REPORT OF THE SURVEY OF SEDIMENT BELOW STREAM GAGING SITES 1, 2, AND 3 IN THE H. J. ANDREWS EXPERIMENTAL FOREST WATER YEAR 1990

By
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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 designated as the undisturbed control. Road building was completed in Watershed 3 during 1959 and after 3 years of monitoring for road building effects on the watershed, logging took place in 1962 and 1963. Approximately 30% of the watershed has experienced clear cutting and road building. Logging in Watershed 1 was accomplished without road building. Cutting continued from 1962 through 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 inportant in the production of bedload in the study watersheds. Swanson (unpublished data) has done a field reconnaissance study of mass movement features in the study watersheds and the Watershed Project field crew have made observations that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 Dyrness (1967 and unpublished data) and Fredriksen (1963, 1965) have also documented failures in the study watersheds (Figure 1).

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

In December 1964, heavy rain and melting snow triggered three large (volumes larger than 500m^3) road-fill failures (D39a & b, D40 in Figure 1) in Watershed 3. The resulting debris torrents buried the gaging station and sediment basin under tons of mud and debris. Mass movement triggered by road failures also occurred in Watershed 3 in WY 1968 and WY 1972 (S30 and S101, respectively in Figure 1).

Storms of WY 1965 also triggered four substantial slides in Watershed 1 (D44, D45, D46, and 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 and S98) on the south side of the basin; low in the watershed. These areas continue to be a source of bedload material. Mass movement in Watershed 2 has been undetected during the length of the study.

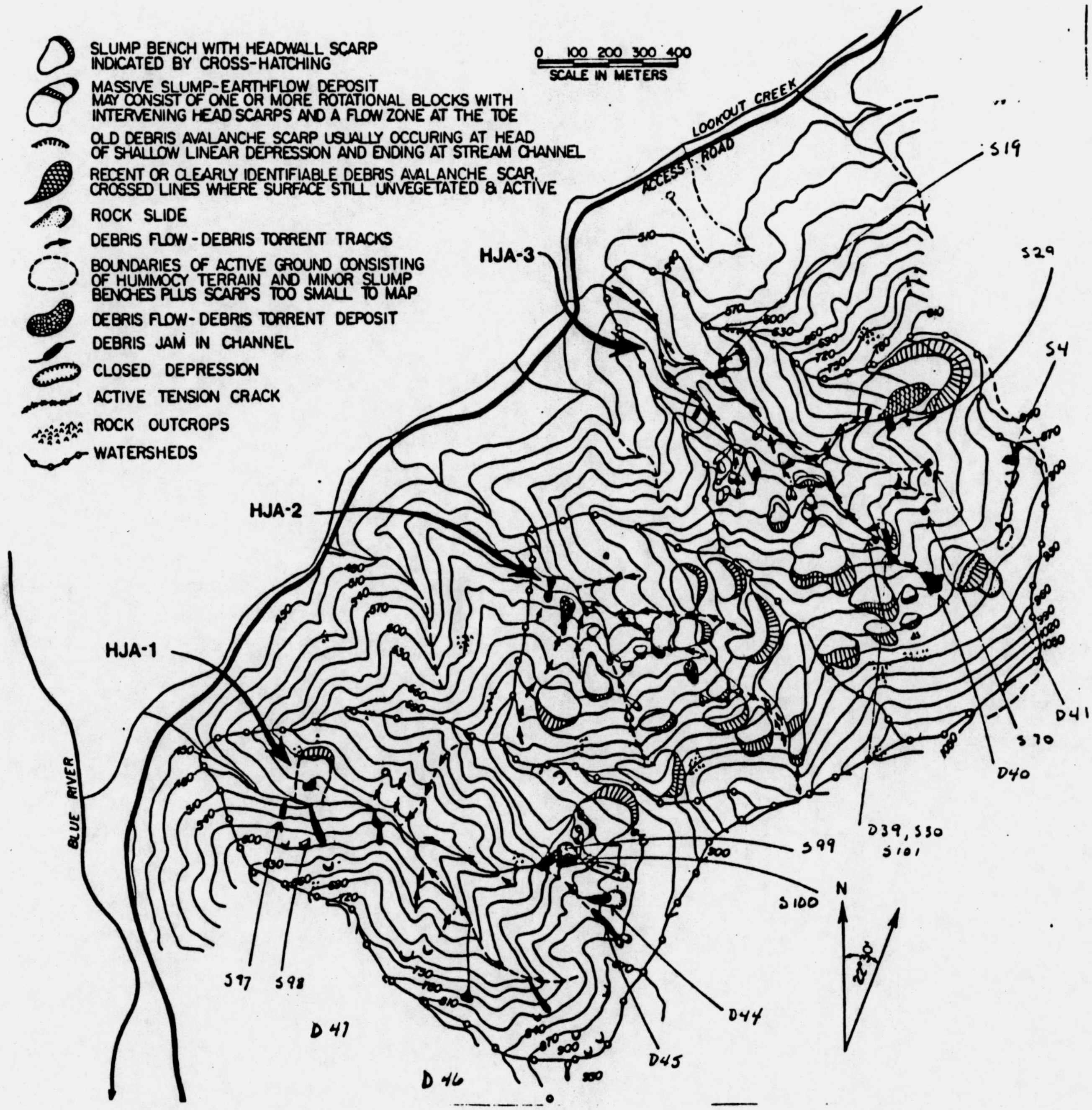

Figure 1 Unpublished map of mass movements in watersheds 1, 2, and 3 in the H.J. Andrews Experimental Forest (R.L. Fredriksen, personal communication). Shaded areas indicate mass movement contributing to bedload production (Dyrness, 1967; F.J. Swanson, unpublished data).

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 stretched 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 neat all three gage houses and in 1977 auxiliary bench marks (1/4" bolts set in concrete) were established near each of the catchment basins. These new bench marks replace nails or spikes driven into stumps or trees as reference points. Annual checks, which monitored the elevational difference 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 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 is used as a baseline for comparison to future surveys.

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 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 section. In order to detect any accumulation or erosion of material in the channel, several survey lines were extended. No distinction could be made, however, among sediment generated in this section, sediment trapped in the section or material that moved through the section. In August 1980 the Blue River YACC lined the channel with concrete. We now expect that all sediment accumulated in the sediment basin will have come from the watershed study area.

In an effort to reduce confusion over the timing and volume of material delivered to the Watershed 1 sediment basin during individual storms, a device for measuring the profile of the sediment pile was installed in September 1981. Pulleys were fixed to two trees growing in appropriate positions ate either end of the long axis of the sediment delta. A plastic-coated wire was run between the two pulleys - washline style. A hook was attached to the wire and a fabric measuring tape attached to a lead clock weight was strung through the hook. A nail driven into one of the trees was used as a measurement point. The wire was advanced at one meter intervals, where the weight was lowered to the surface of the water and the tape distance recorded. Then the weight was lowered to the bottom of the basin and a second tape distance was recorded. This procedure was repeated at each meter along the axis of the delta. A meter stick (partially submerged) attached to another basin-side tree served as a staff gage and was used to normalize differences in water surface level between surveys.

CALCULATIONS

Determination of sediment basin accumulation is based on the change in average bottom elevation by comparing the same survey points in two annual surveys. Initially 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 calculated decreases in bottom elevation. Errors in rod placement or instrument readings were hard to quantify, but some potential errors could be eliminated. Points on steep slopes of the sediment basins, which accumulate virtually no sediment, may have produced erroneous rod readings. The entire cross-section is surveyed to monitor bank slumping or high levels of basin filling, but slope points have been eliminated from the calculations. These points occupy less than ten percent of the basin area at all three watersheds.

The number of points included in any calculation is variable, depending on the amount of filling. When a basin is filled to near capacity, points on the bottom that may have been on a steep slope in a previous survey are included in the calculations. Therefore, all points along the cross-section line are recorded.

Rod measurements for survey points included in the calculations are totalled and averaged, yielding an <u>average rod reading</u>. A <u>line of sight</u> is determined by adding the mean of the bench mark readings to an arbitrary elevation of the auxiliary bench mark (100.00 meters) and further adjusting by any change in elevational difference between the permanent and auxiliary bench marks. The average rod reading subtracted from the line of sight provides an <u>average bottom elevation</u>. By subtracting the previous bottom elevation from the current value and multiplying by sediment basin area, the volume of accumulated sediment is determined. This volume divided by watershed area determines the yield of bedload per unit area of watershed.

Since a small difference in bottom elevation multiplied by sediment basin area results in a substantial value for accumulated material; and since adjustments for errors in rod readings and instrument level cannot be made, a difference in bottom elevation of plus or minus .01 meters is regarded as "no change".

EXAMPLE:

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                             ROD READINGS
AVERAGE ROD READING = ----------------
                             NO. OF POINTS
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LINE OF SIGHT = ELEV AUX BENCH MARK + MEAN BENCH MARK + CORRECTION VALUE

Δ BOTTOM ELEVATION = LINE OF SIGHT - AVERAGE ROD READING

ACCUMULATION = Δ BOTTOM ELEVATION * SEDIMENT BASIN AREA

ACCUMULATION/UNIT AREA = ACCUMULATION / WATERSHED AREA

SEDIMENT BASIN SUMMARY - WATER YEAR 1990

The sediment basin survey at WS#1 was done on August 21, 1990. Surveys at WS#2 and WS#3 were done on August 22, 1990. The basins at WS#1 and WS#3 were cleaned, and a resurvey was done at WS#1 on August 23, 1990. After cleaning at WS#3, a sidewall was built, and the basin was resurveyed on September 5, 1990.

Storm season precipitation was below normal (Table 1), continuing the trend of below normal precipitation (Figure 2). Two major storms were recorded on the H.J. Andrews (Table 2). Both storms occured during periods of intense precipitation preceded by several days of moderate precipitation. Observations indicate that snowmelt was not significant in either storm.

The first storm of the season occured on Jan. 7, 1990. The three day period before the storm recieved 89.41mm of precipitation. On Jan. 7, 1991, 91.69mm of precipitation fell. Stream flows before the storm were having small peaks in response to each moderate intensity storm. On Jan. 6, 1990 at about 2300hrs, streams began rising. A brief drop in stream flows occured about 0500hrs on Jan. 7, 1990, but by 0600hrs flows were rising again. The peak flows occured at about 2100hrs. The storm was accompanied by the strongest winds to occur since the Columbus Day storm of 1962. Each study watershed had a considerable amount of blowdown and wind damage.

The second storm of the year was much like the January storm except for the high winds. Like the first storm, the five day period before the storm recieved 102.87mm of precipitation produced by a series of low to moderate intensity storms. On April 27, 1990, 123.44mm of precipitation fell. Stream flows were having small peaks in response to the small storms proceeding the large event. On April 26, 1990 at about 2000hrs, stream flows began to rise rapidly, and continued to rise untill peak flows occured at about 2000hrs on April 27, 1990.

A small storm occured on Febuary 9, 1991. It occured after two days of moderate to high intensity precipitation which produced 87.12mm in the two days. Stream flows began to rise at about 0100hrs on Feb. 8, 1990, and increased steadily untill peak flows were reached at about 2300hrs on Feb. 9. Flows produced by this storm were below the level of a major storm (Table 2) and it is mentioned only because it did produce some bedload material in WS#1.

Storm bedload estimates at WS#1 indicate almost half of the beload material was deposited during the April storm (Figure 3). The January storm produced a slightly smaller deposit, and the small storm in Febuary produced 10% of the bedload at WS#1 in water year 1990.

Observations indicate that WS#2 and WS#3 had a similar pattern of bedload delivery, despite that the survey of WS#2 shows a loss in bedload material. The field crew reported the presence new beload material in both basins after the two major storm events. The field crew had estimated a new deposit of material at WS#2 of about 3 cubic yards after the January storm. They also reported that a large tree had fell across the flume at the basin entryway,and that another tree top had dropped into the basin at the delta area just below the flume. The trees were left in place untill the survey. At WS#3, the field crew noted that the channel between the flume and basin had changed after the January storm and there were signs of recent bank failures. No estimates for deposits at WS#3 after the January storm were reported.

The storm in April did not produce as much material from the watersheds as the January storm, but it did produce some interesting results. At WS#2, the tree in the flume dammed up the flow into the basin and flooded the low areas then flowed back into the basin near the spillway. This episode may account for the loss of bedload material measured during the survey.

At WS#3 the flow produced by the April storm washed out the soil slope of the basin, and blew out a portion of the damm near the road. The field crew reported no obvious losses or gains of bedload from this episode. To prevent any further washing, a sidewall was built at WS#3 after cleaning. The addition of the sidewall did not significantly change the effective collection area of the basin and the value of $71m^2$ will continue to be used in future bedload accumulation calculations at WS#3.

WS#1 was cleaned in the same manner as in water year 1989. Very little material was removed from the basin, and the heavier gravels were spread over the areas of fines and organic material. The field crew reported a noticable improvement is the firmness of the basin bottom after 1989, so this practice will continue for at least one more year.

DISCUSSION - SEDIMENT BASINS - WATER YEAR 1990

Long term precipitation patterns from the H.J. Andrews Climatic Station raingage show that the 1980's began with a period of increasing precipitation, and ended with a drying trend which started in 1984 (Figure 2). In 1988,1989, and 1990 precipitation was slightly less than the long term average.

Sediment production values from the study watersheds do not closely reflect precipitation trends (Figure 4). The number of storms and storm intensity appear to determine sediment production. Since no large mass movements were reported in the study watersheds during the report period, bedload production was derived from channel storage or from small bankside failures. Intense precipitatiion on saturated soils can trigger such small failures, and can produce stream discharge high enough to overturn the stream bed and redistribute sediments. This was the case for both major storm events that occured in 1990. It is possible that a portion of the bedload production resulted from the large amount of blowdown that occured during the high winds of the January storm, but no direct observations or measurements were reported.

The ratio of sediment production between the control watershed (WS#2), and the two logged watersheds (WS#1 and WS#3) has been in a downward trend since the second year after logging activities were completed (Figure 5). This suggests that disturbances within the watersheds may affect the quantity of bedload material produced by a watershed, but their influence declines as the watershed recovers from the disturbance.

In WY1990 the January storm produced the greatest amount of bedload discharge. This seems to be a common pattern of production in the study watersheds. It is thought that early storms flush out material that has accumulated in the active summer stream channel and the adjacent channel area. Later storms of near equal intensity tend to produce little new material unless they are of great enough intensity to overturn the steambed. Both cases of later storm bedload production occured in WY1990. The Febuary storm produced a very small portion of the annual bedload at WS#1 as would be expected with its relativly low discharge (Table 2). The April storm on the otherhand produced discharge levels similar to the January storm and only a little less bedload material. As mentioned before, the disturbances that resulted from the high winds of the January storm may have had a significant influence on bedload production during some or all the storm events.

Plans have been made to begin a manuscript addressing the sediment relationships in watersheds 1,2, and 3. The role of storm frequency, storm intensity, and melting snow in sediment production will be investigated further in this work.

LITERATURE CITED

Dyrness, C.T., Mass soil movements in the H.J. Andrews Experimental Forest. USDA Forest Service Research Paper PNW-42. Portland, Oregon; Pacific Northwest Forest and Range Experiment Station; 1967

Fredriksen, R.L., A case history of a mud and rock slide on an experimental watershed. USDA Forest Service Research Note PNW-1. Portland, Oregon; Pacific Northwest Forest and Range Experiment Station; 1965

Fredriksen, R.L., Christmas storm damage on the H.J. Andrews Experimental Forest. USDA Forest Service Research Note PNW-29. Portland, Oregon; Pacific Northwest Forest and Range Experiment Station; 1965

Table 1 Storm Season Precipitation (October - April)

WATER YEAR	PPT. (mm)	PPT. (in)	#MAJOR* STORMS	PERCENT STORM SEASON MEAN
1980	1775	69.94	1	91
1981	1741	68.59	3	89
1982	2473	97.42	7	128
1983	2244	88.41	4	114
1984	2223	87.59	2	113
1985	1785	70.31	0	91
1986	1941	76.49	2	99
1987	1510	59.50	2	77
1988	1612	63.53	2	82
1989	1975	77.83	2	101
1990	1634	64.33	2	84

Mean of storm season precipitation 1957 - 1990 = 1956 mm
* A storm during which peak discharge at WS#2 exceeds 7.6 cfs

Table 2 Major storms for Water Year 1990 , Peak Flow

WY	Date	Watershed 1 (ft)	Watershed 1 (cfsm)	Watershed 2 (ft)	Watershed 2 (cfsm)	Watershed 3 (ft)	Watershed 3 (cfsm)
1990	01-07-90	1.217	99.56	0.788	56.16	1.045	58.14
	02-09-90	0.782	40.85	0.492	24.03	0.654	24.79
	04-27-90	1.260	106.77	0.764	52.83	1.001	53.76

Table 3 Sediment Accumulation Water Year 1987 - 1990

Site	Survey Points	Mean Bottom Elevation (m)	Change Bottom Elevation (m)	Total Accumulation (m^3)	Sediment Production (m^3/ha)	Ratio
			WATER YEAR 1987			
WS-1	198	98.10				
	198	98.37	0.27	53.40	0.56	3.50
WS-2	172	98.11				
	172	98.17	0.06	9.77	0.16	
WS-3	233	97.41				
	233	97.47	0.06	5.18	0.05	0.31
			WATER YEAR 1988			
WS-1	184	97.86				
	184	98.01	0.15	29.02	0.30	
WS-2	172	98.17				
	172	98.16	-0.01*	0.00	0.00	
WS-3	162	97.12				
	162	97.11	-0.01*	0.00	0.00	
			WATER YEAR 1989			
WS-1	184	98.01				
	184	98.42	0.41	80.97	0.84	2.47
WS-2	172	98.16				
	172	98.26	0.12	20.37	0.34	
WS-3	162	97.11				
	162	97.40	0.29	24.10	0.24	0.71
			WATER YEAR 1990			
WS-1	190	98.22	0.17	34.08	0.36	0.00
	190	98.39				
WS-2	172	98.28	-0.02@	0.00	0.00	
	172	98.26				
WS-3	185	97.15	0.11	8.21	0.08	0.00
	185	97.26				

* - A value of ± .01m is below the resolution of the bed load survey. Values are included for purposes of comparison only. No sediment accumulation is reported for WS-2 and WS-3 during WY 1988.

@- The negitive value at WS#2 in 1990 was due to the introduction of a old growth tree near the basin entryway. The tree altered the flow into the basin and disturbed the material in the basin allowing easy transport. For purposes of comparison, no sediment accumulation will be reported at WS#2 for 1990.

	WS-1	WS-2	WS-3
Watershed area (ha)	96	60	101
Sediment basin area (m^2)	198	175	83 (1990 value = 71)

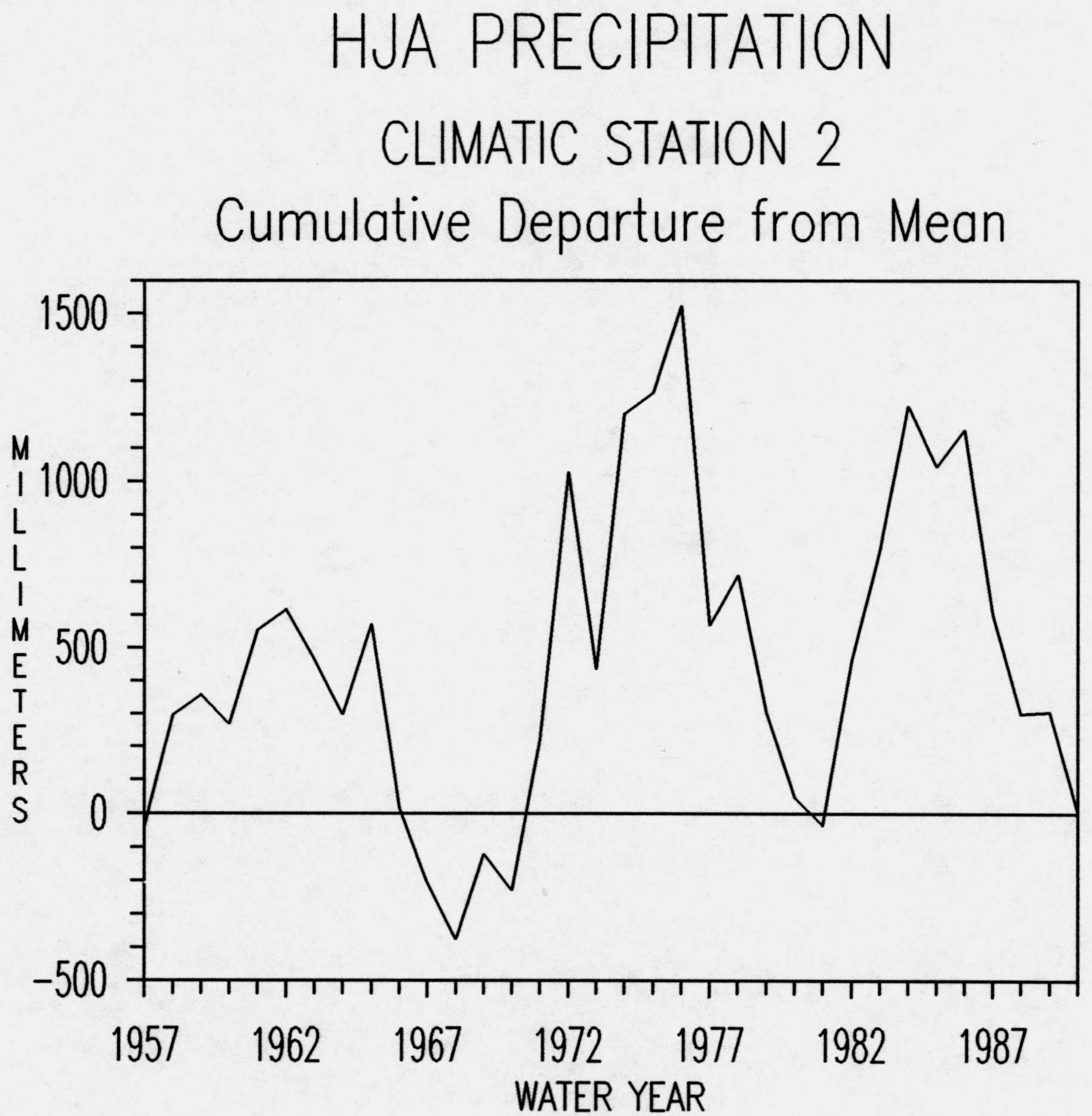

Figure 2) A drying trend beginning in 1984 continued through 1990.

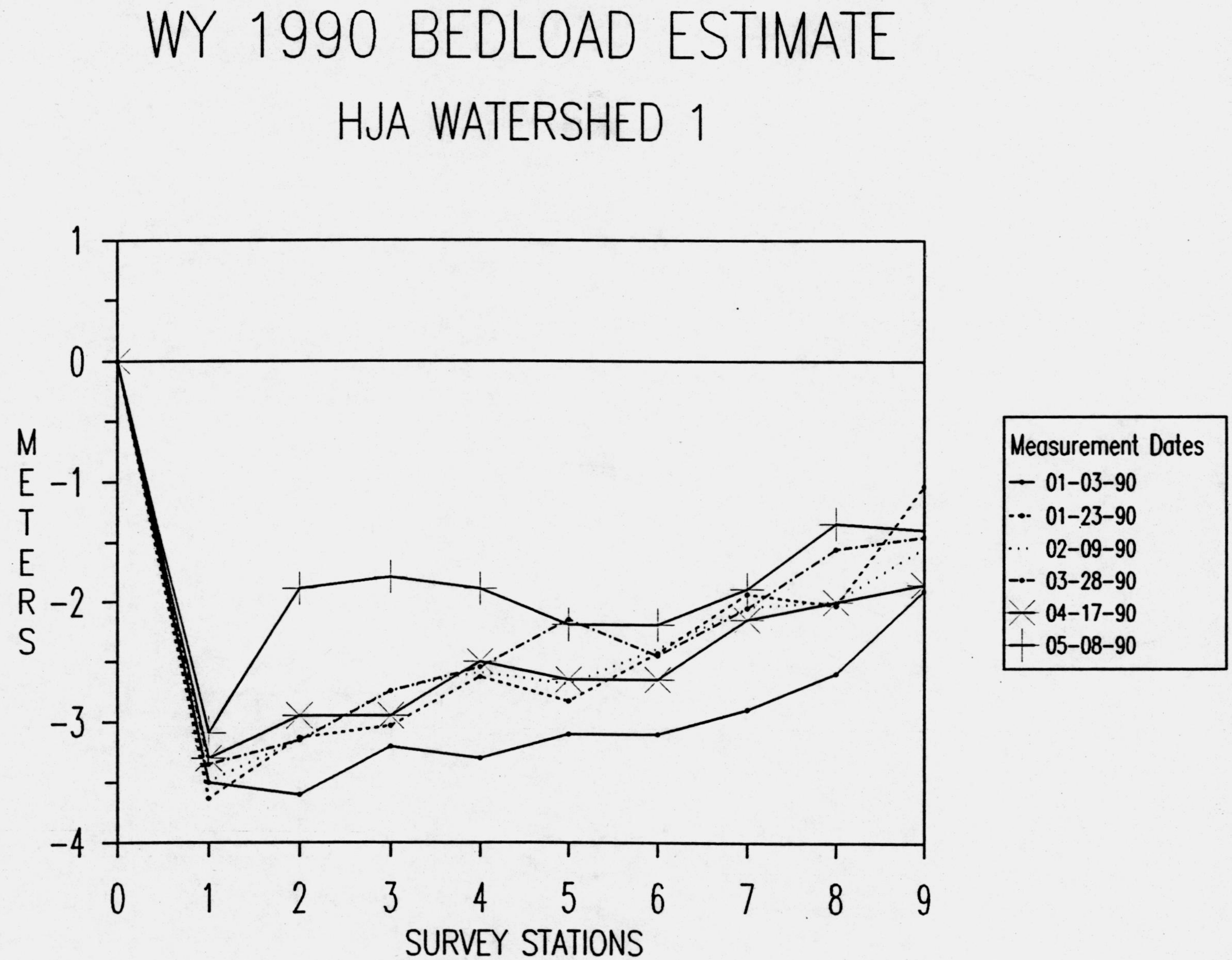

Figure 3) Similar amounts of bedload were delivered during the January and the unusual April storm. A small amount was deposited during the Febuary storm.

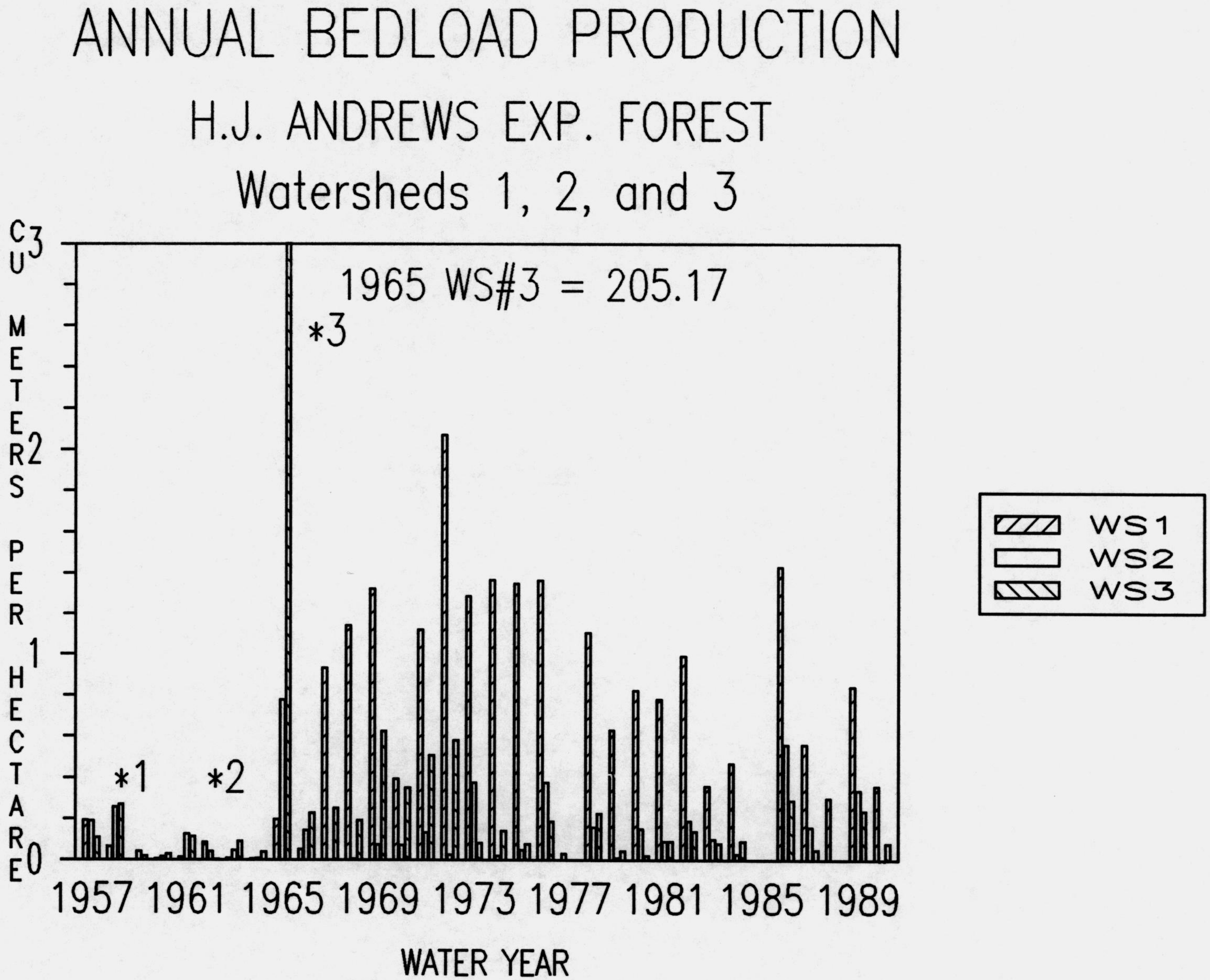

Figure 4) No trend is apparent in bedload production since the drought in 1977. *1 Road building completed in WS# 3. *2 Logging completed in WS# 3. *3 Logging and slash burning completed in WS# 1.

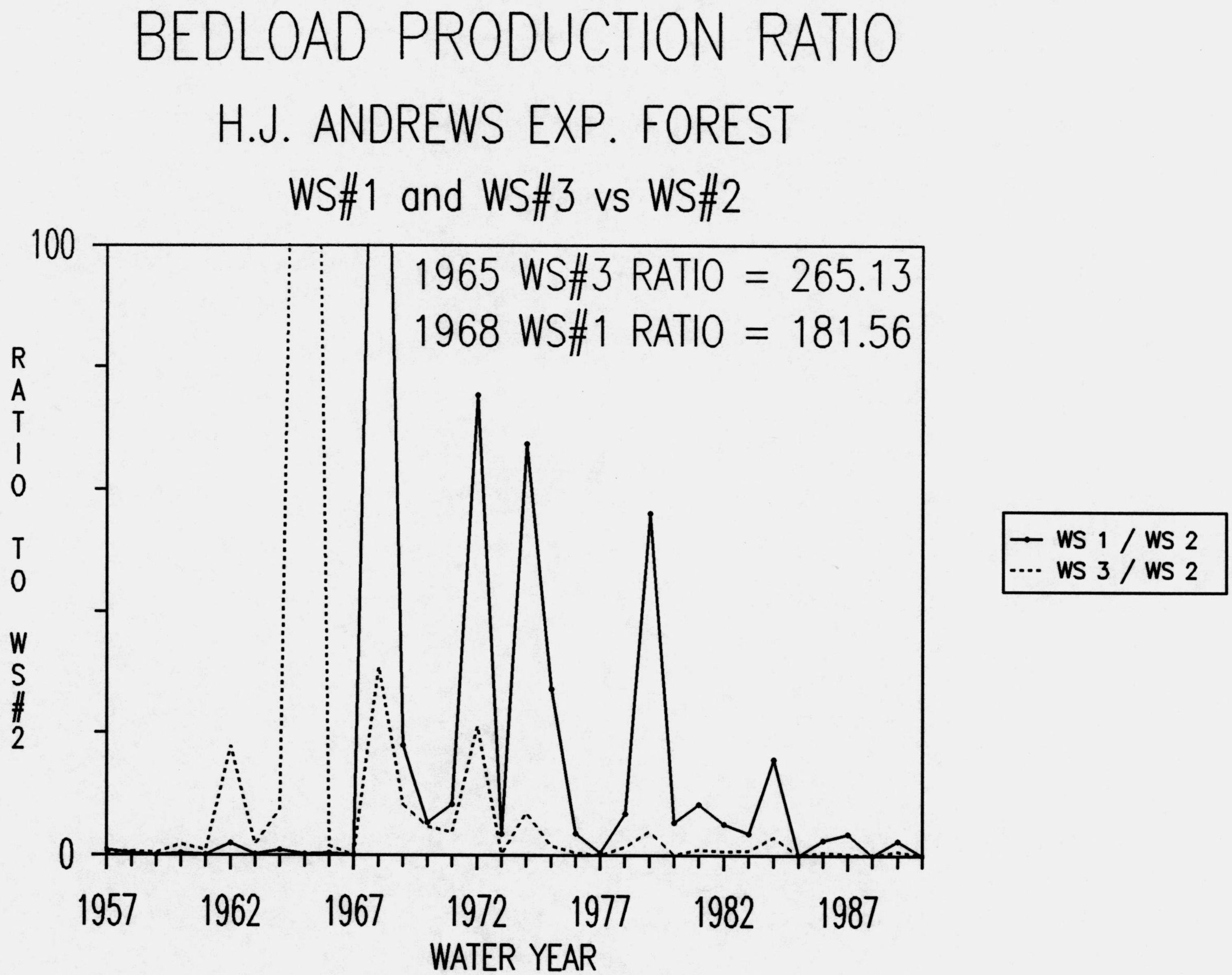

Figure 5) Bedload production ratios have declined since logging was completed at WS# 3 in 1963, and in 1967 at WS#1. WS#1 continues to produce the highest bedload ratio of the two wastersheds since 1965.