Seasonal changes in the amount of litter layer and soil erosion in the forest floor －an impoverished understory by deer impact at Doudaira, Tanzawa Mountains－

Taeko WAKAHARA[1], Yoshiharu ISHIKAWA[2], Katsushige SHIRAKI[3], Hiroto TODA[4], Takahiro MIYA[5], Fumiko KATAOKA[6], Masakazu SUZUKI[7], and Yoshimi UCHIYAMA[8]

[1]Member of JSECE, United School of Agricultural and Science, Tokyo University of Agriculture and Technology
(3-5-8 Saiwai-cho, Fuchu, 183-8509, Japan)
E-mail:amusel@cc.tuat.ac.jp

[2] Member of JGS, Professor, United School of Agricultural and Science, Tokyo University of Agriculture and Technology
(3-5-8 Saiwai-cho, Fuchu, 183-8509, Japan)
E-mail: y_ishi@cc.tuat.ac.jp

[3] Member of JSECE, lecturer, United School of Agricultural and Science, Tokyo University of Agriculture and Technology
(3-5-8 Saiwai-cho, Fuchu, 183-8509, Japan)
E-mail: shirakik@cc.tuat.ac.jp

[4]Associate professor, United School of Agricultural and Science, Tokyo University of Agriculture and Technology
(3-5-8 Saiwai-cho, Fuchu, 183-8509, Japan)
E-mail: todah@cc.tuat.ac.jp

[5] Member of JSECE, Sabo frontier foundation
(2-7-4 Hirakawacyo, Chiyoda-ku, Tokyo, 102-0093, Japan)
kikaku@sff.or.jp

[6]OKABE Co.,Ltd.
(4-21-15 Mukoujima, Sumida-ku, Tokyo, 131-0033, Japan)
Tel:(03)3624-5111

[7] Member of JSECE, Professor, Graduate School Agricultural and Life Sciences, The University of Tokyo
(1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan)
E-mail: Suzuki@fr.a.u-tokyo.ac.jp

[8] Member of JSECE, Kanagawa Prefectural Natural Environment Conservation Center,
(657 Nanasawa, Atsugi, Kanagawa Pref., 243-0121, Japan)
E-mail: uchiyama.vka1@pref.kanagawa.jp

Soil erosion has been progressing over a large area in Doudaira (located in East Tanzawa of Kanagawa Prefecture) owing to the sika deer (*Cervus nippon*) feeding which has in turn resulted in a reduction in the understory of beech (*Fagus crenata*) forests. Three test blocks which have different understory rates were set in Doudaira and the soil erosion content from July 2004 to December 2006 was monitored. The results revealed that if the rate of understory is smaller, the litter depositional volume will be smaller and erosion amount increase. The 1% of understory area's erosion depth was 2-10 mm per year. At the study site, litter from Buna tree is always deposited on the forest floor. However, the amount of litter is decreased partly through the processes of decomposition and partly washed through the action of overland flow. Therefore the amount of litter changes by season. At the 1% of understory area, in summer (Jul.-Sep.) which has less litter, infiltration rate decreased and surface flow rate increased rather than Spring (Apr.-Jun.) and Autumn (Oct.-Nov.). Even in the case of equal rainfall amounts, soil erosion progresses more in summer. It is clear that most of the soil erosion occurred in summer, as there is much rain in this season.

Key Words : *beech (Fagus crenata) forests*, *browsing impact by sika deer (Cervus nippon)*, *litter*, *soil erosion*, *understory*

1. INTRODUCTION

Soil erosion has been progressing over a large area in Doudaira (located in East Tanzawa of Kanagawa Prefecture) owing to the increasing sika deer (Cervus Nippon) feeding, which has in turn resulted in reduction in the understory of beech (Fagus crenata) forests. With the decrease of understory, foliar litter layer on the forest floor is also dwindling and the soil erosion, which is progressing extensively, has become a serious problem. Erosion of soil surface contributes to inhibition of tree growth, fallen trees, and so forth, and deteriorates the ecosystem.

Generally, soil erosion is inhibited by the understory vegetation and the litter layer in a healthy forest. Unlike a case of soil erosion caused in a bare land, this study site is provided with a large quantity of litter fall from upper-story beech trees in autumn. However, the quantity of litter is decreased partly through the hauling by surface flow or wind, partly through the process of microbe decomposition, and partly through the deer feeding. The understory and the litter coverage on the forest floor changes by season. It seems that the amount of the soil erosion has changed with the change in the amount of litter. There are some studies on the relationship between the understory, litter coverage and the soil erosion in conifer forests of Japanese cypress and Japanese cedar (Kiyono 1988, Miura 2000). However, there has been few studies about soil erosion in beech forests where the understory is reduced by deer feeding, and there are a lot of uncertainties points about the reality of the soil erosion.

The purposes of this study are: first, to clarify canopy throughfall and seasonal change of soil erosion contents and litter flow; secondly, to clarify the relation between the amount of litter, understory and the soil erosion; and thirdly, to clarify the movement and supply amount of litter and decomposition rate of litter in Doudaira, the beech forest where the understory is reducing.

2. SITE AND MEASUREMENTS

(1) About the Site Characteristics

The study site was set in Doudaira, East Tanzawa of Kiyokawa-mura, Aiko-gun, Kanagawa Prefecture (Fig. 1). Dodaira is located in the Shiomizu River valley, upstream of Miyagase Dam located in the Sagami River valley. Its geology belongs to Neogene, Tanzawa group. It is at an altitude of about 1,190m, 5 to 33 degrees in slope gradient and covered by 2 to 3 meter-thick loam layer (volcanic ash). Beech trees over 10 meters tall are eminent in the site. Until around 20 years ago, Suzutake (Sasamorpha borealis) as tall as 1.5-2 meters were eminent in the understory, but now they have declined by deer feeding, and only several kinds of plants have survived a decay from deer feeding. Several species such as Momiji-ichigo (Rubus palmatus), Bara ichigo (Rubus illecebrosu), Oobano yaemugura (Galium pseudoasprellum) have recovered inside a 2-meter high vegetation fence set up to prevent deer feeding.

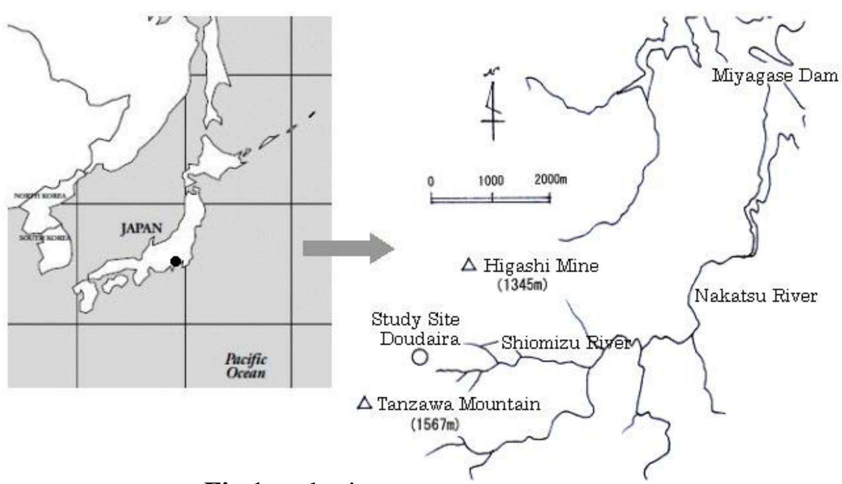

Fig.1 study site

(2) Measurements

a) Setting test blocks for monitoring the soil erosion contents and checking the amounts of rainfall, surface flow, soil erosion and litter flow

To check the difference in the rates of soil erosion, litter flow and surface flow due to the difference in understory vegetation coverage and litter sediment, three test blocks (2m×5m=10 ㎡) which have different understory rates were establish as shown in Fig. 2. A block of high coverage of about 80% of understory area and a block of medium coverage of about 40% of understory area were set inside the protected area, and a block of low coverage of about 1% of understory area was set outside the fence. A rain gauge for monitoring the canopy throughfall was set beside each test block, and a box (0.4×0.4×2m) was set at a lower part of each test block to estimate the amounts of soil erosion, litter flow and surface flow. All of the test blocks were close to one another on the same slope of 33 degrees in grade.

At intervals of one to two weeks, the contents of the boxes were collected 15 times from July 5th to November 21st, 2004, 27 times from March 20th to December 4th, 2005, and 31 times from March 31st to December 3rd, 2006, respectively. Then, of the collected contents of each box, the soil and the litter were separated by washing, and the absolute dry mass of each was measured. Samples of topsoil were taken from the site to determine their absolute dry mass and dry unit weight.

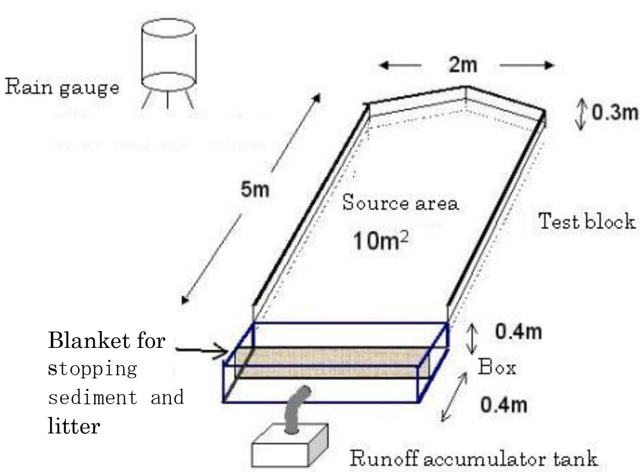

Fig.2 test block

b) Study of litter sediment and understory vegetation amount

To measure the amount of litter sediment and understory vegetation amount of each test block, a quadrat (0.5×0.5m) was set up near each test block. The absolute dry masses of the litter and the understory vegetation in each quadrat were measured. Samples were collected 17 times from April 2nd to November 20th, 2005, every one to three weeks, and 8 times from April 2nd to November 19th, 2006, every month or so. The quadrats were moved after each observation.

c) Study of amount of litter supplied from canopy, amount of litter movement on slope and its decomposition rate.

To clarify the seasonal change of the litter sediment, annual balance, and litter movement on the forest floor, three litter trapping fences (Fig.3) were set up at the upper (about 33 degrees), a middle (about 20 degrees) and a lower parts of the slope (about 5 degrees), respectively. All of the litter trapping fences were set up outside the vegetation protecting fence. Each litter trapping fence is about 0.9m high and has four openings 1m wide and 1m deep in four directions respectively and catches litter

Fig.3 litter trapping fence

by its net (1mm mesh). Two openings faced in the maximum slope direction (north-south direction) while the others faced orthogonal to the maximum slope direction (east-west direction). In the center of the litter trapping fence, a litter trap (1m×1m, with a mesh net of 1mm) was set up to catch the litter from the canopy.

The litter trapping fence at the upper and middle parts of the slope were monitored 27 times from March 20th to December 4th, 2005, and 31 times from March 31st to December 3rd, 2006, every one or two weeks. The litter trapping fence at the lower part was checked 20 times from May 29th to December 4th, 2005, and 31 times from March 31st to December 3rd, 2006, every one or two weeks, respectively. The collected litter was oven-dried, and the weight was measured.

To investigate the process of microbe decomposition speed of the deposited litter, litter bags were set beside the test blocks on December 5th, 2004. The litter bags were collected every four months, and the contents were oven-dried to measure the absolute dry masses.

3. RESULTS AND DISCUSSION

(1) Canopy throughfall, seasonal change of soil erosion contents and litter flow

The accumulated canopy throughfall during the observation period was 2340.2 mm from July 5th to November 21st, 2004 (139 days), 2346.5 mm from March 20th to December 4th, 2005 (259 days), and 2502.1 mm from March 31st to December 3rd, 2006 (248 days). The observation period was as short as 139 days in 2004 but with much rainfall brought by a number of successive typhoons in 2004 than in 2005 and 2006. The highest rain fall was recorded in summer, 2005, while in 2006 it was autumn that had the most rainfall.

Fig.4 shows the relationship between the soil erosion depth (an average soil erosion depth obtained, supposing that 5,600g of soil mass is equal to 1mm of soil erosion depth) and the litter sediment at the law coverage (1%) block, the medium coverage (40%) block and the high coverage (80%) block of the understory vegetation area in 2004 to 2006. The lower the coverage block was, the more the soil erosion contents were, and the smaller the litter sediment was. In the low coverage block, the erosion reached as deep as 10 mm in 2005.

Fig.5 shows the transition between the canopy throughfall, soil erosion contents and litter flow rate in the law, medium and high coverage blocks in each observation period in 2004 to 2006. Basically, the periods which had a high accumulated canopy throughfall during the observation period had much soil erosion. Especially, July to September tended to have more soil erosion to the same rainfall than other months. The litter flow rate progressed more in April and November to the equal amount of rainfall. This is because in autumn a large amount of the litter was supplied from the canopy and resulted in a large amount of litter sediment.

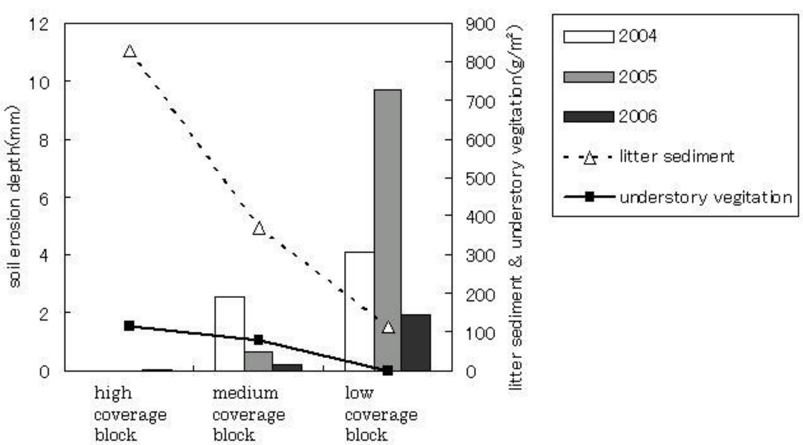

Fig.4 relationship between the soil erosion depth and the litter sediment at each understory vegetation area in 2004 to 2006

(2) Litter sediment, understory vegetation amount, and soil erosion rate per unit rainfall

Fig. 6 shows the transition in soil erosion rate, surface flow rate, understory vegetation amount and litter sediment per 1 mm of canopy throughfall in 2005 and 2006. In the high and the middle coverage block, no definite relationship is recognized between the understory vegetation amount and the transition in the litter sediment as well as the soil erosion contents per unit rainfall and the surface flow rate.

On the other hand, since the low coverage block is nearly a bare ground, it contributes less or no effect to restrain soil erosion due to understory vegetation. Therefore, the soil erosion rate and surface flow rate per unit rainfall attains the highest values in summer (July to September) when the litter sediment is least. It is considered that the litter sediment has a great influence on the soil erosion contents per unit rainfall.

(3) Litter flow rate, supply amount and microbe decomposition speed

The litter flow rate and the litter amount supplied from the canopy were measured at the litter movement measuring fence in 2005 and 2006. The litter of about 400g/m^2 is supplied annually from upper story trees, and on a steep slope a large amount of litter flowed down. At a lower part of a gentle slope, the lateral litter flow was as great as the downward flow rate. This shows that the litter supplied from the canopy moves in a large quantity downward or laterally from the upper part of the slope and that in a steep slope, in particular, loss of litter is distinctive.

It turned out from an average daily litter supply amount that the litter is supplied mostly from the end of September to the beginning of November. Also, a change in mass of the litter inside the litter bag decreased substantially linearly in April to December, showing a decrease in mass of about 0.22 % daily during this period.

4. CONCLUSION

An on-the-spot survey was conducted on the depressed area in Dodaira, Tanzawa, and a study was conducted what influence the coverage of underway vegetation gives to the soil erosion contents and the

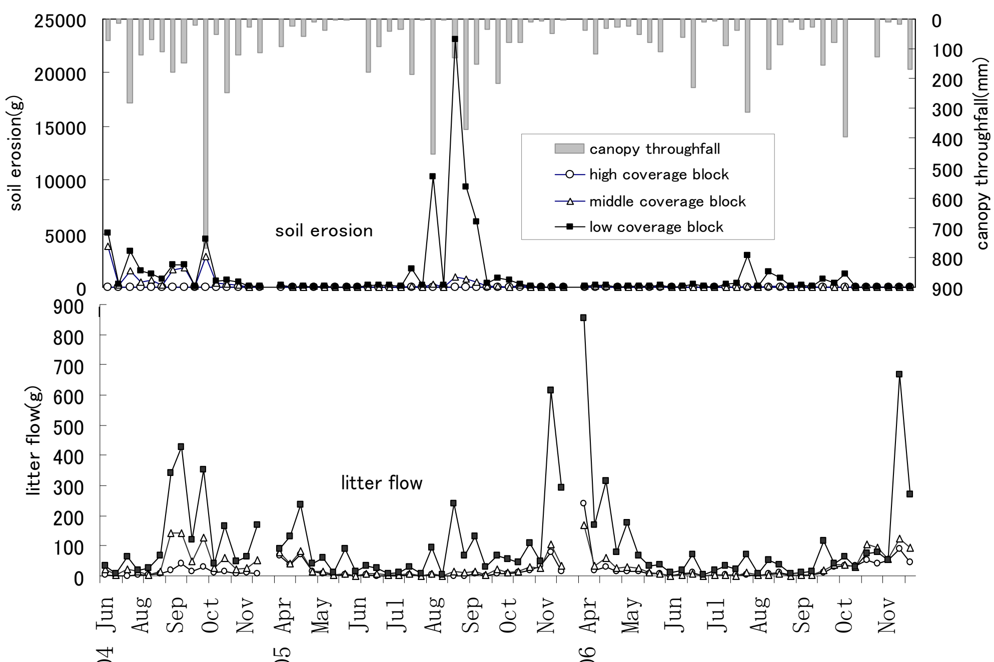

Fig.5 transition between the canopy throughfall, soil erosion contents and litter flow rate in the low, medium and high coverage blocks in each observation period in 2004 to 2006

outflow of the surface flow. The study revealed that a decline in understory vegetation brings about a decrease in litter sediment, resulting in an increase of soil erosion and surface flow. The understory vegetation catches the litter, and deposition of the litter restrains the soil erosion. In Dodaira where the understory vegetation declines distinctively, it turned out that the seasonal change in litter sediment has a great influence on the seasonal change of the soil erosion contents. It is considered that settling the beech litter on the understory would reduce the soil erosion and lead to prevent the understory from decaying and to recover the vegetation.

Finally, I would like to express my heartfelt gratitude for your great support and cooperation.

REFERENCES

1) Kiyono, Y: Analyses of factors affecting A_0-layer coverage in Chamaecyparis obtusa plantations, Journal of the Japanese Forest Society, Vol.70, No.2, pp. 71-74, 1988.

2) Miura, S.: Proposal for a new definition to evaluate the status of forest floor cover and floor cover percentage (FCP) from the viewpoint of the protection against raindrop splash, Journal of the Japanese Forest Society, Vol.82, No.2, pp. 132-140, 2000.

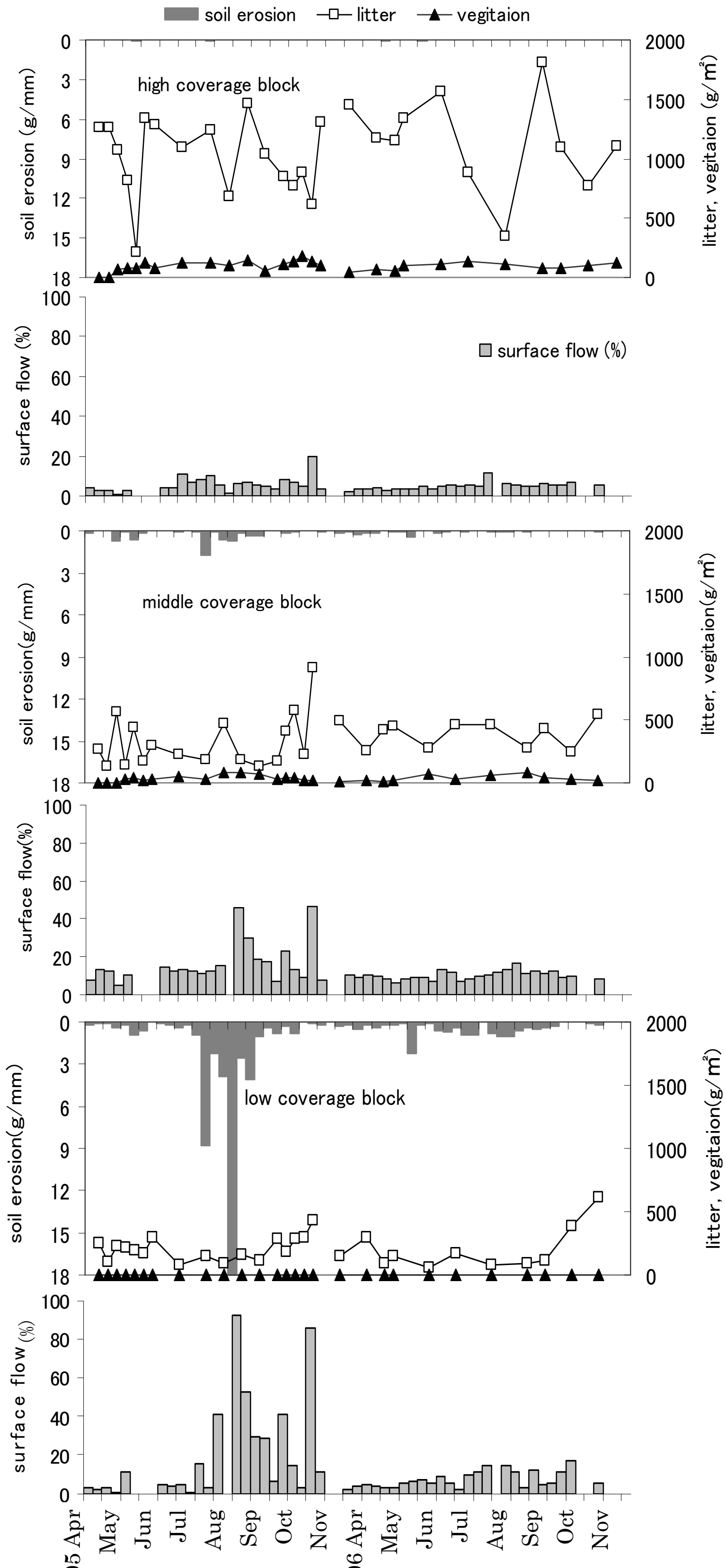

Fig.6 transition in soil erosion rate, surface flow rate, understory vegetation amount and litter sediment per 1 mm of canopy throughfall in 2005 and 2006