Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AHW027-P01 Room:Convention Hall Time:May 23 16:15-18:45

The estimation for temporal and spatial fluctuations of litter moisture in three forested areas, Japan

Koji Tamai[1*], Yoshiaki GOTO[1]

[1]Forestry & Forest Products Res. Inst.

Mapped estimates of the risk of forest fire would benefit forest management, and could be used to decide restrictions on the public use of forest areas.

In this study, the litter moisture contents were predicted with the tank model and the degrees of hazards of forest fire hazard were estimated at each 8-9 forest stands in three forested areas, Tatsunokuchi-yama Okayama, Tatsuta-yama Kumamoto, and Tsukuba-san Ibaraki, in Japan. Model was adapted to 8-9 forest stands in each area.

Fuel moisture decreased with each speed for each forest stand among simulated days depending the solar radiation on the each forest floor. Litter moisture was less than 0.2g g-1 and fire risk is judged to be highest in almost forest stands on the day after long drought period. On the other hand, spatial variation of litter moisture was widest to be 0.19 - 0.80g g-1 on the day during the drying process. This means that litter drying speed and fire risk is different between forest stands. Thus, it is significant to construct the system to warn forest fires for each forest stand to manage the people’s activities in this public forested area for preventions of the forest fire.

The data of precipitation and net radiation in Tsukuba-san is provided by Dr. Shin’ichi Iida. We appreciate his work for this study.

Keywords: Tank model, Solar radiation on the forest floor

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Homeostasis of evapotranspiration measured during the succession from Japanese red pine to evergreen oak

Shin'ichi Iida[1*], Tadashi Tanaka[2], Michiaki Sugita[3]

[1]FFPRI, [2]Univ. Tsukuba, [3]Univ. Tsukuba

Introduction

The succession from Japanese red pine (*Pinus densiflora*) to evergreen broadleaved forest comprising mainly evergreen oak (*Quercus myrsinaefolia*) are widely observed (Yamashita and Hayashi, 1987). During the succession causing the change in forest structure, the change in evapotranspiration process would occur. Delzon and Loustau (2005) measured the transpiration and the evapotranspiration for several stands which have different ages, and reported that the transpiration decreased with the increase in age, but the evapotranspiration was not changed, "homeostasis of evapotranspiration". Similar homeostasis might occur during the succession. We measured the evapotranspiration at the beginning and the end of a 17-year period from 1985 to 2002 during which the forest changed from the pure red pine forest to the multi-layered forest of red pine and evergreen oak.

Method

We measured the evapotranspiration with energy-balance and eddy-covariance method in a secondary forest of Japanese red pine in the Terrestrial Environment Research Center, University of Tsukuba. The interception loss was calculated as the difference between the gross rainfall (P) and the sum of throughfall (TF) and stemflow (SF). Based on the sap flux density measurements, the transpiration from red pines (TR_P) and the transpiration from lower-layered evergreen trees (TR_L) were estimated in 2002. To estimate the depth of water uptake by root system, we measured soil water potentials by the tensionmeter nests around trees in 2004. We described the details of the forest structure in Iida et al. (2001 and 2003) and of the hydrological measurements in Iida et al. (2005, 2006 and 2008).

Results and Discussion

We show the annual values, for example ET, I, TR_P, TR_L and so on, as the proportion to P (%). Decline in the stand density of red pine caused decreases in TR_P from 28% in 1985 to 10% in 2002 and in I from 17% to 9%, while ET was 53 and 52% in 1985 and 2002, respectively: ET did not change and the homeostasis was found. The decreases in TR_P and I were counterbalanced by TR_L.

The throughfall (TF) did not change: the decrease in I was resulted from the significant increase in SF. More vertical branches and smoother bark of the lower canopy trees enhanced SF. Concentrated input of SF infiltrates around the tree base. Smaller SF of red pines suggested smaller available water for the uptake by the root system. We found that the lower soil water around the red pine after the rainfall events, and that the red pines uptake water from deeper soil in summer. These results corresponded with the report by Yamanaka et al. (2006).

These results indicated that lower-layered evergreen trees concentrated larger amount of water to their root systems to use for larger transpiration compared with red pines, and could imply that the evergreen trees had the advantage for the competition of soil water. However, the lower canopy trees had worse radiation condition which could adjust TRL and resulted in the counter-balancing effect on ET. The conditions of soil water and radiation will change with proceed of the succession: predicting the homeostatic control of ET by the ecosystem is very difficult. If the evergreen trees would have the closed canopy, the competition of water and radiation among the evergreen trees would be very severe and ET may not continue increasing. The future measurements must be need to predict that the ecosystem keep the homeostasis of ET in the climax or not.

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Keywords: succession, evapotranspiration, homeostasis, transpiration, water uptake by root system

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Runoff change in a catchment of decisuous forest without any treatment for sixty years

Makoto Tani[1*], Ikuhiro Hosoda[2]

[1]Grad. School. Agric., Kyoto University, [2]Kansai Br., For. & For. Prod. Res. Inst.

In many hilly moutains in Japan (satoyama) that people collected firewood and muck for hundreds of years, vegetation has been grown up naturally without uses and treatments after the energy revolution around 1960. Its effects on rainfall-runoff responses is widely interested from a view-point of flood control and water resources management. Long-term observations in small catchments with such a vegetation process since early 20th Century can be analyzed for evaluating these effects.

This sdudy tried to assess a data set obtianed from a 60-year observation in Tatsunokuchi-yama Kitatani catchment(17.3 ha, Paleozoic formation) near Okayama City. The annual precipitation and air tempearture were 1236 mm and 13.5 degC.

The annual water balance showed an obvious change in the annual-unit water storage, and the annual evapotranspiration (ET) was controlled by annual air temperature. An intereting finding for ET was an additional increase to this tempearture effect in recent years after 1990.

Using monthly ET estimated from Hamon's Equation (Tani and Abe, Bul. FFPRI 1987) and the annual ET obtained above, a simulation of rainfall-runoff response for the 60 years in this catchment was attempted by a runoff model (HYCYMODEL)(Tani et al., Hydrological Processes in press). Although an additional analysis by a high-resolution data set is needed, our simulation using the daily-data set found no drastic change in the buffering effect of runoff. Revegetation work operated for a bare land in granite mountains can convert ground-surface flow into subsurface flow, providing an obvious buffering effect. However, we can suppose that the period of 60 years was too short for a development of soil producing an increase of the buffering effect.

Our previous study on storm runoff responses in this catchment (Tani., J. Hydrology 1997) demonstrated that the storm runoff volume approached the rainfall volume after the wettest condition for a large storm event of the total rainfall over 300 mm. A HYCYMODEL simulation using the hourly data for one of these large storm evants suggested that runoff buffering potential (Tani, J. Hydrology 2008) still remained valid for this condition.

We can summarize that forest cutting may be desirable for the water use under a dry condition compared to humid climate in Japan because the minimum annual precipitaion of 622 mm was recorded in 1939 and ET has increased in recent yeras after 1990. Nonetheless, a large-scale clear cutting should be avoided from a view point of soil conservation because of the runoff buffering potential mainteined during large storm events.

Keywords: Runoff response, Evapotranspiration, Deciduous forest, Long-term change, Water resource, Satoyama

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Variation of basin retention and changes of vegetation - transit in Tatsunokuchi-yama

Ikuhiro Hosoda[1*]

[1]Kansai Research Center, FFPRI

Forest has effect to decreases total rainfall amount by canopy interception, and also has effect to delay water discharge by high infiltration rate of forest soil. By these effects, forest is regarded that reduces flood runoff. In a recent tendency to increase local heavy rainfall, it is thought that the forest's flood reducing function is getting more important. However, the function, it must be depending on forest condition, has not been clearly revealed. Accordingly, inter-annual changes of retention curves in Kita-tani (TK) and Minami-tani (TM) in the Tatsunokuchi-yama forested experimental watershed where runoff has been observed since 1937 were analyzed, and were compared with changes of forest conditions.

Retention curve is expressed as relationship between rainfall (P) and loss (L) which is difference between P and direct runoff in unit hydrograph. Approximation of P-L relationship in this study is; $L=S\{1-\exp(-KP)\}$. Since L=S when P is infinity, S is called maximum basin storage (Fujieda, 2007). But, since L is consisted of part of baseflow, basin storage change, and evapotranspiration, L is not necessarily stored in basin. Hence, S is called maximum retention amount in this study. Changing rate of L depending on P is represented by K; greater K gives more rapid increasing of L depending on increasing of P for same S.

For each flood event with peak daily runoff was greater equal 1 mm from 1937 through 2009, direct runoff was calculated by graphical method. L was obtained by subtraction of the direct runoff from P in the direct runoff period. To average fluctuation of inter-annual rainfall conditions, retention curves were regressed using P and L in every 5-year with yearly step. Correlation coefficients were greater than 0.8 except 2005-2009 in TK (0.7). Obtained regression constants S and K were recognized as 5-year moving average of retention curve. Furthermore, 5-year running median of S and K were calculated to clarify the inter-annual trends.

S ranged about from 50 to 400 mm. The time series patterns of S were different from the pattern of P, and TK has different variation pattern of S from TM. S became greater when forest was growing thickly. In contrast, S became smaller when pine wilt disease or forest fire occurred, and clearcut was conducted. Therefore increasing of S must be mainly derived from increasing of evapotranspiration. When S in TK and TM are compared, S in TM varied greater than S in TK. This difference might be not only derived from runoff characteristics based on individual topography and geology, but vegetation background; TK was covered with naturally regrown secondary forest since 1948, whereas coniferous trees were planted in TM.

K ranged about from 0.002 to 0.018, and showed antiphase of S. S-K relationships were not different between TK and TM, and were approximated to an exponential function. K rapidly decreases with increasing of S, and becomes almost constant when S is greater than 200 mm. Although K is small when forest is thickly growing, greater S gives greater increasing of L following increasing of P compared with condition which is greater K and smaller S.

Overall, it was recognized that S increased along with growing of forest. Thus, it is clear that thickly growing of forest controls flood runoff. However, S especially became greater when pine trees grew all over the watershed. In comparison, effects of regrown secondary forest and partly planting of conifer were gently appeared on variation of S. It is concluded that effect of forest growing on S is different by forest type. While change to mixed forest is promoting from a view point of biological diversity, when conservation of urban area is considered in a recent tendency to increase local heavy rainfall, it is suggested that appropriate arrangement of conifer in suburb forest can be one of effective flood measures.

Reference

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Keywords: retention curve, forest condition, long-term variation, Tatsunokuchi-yama forested experimental watershed, flood mitigation