P-037

Bedload Yield in Forest Catchments with Different Histories of Mass Movement

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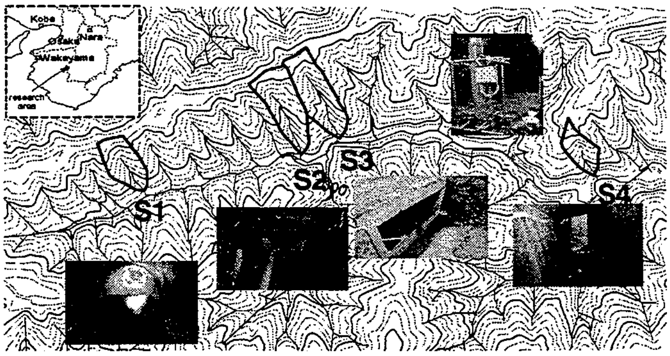
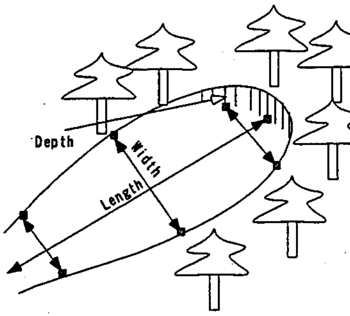
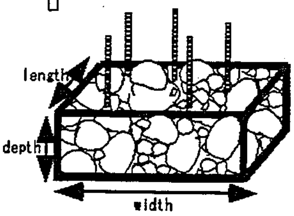
1 Introduction

Many bed load transport studies have been conducted in forest streams; however, most of these previous studies were performed in low gradient channels (gradients < 10%). In headwater streams, there are many of opportunities for sediment inputs from adjacent hillslopes. Major sediment sources are landslides and debris flows. Sediment supply and channel condition affect sediment storage in and near channels. Sediment storage in headwaters depend on (i) history of landslides and debris flows in the catchment; and (ii)connectivity of sediment between hillslopes and channels. Sediment storage in the channel may be the main factor determining bed load yield. The objectives of this study are to determine: (1) type, extent, and persistence of various sediment sources on the hillslope; (2) linkages amongst hillslope process, sediment storage in the channel, and characteristics of the channel; and (3) relationships between storm flow and bedload yield for different channel-hillslope sediment conditions and connectivities.





Mass movement



Channel deposits

2 Study site and methodology

The study site is located on Totsugawa village (34° 04′ N, 135° 04′ E) in southern Nara prefecture. Dominant vegetation is Japanese cedar and hionoki. Average temperature and precipitation at this site is 10-11℃ and 2400 mm, respectively; altitude ranges from 860m to 1370m. Four catchments (S1 – S4), with different geomorphic characteristics and histories of plantation and mass movements, were selected for this study. S1 recently experienced debris flow, most of which was flushed from the channel; S2 has old landslides, but much sediment remains in the channel; S3 recently experienced a debris flow, but much of the sediment remained in the channel; and S4 has evidence of some older mass dynamics appear not so active. (Table.1)

Channel topography, movement with small accumulations in the channel, contemporary sediment gradient, slope distance, and orientation were measured. Also, location of major sediment sources, such as landslides, deposition in channel, uprooted trees, and bank erosion, were mapped. We estimated the volume or area of sediment sources by simple dimensional analysis. Length, width and depth were measured to estimate the volume of landslides, channel deposits, and uprooted trees (1). Length and exposed bank height are measured to estimate the area of active bank erosion (2).

$$\text{Volume } (m^3) = \text{Length} * \text{Width}_{avge} * \text{Depth}_{avge} \quad \cdots(1) \qquad \text{avge: average}$$

$$\text{Area } (m^2) = \text{Length} * \text{Height}_{avge} \quad \cdots(2)$$

Water discharge is monitored every 5 minutes at rectangular or V-notch weirs at the catchment outlets. Bed load sediment behind the weir was sampled after every major storm after substantial accumulation. Precipitation and temperature are continuously monitored. Both wet and dry weights of bedload sediment samples were measured. After drying (24 hours at 100℃), samples are sieved into 1mm, 2mm, 4mm, 8mm, 16mm, 31.5mm, 63mm size fractions. This spring, an automatic water sampler will be installed to measure suspended sediment (> 1mm)

	Time since Plantation, yr	Drainage Area, ha	Stream length, m	Mean gradient, %	Landslides and debris flows *1	Volume of mass movement, m3	Channel deposits, m3	Bank erosion, m2	Uprooted tree, m^3 *2	
									near	far
No 5	30	4.64	245.38	0.57	2004(1)/1989 (1)	532.37	12.43	767.55	0	(0)
No 11	27	6.35	289.73	0.44	1989(8)/1964(2)/unknown(2)	790.49	244.96	119.02	1.01 (2)	(1)
No 12	15	6.08	472.59	0.46	1964((2), 2004(1))/unknown(2)	162.32	183.03	921.52	2.80 (1)	(0)
No 17	89	3.84	200.11	0.59	unknown(2), but very old	129.48	79.14	0	22.95 (5)	(38)

(Table. 1) *1: (number of landslide) *2: (number of fallen tree) include root volume

Term 1: 7 Oct – 29 Oct. 2004. Total precipitation during this term = 319mm

Term 2: S3 & S4: 30 Oct. – 19 Dec. 2004; S1 & S2: 4 Dec. – 19 Dec. 2004.

Total precipitation during this term= 405mm

and peak discharge

Term 3: 20 Dec. 2004. – 12 Mar. 2005.

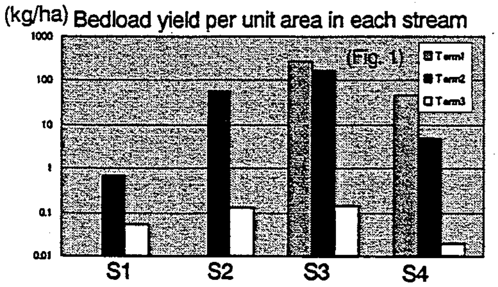
Total precipitation during this term = 220mm

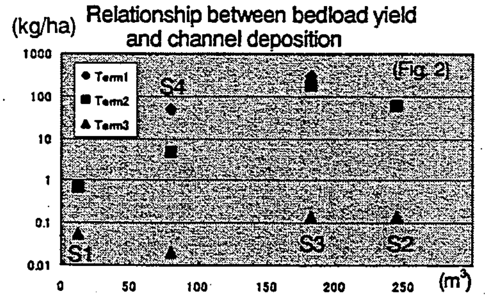
4 Result and Discussions

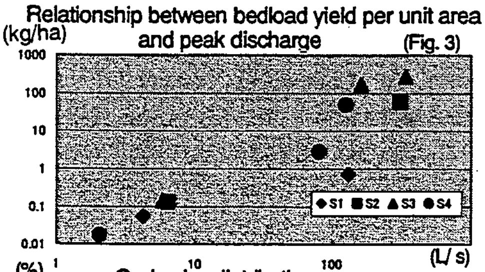
Bedload yield per unit contributing area in each stream and the relationship between bedload yield and channel deposition indicated that S3 produced the most bedload sediment, followed by S2, S4, and S1 up through Term 2; for Term 3, S3 also produced the most sediment followed by S2, S1, and S4 (Figs. 1 & 2). Bedload yield per unit area was highly correlated with peak discharge of the largest storm during a given term (Qmax) (Fig. 3). Terms 1 and 2 experienced large rain events, thus inducing high rates of bedload transport.

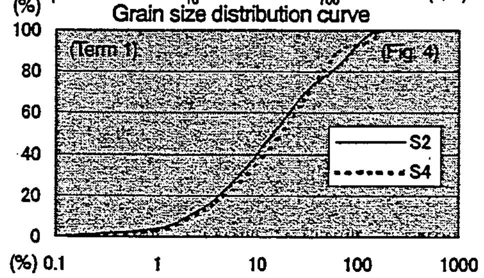
The ratio of bedload yield per unit area to channel deposits in S2 is similar or less than that of S3, while volume of channel deposits in S2 is greater than in S3. The largest landslide in S2 is relatively old (before 1989). Therefore, some of the earlier channel deposits in S2 may been transported and the system may now be approaching equilibrium.

In S4, proportionally more bedload is transported in large storms than during periods with relatively small storms, compared to other streams. S4 is has old landslides in the upper catchment and distributed channel deposits (some stored behind wood debris). Channel deposits in S4 seem to be stable, but once stream power exceeds some threshold, channel deposits in S4 may be released and move to downstream as a 'domino' effect (e.g., possibly released from behind woody debris). The grain size distribution curve of S2 was similar to S3. Sediments in these two streams are poorly graded (Figs. 4 – 6). Grain size distribution of S1 and S4 sediment is characterized by higher amounts of relatively coarse materials. For the three sample periods, d_{50} was larger in Terms 1 and 2 compared to Term 3. Transported sediment size appears to relate to channel gradient and water discharge, because channel gradient affects shear stress. Furthermore, S1 is characterized by less finer material than S4. Because mean gradient of S4 is steeper than that of S1, there seems to be another factor accounting for this grain size distribution. S1 experienced a debris flow last year but sediment in the channel was mostly flushed out. S4 contains old landslides and many uprooted trees which fell into the channel area, trapping some of the sediment. Such roughness elements may control sediment transport and thus influence bedload yield.


(kg/ha) Bedload yield per unit area in each stream


(kg/ha) Relationship between bedload yield and channel deposition


Relationship between bedload yield per unit area and peak discharge


Grain size distribution curve