TECHNICAL NOTES

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EFFECTS OF PLANT STRUCTURE AND COMPOSITION ON UPLAND HYDROLOGIC CYCLES:

JUNIPER WOODLANDS

Juniper cover represents a sizeable acreage in Oregon and is increasing perhaps partly due to management practices. It is commonly known that juniper is a heavy user of moisture and as a result limits the production of more useful cover for erosion control, forage and water production.

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EFFECTS OF PLANT STRUCTURE AND COMPOSITION ON UPLAND HYDROLOGIC CYCLES: JUNIPER WOODLANDS

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Although we are aware plant composition and ecological condition of upland vegetation influences riparian zones, it is difficult to quantify the effects. This paper will describe changes in upland water cycles as a result of vegetation being altered from sagebrush bunchgrass to juniper woodlands, with particular emphasis on interception and transpiration. Juniper and pinyon-juniper woodlands occupy approximately 64 million acres in the western United States. Western juniper alone occupies 1.7 to 2.8 million acres. It has been estimated that juniper has more than doubled its distribution and density in the last 100 years. These woodlands occupy an important position in uplands between the desert floor and the pine forests. When evaluating changes in riparian zones we cannot ignore major changes in upland plant community composition from sagebrush bunchgrass to juniper woodlands in the last 100 years.

As upland vegetation succeeds from sagebrush bunchgrass to juniper woodlands major changes occur both above and below ground that influence sedimentation, runoff, infiltration, precipitation interception and water use on the site. Total aerial canopy cover may or may not decrease but canopy distribution significantly changes. Structure of the aerial canopy cover is altered from being widely dispersed to one of large interspaces surrounding dense clumped canopies. This change also affects litter distribution on the site. The canopy structural change affects precipitation interception and transpiration. Changes below ground also occur with the decline in fibrous roots of herbaceous plants, which primarily occupy the upper 30 cm, replaced by deeper rooted woody plants.

Runoff has been consistently correlated with kind and amount of vegetation. Precipitation events ranging from 3.8 to 7.6 cm/hr have recorded runoff to be 4 to 9 times higher respectively, on bare soil than soil containing plant cover. The effect of spatial distribution of cover has not been documented. Sedimentation rates in a juniper woodland, however, have been reported to be 3 and 3.6 times higher than in sagebrush bunchgrass and grassland communities, respectively. Sedimentation on bare ground has been reported to be 20 times higher than on a natural sagebrush bunchgrass community. Both soil organic matter and aboveground biomass have been noted to be important factors in controlling sediment production. Widely dispersed litter and plant cover in a sagebrush bunchgrass community may act as a more effective sieve for capturing sediment and dissipating energy from runoff than would occur in the more clumped distribution of a woodland. Fibrous root systems have also been observed (however not documented) to be more effective soil binders than woody plant roots.

Infiltration rates play a major role in both runoff and sediment production. Infiltration rates are influenced by aggregate stability, organic matter, mulch, standing crop, bulk density and ground cover. Again spatial distribution of these components has not been evaluated. It has been reported that soils occupied by fibrous roots have higher infiltration rates than soils occupied by tap rooted plants. As juniper dominance increases on the site and understory vegetation declines, characteristics desirable for minimizing runoff and sedimentation, and maximizing infiltration rates decline in the interspace. We feel that larger interspace areas found in a juniper woodland will result in an overall increase in runoff and sediment production, and a decrease in infiltration rates , and an increase in evaporation.

Soil water extraction is also altered on the upland as it changes from a sagebrush bunchgrass to a juniper woodland community. Due to the evergreen character of juniper, and the winter persistent leaves on sagebrush, soil moisture is extracted from the soil at a more rapid rate early in the growing season as compared to a grass dominated site. More important is the change in depth of soil moisture extraction from the soil profile. It has been well documented that grasses effectively utilize water in the upper portion of the soil profile while shrubs also use moisture effectively well below 60 cm. Sites dominated by herbaceous vegetation are significantly wetter below 1 m in the soil profile than sites occupied by woody vegetation.

Interception of precipitation by western juniper tree canopies represents a considerable loss of moisture. Interception over a 12 month period, ranged from 53 to 71 % in trees ranging in size from 4 to 10.4 m in height respectively. Throughfall was 45 % in the smaller trees and 28 % in the larger trees. Stemflow only accounted for 2.3 to 0.8 % of the total precipitation. In a single rainstorm of 58.2 mm which continued for a 2-day period, 63, 76, and 90 % of the moisture was intercepted by small, medium, and large trees, respectively. Percentage of moisture intercepted by trees may not decrease as precipitation increases if that precipitation comes as snow. Interception will decline with wind. If a typical western juniper canopy cover of 20 % is selected, and the canopy is made up of large trees, then the loss of moisture to the soil system would be approximately 14 %. In woodlands exceeding 30 % canopy cover, moisture loss could exceed 20 % of the total annual precipitation.

Soil water transpired by a juniper woodland can be estimated by knowing the size of the transpiration surface (juniper leaf area) and the rate water is passing through the leaf into the atmosphere which is a function of leaf conductance and vapor pressure deficit. Leaf area is predicted by measuring the average basal area or sapwood area of the woodland. Leaf conductance is controlled by air and soil temperature, vapor pressure deficit, soil water and plant water status. A tree with a basal diameter of 30.5 cm would have a leaf area of 188 m2. Estimated total water use by this tree would be 53 liters per day on a mild spring day and 121 liters per day on a hot summer day. As the juniper stand increases in size and density, transpiration and interception by the juniper trees easily accounts for the largest percentage of water received by the site.

Although there is strong evidence that water cycles are significantly altered as uplands change from a sagebrush bunchgrass to a juniper dominated community, the impact to riparian zones is very difficult to quantify. Changes, however, in sedimentation, infiltration and runoff in juniper woodlands suggest potential decreases in water quality, increases in peak flow, decreases in annual flow, and decreases in total annual water yields.

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