United Slates
Department of
Agriculture

Forest Service

Pacific Northwest
Forest and Range
Experiment Station

Research Note
PNW-361
May 1980

Soil Water Trends After Clearcutting in the Blue Mountains of Oregon

G. O. Klock. Research Soil Scientist
W. Lopushinsky, Principal Plant Physiologist

Abstract

A 20-percent reduction in evapotranspiration as measured by a 20-cm increase in soil water content is expected to result in an insignificant increase in streamflow by clearcut lodging in the study area.

Keywords: Soil water, evapotranspiration, streamflow -)forestry methods, logging (-hydrology, clearcutting systems, Oregon (Blue Mountains).

Introduction

The influence of management activities on soil moisture in the forest and their potential effects on streamflow are concerns of forest managers. Activities that increase streamflow could increase channel instability and turbidity and lower the quality of stream waters. Klock and Helvey (1976) showed that removal of vegetation by wildfire in a stand of mixed conifers in north-central Washington had an important impact on the minimum content of soil water in the fall and caused watersheds to yield more water through increased streamflow. Ross (1971) also showed that soil water was influenced by strip clearcutting and selective cutting in an even-aged mixed conifer forest in northeast Oregon. If logging influences soil water and streamflow on east Cascade slopes, the extent of its effect should be defined.

In 1965, the USDA Forest Service established a program in the Umatilla National Forest, Oregon, to evaluate the effects of current management practices on water yield, sediment production, and flood reduction. The Umatilla Barometer Watershed consists of basins of the North and South Forks of the Umatilla River, which flows into the Columbia. The High Ridge evaluation area, in the upper elevations of the South Fork, was chosen for intensive evaluation of management practices in the Barometer Watershed. The analyses and prescriptions for the High Ridge area were designed to describe streamflow and its response to current techniques of timber harvest, prescribe management practices for highest water yield and least production of sediment, and evaluate techniques for predicting water yield. We describe changes in soil water in areas clearcut during the evaluation period.

The High Ridge evaluation area is in the Blue Mountains of northeastern Oregon, about 22 km northwest of Elgin and 8 km southwest of the Spout Springs Winter Recreation Area (sections 31 and 32, T. 3 N., R. 38 E., and sections 5 and 6, T. 2 N., R. 38 E., Willamette meridian). The evaluation area consists of four small watersheds, (table 1). Elevations range from 1 439 to 1 617 m, and the gentle northeast slopes range from 2 to 25 percent. The dominant vegetation is a mixture of grand fir (Abies grandis (Dougl. ex D. Don) Lindl.), Engelmann spruce (Picea engelmannii Parry ex Engelm.), subalpine fir (Abies lasiocarpa (Hook.) Nutt.), and western larch (Larix occidentalis Nutt.), with some associated Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) and lodgepole pine (Pinus contorta Dougl. ex Loud.).

Table 1—Average annual runoff and timber harvested in August and September 1976 from four small watersheds in the High Ridge area, Umatilla National Forest, Oregon.

Watershed	Area	Average annual runoff	Timber volume removed	Portion of stand removed
	Hectares	Centimeters	Mfbm	Percent
I	24.4	43.9	1,233	43
II	29.6	51.6	2,348	50
III	53.3	51.8	0	0
IV	118.1	47.8	1,562	22

The area is underlain by Columbia River basalts (Baldwin 1964). Soils (Helter silt loam) (Geist and Strickler 1978) are of both aeolian and residual origin. The Helter series has a 0.1- to 1-m surface layer of ash from relatively recent (less than 6,700 years) volcanic activity in the Cascade Range overlying the buried soil horizon. It belongs to the association of Western Brown Forest, Regosols, and Lithosols and is known as a typic vitrandept. Although both the upper and lower horizons are classified texturally as silt loams, they show a marked difference in physical properties. Bulk densities of the upper soil average nearly 0.65 gm/cm^3 and the buried soil horizons above the weathered basalt average nearly 1.3 gm/cm^3. The upper soil has high water-holding capacity because of its ash component.

A description of the climate and hydrology of the area is being prepared.[1/] Average annual precipitation for 1967-78 was 142.47 cm, ranging from 73.15 (1972-73) to 190.25 cm (1973-74). Between October 1 and May 31, 87 percent of the yearly total falls generally as snow. Maximum snow depth was reached in late March to early April and averaged 153.6 cm for the period 1972-77. About 80 percent of the annual streamflow occurred during snowmelt in May and June. Average annual run-off from the four watersheds for 1967-76 is shown in table 1. If we assume no deep seepage occurred, seasonal evapotranspiration was over 90 cm.

Methods

Watershed III was designated for a control and remained uncut. In August and September 1976, watersheds I, II, and IV were cut as prescribed (Johnson and Calane 1977). Watershed I was patch logged in two blocks of 3.64 and 8.50 ha. Logs in clearcuts were piled by machine and burned on September 21, 1976. The unburned fuels were machine-scattered after burning. Half of each clearcutting was seeded with a mixture of grasses to control erosion in October 1976 and planted with Engelmann spruce and western larch in April 1977. Watershed II was partially cut, and all unmerchantable material was yarded and burned. No plantings for control of erosion or reforestation were made. Watershed IV was patch logged in small areas of 0.81 to 2.43 ha, totalling 19.92 ha. Timber volumes and percentage of the stand removed are shown in table 1.

In 1972, access tubes for a neutron probe soil moisture meter were installed at two midelevation locations each in watersheds I and IV and at one location at the lower elevation of watershed III. Tubes were installed in watersheds I and IV about 30 m outside the boundary of future clearcuttings. No tubes were installed in the partially cut watershed II because of the high variability in selected tree locations and the high cutting variability. At each location, three tubes in a triangle, about 4.5 m on a side, were installed to about 150 cm, which is below the major rooting zone. Volumetric measurements of soil water were made at 15-cm intervals, beginning at 30-cm.

In 1977, two additional sets of 3 tubes were installed at two locations (12 tubes) in both watersheds I and IV. Each of these sets was paired with a set installed in 1972, 30 m inside the clearcutting. Measurements of soil water were made periodically during the summer from 1972 to 1978 in the undisturbed timber areas and in 1977 and 1978 in the clearcuttings.

---

[1] Report, "Baseline climatic and hydrologic relationships for the High Ridge Evaluation Area," by W. B. Fowler, J. D. Helvey, and C. Johnson, to be published by Pacific Northwest Forest and Range Experiment Station, Portland, Oreg.

Results and Discussion

Water measurements in the soil profile from 30 to 136 cm are pooled for all dates from 1972 to 1978 in figs. 1, 2, and 3. Values measured in 1977 and 1978 and differential water content between uncut and clearcut areas are shown in table 2.

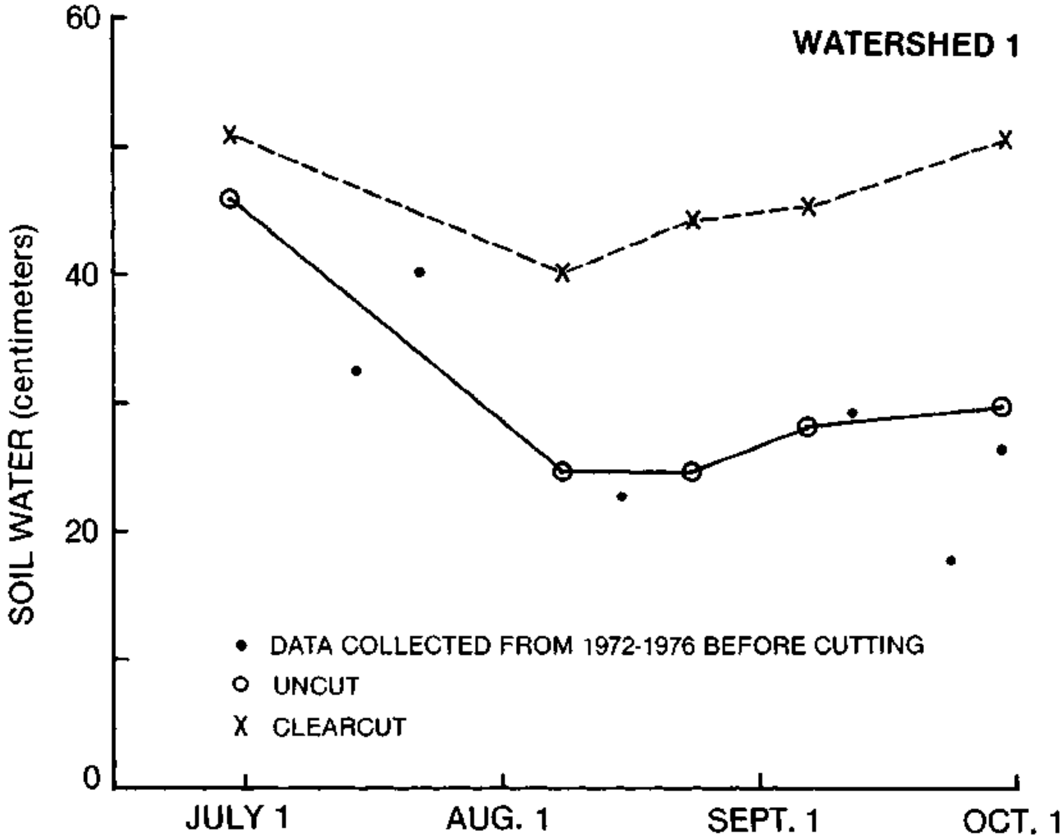

Figure 1.--Seasonal content of soil water in the upper 150 cm of the soil mantle in the east aspect of watershed I. Solid line connects periodic measurements taken in 1977 and 1978 after clear-cutting, fall 1976.

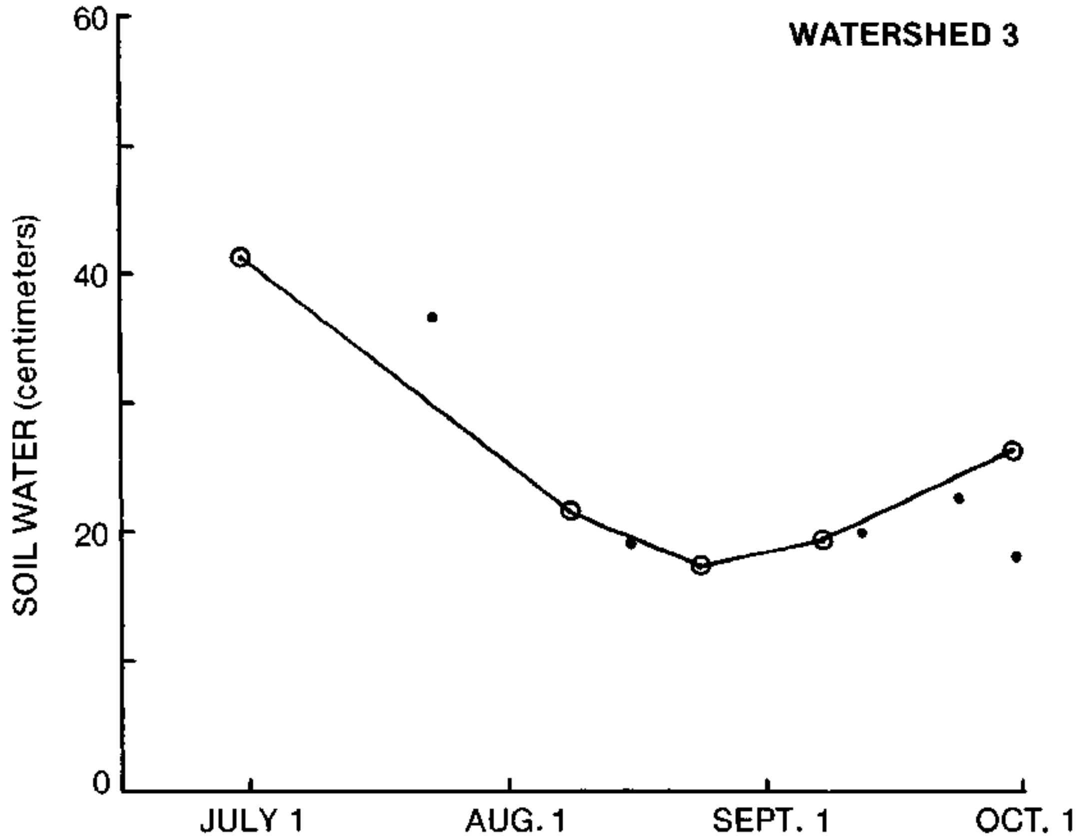

Figure 2.--Seasonal content of soil water in the upper 150 cm of the soil mantle in the control watershed III. Solid line connects periodic measurements taken in 1977 and 1978. Solid dots are data points collected from 1972-1976 before cutting.

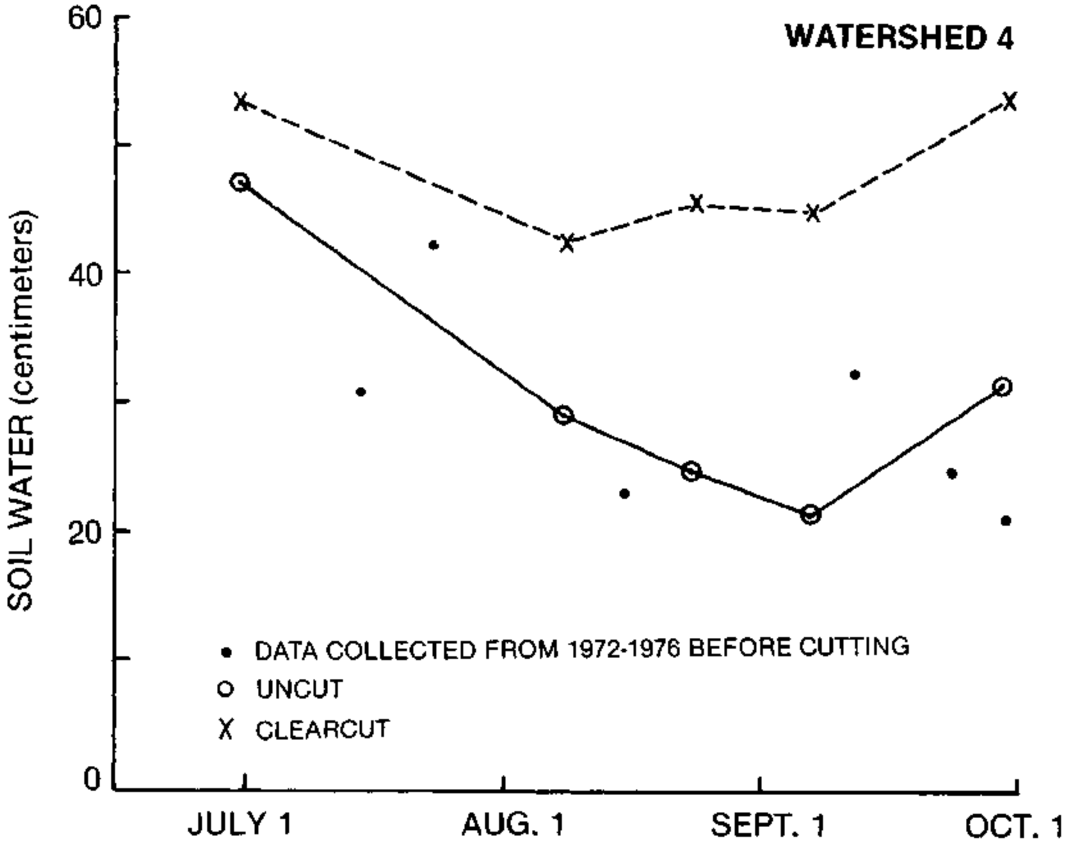

Figure 3.--Seasonal content of soil water in the upper 150 cm of the soil mantle in the north aspect of watershed IV. Solid line connects periodic measurements taken in 1977 and 1978 after clear-cutting, fall 1976.

Table 2—Soil water contents for the High Ridge area during 1977 and 1978 (15- to 136-cm soil profile depth)

Date	Watershed I			Watershed III (control)	Watershed IV		
	Uncut	Patch logged	Diff.	Uncut	Uncut	Patch logged	Diff.
	Centimeters						
8/23/77	24.3	44.0	19.7	17.6	24.4	45.7	21.3
9/27/77	29.5	50.3	20.8	26.6	31.5	54.1	22.6
6/28/78	45.5	50.7	5.2	41.4	47.1	53.5	6.4
8/8/78	24.5	40.0	15.5	21.6	28.9	42.8	13.9
9/6/78	28.1	45.3	17.2	19.4	21.4	45.0	23.6

Seven years of records indicate that minimum soil water contents are reached in late August. Because precipitation generally equals or exceeds evapotranspiration demands after early September in this area, soil water generally increases after this date. Trends in water content should be similar in most mixed conifer stands to the upper elevations of the Blue Mountains in Oregon and Washington. Similar trends were also observed by Ross (1971), but he could not fully substantiate a reduced depletion of soil water for all years in clearcut areas tested in mixed conifer stands. Our data, however, indicate (table 2) that soil water depletion is nearly 20 cm less in the patch clearcut stands at High Ridge for 2 years after cutting. Differences may result from measurement techniques. We placed the three tubes in an equilateral triangle at each site; Ross (1971) used the transect method, with one tube at a location. Our experience indicates that the equilateral placement is more effective in measuring changes in soil water than the transect method because it accounts better for spatial variability.

The 20-cm reduction of the estimated 90-cm average evapotranspiration, shown by increased soil water after patch clearcutting, would be expected to be reflected in increased streamflow from the High Ridge area. In watershed I, 43 percent of the stand was clearcut. Thus, the reduction in evapotranspiration could potentially show up as an increase in streamflow of 8.6 cm, which would be a potential increase in total annual flow of 20 percent. In watershed IV, 22 percent of the stand was clear-cut, which could contribute 4.0 cm to streamflow, or a potential increase of 8 percent. Past experience on watershed I (see footnote 1) has indicated that detecting such increases in runoff is extremely difficult. Therefore, although the reduction of evapotranspiration on watershed I may lead to increased streamflow, variability in hydrologic characteristics and precision of streamflow measurements appear to prevent its detection by streamflow monitoring. The streamflow calibration on watershed IV is better than that developed for watershed I. The additional incremental runoff from watershed IV will be so small, however, that it may be undetectable.

As the area continues to revegetate, the evapotranspiration will increase toward precutting rates. Thus, maximum potentially detectable increases in streamflow from increases in soil water were to be expected during the runoff year from October 1, 1977, to September 30, 1978, in the High Ridge area.

Literature Cited

Baldwin, Ewart M. 1964. Geology of Oregon. Ed. 2, illus. Univ. of Oregon Coop. Bookstore, Eugene, Oreg. 165 p.

Fowler, W. B., J. D. Helvey, and C. Johnson. 1979. Baseline climatic and hydrologic relationships for the High Ridge Evaluation Area. USDA For. Serv. Gen. Tech. Rep. PNW-91. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Geist, J. Michael, and Gerald S. Strickler. 1978. Physical and chemical properties of some Blue Mountain soils in northeast Oregon. USDA For. Serv. Res. Pap. PNW-236, 19 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Johnson, C., and E. Calane. 1977. Hydrometeorological Data Bank Water Year 1976 - Umatilla River Barometer Watershed. Unnumbered publication, Umatilla National Forest. Pendleton, Oreg. 120 p.

Klock, G. O., and J. D. Helvey. 1976. Soil-water trends following wildfire on the Entiat Experimental Forest. Proceedings of the Annu. Tall Timbers Fire Ecol. Conf. no. 15, p. 193-200. [Portland, Oreg., Oct. 1974.] Tall Timbers Res. Stn., Tallahassee, Fla.

Ross, Richard N. 1971. Snow and soilwater response to logging. M.S. thesis, Colorado State Univ., Fort Collins. 85 p.