

Accelerated mass wasting after logging and slash burning in western Oregon

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ABSTRACT—Clearcut logging and slash burning in a steep 237-acre watershed in western Oregon resulted in increased rates of soil movement, especially on slopes unprotected by organic debris. During the first growing season after burning, soil movement, which largely occurred as dry ravel, was most pronounced on 80-percent slopes (versus 60-percent), on south aspects (versus north), and in areas having little plant cover (versus well-vegetated areas). By the second growing season after burning, rapid invasion by vegetation essentially halted soil movement on all slopes except extremely stony talus areas.

SOIL movement may decrease site productivity significantly either by removing the more productive surface soil or by covering the surface with less productive material. During the dry season, soil movement also is a substantial source of stream sediment, although its effect on site deterioration often is overlooked because it is not always obvious and frequently does not appear to involve large amounts of soil.

Research in southern California has shown that dry-season debris ravel on steep slopes results in substantially more erosion than wet-season movement (1). In the Pacific Northwest, dry-season debris movement on steep slopes may be an important cause of mortality among planted Douglas-fir seedlings (3).

Our study was conducted in a clearcut 237-acre watershed in the H. J. Andrews Experimental Forest, located on the west side of Oregon's Cascade Range. The climate is typically wet with mild winters and dry, cool summers. Precipitation averages 88 inches a year, about 90 percent of which falls mainly as rain from October through April. Rainfall intensities are seldom high enough to cause overland flow on these soils.

Watershed slopes average about 65

percent. There are several nearly vertical rock outcrops as well as steep downward-trending ridges between tributary drainages. Soils tend to be shallow, stony, and extremely permeable; they transmit water rapidly.

The watershed was skyline logged from 1962 to 1966. Logging debris was broadcast burned in the fall of 1966. A soil condition survey in the spring of 1967 revealed the slash burn to be about average for the region. The survey also revealed considerable surface soil movement, especially on steeper slopes where most organic debris had been burned. A limited sampling of erosion was undertaken to provide rough estimates of soil movement in the watershed and to determine variations in the rate of soil movement resulting from climatic events, slope steepness and aspect, and amount of vegetative cover.

Study Methods

Two soil collection boxes, 8 feet long by 1½ feet wide, were located in each of five slope-soil condition classes—one on a north-facing slope and one on a south-facing slope (Figure 1). The five classes were (1) 80-percent slope, soil bare with obvious movement; (2) 80-percent slope, soil disturbed¹ but with some vegetation; (3) 60-percent slope, soil bare and moving; (4) 60-percent slope, soil disturbed but with some vegeta-

¹Disturbed condition ranged from forest litter removed and bare mineral soil exposed to deep disturbance involving complete removal of surface soil.

tion; and (5) 80-percent talus slope composed of platy fragments of andesite or welded tuff. Undisturbed areas in the watershed were not sampled under the assumption that no measurable soil movement would occur there.

The collectors were placed just below ridge tops and other topographic breaks so it would be possible to define the contributing areas. These areas were corrected for slope so all areal measurements would be on a horizontal basis. Size of contributing areas ranged from about 0.01 to 0.06 acre.

To estimate total soil movement in the watershed, total area within each sampled class was estimated using a planimeter on aerial photographs.

Precipitation during such collection period was taken from records for five rain gauges located near the experimental area.

Results

Rates of soil movement were appreciably higher on 80-percent slopes than on 60-percent slopes (Table 1). An average total catch by the four boxes on each slope class (excluding two collectors on the talus material) was 89.6 cubic feet per acre on 80-percent slopes and 20.6 cubic feet per acre on 60-percent slopes.

During the first growing season after slash burning, more surface soil moved on bare slopes than on vegetated slopes—at least half again as much on three of four plot sets. The

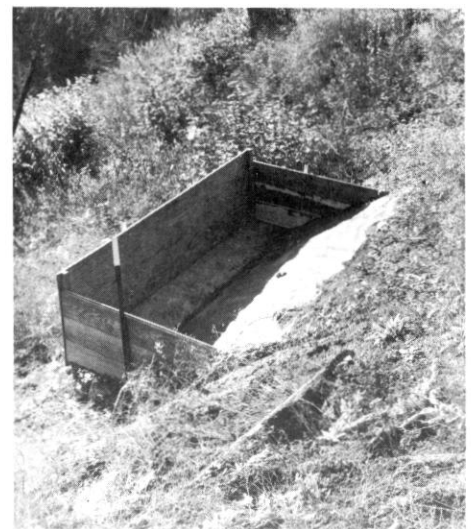


Figure 1. Soil collection box on an 80-percent, south-facing slope 2 years after slash burning (October 1968).

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Table 1. Cumulative volume of soil and rock debris caught in 10 collectors on 60- to 80-percent slopes over an 18-month period beginning July 7, 1967.

Collection Date	80-Percent South		80-Percent North		60-Percent South		60-Percent North		80-Percent Talus	
	Bare ^a	Vegetated	Bare	Vegetated	Bare	Vegetated	Bare	Vegetated	West	North
	cu ft/a									
8- 3-67	32.0	33.5	5.0	5.0	22.7	0	4.4	2.1	34.8	95.2
9-13-67	73.8	54.4	50.0	11.7	40.9	0	4.4	2.1	45.2	289.6
10-26-67	95.9	71.2	54.0	11.7	52.3	0	4.4	2.1	55.6	332.1
2-13-68	111.9	113.7 ^b	58.5	13.3	63.3	0.7	7.4	3.2	83.4	400.9
4-10-68	116.8	144.2	61.2	14.9	71.2	0.7	7.4	3.2	107.7	453.7
5- 8-68	118.0	148.3	61.7	16.2	71.2	0.7	7.4	3.2	112.9	477.5
6-19-68	118.0	152.4	— ^c	16.2	71.2	0.7	7.4	3.2	116.3	490.7
9-10-68	118.6	158.6	— ^c	19.5	71.2	0.7	7.4	3.2	116.3	502.7

^aPrototype collector installed May 11, 1967. Total catch from May 11 to July 7 was 190.3 cubic feet per acre. Remaining nine collectors were installed July 6 and 7, 1967.

^bLarge increase caused by small landslide in the center of the contributing area.

^cCollector accidentally destroyed and contributing area greatly disturbed.

one exception resulted from a small landslide on the 80-percent south vegetated plot (Table 1).

By the end of the summer of 1967, bare plots averaged about 5-percent vegetative cover. Cover on vegetated plots ranged from 30- to 40-percent. However, rapid invasion of vegetation (mainly *Epilobium paniculatum*) in 1968 eliminated much of this difference. By the end of the 1968 growing season, plant cover averaged 50 percent on bare plots and 75 percent on vegetated plots. The stabilizing effect of the vegetation is shown in table 1. During the entire 1968 growing season, little soil movement occurred, even on 80-percent slopes.

Slope aspect seemed to have almost as much effect on soil movement as steepness. Soil losses on south slopes averaged 87.3 cubic feet per acre as opposed to 23.0 cubic feet per acre on north slopes. The fact that south slopes tend to dry out more quickly probably accounts for this difference. The soils apparently are less cohesive when dry. Thus dry-season movement tends to be considerably higher than wet-season movement. Data from the bare 80-percent south plot show that soil movement totaled 265 cubic feet per acre during a 4-month period with little rain (3.56 inches) compared with 44 cubic feet per acre during a 7½-month period with 61 inches of rain.

Three factors—slope steepness, aspect, and vegetative cover—obviously operate together, not separately. Thus soils subject to movement because of steep topography show a much greater degree of instability when they also are bare and/or on a south-fac-

ing slope. Soil movement on bare south slopes surpassed movement on vegetated north slopes by eight times. On 80-percent south slopes, 26 times as much movement occurred as on 60-percent north slopes. Movement on 80-percent bare slopes exceeded movement on 60-percent vegetated slopes by 46 times.

Stratification of the watershed placed about 73 percent of its area in the sampled classes, about half facing south and half facing north. By expanding the data to all similar areas, total soil movement within the watershed for the 16-month sampling period was estimated. The total was 12,378 cubic feet, the equivalent of 0.014 inch over the entire watershed (Table 2).

The fact that almost three-fourths of the estimated soil and rock movement in the watershed originated

from talus slopes emphasized the extremely unstable nature of these areas (Table 2). Consisting mainly of platy rock fragments, these areas were unstable before logging and supported a rather low number of tree stems per acre. Logging and burning apparently increased this instability, especially on the north-facing plot (Table 1). Because of the continuing instability and stony soil, reforesting these areas will be a slow process.

Conclusions

Slash burning on steep slopes contributes to surface soil movement by removing litter and vegetation which help stabilize the soil. After clear-cutting, but before slash burning, about 12 percent of the watershed was bare mineral soil (3). After burning, 55 percent of the watershed area was bare mineral soil. Because of rapid revegetation, however, serious soil movement occurred only during the first growing season.

In the first 2 months of operation, one prototype collection box caught over 190 cubic feet of material per acre. In the next 16 months, when all 10 collectors were in use, the same box caught only 118 cubic feet of material per acre (Table 1). Thus of the total soil movement measured on this plot, 62 percent was measured before the other nine collectors were installed. If we apply these percentages to all collectors, less than 40 percent of the total soil movement occurring after burning was measured. Future studies of this sort, therefore, should be initiated as soon after burning as possible.

Table 2. Watershed area and estimated total surface soil moved in the experimental watershed by sampled class, July 1967 to September 1968.

Slope/Aspect/ Condition Class	Watershed Area (a)	Volume (cu ft)
80% south-bare	5.1	604
80% south-vegetated	9.4	1,494
80% north-bare	5.1	314
80% north-vegetated	9.4	184
60% south-bare	6.5	468
60% south-vegetated	58.3	41
60% north-bare	6.5	49
60% north-vegetated	58.3	187
80% talus	14.6	9,037
Total	173.2 ^a	12,378

^aAbout 27 percent or 64 acres of the watershed was not included in the sampled classes, being rock outcrop, undisturbed, or slopes less than 60 percent.

Whenever steep south slopes are logged, care should be taken to preserve as much vegetation as possible. On any steep, unstable area, other means of slash disposal, such as clean yarding or chipping and returning slash to the slope, should be considered as alternatives to broadcast burning.

REFERENCES CITED

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