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INFILTRATION IN A WESTERN LARCH--DOUGLAS-FIR STAND FOLLOWING CUTTING AND SLASH TREATMENT

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Modification of the water-absorbing capacity of the soil is a critically important change that can take place when forest stands are harvested. This environmental change may escape the casual observer. Before its full importance can be assessed careful measurements are required.

Opportunity to explore the relative changes in infiltration capacity produced by logging and slash treatment in a western larch (Larix occidentalis)--Douglas-fir (Pseudotsuga menziesii var. glauca) stand was provided in 1952 following the installation of a harvest cutting study in western Montana.[2/] Five-year records show that immediate and variable reductions in infiltration capacity occur on broadcast burned, scarified, and tractor skid road surfaces; but improvement can be expected within a few years, except on surfaces that have been compacted excessively.

STUDY AREA AND TREATMENT

The study area is within the Coram Experimental Forest on a northwest slope averaging 20 percent. The silty clay loam soil is derived from shale. No detailed soil analyses have been made on the tract.

Before logging, the stand consisted mainly of overmature and mature western larch and Douglas-fir trees on site quality IV. The main stand was 280 to 300 years old but contained some scattered larch trees 500 years old. The original stand averaged 25,400 board feet per acre, 73 percent of which was western larch; the remainder was chiefly Douglas-fir and other species.

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2/ This study was started by A. L. Roe and A. E. Squillace, foresters, Intermountain and Southeastern Forest and Range Experiment Stations, respectively.

The stand was logged during the winter, spring, and summer of 1951. Logs were skidded with a jammer near the roads and with Allis Chalmers HD7 and Caterpillar D-4 and D-7 Crawler tractors in locations beyond reach of the jammer.

Timber harvest removed 77 percent of this volume, and left a seed-tree reserve of 5,800 board feet per acre, 71 percent of which was western larch.

Following logging, the cutover area was divided into several blocks and each was randomly assigned a slash treatment. Slash was piled with an Allis Chalmers HD7 tractor equipped with a brush buncher blade on some of the blocks during the summer and fall of 1951. Other blocks were broadcast burned in September 1951 and May 1952.

METHODS AND MATERIALS

Four reference stations were established within the cutover stand on each of the following four soil surface conditions:

Undisturbed--natural, undisturbed forest floor.

Scarified--duff removed or disturbed excessively by the tractor in the process of piling slash and soil scarification.

Broadcast burned--areas or "spots" broadcast burned.

Tractor skid road--surface of roads used in tractor skidding of logs. Does not include jammer roads.

At each station a series of three infiltration experiments, on areas spaced about 5 feet apart, was made annually on each surface condition from 1952 through 1956 in late August or early September. Thus annually 12 tests were made on each type of surface condition, making a total of 60 for the 5-year period (240 for the entire experiment). The sites for infiltration runs in each successive year were located to avoid the effects of disturbance from runs made in previous years.

These infiltration checks were made with 6-inch infiltrometer rings, using the installation and presoaking techniques described by Friedrich (2). The time required for 1 inch of water to disappear into the soil after a 5-minute presoaking period was used as a measure of infiltration.

RESULTS

The first year following logging and slash disposal the water-absorbing capacity of the soil on tractor skid roads and scarified areas was substantially less than on undistubed areas. On broadcast burned surface the infiltration capacity was also lower than on undistubed areas, but the difference was less.

Figure 1 shows these differences in each year following logging by expressing the average rate of water absorption on each surface condition as a percentage of that absorbed by undisturbed soil. The first year after logging the infiltration capacity of tractor skid roads, scarified areas, and broadcast burned surfaces averaged 4.1, 15.4, and 62.5 percent, respectively.

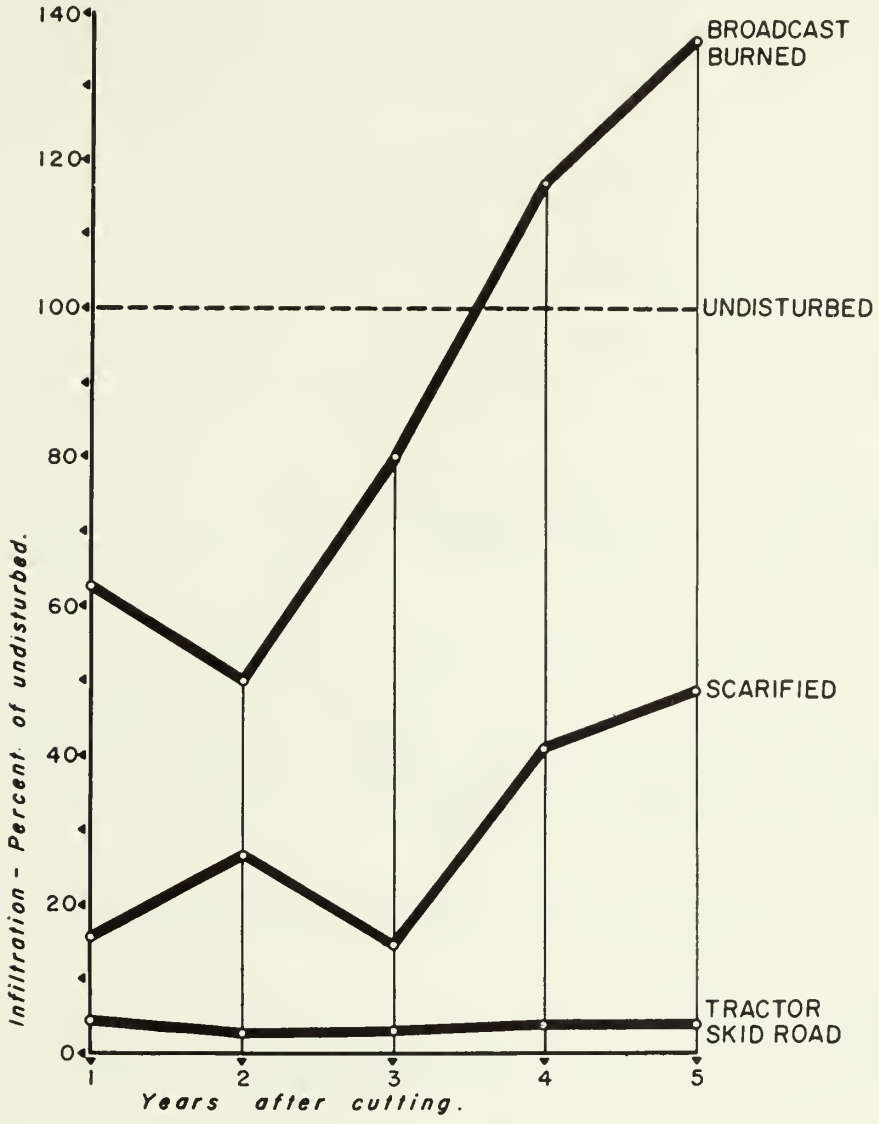

Figure 1. Infiltration on three soil surfaces as a percentage of infiltration on undisturbed soil.

During the succeeding 4 years capacity for water intake improved markedly on scarified and burned surfaces, but virtually no change was apparent on tractor skid roads.

A word of caution is necessary concerning the interpretation of these results. In this study only relative infiltration capacities were measured. The ring infiltrometer is satisfactory for this purpose, but it cannot make absolute quantitative measurements. For one thing, this device does not measure the effect of raindrop impact, which tends to reduce infiltration. Also, the technique used here measured water intake of the soil below a variable head of standing water. This procedure tends to estimate infiltration conservatively.

DISCUSSION

The relative differences in infiltration capacity on the various surfaces have practical implications. The extremely low capacity on tractor skid roads throughout the 5-year period probably resulted from soil compaction and plugging of the surface soil pores. Such impairment in water-absorbing capacity for long periods can lead to high runoff rates and soil erosion.

In this connection, the infiltration capacity of tractor skid roads 2 years after logging in 180-year-old lodgepole pine in Montana was found to be only 5 percent of that on undisturbed areas (1). In 20- to 30-year-old cuttings in Montana lodgepole pine, sediment production from eroding roads was still continuing (6).

Broadcast burning is a desirable method of slash disposal in western larch--Douglas-fir forests on steep slopes for both fire protection and regeneration (3). According to this study, broadcast burned surfaces lose considerable infiltration capacity for a few years, but they recover it rapidly. Theoretically the reduction is probably due to destruction of surface litter and incorporated soil organic matter and the attendant decrease in macroscopic pore volume. Studies in the Douglas-fir region (5) have reported much larger infiltration reductions on severe burns.[3/] However, the surface characteristics after the fire and the fairly rapid recovery in infiltration capacity indicates that the burn in this study was not severe.

A possible explanation of this recovery and improvement in infiltration capacity beyond that on undisturbed soil surface in the fourth and fifth years is the release of nutrients bound in organic matter and subsequent vigorous growth of vegetative cover. It is well established, for example, that almost immediately following burning, the amounts of exchangeable calcium, potassium, and available phosphorus increase in the upper soil layers. Later, through nitrification, the available nitrogen content may also increase, particularly following rapid, light burns (5). A larger quantity of nitrogen in the soil following burning could also have contributed to the observed flourish of plant growth and resultant betterment in infiltration capacity.

3/ Burns that completely consume all organic litter and bake the mineral soil to a highly crusty state.

Soil scarification aids establishment of western larch--Douglas-fir reproduction (3). However, experience has shown that scarification by heavy machinery used in slash disposal is sometimes greater than that required for adequate regeneration. Usually additional soil compaction occurs over areas previously disturbed in logging when slash is bunched with a tractor. To a degree this is inevitable, yet certain precautions could be taken by the tractor operator when bunching slash to keep both these effects to the minimum. For example, if areas are already scarified adequately the tractor could be run over nonscarified ground instead of over previously disturbed soil.

Only a few extra trips by a tractor can greatly change the physical properties of forest soils. In a recent study, in Washington, on soils of the Olympic Series (4), four trips with an HD20 tractor reduced the macroscopic pore space by one-half, and the infiltration rate by more than 80 percent. Under moist soil conditions only one trip caused similar reductions.

Ordinarily, partial removal of plant cover and disturbance to the soil surface by a tractor should not result in excessive and prolonged infiltration reductions. The reduction shown here most likely reflects the effect of compaction rather than scarification *per se*.

Because skid roads and other scarified surfaces that are compacted can be critical areas from an infiltration standpoint, this important question arises: To what extent are these two conditions created by logging and by different slash treatments? To answer this question, we analyzed the surface conditions on areas within the cutover stand treated by different methods of slash disposal.

Measurements (table 1) show that skid roads covered 5 percent or less of the area in each treatment. This area is not large considering the cut was nearly 20,000 board feet per acre. In fact, it is this small because most of the volume was yarded with a jammer. Unfortunately the area in haul roads was not measured.

Table 1.--Effect of jammer-tractor logging and different slash treatments upon surface condition

Slash treatment	Area of forest in different surface conditions following logging and slash treatment			
	Undisturbed	Burned	Scarified	Skid road 1/
	Percent			
No treatment	91	--	8	1
Lop and scatter	83	--	17	--
Hand pile and burn	76	3	16	5
Broadcast burn	45	39	13	3
Dozer pile and burn	31	9	55	5

1/ Variation between treatments due to sampling errors.

Logging operations alone scarified 8 percent of the cutting area, and logging plus dozer piling and burning scarified 55 percent (table 1). Scarification over 47 percent of the area could be attributed to dozer piling alone. This amount is not excessive. Even more scarifying is desirable for adequate establishment of natural regeneration, provided it is uniformly distributed. However, when an entire cutover is subjected to this type of treatment, soil compaction must be kept at a minimum.

SUMMARY

Infiltration tests were made annually during a 5-year period in a mature western larch--Douglas-fir stand following timber harvest and slash treatment. These tests were made on soil showing four surface conditions: tractor skid roads and scarified, broadcast burned, and undisturbed areas.

The first year after logging the infiltration capacity of skid roads, scarified areas, and broadcast burned surfaces averaged 4.1, 15.4, and 62.5 percent, respectively, of the capacity of undisturbed soil. During the succeeding 4 years the water intake capacity of scarified and lightly burned surfaces improved fairly rapidly, but the skid roads showed virtually no improvement.

Because both soil scarification and burning aid establishment of western larch and Douglas-fir reproduction, excessive soil compaction must not be permitted during slash treatment with heavy machinery. Impairment in water-absorbing capacity of the soil for long periods by compaction can lead to high runoff rates and soil erosion.

LITERATURE CITED

1. Boe, Kenneth N.
   1951. Office report dated November 21, 1951, in the files of the Intermountain Forest and Range Experiment Station, Missoula, Montana.

2. Friedrich, C. A.
   1951. Suggestions for the manufacture and operation of a six-inch infiltrometer ring. U.S. Forest Serv. Northern Rocky Mountain Forest and Range Experiment Station Research Note 104. 3 pp.

3. Roe, Arthur L.
   1952. Larch--Douglas-fir regeneration studies in Montana. Northwest Sci. 26: 95-102, illus.

4. Steinbrenner, E. C.
   1955. The effect of repeated tractor trips on the physical properties of forest soils. Northwest Sci. 29: 155-159, illus.

5. Tarrant, Robert F.
   1956. Effects of slash burning on some soils of the Douglas-fir region. Soil Science Soc. Amer. Proc. 20: 408-411, illus.

6. Trimble, G. R., Jr., and Norman R. Tripp
   1949. Some effects of fire and cutting on forest soils in the lodgepole pine forests of the northern Rocky Mountains. Jour. Forestry 47: 640-642.