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**Soil-Moisture Depletion by a Central Washington  
Lodgepole Pine Stand**

The objective of the study reported here was to determine for a particular but representative area the change in the summer soil-moisture regime caused by the removal of a lodgepole pine (*Pinus contorta* Dougl.) overstory.

Few, if any, soil-moisture studies have been reported for the forested lands of eastern Washington. Several workers, Barrett and Youngberg (1965), Dahms (1967), Tarrant (1957), Wilm and Dunford (1948), and Ziemer (1964), for example, have conducted investigations in other parts of the West with varying results. It is fairly well established that autumnal soil-moisture deficits can be decreased by removing or deadening all vegetation if the soil is not extremely shallow. Quantitative effects under various physiographic conditions and the effect of only partial removal of vegetation, such as ordinary timber harvest or thinning, are less clear. This study is of the effect of timber removal on autumnal soil-moisture deficits in eastern Washington.

**Area Description**

The study area is located in the Lake Creek Basin on the Entiat District of the Wenatchee National Forest. The plots, at an elevation of 5300 feet, have a slope of 35 per cent with an ENE aspect.

The climate of the area is cool and humid, but with dry summers. No year-round climatological records are available for the site, but on the basis of area climatological descriptions and nearby records, I estimate a mean maximum temperature in July of 74° F., a mean minimum in January of 12° F., and an annual precipitation of between 40 and 50 inches. About 85 per cent of this occurs as snow between the months of October and May.

The vegetation consists of an overstory of lodgepole pine with a sparse understory of *Vaccinium caespitosum*, *Pachistima myrsinites*, *Spirea densiflora*, and *Lupinus* spp. The vertical projection of the understory covers only 24 per cent of the area. The lodgepole pine stand is 60 years old, averages 4416 stems per acre, and has an average basal area of 145 square feet per acre. The diameter of the trees averages 2½ inches and ranges from less than 1 inch to 6 inches.

The soil is well drained, moderately coarse textured, and derived from volcanic ash and pumice. The profile starts with a 1-inch highly decomposed litter layer with just a trace of an A2 below it. A B2ir horizon, consisting of a gravelly, sandy-loam pumice, extends to 16 inches. The C horizon starts at 16 inches with a "popcorn" pumice gravel layer from 16 to 25 inches. From 25 to 30 inches there is a sand layer which seems

to be the lower limit of root growth. Below 30 inches pumice gravel is again encountered, and it continues to a depth of 72 to 84 inches where the highly fractured granodiorite bedrock appears.

### Experimental Procedures

During the summer of 1962, four blocks of two plots each were established. The plots are 30 x 30 feet with a 15-foot isolation strip surrounding them. One plot in each block was randomly designated the control plot and the other designated the treatment plot.

On each plot, three randomly located neutron probe access tubes were installed, extending to bedrock. In late May of 1963, as soon as the snow was off the plots, a series of biweekly readings was initiated. These readings were continued until the fall rains brought an end to the soil-drying period. This pattern of readings was repeated the following year.

In late fall of 1964 the treatment plot in each block, with its isolation strip, was cleared, and the cut material was removed by hand from the plot. Biweekly soil-moisture readings during the growing season were then repeated for two more years.

For all of the soil-moisture determinations, neutron probe readings were taken at 6-inch intervals in the upper 2 feet of soil, and at 1-foot intervals for the remainder of the soil profile.

In addition to soil moisture, an inventory of vegetation and rainfall was acquired.

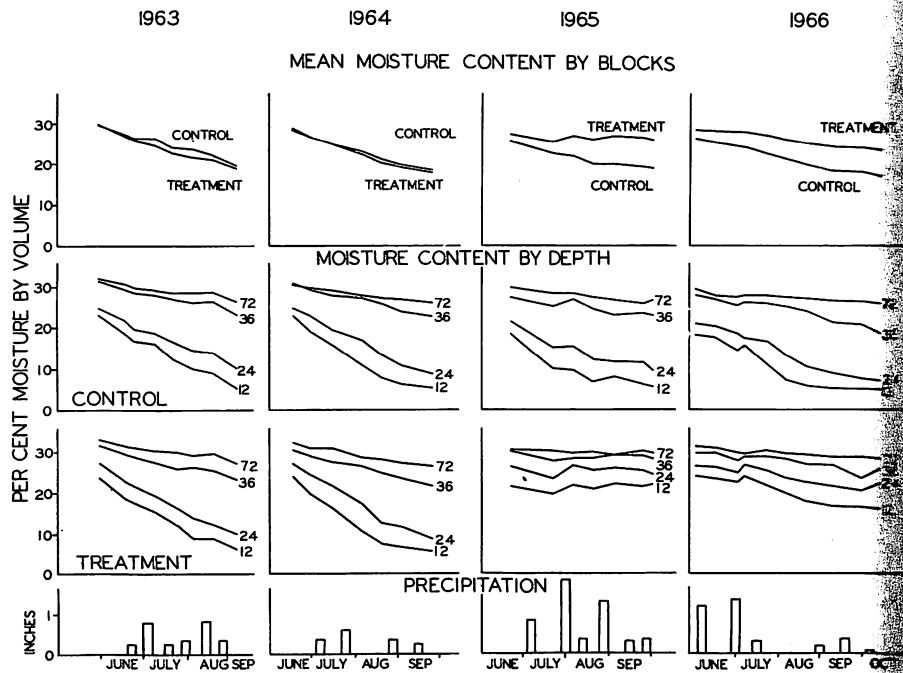


Figure 1. Soil-moisture trends showing moisture depletion during the two pretreatment years and the two years following cutting of the treatment plots. Precipitation is also shown.

### Results and Discussion

The results of this study are shown in Figure 1. The top row compares the mean soil-moisture content for the entire soil profile of the control plots with that of the treatment plots. During 1963 and 1964, the treatment plots had not yet been treated, and the moisture declines paralleled each other quite closely. In 1965, however, although the uncut control followed essentially the same pattern as the previous two years, the treatment plot showed little decline; and this pattern was again repeated in 1966. In specific figures, we find a net mean difference of 5.8 per cent. For a 6-foot soil profile this amounts to a net gain of 4.2 inches as a result of removing the overstory. I do not mean to imply that this is a realizable gain in terms of streamflow. Much can happen to that water before it gets into the stream; but it is a potential gain.

Where does this reduction in water use occur? The lower two rows of graphs depict soil moisture for 12-, 24-, 36-, and 72-inch depths. The bottom row refers to the treatment plots while the row just above refers to the control plots. During the first two years, prior to treatment, the control and the treatment plots show essentially the same pattern. During the last two years, the 36-inch and 72-inch lines are still quite similar for both the control and treatment plots. The treated plots show some decrease in water use, but the change is small. The plot of soil moisture at the 12- and 24-inch depths, however, shows a considerable difference, indicating that most of the soil moisture used by the trees has come from the upper 2 feet of the soil. This, of course, was to be expected from the fact that the roots were limited primarily to the upper 2 feet, but it does show that there has been relatively little movement of moisture from the lower horizons up into the upper 2 feet.

This could possibly be the result of very slow rates of unsaturated flow in pumice

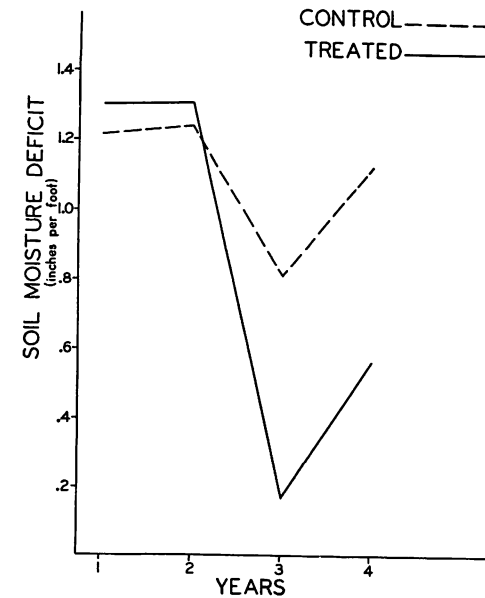


Figure 2. Mean soil-moisture deficits for each year of the study, by treatment. This illustrates the large decrease in moisture depletion that occurred following cutting, and explains the highly significant year X treatment interaction found in the analysis of variance.

soils, as reported by Youngberg and Dyrness (1964), or it could be caused by the presence of the sand layer at about 2 feet.

The graph of precipitation across the bottom has been added to help explain the differences in soil-moisture use pattern from year to year.

A split plot analysis of the data was performed in which the "main plots" were the treatment versus control plots, and years were considered the subplots. This analysis showed a highly significant year-treatment interaction, indicating that the treatment that occurred between the 1964 and 1965 measurements did indeed significantly reduce soil-moisture deficits. We saw this in Figure 1, but the interaction effect is more clearly illustrated in Figure 2. The large decline in soil-moisture deficit the third year in both treated and control plots resulted from greater than normal summer precipitation.

This study has shown that significant potential savings of soil moisture are possible by cutting lodgepole pine in the conditions prevalent in the eastern Cascades. Further studies are necessary to determine the persistence of the treatment effect, the effect of thinning, and whether or not the water saved will show up as streamflow or will be utilized some place else on the watershed.

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## Soil Temperatures near a Desert Steppe Shrub<sup>1</sup>

The landscape of much of south-central Washington is dominated by natural vegetation of a fairly uniform appearance consisting of widely spaced shrubs about a meter tall with an "understory" of grasses and forbs growing beneath and between the shrubs. The shrubs are long lived, so any alteration in the environment which the shrubs induce is quasi-permanent. Although the total effect of the shrubs on the small herbaceous plants growing on the desert steppe floor must be rather small, the plants growing near the shrub will certainly be affected. One of the most pronounced effects of the shrubs is the pool of shade cast by the shrub, which provides a substantially cooler environment on the protected side of the shrub. Since observations showed a significant difference in phenology of cheatgrass, *Bromus tectorum*, when growing in the shady side compared with the sunny side of the same shrub, an investigation was begun to define more carefully the environmental differences between shady and sunny sides.

The purpose of the first phase of the investigation was to measure the pattern of soil temperature around a shrub. Although soil temperature in itself will not define an environment, it is closely tied to both insolation and ventilation, as well as soil characteristics. Thus, the pattern of soil temperatures may be used to illustrate differences between two environments in an integrated sense; to *define* the differences requires more versatile and specific measurements, especially the radiation balance.

The effect of shading on plant growth has been documented for some grasses; for example, Reid (Shaw, 1952: 381) showed that velvet bent grass grown in half-day shade produced only one-third the root weight of grass grown in full sun. More generally, the effect of vines on air temperatures near the surface (Geiger, 1965: 295) is pronounced, and one may also suppose a similar effect on soil temperature. Geiger's sketch indicates that the air temperature between rows of vines is higher than under the vines in vineyards planted with north-south rows. He ascribes the low temperatures to direct shading and the warm areas between the rows to protection from ventilation. Geiger also quotes (p. 290) some soil temperatures at 10 cm depths under various natural communities. The data show soil temperatures varying in space from 23 to 42 C under 90-cm tall evergreens whose canopies covered 75 per cent of the ground, with air temperatures at 2 meters of 22 to 28 C. One may surmise that steppe lands, sparsely

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