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SOIL WATER DEPLETION AFTER FOUR YEARS OF FOREST REGROWTH IN SOUTHWESTERN WISCONSIN [1]

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ABSTRACT.—The effect of cutting on water depletion from a 150-cm soil mantle does not appear to have diminished by the 7th year after the trees were cut. Mean seasonal depletion was 41, 64, and 146 mm for all vegetation removed, woody vegetation only removed, and uncut treatments, respectively. After 4 years of regrowth, the original bare and clearcut treatments depleted only 21 and 35 percent as much water as the uncut forest.

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METHODS

The study site, a forested north slope on the Coulee Experimental Forest in southwestern Wisconsin, has been described previously (Sartz 1972a). Annual precipitation averages 800 mm, about two-thirds of which falls as rain during the growing season (May to mid-October). Soil water content is normally greatest in early spring, diminishing gradually over the growing season because of evapotranspiration and drainage. Rarely do summer rains recharge the soil mantle enough to deliver water to the ground water system.

The original study design included four treatments: (1) woody vegetation only removed ("clearcut"); (2) all vegetation removed ("bare") (in addition to cutting the trees, the herbaceous vegetation was killed or clipped for 3 years on a circular plot 2 m in diameter to minimize transpiration loss); (3) uncut; and (4) uncut forest with litter removed. However, after it was found that litter removal did not affect water depletion, the data for the two uncut treatments were combined.

Each treatment had four replicates in a paired-plot design for the secondary treatments (plots with woody vegetation removed vs. plots with all vegetation removed, and plots with litter removed vs. undisturbed plots). The paired plots were centered in 62- by 44-m blocks that were laid out along a 265-m stretch of slope. A block width of 44 m was considered to be the minimum needed to overcome border affects. Mean slope is 32 percent.

Originally one neutron meter access tube was installed in each plot, but after analysis of sampling variation in the first year's data (Sartz 1972a), a second tube was added. Each tube was

[1] *The research was conducted in cooperation with the State of Wisconsin Department of Natural Resources.*

treated as an independent sample, resulting in 8 samples for each of the clearcut treatments and 16 for the uncut forest treatment after the first year. Details of the study site, installation of access tubes, and a description of the neutron meter and measuring procedure, are given in two previous papers (Sartz 1972a, 1972b).

Soil water content was logged with the neutron meter in early spring (about mid-May) and again in late summer. Readings were taken at 30-cm intervals beginning at a depth of 30 cm. Sampling depth differed among plots according to depth to the layer that could be penetrated by hand augering. This was assumed to be the lower limit of the soil mass affected by transpiring vegetation. All plots (tubes) could be sampled to 120 cm, and 4 bare, 4 clearcut, and 11 uncut plots to 150 cm or deeper. Depletion values are based on the modal depth of 150 cm.

Seasonal depletion was assumed to be the difference between early spring and late summer water contents during the 4-year period of regrowth reported here. Measurements were made at 2-year intervals.

RESULTS AND DISCUSSION

Water content at the beginning of the growing season was similar for each of the 5 years (3 initially, plus 2 during the 4-year regrowth period) studied. Means for the 150-cm soil mantle ranged from 468 to 481 mm for the three conditions (table 1). This is about 30 percent by volume, and approximates field capacity. Considering the sampling errors involved (Sartz 1972a) it seems reasonable to assume that the soil mantle was fully charged on all plots each spring.

Vegetation Changes

Herbaceous vegetation was suppressed on the bare plots but was allowed to grow on the clearcut plots during the initial 3 years of study. Ferns grew denser and blackberries (*Rubus* spp.), hazel (*Corylus americana* Marsh), and other weed species invaded many plots. The cut plots were covered with a dense tangle of blackberries, ferns, and tree sprouts by 1973 (5 years after cutting, and 2 years after vegetation was allowed to grow). Two years later, the area was an impenetrable jungle. Aspen sprouts were up to 3 m tall, and trails cut through the plots for the spring measurements were completely grown over by the end of the summer. Some of the bare plots that had been treated with the herbicide simazine 80W in 1969 still had sparse growth around the neutron meter access tubes, but most could not be distinguished from the tangle that surrounded them.

Table 1.—*Water content of a 150-cm soil mantle at the beginning of the depletion period.*

Forest Condition	Before regrowth 1969	1970	1971	After regrowth 1973	1975	Mean
			mm			
Bare	484	508	482	463	466	481
Clearcut	466	490	460	467	461	469
Uncut	471	472	460	481	455	468

Soil Water Depletion

Four years of regrowth appeared to have little effect on soil water depletion (table 2). Since the data showed no trend with time, means were computed from the five sets of measurements. The values, expressed as a percent of depletion by the uncut forest, were 26 and 42 for the bare and clearcut treatments, respectively. Mean seasonal water depletion by depth for a 7-year period was similar for cut and uncut plots as seen in the following tabulation:

Depth (cm)	*Bare* ---	*Clearcut* (Percent)	*Uncut* ---
30	25	21	25
60	21	18	21
90	23	21	21
120	18	23	18
150	13	17	15

Because depletion values reflect rainfall gains as well as evapotranspiration losses, one would expect the values to vary from year to year, even with an unchanging vegetation. Thus, in 1973, high July-August rainfall (280 mm compared with 100 to 140 mm the other years) tended to mask the losses from evapotranspiration. Differences in the length of the depletion period and in potential

Table 2.—*Seasonal water depletion in a 150-cm soil mantle*

Forest condition	Before regrowth 1969	1970	1971	After regrowth 1973	1975	Mean
			mm			
Bare	[1]29(15)	77(41)	64(35)	8(17)	25(21)	41(26)
Clearcut	58(29)	120(64)	85(47)	15(33)	42(35)	64(42)
Uncut	197	187	181	46	120	146

[1]Figures in parentheses are seasonal water depletion as a percent of depletion in uncut plots.

evapotranspiration would also affect the amount of depletion measured from one year to another. This is an inherent weakness in the depletion method of comparing water use by different vegetations.

Soil water depletion by cut and uncut forest in the Driftless Area of southwestern Wisconsin was studied by Sartz (1972b). Seasonal depletion attributed to evapotranspiration in a 150-cm soil mantle averaged 188 mm on uncut plots, 87 mm on clearcut plots, and 57 mm on plots without vegetation. Similar relations have been reported from other regions using streamflow as the measured parameter; however, the initial effect of forest cutting diminished rapidly with the regrowth of vegetation (Lull and Reinhart 1967). Four years after clearcutting, the initial gain in streamflow had diminished 53 percent on a West Virginia stream (Lull and Reinhart 1966) and 36 percent on a North Carolina stream (Kovner 1956). An exception to this was reported by Mader, MacConnell, and Bauder (1972) in Massachusetts when the vegetation removed was in the riparian zone. They showed that increases in soil water storage were maintained in spite of rapid regrowth of herbaceous vegetation.

The change in soil water depletion reported by Sartz (1972b) in the Driftless Area was the result of 3 consecutive years of maintaining the vegetation according to the prescribed treatments. Beginning with the fourth year after timber removal, vegetation was allowed to regrow to assess the effect of regrowth on water depletion. This paper reports the results from a 4-year period of regrowth.

In view of the rapid reduction in streamflow with forest regrowth found on Appalachian catchments (Lull and Reinhart 1967, Troendle 1970) it seems surprising that the soil water depletion differences between cut and uncut forest reported here persisted with no apparent diminution through a period of vigorous vegetation regrowth. Perhaps the difference between their results and these is related to differences in the kind of regrowth. The dominant regrowth on these plots was largely herbaceous; and even though it appeared to provide a continuous green cover, its transpiring surface was obviously much smaller, and its root system much less developed than in the uncut forest. Regrowth on the Appalachian catchments probably included more tree sprouts, which, using the already developed root systems of the parent trees, would be able to extract more water from the soil.

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