REPORT OF THE SURVEY OF SEDIMENT BELOW STREAM GAGING SITES 1, 2 AND 3 IN THE H. J. ANDREWS EXPERIMENTAL FOREST WATER YEAR 1980

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SITE HISTORY

Experimental timber harvest on Watersheds 1, 2, and 3 was an early forest research project in the H. J. Andrews Experimental Forest after its establishment in 1952. Watershed 2 was designed as the undisturbed control. Road building was completed in Watershed 3 during 1959 and after 3 years of monitoring for road building influences on the watershed, logging took place in 1962 and 1963. Approximately 30% of the watershed is in clearcut and road. Extensive road repairs were made in the summer of 1968. Logging in Watershed 1 was accomplished without road building. Cutting continued from 1962-1966, when the entire watershed had been clearcut and slash burning had been completed. No other major management activities have occurred within the watersheds.
Large mass movements have been important in the production of bedload in the study watersheds. Swanson (unpublished data) has done a field reconnaissance study of mass movement features and the watershed project field crew have made observations that have generated a partial history of recent mass-movement events in the basins. Dyrness (1967 and unpublished data) and Fredriksen (1963, 1965) have also documented failures in the study watersheds (see fig. 1).

Roadfill failures have frequently delivered sediment to the stream channel in Watershed 3. Such a failure in WY 1962 (S29, fig. 1) entered the channel and eroded 3000 feet of tributary and mainstream. The debris torrent did not reach the gaging station or settling pond (Dyrness, 1967).

In December 1964, heavy rain and melting snow triggered three large (volumes over 500 yd^3) road fill failures (D39 A&B, D40) in Watershed 3. The resulting debris torrents buried the gaging station and sediment basin under tons of mud and debris. Mass movement resulting from road failures also occurred in Watershed 3 in WY 1968 and 1972 (S30, S101).

Storms of WY 1965 also triggered four substantial slides in Watershed 1 (D44, D45, D46, D47). In WY 1968 two large slides (S99, S100) related to earthflow activity began delivering sediment to the stream in Watershed 1. This area continues to be active. Heavy rainfall in 1972 triggered two slides (S97, S98) on the south slope, low in the watershed that continued to be a source of bedload material. Mass movement in Watershed 2 has been rare during the length of the study.

Figure 1 - Mass Movement Reference Map

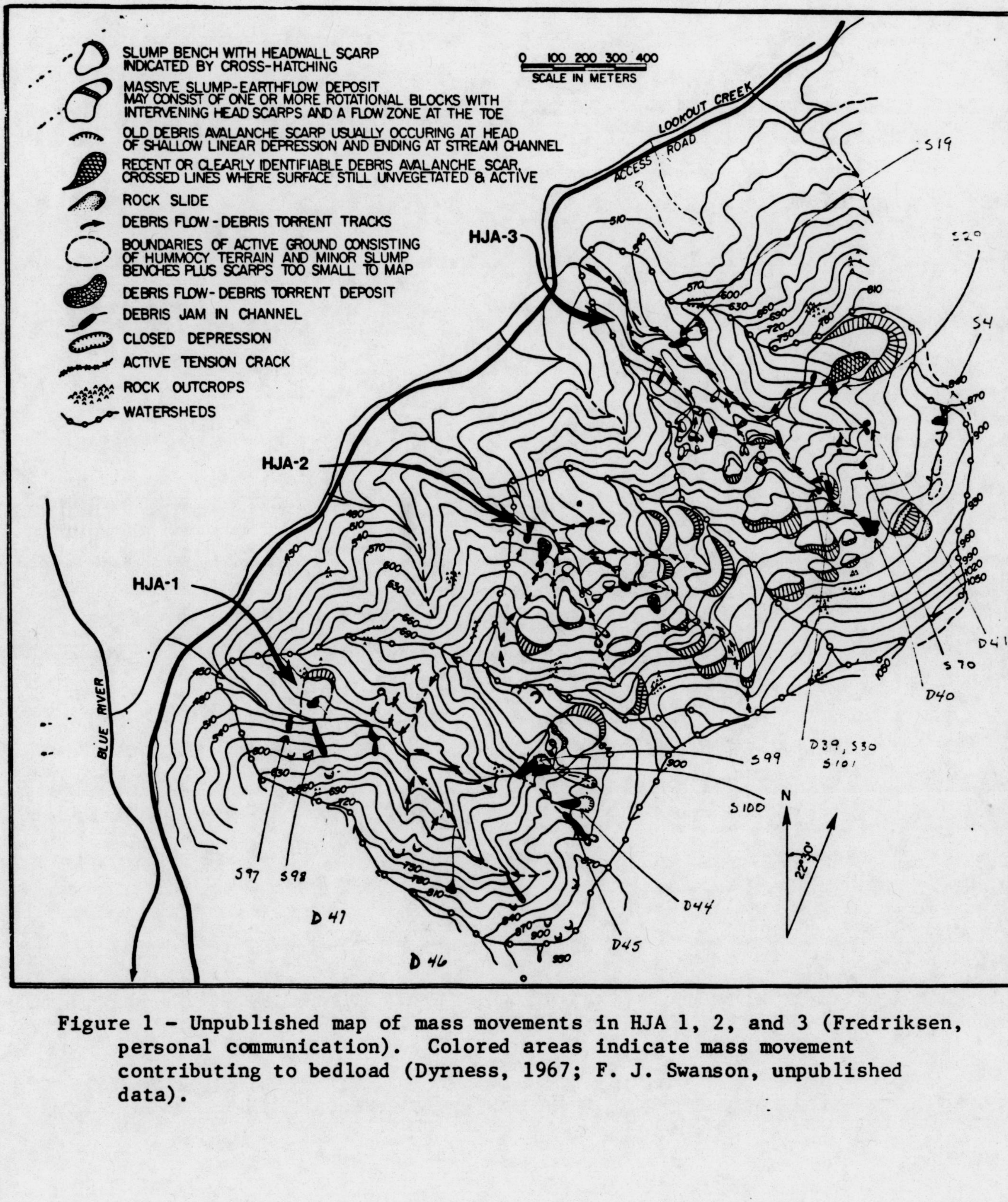

Figure 1 - Unpublished map of mass movements in HJA 1, 2, and 3 (Fredriksen, personal communication). Colored areas indicate mass movement contributing to bedload (Dyrness, 1967; F. J. Swanson, unpublished data).

MEASUREMENTS

Basin surveys have been designed to determine a change in average bottom elevation between annual surveys. Monumented cross sections are spaced at regular intervals along a primary control line, which runs the length of the basin dam. Survey points are spaced at intervals along the cross section lines, three-foot intervals at Watershed 1 and Watershed 2 and two-foot intervals at Watershed 3.

The survey is conducted using a level or a transit, a tape, and a leveling rod. The tape is run between cross section end posts and the rod is placed on the basin bottom at each of the prescribed survey points. At each point a level reading is made with the surveying instrument and recorded.

Permanent bench marks have been established near all three gage houses and in 1977 auxiliary bench marks (1/4 bolts set in concrete) were established near each catchment basin. These new bench marks replace nails or spikes driven into stumps or trees as reference points. annual checks, monitoring elevational distance between bench marks and reference points, showed unexpected changes. The reference point on the Watershed 3 dam was actually sinking, while at Watershed 1 and Watershed 2 stumps containing the reference spikes were deteriorating and reliable measurements became increasingly difficult. The elevational difference between auxiliary bench marks and permanent bench marks continues to be monitored.
As part of the sediment basin survey, a check on the auxiliary bench mark elevation is made at the end of alternate cross-section transects. This procedure reveals any change in the elevation or level of the surveying instrument.

When catchment basins near or reach capacity, they are emptied. Local contractors are employed and usually a front-end loader or clam-shovel is used to clean the basin. After emptying, the basin is resurveyed--this survey being used as the baseline for comparison.

Following debris torrents and subsequent burial of the gaging station and sediment basin at Watershed 3 (see 1965 report), the catchment basin was remodeled in December of 1965. Details can be found in the 1966 report. A new survey was made in that month, but further modification was done in April 1966, followed by a new base survey in August 1966.

In 1976, the channel between the flume and the sediment basin at Watershed 2 was excavated to reduce the entrainment of bedload material in this seciton. In order to detect any accumulation or degradation in the channel several survey lines were extended.

CALCULATIONS

The determination of sediment accumulation is based on the average change in bottom elevation between two annual surveys. This is accomplished by comparing the change for the same survey points between any two surveys. Originally all points between cross section end posts were included in the calculations, but in years of little or no bedload accumulation small errors began to compound and led to negative values for bedload accumulations. Errors in rod placement or instrument readings are difficult to quantify, however some potential errors can be eliminated. One such potential error is rod placement on steep slopes at the edges of the sediment basin. These slopes accumulate virtually no sediment and may provide some very misleading rod readings. The entire cross section line is surveyed to monitor bank slumping. However, during years of low sediment yield, in an attempt to hold errors to a minimum only points on the bottom are used in calculations--slope points are eliminated. When slope points have been eliminated, the area they represented is less than 10 percent of the sediment basin area.

The number of points included in any calculation is variable, depending on the amount of filling. The catchment basins often fill to, and sometimes beyond, capacity. When a basin is filled near capacity, points on the bottom may have been on a steep slope in a previous survey and are included in the calculations. Therefore, all points along the survey line must be recorded.
Rod measurements for survey points used are totaled and averaged; yielding an average rod reading. A line of sight is determined by adding the mean of the bench mark readings to the elevation of the auxiliary bench mark (designated as 100.000 meters) and adjusting further by any change in the elevational difference between the permanent bench mark and the auxiliary bench mark. The average rod reading subtracted from the line of sight provides an average bottom elevation. By subtracting the previous bottom elevation from the current value and multiplying by sediment basin area, the volume of sediment accumulation is determined. This volume divided by watershed area determines yield of bedload per unit area of watershed.

Example

$$\frac{\text{rod readings}}{\text{\# of points}} = \text{average rod reading}$$

Elevation of auxiliary bench mark + $\bar{X}$ bench mark reading +correction value = line of sight

Line of sight - average rod reading = average bottom elevation

Current average bottom elevation - previous bottom elevation = change in bottom elevation

Δ Bottom elevation x sediment basin area = accumulation

Accumulation - watershed area = accumulation/unit Watershed area

SEDIMENT BASIN SUMMARY - 1980

The 1979 bedload accumulation was cleaned from the WS#1 basin on August 1, 1979 and the resurvey was completed the same day. Neither WS#2 or WS#3 basins were cleaned. The bedload accumulation surveys were completed on July 21, 1980 at WS#1 and July 22,1980 at WS#2 and WS#3.

The 1980 sediment basin surveys marked the changeover to the metric system. Survey lines were still spaced in English units, but all rod readings were read and recorded in meters. In addition calculations were done in metric units. Accumulations are reported in cubic meters and production in cubic meters/ hectare. Auxillary benchmarks were assumed to be at 100.000 meters elevation.

Precipitation during the WY1980 storm season (October through April) was 90% of the long term average for the study watersheds and can be considered to be normal (see Table 1). Major storm activity, however, was limited to a single event on January 11 - 14, 1980.

Minor freshets on October 18, 1979 and December 3 and 4, 1979 carried small amounts of inorganic material and organic debris into all three catchment basins. Observers estimated these amounts to be less than one cubic meter.

Cool temperatures and increased precipitation in late December and early January set the stage for the storm event of January 11 - 14. Late in the afternoon of 1-11, approximately 20 cm. of snow was on the ground at all three watershed gaging stations. On the morning of 1-12 a strong southwest wind was noted as warm by field personnel and the snow depth had been reduced to about 8 cm. By 0945 on 1-13 snow had disappeared from the lower part of WS#1 and covered about ten percent of the lower areas of WS#2 and WS#3. The streams had peaked during the overnight period betrween 1-12 and 1-13. A second peak occurred near midnight on 1-13.

Bedload accumulation at the WS#1 catchment basin was estimated to be greater than 50 cubic meters. Estimates at WS#2 and WS#3 were not made, but fresh material was observed in each basin. No mass failures occurred in the study watersheds, indicating that bedload production was the result of channel and bank erosion. Observations made on 2-6-80 noted that a delta in the WS#2 basin had enlarged, but since no storm events had occurred subsequent to 1-14, that material was likely a result of the earlier storm.

DISCUSSION

Bedload production at WS#1 is down relative to recent years. This could be attributable to the recent declining trend of bedload production (see Fig. 2) as a result of riparian zone recovery. A well established grove of Alnus rubra has extended for nearly 200 meters upstream from the sediment basin. This riparian strip has probably stabilized a significant amount of channel and bank area, reducing erosion potential.

A second possibility for the decline in bedload production during WY1980 may be the lack of intense storm activity. The single storm event was not enough to initiate mass movement processes which provide soil and debris to the stream system. Increased major storm frequency may bring an new surge of bedload production.

Accumulation amounts at WS#2 and WS#3 reflect conditions present just upstream from the sediment basins. In WS#2 the sharp increase in bedload production is related to the deterioration of the organic debris that entered the channel above the gage house in 1974. This material had trapped considerable sediment and was probably responsible for reduced sediment production in recent years. As this organic material continues to decay, an increase in sediment production can be expected.

The depressed bedload production at WS#3 is directly related to a large boulder that entered the channel just above the flume in 1979. Sediment is accumulating behind this obstruction and will continue to do so until the stream routes around the boulder or moves it through the flume.

These shifts in recent sediment production trends point out a knotty problem in watershed studies generally, and sediment basins in particular. Changes in conditions near a measurement site may be seen to directly influence data collected. These changes are only very obvious examples of processes that are occurring throughout the watershed. Any temptation to remove obstructions or change any other natural modification anywhere in the study watershed merely to smooth out unruly data, should be avoided if the integrity of the study is to be maintained.

LITERATURE CITED

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Table 1 Storm Season (October through April) Precipitation

Water Year	PPT (mm)	PPT (in)	# Major* Storms	% of Storm Season $\overline{x}$
1974	2850	112.20	4	144
1975	2100	82.68	2	106
1976	2302	90.63	3	116
1977	860	33.86	0	43
1978	1996	78.58	3	101
1979	1588	62.52	2	80
1980	1776	69.94	1	90

Mean of storm season precipitation 1958-1979
$\overline{x}$ = 1998 mm
* = A storm during which the discharge at Watershed 2 exceeds 7.6 cfs

Table 2 Major storms for WY 1978 - WY 1980, peak flow

WY	Date	Watershed 1 (ft)	Watershed 1 (cfsm)	Watershed 2 (ft)	Watershed 2 (cfsm)	Watershed 3 (ft)	Watershed 3 (cfsm)
1978	11-25-77	1.239	103.22	.914	77.27	1.274	83.36
	12-13-77	1.239	103.22	.962	83.32	1.248	80.30
	12-14-77	1.103	81.68	.866	67.68	1.117	65.63
1979	12-4-78	1.089	79.61	.643	37.56	.85	40.28
	2-7-79	1.245	103.72	.780	55.04	1.125	66.49
1980	1-13-80	1.233	102.22	.844	70.49	1.074	61.11

Table 3 Sediment Accumulation WY 1980

Site	Year	Number of points	Line of sight (m)	Avg. Rod Reading (m)	Mean bottom elev.(m)	Δ bottom elev.(m)	Total accum (m^3)	Prod. (m^3 /ha)	Ratio
WS 1	1979	239	101.302	3.190	98.112				
	1980	239	101.188	2.681	98.507	.395	78.93	.823	5.43
WS 2	1979	254	101.790	2.570	99.221				
	1980	254	101.534	2.270	99.264	.043	9.13	.151	
WS 3	1979	221	100.183	2.795	97.388				
	1980	221	100.360	2.946	97.414	.026	2.15	.021	0.14

	WS#1	WS#2	WS#3
Watershed area (ha)	96	60	101
Sediment basin area (m^2)	198	175	83

Figure 2. Annual bedload production in sediment basins watersheds 1, 2, and 3, H. J. Andrews