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Soil Water and Temperature in Harvested and Nonharvested Pinyon-Juniper Stands

Richard L. Everett
Steven H. Sharrow

THE AUTHORS

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RESEARCH SUMMARY

Tree harvesting increased soil water content, but the effect diminished over 4 years. The mean increase in soil water content was 2 to 4 percent the first year following harvest and 0 to 3 percent after 4 years. Although tree harvesting released soil water previously used by tree species, other biotic and abiotic demands increased. We speculate postharvest increases in wind and solar energy at the ground surface and increased understory transpiration in part explain the decline in soil water content differences between harvested and nonharvested plots over time.

Understory cover increased three to six times following tree harvest on north and west aspects. Understory apparently used soil moisture made available by tree harvesting.

Duff soil microsites had consistently greater soil water than transition or interspace microsites. The duff microsite accumulated soil moisture immediately after tree removal similar to that reported for debris-in-place treatments following chaining. The duff microsite serves as both a mineral nutrient pool and a soil water reservoir. Management should consider the impact of tree harvesting and slash disposal on the nutrient-rich and soil water-rich duff microsite. Destruction of duff during tree removal and burning of slash should not be encouraged.
INTRODUCTION

The pinyon-juniper woodlands of the Great Basin has a Mediterranean climate. Soil moisture is depleted in summer, remaining minimal in winter (Gifford and Shaw 1973). Gifford’s (1975) water budget for pinyon-juniper woodlands shows a majority of annual precipitation is lost by evapotranspiration and interception. Little runoff or deep percolation occurs. In environments where water is limiting, natural selection favors those species that compete for soil water and use it effectively. Woodbury (1947) and Plummer (1958) have previously noted the ubiquitous root systems of pinyon (Pinus edulis) and Utah juniper (Juniperus osteosperma) in woodland stands. Systems of single pinyon (Pinus monophylla) and western juniper (Juniperus occidentalis) are composed of surface feeder roots under the tree crown and deeper laterals that occupy the interspace areas between trees (Young and Saez 1984). Jeppesen (1977) found western juniper withdrew much of the winter accumulation of soil moisture before associated understory species broke dormancy. Emmerman (1932) noted that soil moisture withdrawal by pinyon roots closely followed evaporative demand.

Canopy interception reduces the amount of precipitation reaching the soil surface (Collings 1966). Depth of watering was found to be inversely related to canopy density above the sample point Gifford 1970. Stemflow channels precipitation to soils adjacent the tree stem, but the amount is only a small fraction (0.3) of that intercepted by the tree crown (Young and others 1979).

Removal of trees can increase soil moisture. Gifford and Shaw (1973) studied moisture trends in undisturbed pinyon-juniper stands and stands subjected to chaining followed by windowing and burning of debris. Undisturbed woodlands were found to have the least soil moisture and debris-in-place treatments to have the greatest soil moisture accumulation. Skau (1964) suggested that 50% of pinyon-juniper stands may considerably increase water available for forage production. Soil moisture was found to increase over undisturbed stands following felling of alligator juniper (Juniperus deppeana) and Utah juniper (1.1 and 2.5% increase, respectively). The nineths of found understory cover on clearcut plots was believed to be the major cause for the increased tree crown cover. Everett (1984) found understory cover and yield response to tree harvest was greater on tree-associated soil microsites than in the interspace between trees. This may be the result of increased soil nutrient availability (Everett 1984). Improved soil moisture status, or both.

In this study we measured soil microsite potentials and percentage soil moisture in tree-harvested and nonharvested pinyon-juniper stands. Soil water measurements were taken in each of the three major soil microsites (duff, transition, and interspace) in each plot. Measurements were taken in what we believed to be the major rooting zone of herbaceous species on the site (Everett 1984). We asked three major questions of our data: (1) Was there any increase in soil water between (tree-harvested and nonharvested plots)? (2) Was there a difference in soil water among soil microsites? (3) Did soil water vary between 15- and 30-cm soil depths? Finding differences in soil water among soil microsites on harvested plots would suggest that the need for cultural prescriptions to protect these microsites during tree harvest.

METHODS

In 1979 three 0.1-ha plots were cut clearfelled of singleleaf pinyon and Utah juniper. Plots occurred on north, west and south aspects within 2 km of each other on the Shoshone Mountain range of central Nevada. Areas adjacent the tree harvest plots were selected as control and the three pairs of plots fenced to exclude livestock. The understory was composed of perennial grasses Sandberg bluegrass (Poa sandergha), Idaho fescue (Festuca idahoensis), squirreltail (Sitanion hystrix), and junegrass (Koeleria cristata). The ratio of grass to forage was 283:61.2:8:54:1 percent on north, west, and south aspects, respectively. Pinus edulis con- covered juniper cover in all instances. Elevation at the site was 2100 m. Precipitation was estimated at 320 mm, 360 mm, 330 mm, and 459 mm for the 4-year study (1980 to 1983). Estimates were the mean value from the two weather stations in the same vegetation type 10 km and 70 km distant. Soils on the site were classified as clayey-skeletal, mixed, mesic, Lithic Argic Haploxeralfs (USDA 1975). Soils occurred on 14 to 18 percent slopes on north-south ridges. The soil surface was a mosaic of soil microsites. duff, transition, and interspace. Duff microsites occurred under the tree crowns and were defined as those microsites having greater than 0.5 cm depth of continuous needle cover. Transition microsites had discontinuous needle cover of less than 0.5 cm deep in a ring at the tree crown perimeter. Interspace microsites had negligible needle cover and occurred between trees.

Soil Water and Temperature Measurements

Matric water potential was read on soil microsites in harvested and nonharvested plots. In each plot the soil microsites, duff, transition, and interspace adjacent the tree harvest plots were sampled for soil moisture. Gypsum soil moisture blocks (Delharma GB-1 cylindrical gypsum blocks) were pressed into the sides of the plots and soil moisture measured at 15, 30, and 60 cm depths. A copper-constantan thermistor was placed with 15 cm deep block to measure soil temperature. Moisture blocks and thermistors were put in the ground at the time of tree harvest in June 1979 and read from 1980 to 1983. Gypsum blocks remain in good condition for 3 to 5 years under field conditions (Roudy and Winter 1987) and were taken prior to the loss of snow cover (April-May) until late summer (September) at 2- to 4-week intervals. A total of 1,116 soil water and 553 temperature readings were taken during the study. To facilitate comparisons between sample dates, most measurements were taken in May of each year. Thermistor readings in microsomes were converted to temperature readings (°F) using water bath calibration curves. Water content measurements in representative duff and interspace microsomes were converted to bars of soil matric potential using the equation provided by Roudy and others (1986). Bars (h) equals 253 cm divided by the total soluble salts were low (0.1 to 0.4 cm bars) (1 bar) Everett (1984) found that soil moisture was generally 2 to 5 times greater in tree-harvested than nonharvested plots. Matric water potential was not a major contribution to soil moisture reported by Gifford (1970).

Contrary to our expectations, we found soil water to be significantly less under cover increased rapidly. Soil moisture content of soil microsites was uniformly on harvested plots, but variable on harvested plots.

Matric Water Potential

Soil water content was greater on tree-harvested than nonharvested plots, but the difference declined over 4 years (table 1). The ratio for 5 to 10 percent greater on harvested plots but varied from 0 to a 12 difference on harvested plots. Results correspond to what Skau’s (1964) report of a 1 to 2 percent increase in soil water following tree harvesting. But values were within the 30-cm bar depth. The soil water content increase in soil moisture reported by Gifford (1970).

Contrary to our expectations, we found soil water to be significantly less under cover increased rapidly. Soil moisture content of soil microsites was uniformly on harvested plots, but variable on harvested plots.
Table 1.—Percentage soil moisture for harvested and nonharvested plots on south, west, and north aspects (means over all microsites, depths, and sample dates)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>H</td>
<td>N</td>
<td>H</td>
<td>N</td>
</tr>
<tr>
<td>22.6%</td>
<td>17.8%</td>
<td>22.9%</td>
<td>18.4%</td>
<td>19.3%</td>
</tr>
<tr>
<td>West</td>
<td>20.7%</td>
<td>17.7%</td>
<td>19.1%</td>
<td>17.7%</td>
</tr>
<tr>
<td>North</td>
<td>19.5%</td>
<td>15.7%</td>
<td>16.5%</td>
<td>21.3%</td>
</tr>
</tbody>
</table>

H = harvested plot, N = nonharvested plot.

\* = significant differences (p < 0.05) between harvested and nonharvested plot values.

ns = nonsignificant difference.

<table>
<thead>
<tr>
<th>Month</th>
<th>H</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>22.6%</td>
<td>17.8%</td>
</tr>
<tr>
<td>West</td>
<td>20.7%</td>
<td>17.7%</td>
</tr>
<tr>
<td>North</td>
<td>19.5%</td>
<td>15.7%</td>
</tr>
</tbody>
</table>

Figure 1.—Soil moisture content in tree-harvested (H) and nonharvested (N) plots on south, west, and north aspects in 1980, 1981, 1982, and 1983.

Table 2.—Mean percentage soil moisture on harvested and nonharvested plots by year and soil microsites

<table>
<thead>
<tr>
<th>Type of plot</th>
<th>1980</th>
<th>1981</th>
<th>1982</th>
<th>1983</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest</td>
<td>D</td>
<td>T</td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>Nonharvest</td>
<td>D</td>
<td>T</td>
<td>I</td>
<td>D</td>
</tr>
</tbody>
</table>

D = duff microsite, T = transition microsite, and I = interspace microsite.

Water (all years and aspects combined) on harvested plots was 17.7% at 15 cm and 19.6% at 30 cm. Mean soil water on nonharvested plots was 14.9% percent at 15 cm and 15.3% percent at 30 cm. Relatively more moisture was available in subsurface horizons for deep-rooted species. Lateral roots from juniper (Gifford 1980) and pinyon (Emerson 1932) were observed to penetrate deep into the soil. The long-term capability of the trees to capture subsurface soil moisture and associated nutrients is indicated by nutrient accumulation under the tree crowns (Barth 1980; Everett 1984).

Table 3.—Soil moisture at 15 cm depth on harvested and nonharvested plots (mean of all soil microsites and years)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>H</td>
<td>N</td>
<td>H</td>
<td>N</td>
</tr>
<tr>
<td>19.8%</td>
<td>15.2%</td>
<td>19.5%</td>
<td>15.2%</td>
<td>19.5%</td>
</tr>
<tr>
<td>West</td>
<td>20.1%</td>
<td>17.7%</td>
<td>20.1%</td>
<td>17.7%</td>
</tr>
<tr>
<td>North</td>
<td>17.9%</td>
<td>16.7%</td>
<td>17.9%</td>
<td>16.7%</td>
</tr>
</tbody>
</table>

H = harvested plots, N = nonharvested plots.

Significant differences between harvested and nonharvested plots for the same aspect that have different superscripts are significantly (p < 0.05) different.

Soil Temperature

Mean soil temperature at the 15-cm depth was always greater on harvested than nonharvested plots during the growing season (table 3). The obvious loss of tree shade and recorded higher soil temperatures in harvested plots support increased solar radiation to the soil surface. Gifford (1973) reported triple the amount of wind on sites where pinyon and juniper trees had been removed. Evaporative demand on tree-harvested sites would be intensified by both solar and wind increase. Differences in soil water between harvested and nonharvested treatments would be diminished.

Table 4.—Soil temperature at 15 cm depth for soil microsites on harvested and nonharvested plots (mean for all aspects and years combined)

<table>
<thead>
<tr>
<th>Harvest</th>
<th>Nonharvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>T</td>
</tr>
<tr>
<td>15.5%</td>
<td>13.2%</td>
</tr>
</tbody>
</table>

H = harvested plots, N = nonharvested plots.

Microsites with different superscripts on harvested or nonharvested plots are significantly (p < 0.05) different.

Understory Cover

Grass cover significantly increased from 5 to 10 percent on the north aspect and from 2 to 13 percent on the west aspect following tree harvest. Cover on the south aspect was initially low and did not exceed 4 percent after 4 years. Soil water was greatest on the south slope. Perhaps reduced transpiration on this sparsely vegetated site caused this anomaly. Soil water differences between harvested and nonharvested plots were least on north and west aspects where the increase in understory cover was greatest. We observed that microsites with a deep needle cover inhibited understory establishment.

**CONCLUSIONS**

Tree harvesting increases soil water, but only temporally. Transpiration from released understory and evaporation from the soil surface are speculated to rapidly reduce initial postharvest soil water levels. Soil water is relatively greater under the duff surrounding cut stems. These microsites are also nutrient-rich and provide a favorable environment for understory growth at their periphery. Where understory is associated with the duff microsite, these microsites should be protected from destruction during tree harvesting and slash disposal. Because duff tends to inhibit establishment of understory species, this recommendation is not valid when tree harvest sites are to be seeded.

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(Bart 1980; Everett 1984) occur in subsurface horizons. The duff soil microsites had greater soil water content than interspace or transition microsites on harvested plots (table 2). The duff microsite accumulated soil moisture much like the debris-in-place microsite created by chaining and windrowing (Gifford 1980). Differences among soil microsites on harvested plots declined over years. There were no significant differences in soil water content among microsites on nonharvested plots.

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REFERENCES


Soil water and temperature initially increased following tree removal. The duff soil microbial accumulated soil moisture and the transition microsite at the edge of the duff became depleted. The south aspect had the greatest increase in soil moisture and the least understory cover. Differences in soil moisture between harvest treatments declined over the 4-year study as understory cover increased.

KEYWORDS: soil water, pinyon, juniper, Great Basin, tree harvest

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