A2 Analysis of Flood Return Period Change Caused by Forest Recovery, Using Distributed Runoff Model

（分布型流出モデルを用いた森林回復に伴う洪水の確率年変化分析）

Green Engineering for Global Environment
08E12003 Keiichi IGARASHI

Abstract: As flood disaster is increasing, the effect of forest on regulating such disaster has received attention recently and quantification of this effect is one way to understand forest function on regulating floods. In this paper, the evaluation of the function is conducted by focusing on the change in return periods of the peak runoffs with some forest recovery stages, using the distributed runoff model. According to the results, the effect of forest in regulating floods become more powerful gradually with the increase of forest cover, but for extensive rainfall, forest function is limited in lowering flood impacts.
Keywords: forest cover, flood disaster, runoff, runoff model, return period

1. Introduction

Recently, heavy rainfall causes more and more flooding throughout Japan as could be observed at Kita Kyushu in 2012 and at Shiga in 2014. In order to regulate floods, sustainable afforestation and reforestation has been used globally as a measure for flood prevention. Therefore, the goal of this paper is to quantify the forest function in regulating floods in terms of the changes in return periods of peak runoffs using distributed runoff model. Daido River catchment, which is located in the southern part of Shiga Prefecture, was chosen because forest cover was lost in the early 20th Century, but has almost been recovered in this area.

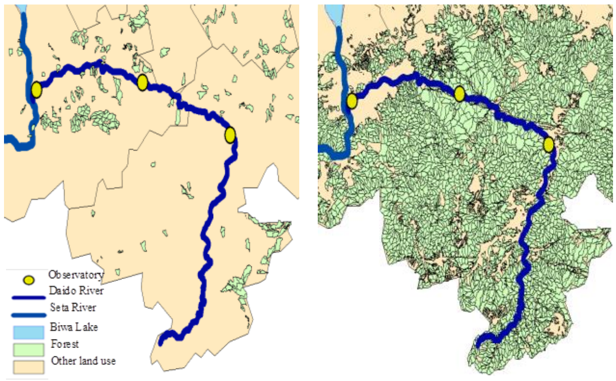
2. Methodology

In contrast to previous study[1)] that assessed only full forest covered and no forest cases, this study regarded successional forest recovery stages. Historical forest map at different coverage levels relative to present (100%, 70%, 50%, 20% and 3%) since 1897 in the area was predicted based on the forest registry[2)] of Shiga prefecture (**Figure 1**). 50 large rainfall events were selected between 1965 and 2013 and hourly runoff at Dairinohashi observatory was simulated in the events with five different forest cover cases by using a distributed runoff model[3)]. In this study, the difference values of roughness coefficient and soil depth for forest and no-forest land use were used in the model. Roughness coefficient and soil depth for forested area were 0.7 $m^{-1/3}$ sec^{-1} and 1000 mm, respectively while these values for non-forest area were 0.2 $m^{-1/3}$ sec^{-1} [4)] and 300 mm[5)], respectively.

Model calculated peak runoff in the rainfall events was used for flood risk assessment. Finally, the change of flood risks by forest cover age was compared based on the return period of peak runoffs that are calculated from probability distribution analysis in the present (100%) forest cover case. Gumbel distribution best fitted the non-exceedance probability of peak runoff among a few tested functions, and the equation of probability distribution is **Eq. 1**.

$$F(x) = exp\left[-exp\left(-\frac{x-86.10}{43.06}\right)\right] \qquad \textbf{(Eq. 1)}$$

where, x is peak runoff [m^3/sec] in an event and return period can be calculated as $1/(1-F_{(x)})$.



(a) 3% of present (b) Present (100%)

Figure 1 Forest cover change in the study area

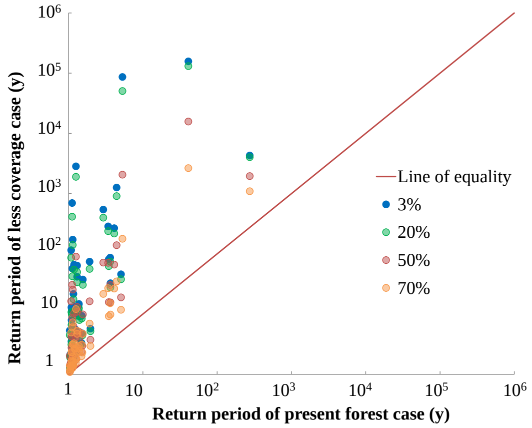


Figure 2 Comparison of return period between present and the less forest cover

3. Results

Figure 2 illustrates the comparison of the return period of peak runoffs between present forested case and the less forested case considering the difference of roughness coefficient and soil depth.

Almost all points for present forest case are located under 10 years return period, but the longest return period shows 274 years and the second longest is 41 years return period.. At the least forested case (3% of present forest), the distance of most points deviates from the line of equality. This distance gradually becomes shorter with increasing forest coverage. Almost all the points are located under 10 years return period in the case of 70% of present forest. Some of these points are discovered within the range over 1000 years return period for the case of 3% of present forest. This implicates that forest recovery decreases the flood risk. Although the return period decrease can also be observed for the two longest return periods, those return periods for present forest are located over 10 years return period. These values imply that the effect of forests on floods is limited for regulating floods in case of extensive rainfall.

4. Discussions

Firstly, forest function is effective when the peak runoff could be indicated by less than 1,000 years return period in the case of 3% of present forest. In contrast, the peak runoffs which are indicated by over 1,000 years return period in the same case are extreme large so that forest cover is not lowering the flood risk even when forests are recovered enough. Secondly, the largest return period decrease was found between forest coverage cases of 20% and 50% of present, and it indicates the most sensitive to this range of forest coverage change. Finally, soil depth has more effect on peak runoff than roughness coefficient. Therefore, surface condition is assumed to less important for the scale of peak runoff and this depends on soil condition.

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