vary morphologically and phenologically but also have distinct ecologic and hydrologic requirements. These factors, having very important management implications, have led to numerous studies characterizing the ecological sites of big sagebrush subspecies. This paper will preview a portion of an overall effort to characterize soils, community structure, production, hydrology, water relations and volatile oils of three subspecies of big sagebrush occurring in eastern Oregon.

EXPERIMENTAL PROCEDURES

Wyoming big sagebrush (A. tridentata subsp. wyomingensis), basin big sagebrush (A. tridentata subsp. tridentata), and mountain big sagebrush (A. tridentata subsp. vaseyana) sites were studied. Four study locations were evaluated near Millican, Baker, Frenchglen, and Squaw Butte. These locations provided a wide range of soil types associated with the three subspecies. At each location, each of the three subspecies habitat types was delineated, and three replications of each measured. Sites selected were in poor to good condition. On each replication, shrub canopy cover was measured with a line intercept and herbage production was clipped, dried and weighed. Soil pits were dug on each replication where soils were characterized. Internal water stress and soil moisture were measured every two weeks in June and July, and monthly August through October on the Squaw Butte study sites only. Internal water stress was measured with a pressure chamber at three-hour intervals from predawn to 5 pm. Soil moisture was measured gravimetrically midday each day internal water stress was measured.

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RESULTS AND DISCUSSION

As shown in Figure 1, potential herbage production increased from Wyoming to mountain big sagebrush sites. Production potential will vary within a subspecies, depending on soils, range condition, and climate. Temperatures and precipitation were often comparable between adjacent Wyoming and basin big sagebrush sites. Soil depth is probably the important factor influencing the difference in potential production between the two subspecies. Soil depth on Wyoming big sagebrush sites studied averaged 32 inches and averaged 53 inches on basin big sagebrush sites. The deeper soils allow for greater soil water storage capacity. Soil depths (49 inches) on the mountain big sagebrush and basin big sagebrush sites were similar but temperatures were usually cooler and precipitation amounts similar or higher on the mountain big sagebrush sites. This means evapotranspiration levels will be lower and more total moisture available on mountain big sagebrush sites when compared with the other two sagebrush species.

Sagebrush canopy cover can attain higher levels on mountain and basin big sagebrush sites than Wyoming big sagebrush (Figure 1). Wyoming big sagebrush canopy cover rarely exceeds 20 percent. However, on basin and mountain big sagebrush sites, maximum shrub canopy cover frequently nears 30 percent, with mountain big sagebrush occasionally approaching 50 percent on higher elevation sites with deep soils. This is supported by work of other researchers in Oregon and Idaho.

Diurnal water potentials in big sagebrush range from -5 to -20 bars early in the growing season to -30 to -60 bars during summer droughts. In June and July, mountain big sagebrush was significantly less water stressed than the other two subspecies (Figure 2). There was no significant difference between basin and Wyoming big sagebrush. Similar internal plant water potentials between Wyoming and basin big sagebrush during the growing season were probably caused by a higher Leaf Area Index and, thus, higher transpiration potentials on the basin big sagebrush site. In August, mountain big sagebrush was the most stressed and Wyoming big sagebrush the least (differences significant for all three subspecies). Although all three subspecies were at high levels of drought stress in August, Wyoming big sagebrush appeared to better cope with the arid conditions.

Seasonal patterns of soil water availability were similar on the basin and Wyoming big sagebrush sites (Figure 2). Adequate moisture levels were available in June during rapid stem and leaf growth. By early to mid-July, soil water decreased to below -15 bars, which coincided with senescence of ephemeral leaves. On the mountain big sagebrush site soil moisture was available through July, and ephemeral leaf senescence occurred two weeks later compared to the other two subspecies. Winward, in Idaho, found similar soil water patterns with these three subspecies. Early depletion of water reserves on the basin big sagebrush site was probably caused by a higher demand for moisture than on the Wyoming big sagebrush sites.

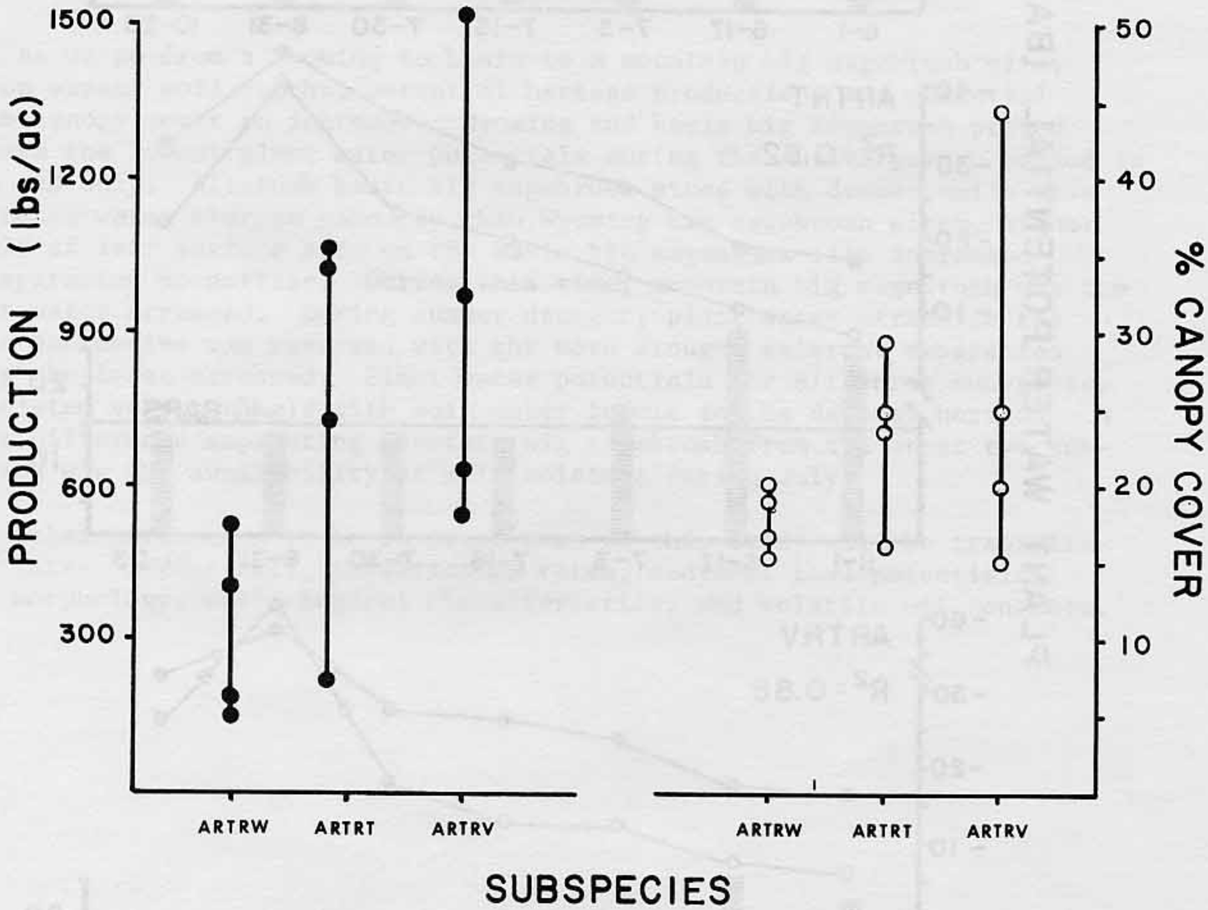

Figure 1. Average production and shrub canopy cover at each of the four locations for Wyoming big sagebrush (ARTRW), basin big sagebrush (ARTRT) and mountain big sagebrush (ARTRV).

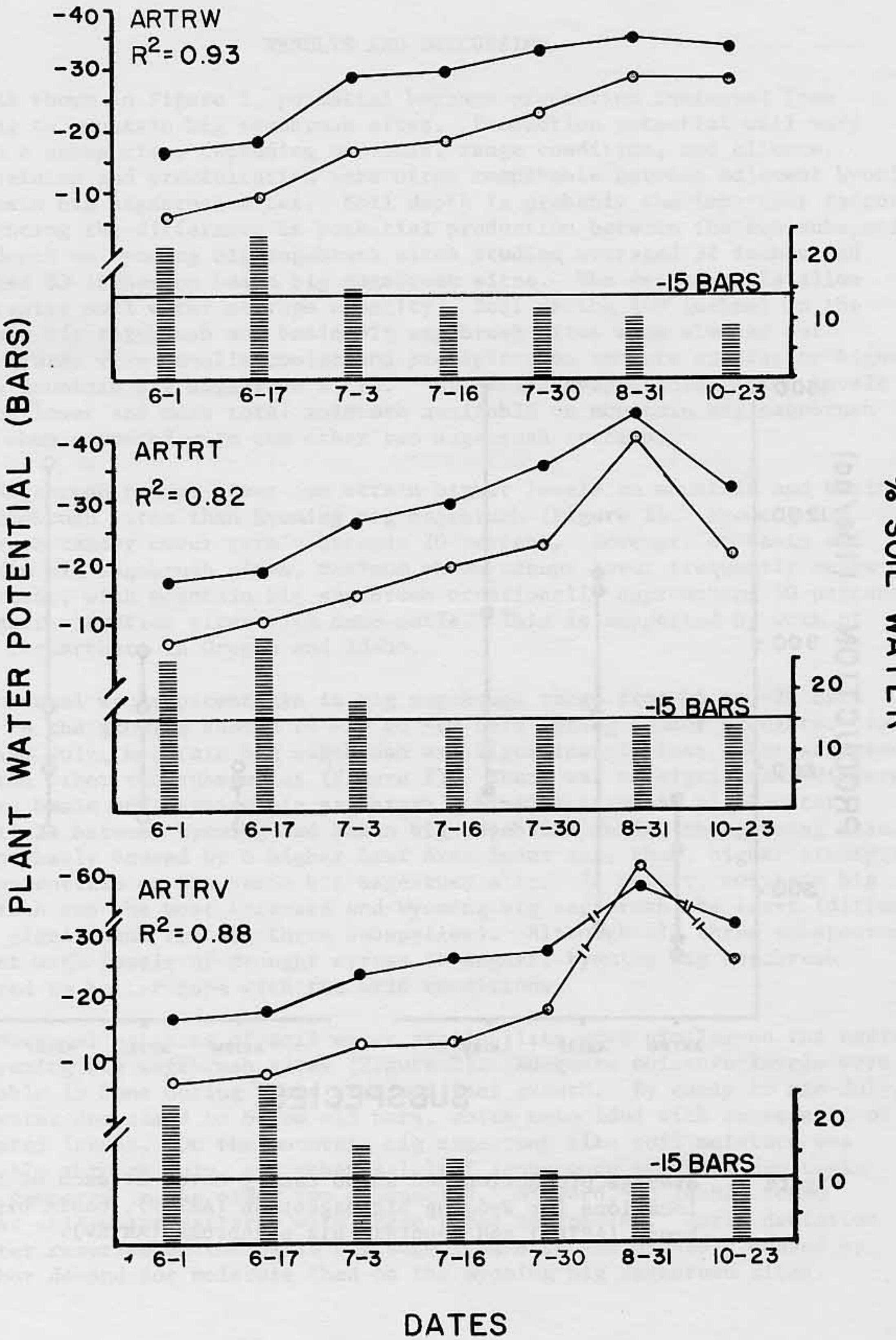

Figure 2. Predawn (o—o) and midday (●—●) plant water potentials from June through October for Wyoming big sagebrush (ARTRW), basin big sagebrush (ARTRT) and mountain big sagebrush (ARTRV). Vertical bars represent percent soil moisture measured in the deepest soil horizon. R^2 is the correlation between midday plant water potential and percent soil moisture in the deepest soil horizon.

Soil moisture in the deepest horizon correlated very strongly with plant water potentials throughout the spring and summer (Figure 2). The strongest correlation was a polynomial relationship:

$$Y = a + bX + cX^2$$

where Y is the estimated value for plant water potential, X is the measured percent soil moisture, and a, b, and c are computed values in the polynomial equation. Moisture in the deepest horizon correlated higher with plant water potentials than any of the other soil horizons.

CONCLUSION

As we go from a Wyoming to basin to a mountain big sagebrush site, we can expect soil depths, potential herbage production, and potential shrub canopy cover to increase. Wyoming and basin big sagebrush proved to have the lowest plant water potentials during the active growth period in June and July. Although basin big sagebrush sites with deeper soils have a greater water storage capacity than Wyoming big sagebrush sites, higher levels of leaf surface area on the basin big sagebrush site increased transpiration potentials. During this time, mountain big sagebrush was the least water stressed. During summer drought, plant water stress in the three subspecies was reversed with the more drought tolerant subspecies being the least stressed. Plant water potentials for all three subspecies correlated very strongly with soil water levels in the deepest horizon. A major difference separating mountain big sagebrush from the other two subspecies was the availability of soil moisture during July.

Other parameters to be reported soon on this study will be transpiration rates, litter fall, infiltration rates, sediment load potentials, soil morphology, soil chemical characteristics, and volatile oil contents.