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Interaction among Vegetation, Soil Erosion, and C/N Accumulations in Headwater Catchments

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1. INTRODUCTION

Soil erosion over forested hillslopes due to decrease of vegetation ground cover is one of the major environmental concerns in steep mountainous watershed and produces excess sediment to downstreams. Reduction of vegetation and litter groundcover can induce severe degradation of both soil physical and geochemical properties (Montgomery, 2007). For instance, Fierer and Gabet (2002) showed that hillslope vegetation types had strong effects on the loss of carbon and nitrogen. In addition to providing litter and protecting the soil from erosion, understory vegetation also contributes to forest ecosystems through nutrient and carbon turnover during decomposition (Teramage et al., 2013) and facilitates increased rates of biogeochemical cycling (Yarie, 1980).

Removal of vegetation ground cover generally causes transient increases in nutrient exports to streams (Hornbeck et al., 1990). The elevation of soil erosion soil C/N accumulation export resulting from vegetation removal has been found to depend greatly on the intensity and extent of removal. Although we realize the importance of vegetation and litter ground cover, most of the previous studies were conducted only in hillslope plot scales, which are rather small areas (e.g., 1 x 1 m and 10 x 10 m). For the forest, land, and water management, watershed scale studies are always difficult because of their wide area and the special heterogeneities of soil, topography, and vegetation conditions. Therefore, the purpose of this study was to quantify the impacts of soil erosion and C/N accumulations in headwater catchment of Tanzawa under the changes of vegetation ground cover.

2. STUDY SITE AND METHOD

Field investigation was conducted on a hillslope in the Oborasawa Watershed, which is located in the eastern part of the Tanzawa Mountains, in the western part of Kanagawa Prefecture, Japan (35 ° 28'N, 139 ° 12'E). The study site was located in two adjacent headwater catchments named as Watershed No. 3 (7ha) and Watershed No. 4 (4.6ha) (Figure 1). The climate is moist and cool, with approximately 3000 mm mean annual precipitation (Shiraki et al., 2007) and 12.5^{o}C mean annual temperature. The elevation ranges from 432 to 878m. The percentage of bare soil slope in Watershed No. 3 was 18%, whereas that in the Watershed No. 4 was 6%. Most of hillslope gradient was more than 45^{o}, which are located to adjacent to channels.

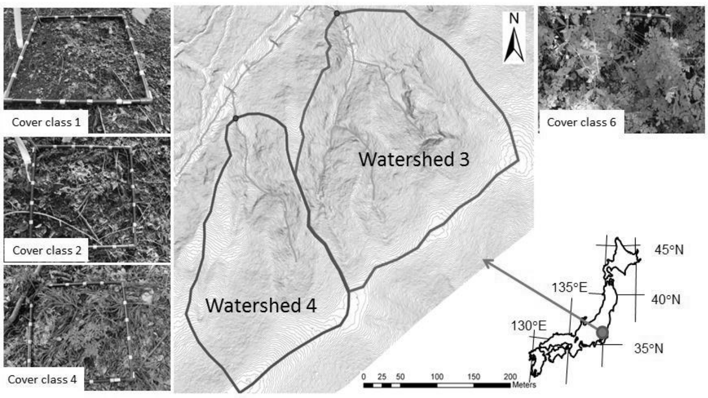

Figure1. Outline of this study site

For investigating catchment-scale vegetation ground cover, we set 50 x 50 cm plots located within catchments including near stream channels to the ridge line. We then classified six categories: (1) bare land, (2) sparse litter cover, (3) rich litter cover**,** (4) understory groundcover < 40%, (5) understory groundcover 40 - 80%, (6) and understory groundcover > 80%. For each location, we measured the above-ground biomass of understory vegetation and litters. All living biomass were clipped above the soil surface at each plot. For all plots, we also measured soil hardness, soil bulk density, water contents. We estimated canopy openness using a fish eye lens and a digital camera. We measured high of soil pedestal as the indication of soil erosion (Sidle et al., 2004). All of the field sampling was conducted in August to September, 2012.

For the further analysis, soil sample was collected to 30 cm depth with a soil core plastic, and divided in 0–2.5 cm, 2.5-5 cm, 5–10 cm, 10–20 and 20–30 cm intervals in each plot for estimating ^{137}Cs activities, and soil carbon and nitrogen. We obtained soil sample and dried for 48h at 105°C, then analyzed by gammma-ray spectrometry. For soil < 1 mm, we estimated carbon and nitrogen contents using CN corder MT – 700 (Yannaco Ltd.).

3. RESULTS AND DISCUSSION

Despite the variably, the quality of vegetation ground cover over the study period was higher in 2012 than in 2010. The amount of vegetation tended to be changed from 25.6 g m^{-2} to 46.9 g m^{-2}, increased 83.3% compare to in 2010 (Fig. 2). The hillslopes of the study area are generally vegetated by annual grassland communities, with little mixing of the vegetation types. The increased of vegetation ground cover has a strong effect on the rates of soil C/N accumulation in this area.

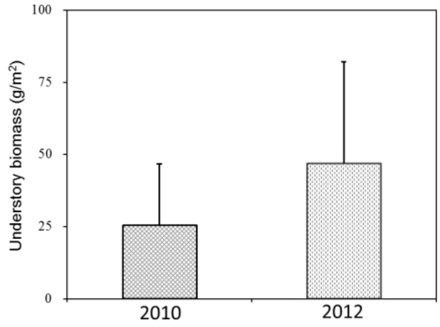

Figure2. Observation result of changes in vegetation ground cover

Percentages of soil carbon and nitrogen tended to be higher with higher of amount of vegetation ground cover, ranged from 5.46 to 10.67 %, 0.40 to 0.79 %, respectively on soil surface. These are also decreased with increased of soil depth. C/N ratio ranged from 13 to 15. Because the C/N ratio forested area around Tokyo areas was ranged from 14 to 18, the C/N ration of our study site tended to lower than the other forested area. Lower C/N ration potentially produce more NO^{3-} in the soil and increases in resultant stream NO^{3-} (Yoh, 2001).

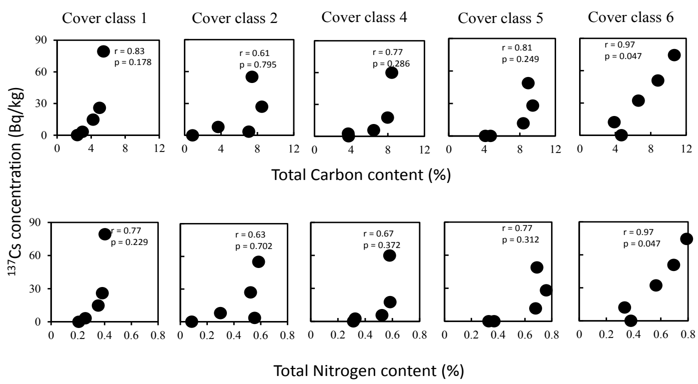

Figure3. Relationship of ^{137}Cs and soil nutrient

The distribution pattern of radionuclides differed by the soil depth. The ^{137}Cs distribution had similar shapes among various cover classes, with peak concentrations in the surface soil (0– 2.5 cm) (except cover class 2) (Fig. 3). We examined soil nutrients contents of the surface soil (0–2.5 cm) and their correlation with ^{137}Cs concentration. In the cover class 6, positive correlation was found for both soil carbon and nitrogen content. In the other cover classes, poor correlation with ^{137}Cs concentration. Hancock et al. (2010) also reported no correlation between ^{137}Cs inventory and soil carbon in an undisturbed area of an open dry-sclerophyll forest. They hypothesized that the movement of soil carbon is not related to erosion processes because its concentration is a peak or equilibrium concentration. That is more related to hillslope position and carbon inputs both from upslope and the immediate area. Therefore soil carbon concentration may be a direct product of mineralization rates rather than being more strongly related to the material deposited and eroded at a point due to enhanced erosion processes on disturbed hillslopes. These results showed that an assessment of the relationship between soil nutrient content and soil erosion using ^{137}Cs, amount of soil erosion play little role in the distribution of soil nutrient in hillslope forest. Vegetative ground cover will be the major contributor to soil nutrient accumulation.

4. CONCLUSION

Findings of our study showed that soil carbon and nitrogen condition had little affected by the amount of surface soil erosion. The contributor of soil surface condition such as amount of vegetation ground cover and litter will be strongly controlled C/N accumulations in this area. Our finding suggested understanding the effect of vegetation ground cover in management practices is necessary for soil conservation.

References

Fierer, N.G., Gabet, E.J., 2002. Carbon and nitrogen losses by surface runoff following changes in vegetation. J. Environ. Qual. 31, 1207-1213.

Hancock, G.R., Murphy, D., Evans, K.G., 2010. Hillslope and catchment scale soil organic carbon concentration: an asessment of the role of geomorphology and soil erosion in and undisturbed environment. Geoderma 155 (1–2), 36–45.

Montgomery, D.R., 2007. Soil erosion and agricultural sustainability. Proceedings of the National Academy of Sciences of the United States of America 104, 13268-13272.

Sidle R.C., Sasaki S., Otsuki M., Noguchi S., Rahim Nik A., 2004. Sediment pathways in a tropical forest: effects of logging roads and skid trails. Hydrological Processes 18: 703-720.

Teramage, M.T., Onda Y., Kato H., Wakiyama Y., Mizugaki S., Hiramatsu S., 2013. The relationship of soil organic carbon to 210Pbex and 137Cs during surface soil erosion in a hillslope forested environment. Geoderma 192, 59–67.

Yoh, M., 2001. Soil C/N ratio as affected by climate: an ecological factor of forest NO^{3-} leaching. Water, Air, and Soil Pollution 130, 661-666.