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

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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

Fujieda, M, 2007. Bulletin of FFPRI, 6(2), 101-110.

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