Suspended sediment transport and radionuclides deposition in mountainous catchments with forest management operations

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1. INTRODUCTION

Suspended sediment (SS) transports in headwater catchments can be accelerated due to soil disturbance by the forest management. For understanding the effects of forest management on SS yields, both types and locations of SS sources should be determined (Eisenbies et al., 2007). Concentration of SS with respect to catchment runoff (e.g., hysteresis pattern) is often used for indentifying potential sources along and near the channels (Smith and Deagovich, 2009). Fingerprinting approaches using activities of fallout radionuclides tracers can also be useful for examining the specific sources within a watershed (He and Walling, 2003). Combination of both analysis of SS responses and fingerprinting will provide clear insight into how forest management changes in sources and flow pathways of SS. Therefore, the objectives of this study are (1) examining runoff responses and changes in SS concentration due to forest thinning, and (2) identifying the sources of SS using radionuclides tracers which was provided the accidents of radionuclides power plant.

2. STUDY SITE AND METHOD

This study is conducted in two headwater catchments (K2-18.1 ha, K3-15.8 ha) covered by 40-50 yrs Japanese cypress and cedar plantations at Karasawayama in Tochigi prefecture (E 36.36 N 139.60). Mean annual precipitation and temperature are 1239 mm and 13.9 °. The altitude ranges from 90 to 290 m. Mean hillslope gradient is 35° (Fig. 1). The K2 was 50% thinning by strip cutting from June to October, 2011. For the removal of commercial timbers, new skid trails were also installed on the hillslopes of K2.

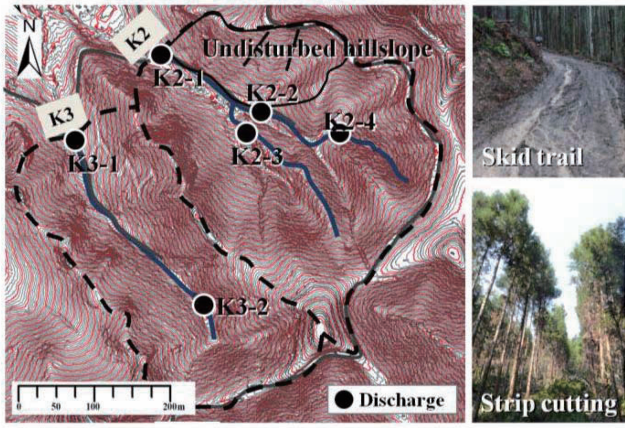

Fig. 1 Location of Karasawayama

We measured discharge using Parshall flumes and water depth probes at gauging stations K2-1 and K3-1 from April, 2010. Nested gauging station was also located within K2 and K3. At the gauging stations of K2-1 and K3-1, we also measured turbidity. For each gauging station, integrated SS samplers were installed for collecting the fine sediment yield during the specific periods. During heavy storm events due to typhoons, water samples were collected using SIGMA automated water samplers. SS concentration in water samples was determined by filtering methods.

For examining specific sources of sediment, we analyzed radionuclides activities in various samples. Soil samples were collected different depths from the surface litter layer to the maximum depth of 30 cm (sampled at 0-2, -5, -10 and -30 increment) using a scraper plate (450 cm^2) on undisturbed hillslope in the K2. The activities of the radionuclides contained in the samples were determined directly by a gamma spectrometry using an n-type coaxial highpurity Ge detector (EGC30-200-R; Eurisys Measures).

3. RESULTS AND DISCUSSDION

Runoff response tended to be delayed to peak precipitation for the most of storm events. During the storm events, we collected water samples from the beginning to the end of storm event on 1-2 September, 2011 (Fig. 2). Both peak responses of turbidity and SS concentrations were occurred at the peak of precipitation (prior to discharge peak). Similar patterns were also observed for the other storm events. Because response of SS concentration estimated by water samples and turbidity were synchronized, we assumed that estimated SS concentration using turbidity can be applied for examining actual SS yields in the catchments.

We compared the SS concentration pre- and during-thinning operations. We selected similar sizes of storm event which occurred the specific periods (Fig.3). During the pre-thinning period, hysteresis pattern was clockwise shapes. This shape indicated that potential sources of SS was located within and/or adjacent to the stream channel (Smith and Dragovich, 2009). In contrast, during-thinning period, the anti-clockwise hysteresis loop occurred. This pattern suggested that potential sources of SS can be expanded around the catchments (e.g., hillslope and/or skid trail) (Klein and Haifa, 1984). Estimated SS yields duing the event was 0.7 kg in the pre-thinning periods and 1.2 kg in the during-thinning periods. In the K2-1, estimated SS tented to be higer in the during-thinning than in the pre-thinning at the other event. Based on the field observation, we found that significant soil erosion occurred on skid trail during thinning.

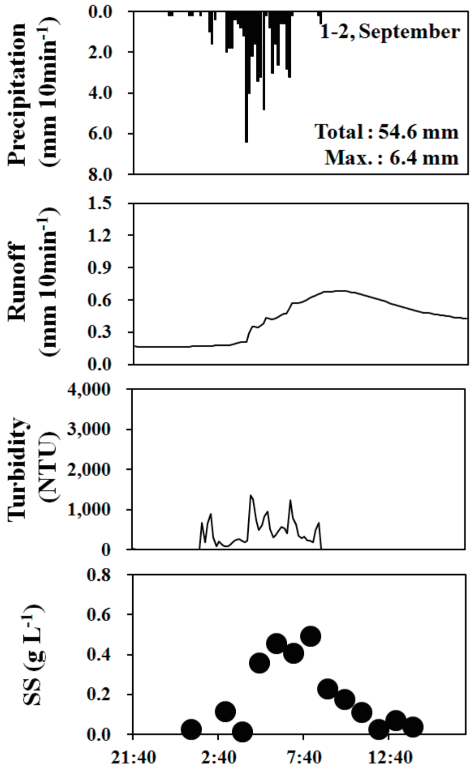

Fig. 2 Response of runoff and SS in the K2-1

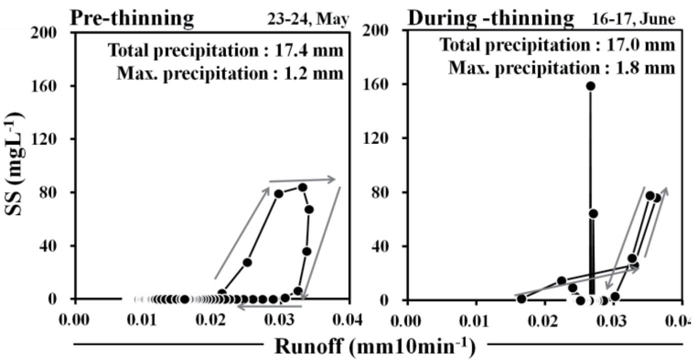

Fig. 3 SS response pre- and during-thinning in the K2-1

The activities of Cs-134 and Cs-137 were accumulated in the upper 5 cm soil depth on the undisturbed hillslope of K2, 2011 (Fig. 4). Total SS amount in integrated SS samplers in the K2 was 0.18 kg, while one in the K3 was 0.02 kg. Therefore, as shown in the SS concentration (Fig. 3), this result confirmed that SS yield in the thinned catchment tended to be greater. Despite the amount of SS yields, mean Cs-134 activity in integrated SS samplers in the K2 (456 Bq kg^{-1}) tended to be lower than ones in the K3 (764 Bq kg^{-1}). Patterns were also similar to Cs-137 activity. This result suggested that soil in the K2 was severely disturbed due to skid trails installation and fine sediment located in more than 5 cm in soil depth (not contaminated by radionuclide) was transported in the K2. Moreover, because of the dilution of radionuclides activities by non contaminated soil, radionuclides in the K2 tended to be lower than the K3.

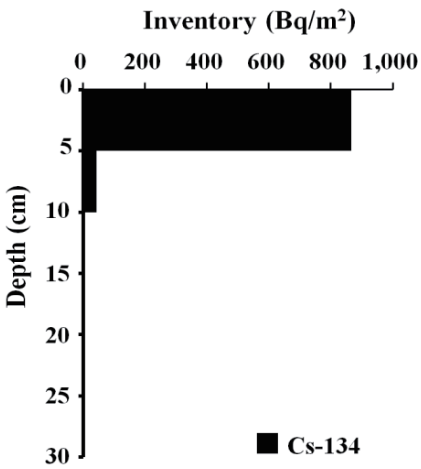

Fig. 4 Depth distribution of Cs-134 at the undisturbed hillsolpe

REFERENCES

Eisenbies MH, Aust WM, Burger JA, Adams MB (2007): Forest Ecology and Management **242**: 77-98.

He Q, Walling DE (2003): Hydrological Processes **17**: 901-9016.

Klein M, Haifa (1984): CATENA **11**: 251-257.

Smith HG, Dragovich D (2009): Hydrological Processes **23**: 2415-2426.