# REPORT OF THE SURVEY OF SEDIMENT BELOW STREAM GAGING SITES 1, 2, AND 3 IN THE H. J. ANDREWS EXPERIMENTAL FOREST WATER YEARS 1986 - 1989

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 Swanson (unpublished data) has done a field reconnaissance study of mass movement features in the study watersheds and the Watershed Project field crew have made observations that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 Dyrness (1967 and unpublished data) and Fredriksen (1963, 1965) have also documented failures in the study watersheds (Figure 1).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 $500 m^3$) 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.

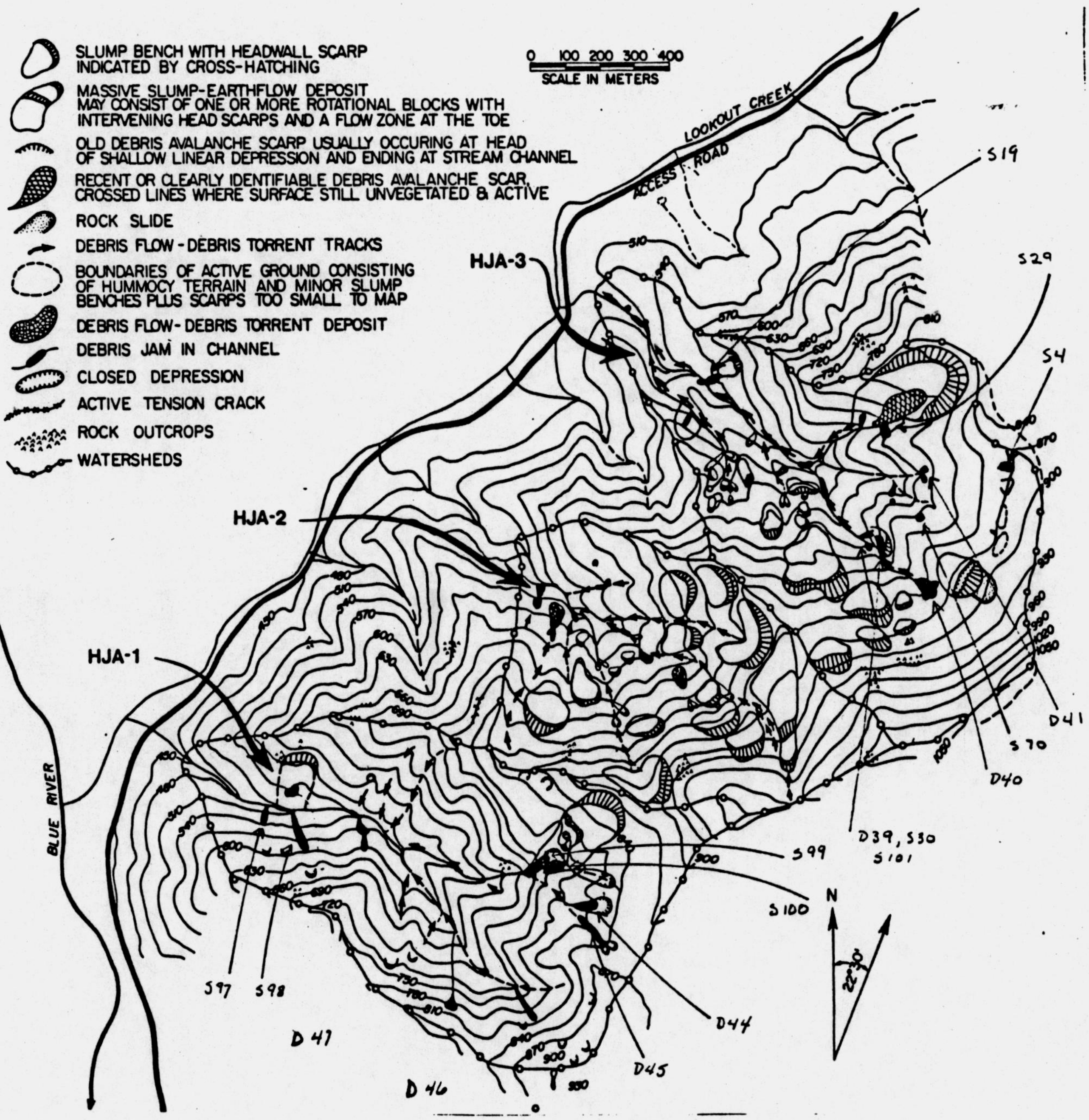


Figure 1 Unpublished map of mass movements in watersheds 1, 2, and 3 in the H.J. Andrews Experimental Forest (R.L. Fredriksen, personal communication). Shaded areas indicate mass movement contributing to bedload production (Dyrness, 1967; F.J. Swanson, unpublished data).

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 average rod reading. A line of sight 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 average bottom elevation. 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:

$$\text{AVERAGE ROD READING} = \frac{\text{ROD READINGS}}{\text{NO. OF POINTS}}$$

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 WY 1986

The sediment basin at WS#1 was surveyed on August 12 , 1986. The bedload accumulation was removed and the basin was resurveyed on August 14, 1986. The basin at WS#2 was surveyed on August 12, 1986. Bedload material was removed and the basin was resurveyed on August 14, 1986. The basin at WS#3 was surveyed on August 13, 1986. Bedload material was removed and the basin was resurveyed on August 15, 1986.

Storm season precipitation in the H.J. Andrews was slightly below the long-term average (Table 1). Two major storms occurred in the study watersheds during the month of Febuary (Table 2). Peak flows in each of the storms were preceded by moderate to intense rainfall for five days. Observations indicate that snow melt was not associated with either of the storms.

The first storm of the season lasted for seven days. Starting on Feb. 11, moderate intensity rainfall occured through Feb. 15. Heavy precipitation fell on Feb. 16 and 17 bringing the total precipitation to 198mm when the streams reached their peak flow.

The second storm closely followed the first. Heavy precipitation continued to fall on Feb. 18, then dropped to moderate levels on Feb. 19 and 20. Heavy precipitation returned on Feb. 21, and continued untill peak flows were reached on Feb. 22. Over the 48 hour period of Feb. 21 and Feb. 22, 174mm of precipitation had fallen. The storm triggered several debris torrents in the H.J.Andrews, one which destroyed the stream gage station at WS#10.

The Febuary storms produced 72% of the material measured in storm estimates at WS#1 (Figure 3). Small storms early in the year were responsible for the remainder of the material measured. Observations of WS#2 and WS#3 indicated a similar pattern of of bedload delivery to the sediment basins.

There were no reports of mass movement or failures within any of the study watersheds, but the field crew observed that after the Febuary storms there was evidence of major channel errosion at all watersheds, and the formation of new pools in the stream at WS#3.

# SEDIMENT BASIN SUMMARY WY 1987

Sediment basins at WS#1 and WS#3 were surveyed on August 25, 1987, and WS#2 was surveyed on August 26, 1987. Basins at WS#2 and WS#3 were not emptied in 1987, but WS#1 was emptied and resurveyed on August 27, 1987.

Storm season precipitation was well below the long-term average (Table 1), but two major storms occured during the water year. Peak flows in each storm were preceded by intense rainfall for two days. Observations indicate that snow melt was not associated with either storm.

The first storm of the season lasted several days. Streams began rising on Nov. 20 and continued a steady rise untill Nov. 21 at 0400 hr., when a secondary peak was attained. The drop in stream flow was brief and the streams began a steady rise untill peak flows were reached at about 0230hr. on Nov. 22. By the time peak flows were reached, 154mm of precipitation had fallen in this storm.

Observations indicate that freeze-thaw errosion activity was taking place on the watersheds prior to the start of the second storm. Heavy precipitation beginning on Nov. 26 brought stream flow up gradually. By the time the streams peaked at about 0600hrs on Nov.28, 128mm of precipitation had fallen in this storm.

More than 60% of the bedload material measured in storm estimates at WS#1 was deposited before Dec, 17, 1986 (Figure 4). Additional material was estimated or observed to have been deposited in the basin by Mar. 9, 1987.

Observations of basin accumulation at WS#2 and WS#3 indicate that the bulk of material deposited in the basins occurred during the storm of Nov. 28. A small amount of new material was noted at these two basins on Feb. 18, 1987.

There were no reports of mass movement or failures in WS#1 or WS#2. One small bank failure was reported at WS#3 between the gaging station and the sediment basin. Field crew observations indicate that heavy frost heaving took place on the watersheds throughout the storm season. It may be possible that the material reaching the basins in 1987 could have come from this source.

SEDIMENT BASIN SUMMARY WATER YEAR 1988

Sediment basins at WS#1 and WS#3 were surveyed on July 27, 1988. The basin at WS#2 was surveyed on July 28, 1988. Since so little bedload materal had accumulated in the basins, no material was removed.

Storm season precipitation in the H.J.Andrews was 18% below the long-term average (Table 1), continuing the recent trend of below average seasons (Figure 2). Two major storms were recorded in the H.J.Andrews (Table 2). Both storms were preceded by 4 or more days of light to moderate precipitation. The second storm of the season was associated with melting snow.

The first storm of the season was preceded by 8 days of light to moderate precipitation, but stream flow remained low untill about 0800hrs. on Dec. 8 when the stream flows began to rise gradually. Stream flows peaked near 0800hrs on Dec. 9 after heavy precipitation. For the 48hr. period of Dec. 8 thru Dec. 9 123mm of precipitation had fell.

Observations indicate that 3 to 4 inches of snow was present on the study watersheds prior to the start of the second storm. The storm was preceded by three days of light precipitation and one day of heavy precipitation the day before peaked flows were reached. Stream flows began to rise on Jan. 9, and continued to rise at a steady rate untill peak flows were reached on Jan. 10 at about 1000hrs. By the time peak flows were reached, 133mm of precipitation had fallen in this storm.

Measurements of bedload materials in WS#1 indicate that almost 60% of the material was deposited between Dec.29, 1987 and Jan.21, 1988 (Figure 5). Between Dec.8,1987 and Dec.29, 1987, 25% of the material was deposited. The remainder of the material accumulated was deposited between Mar.2, 1988 and Mar.23, 1988.

Sediment basin surveys indicate that virtually no bedload accumulation occured in the basins at WS#2 and WS#3 (Table 3). The field crew noted on Jan. 22, 1988 that new bedload material had been deposited in the basins. This would indicate that the timing of bedload production from these watersheds was similar to that of WS#1.

SEDIMENT BASIN SUMMARY - WATER YEAR 1989

Sediment basin surveys at WS#1 and WS#3 were conducted on August 8, 1989. The survey at WS#2 was done on August 9, 1989. The basins at WS#1 and WS#3 were cleaned, and a resurvey of the basin at WS#1 was done on August 10, 1989. After cleaning the basin at WS#3, the basin dam and sidewall were removed and a new dam was built. WS#3 was resurveyed on August 16, 1989.

Storm season precipitation on the H.J. Andrews was near normal (Table 1), ending the recent trend of below normal precipitation (Figure 2). Only two major storms were recorded on the H.J. Andrews (Table 2). One of the storms was associated with melting snow. Both storms were preceded by two days of intense precipitation.

The first storm of the season occured on Nov. 22, 1988. The period before the storm was one of near constant precipitation. Between Nov. 1 and the time of the storm, there was only one day precipitation did not occur. Stream flows before the storm were having small peaks in response to each moderate intensity storm. On Nov. 21 1988 at about 0300hrs, streams began rising at a fast rate. A secondary peak was reached at about 0500hrs on Nov. 22, then was followed by a brief drop in stream flow. After a very rapid rise in stream flows, the peak flows were reached at about 1300hrs on Nov. 22. In the 24 hour period of the storm, 131mm of precipitation had fallen.

Observations indicate that there was 2-3 inches of snow on the study watersheds prior to the second storm of the season. Like the fisrt storm, the second was preceded by a period of near constant, but light precipitation. Heavy precipitation beginning on Jan.8, 1989 brought stream flows up gradually. Even heavier precipitation on Jan. 9 triggered a very rapid rise in stream flows, and peak flows were reached at about 2100hrs on Jan.9, 1989. In the 24 hour period of the storm, 158mm of precipitation had fallen.

Storm bedload estimates at WS#1 were not begun untill Nov. 30 , 1988, so there was no estimate of the bedload production of the Nov. 22 storm. The field crew observations indicate that new material was deposited in the basin between Nov.9 and Nov. 30. The new material volume was estimated at .45$m^3$. All of the bedload material that was measured was deposited before Jan.11, 1989 (Figure 5). The field crew estimated this deposit at 8$m^3$. The crew also notes that major channel errosion had taken place during the same time period.

Observations indicate that WS#2 and WS#3 had a similar pattern of bedload delivery. Major channel errosion was also noted in these wastersheds on Jan.11. The field crew reported that a large tree had fell into the basin at WS#2 sometime between Dec. 20 and Jan. 11. The tree had gouged out one corner of the deposit in the basin. The crew felt that some organic debris and some bedload material may have been lost due to the gouging action of the treecoupled with a high flow of water through the basin. No estimate of the lost material was reported. There were no reports of mass movement or failures within the study watersheds during the water year.

Removal of the basin sidewall at WS#3 changed the effective collection area of the basin. Removal of the sidewall resulted in a reduction in the collection area due to the slumping of the bank behind the sidewall. Basin area was reduced from 83$m^3$ to 71$m^3$. These values include a portion of the streambed leading into the basin. Future measurements of this basin will use the new basin area in the calculation of bedload accumulation.

SEDIMENT BASIN SUMMARY - WY1989 CONTINUED

A different method of basin cleaning was done at WS#1. Only a small amount of material was actually removed from the basin. This material consisted mainly of fines and organic debris. The deposits of gravels and heavier material were then spread out over the areas where the fines and organic debris was removed. This method was done in a effort to make the bottom of the basin more firm. In recent years it has been difficult to clean this basin due to the soft bottom. The tractor used to clean the basin would become stuck in these soft areas, and would have to dig quiet deep into the basin before a firm bottom could be found. Over time the depth of the basin was at a point that the dam might be undermined. By filling in the soft areas, a better cleaning surface is made,and the risk of undermining the dam will be reduced. This method of cleaning will be continued when possible untill the bottom of the basin is firm.

DISCUSSION

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 1985 (Figure 2). In 1988 and 1989 precipitation leveled off near the long term average.

Sediment production values from the study watersheds do not closely reflect precipitation trends (Figure 7). 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 precipitation on saturated soils can trigger such small failures. A period of intense rainfall on saturated soils, or rainfall that melts an existing snow pack can produce stream discharge high enough to overturn the stream bed and redistribute sediments. Both of these precipitation phenomena occurred in the study watersheds.

In WY1986 two storms in Febuary produced the greatest amount of bedload discharge. The storm of Febuary 22, 1986 was of great enough intensity to trigger several debris avalaches on the H.J.Andrews Experimental Forest, and caused channel errosion within the study watersheds. Stream discharge levels produced by this storm were high in the storm history of these watersheds. Storms early in the season produced small amounts of bedload material as has been the pattern of sediment production during the Watershed Study.

In WY1987 early storms in November produced over half of the bedload production at WS#1. As mentioned before, 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 stream bed. Storms in Febuary produced the other portion of the bedload production at WS#1.

In WY1988 sediment basins at WS#2 and WS#3 recieved virtually no bedload material. Accumulations at WS#1 were measurable, but were historically low. Sediment production at WS#1 was related to the Two major storms that occurerd during the water year. The first storm in December produced 25% of the bedload. The second storm in January produced almost 60% of the bedload material. The second storm included a component of melting snow. This storm was of great enough intensity to overturn the stream bed at WS#1.

In WY1989 two early storms ( One in November and one in January.) were responible for all of the bedload production from the study watersheds. The storm on January 9, 1989 produced the greatest quantity of bedload material. This storm included a component of melting snow. The storm produced some of the highest peak flows of the report period(Table 2). Major channel errosion was reported in all the study watersheds after this storm. This pattern of bedload production was consistant during the report period and the history of the study.

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

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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 | 90 |
| 1981 | 1741 | 68.59 | 3 | 89 |
| 1982 | 2473 | 97.42 | 7 | 126 |
| 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 |

Mean of storm season precipitation 1957 - 1989 = 1965 mm
* A storm during which peak discharge at WS#2 exceeds 7.6 cfs

Table 2 Major storms for Water Year 1986 - 1989, peak flow

| | | Watershed 1 | | Watershed 2 | | Watershed 3 | |
|---|---|---|---|---|---|---|---|
| WY | Date | (ft) | (cfsm) | (ft) | (cfsm) | (ft) | (cfsm) |
| 1986 | 02-17-86 | 0.844 | 47.66 | 0.613 | 34.17 | 0.746 | 31.50 |
| | 02-22-86 | 1.416 | 135.05 | 1.096 | 107.84 | 1.367 | 94.76 |
| 1987 | 11-22-86 | 1.010 | 68.41 | 0.667 | 40.38 | 0.936 | 47.59 |
| | 11-28-86 | 0.827 | 45.75 | 0.651 | 38.49 | 0.844 | 39.42 |
| 1988 | 12-09-87 | 0.953 | 60.86 | 0.615 | 34.40 | 0.968 | 50.59 |
| | 01-10-88 | 1.110 | 82.73 | 0.757 | 51.87 | 0.954 | 49.27 |
| 1989 | 11-22-88 | 0.816 | 44.53 | 0.650 | 38.37 | 0.788 | 34.80 |
| | 01-09-89 | 1.510 | 153.70 | 1.023 | 94.09 | 1.394 | 98.19 |

Table 3 Sediment Accumulation Water Year 1986 - 1989

| Site | Survey Points | Mean Bottom Elevation (m) | Change Bottom Elevation (m) | Total Accumulation ($m^3$) | Sediment Production ($m^3$/ha) | Ratio |
|---|---|---|---|---|---|---|
| | | | WATER YEAR 1986 | | | |
| WS-1 | 205 | 97.98 | | | | |
| | 205 | 98.67 | 0.69 | 136.62 | 1.43 | 2.55 |
| WS-2 | 194 | 98.97 | | | | |
| | 194 | 99.16 | 0.19 | 33.90 | 0.56 | |
| WS-3 | 234 | 97.36 | | | | |
| | 234 | 97.71 | 0.35 | 29.13 | 0.29 | 0.52 |
| | | | 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 |

* - A value of $\pm$ .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.

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

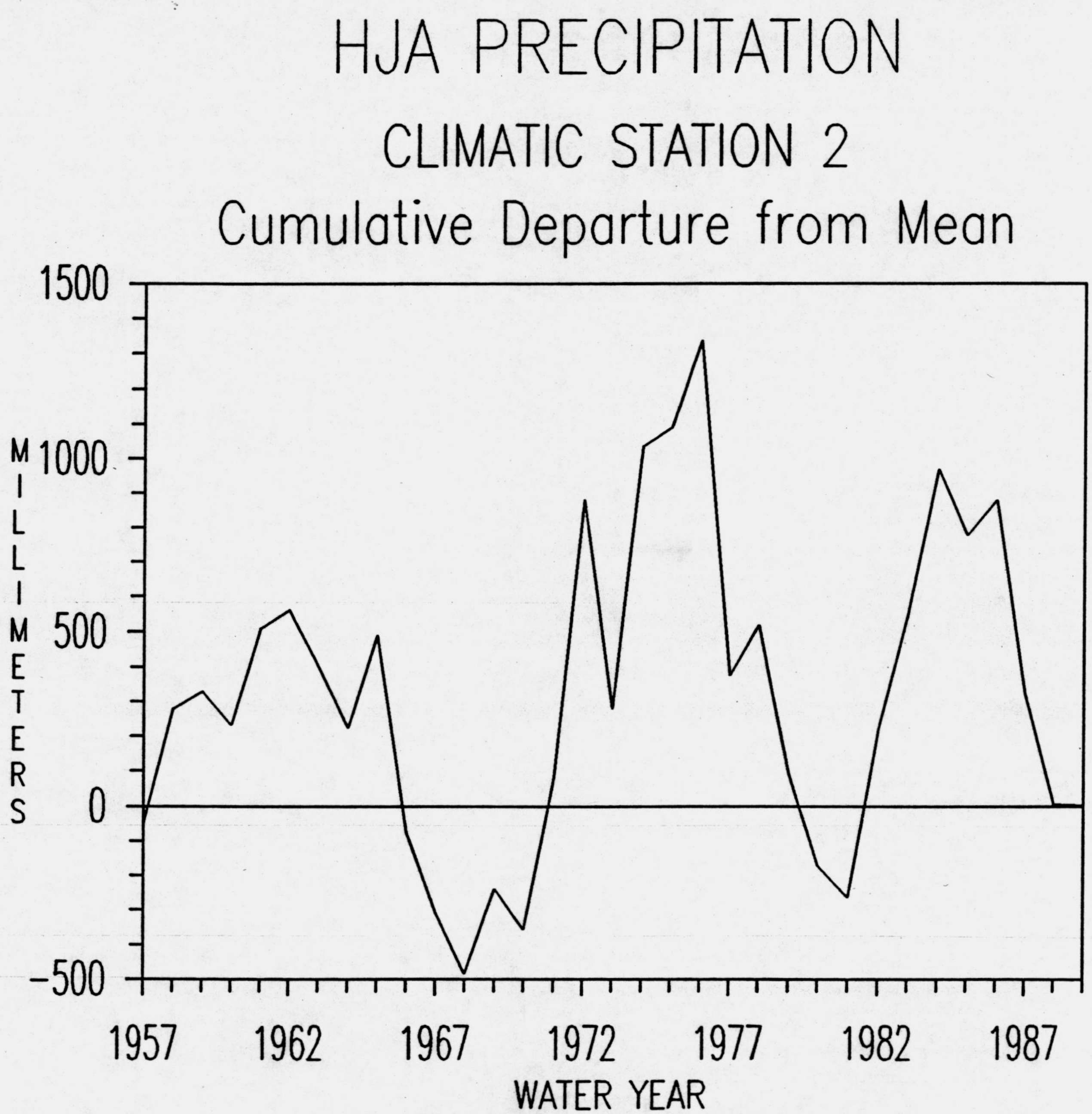


Figure 2) A drying trend beginning in 1984 continued through 1989. Precipitation for 1988 and 1989 was near the mean value.

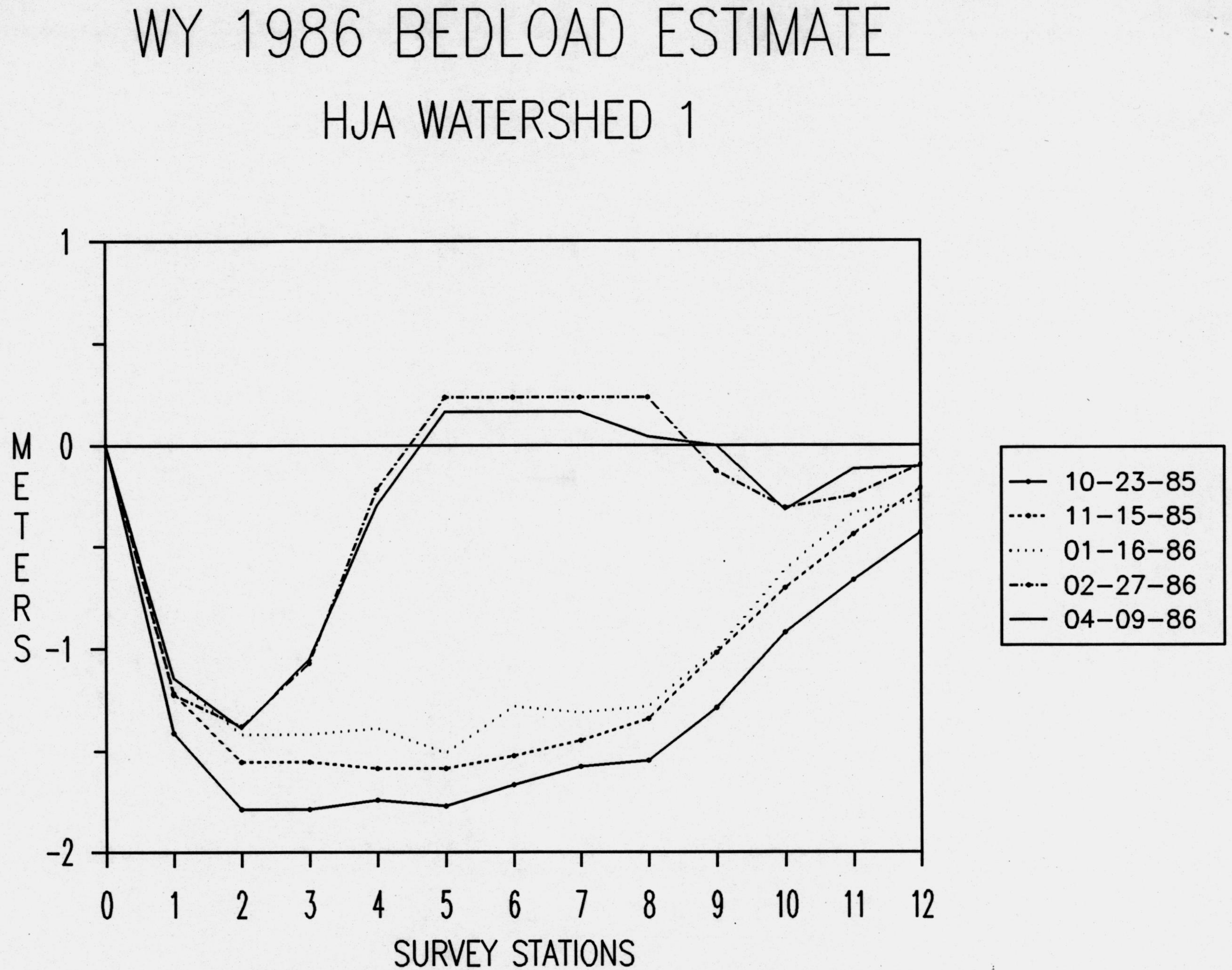


**Figure 3** Febuary storms produced the greatest volume of bedload in WY 1986.

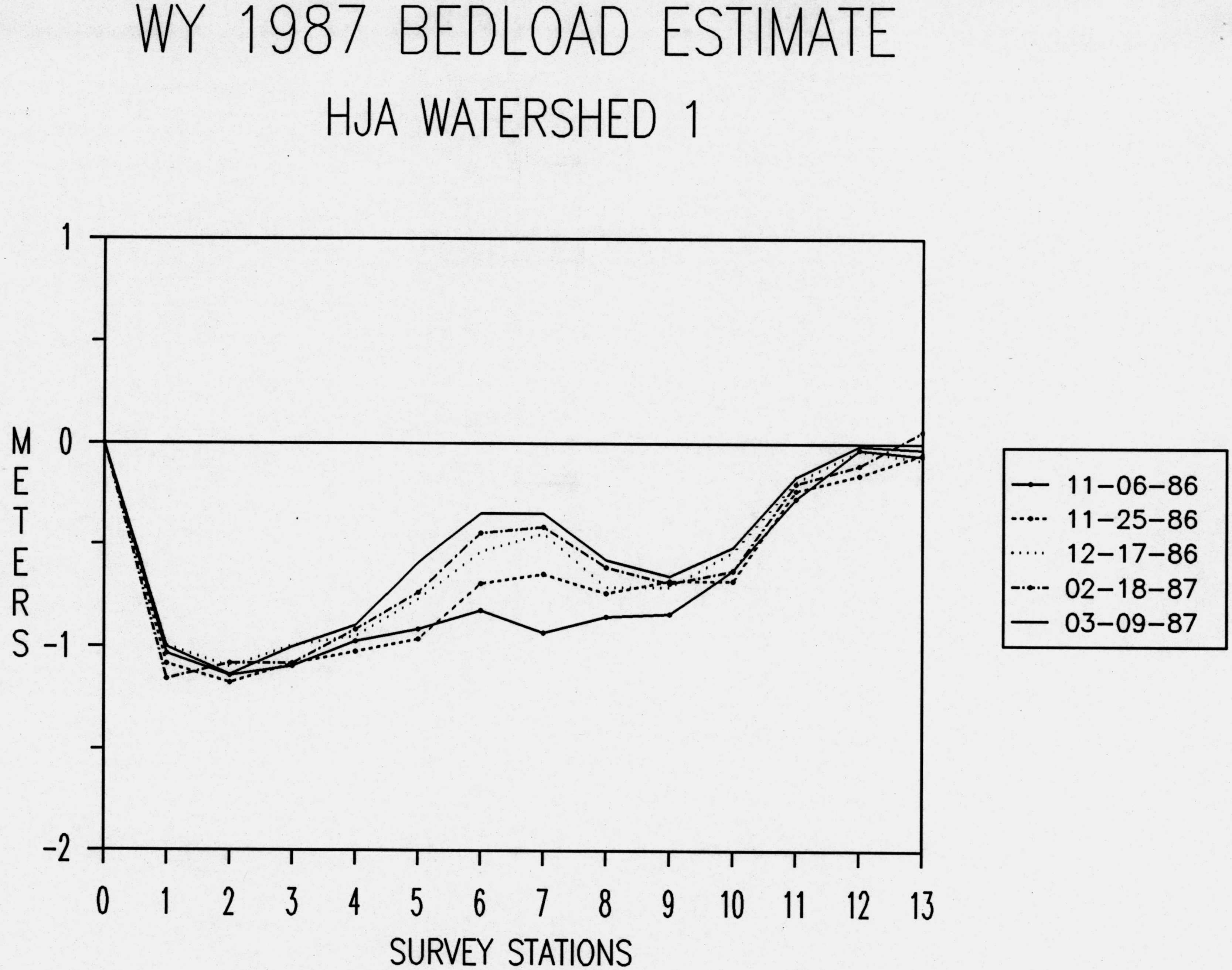


Figure 4 Early storms produced half of the bedload volume in WY 1987. Febuary storms produced the other half.

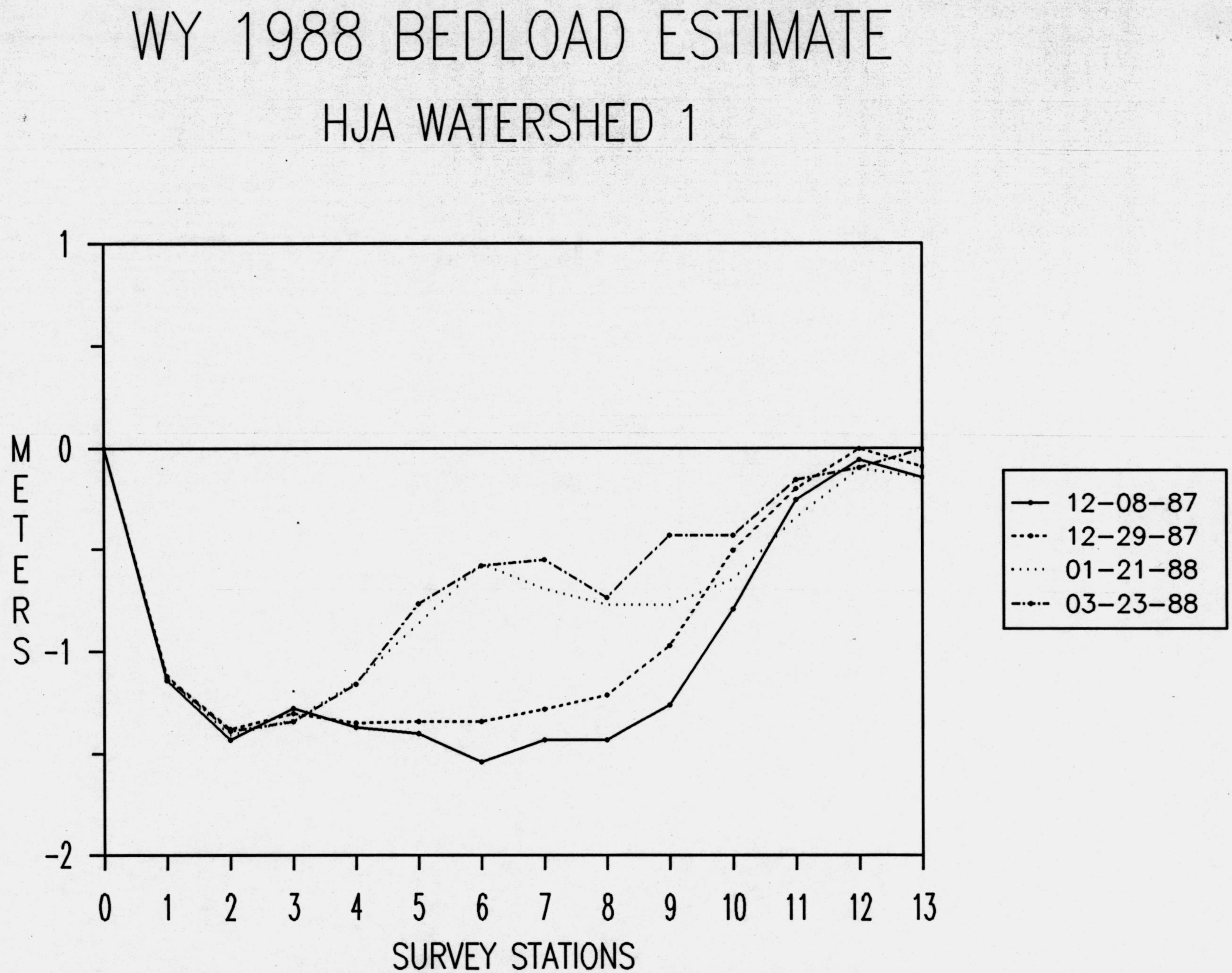


Figure 5 January storms produced the greatest volume of bedload in WY 1988. Storms in December and March produced similar small volumes of bedload.

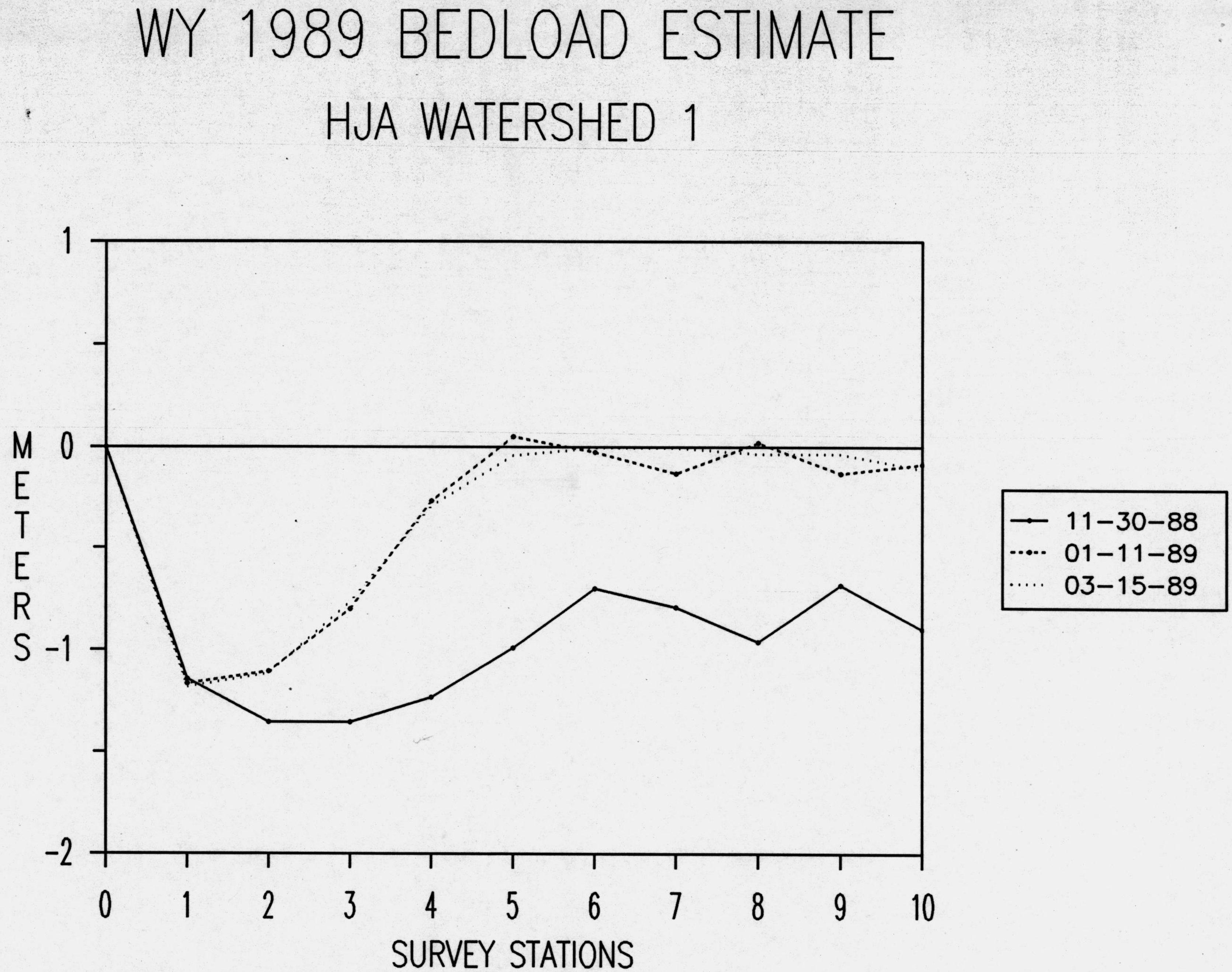


Figure 6 January storms produced all the estimated volume of bedload in WY 1989.

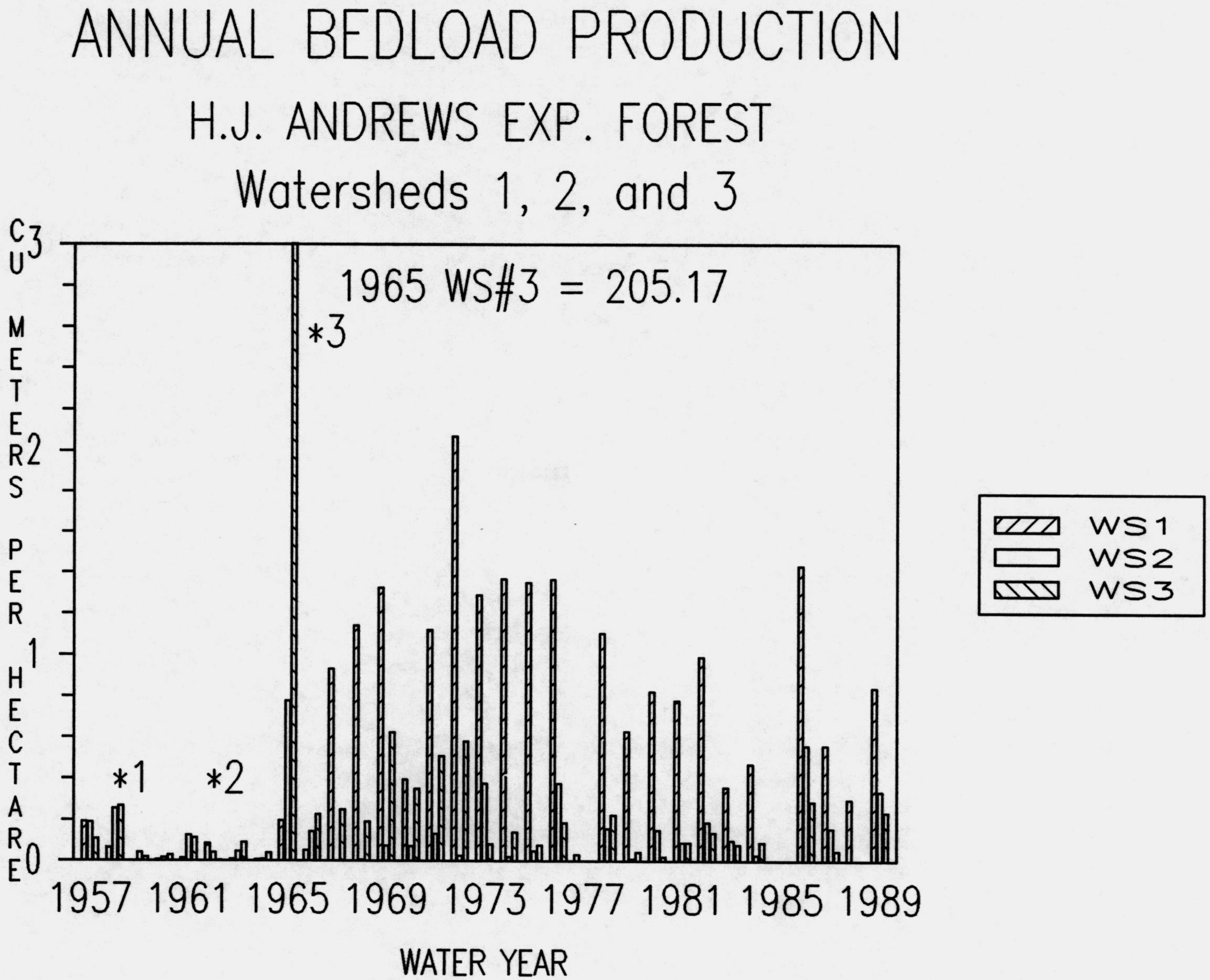


Figure 7) No trend is apparent in bedload production since the drought in 1977. *1 Road building completed in WS# 3. *2 Logging completed in WS# 3. *3 Logging and slash burning completed in WS# 1.

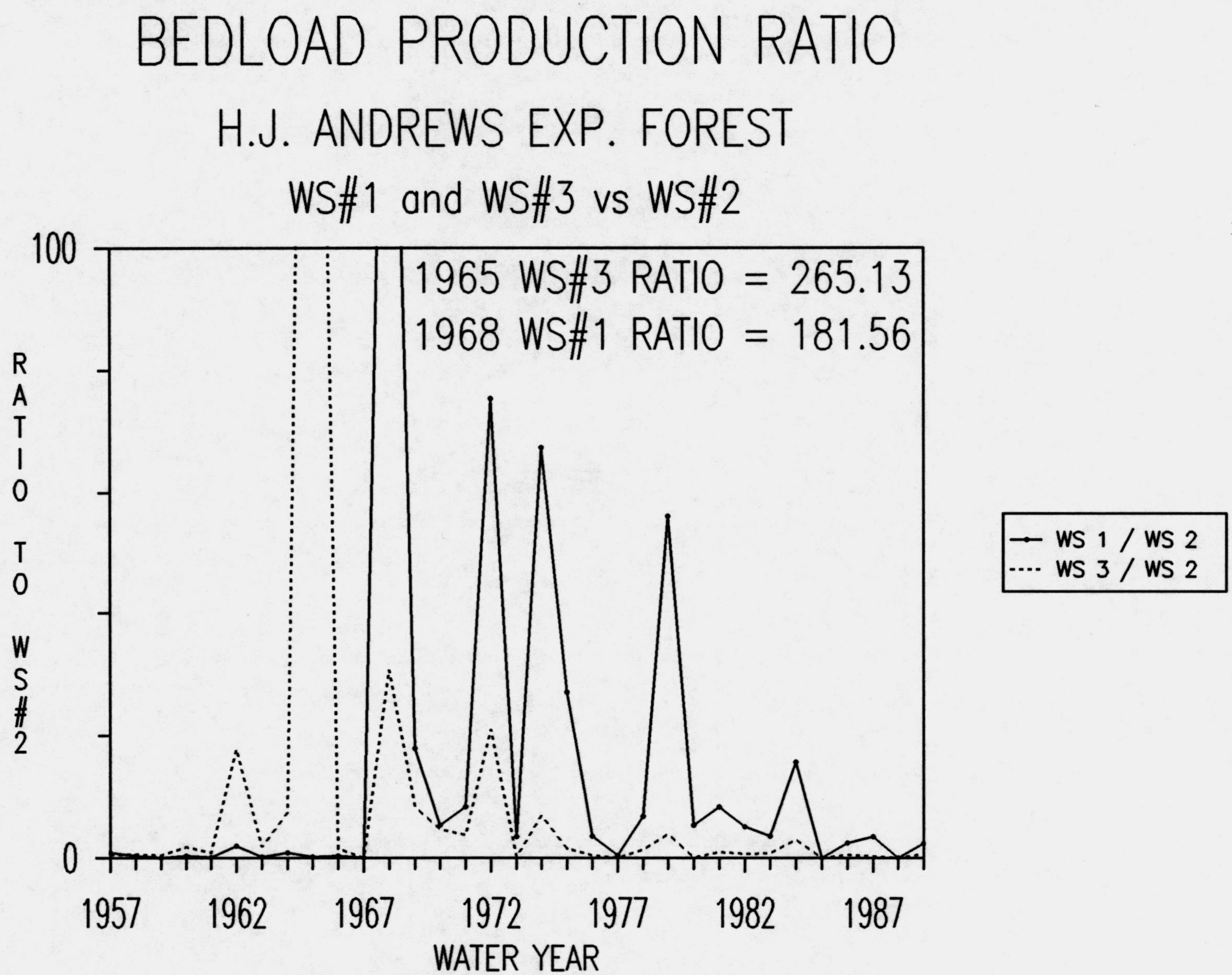


Figure 8) Bedload production ratios have declined since logging was completed at WS# 3 in 1963, and in 1967 at WS#1. WS#1 continues to produce the highest bedload ratio of the two wastersheds since 1965.