Forest thinning and scale effects on hydrological processes in forested headwater

O Bui Xuan Dung, Takashi Gomi, Mario Hiraoka — Tokyo University of Agriculture and Technology
Yuichi Onda — University of Tsukuba

1. INTRODUCTION

Different hydrological responses at different scales were major issues for understanding hydrological processes. The effects of forest management on hydrological processes depend on the scale, ranging from plots, hillslopes, small catchments, to downstream (Gomi et al., 2008; Dung et al., 2012). The increase in water yield is inversely related to basin size. Increased annual runoff varied in drainage area < 100ha (Buttle, 2011). Nested-catchment monitoring with experimental forest thinning will show how effects of forest management varied with respect to catchment sizes. For comprehensive understanding the effects of scaling on hydrological process after thinning, *we evaluated: (1) the effects of forest thinning on hydrological processes, and (2) examining hydrological responses to catchment scales after thinning.*

2. STUDY SITE AND METHOD

This study was conducted in nested headwater catchments covered by 22-50 years Japanese cypress and cedar plantation at Tochigi prefectures (36°22′ N, 139°36′ E), Japan. The area of nested catchments K2-1 (including K2-2, K2-3, and K2-4) and K3-1 (as K3-2) is 17.1, and 8.9 ha, respectively (Fig. 1). Mean annual precipitation and air temperature was 1239 mm and 14°C, respectively.

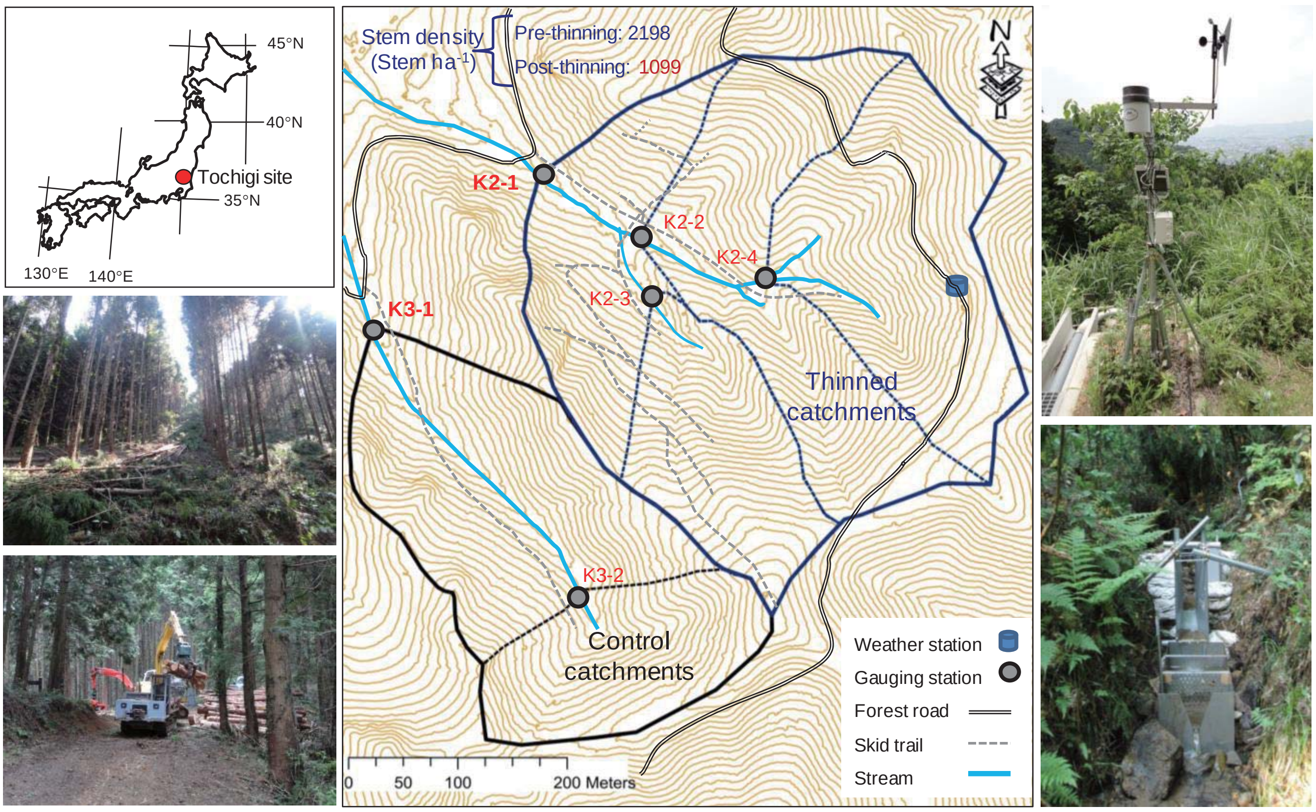

Figure 1. Location and topography of study catchments with treatment characteristics and monitoring stations

We installed Parshall flume and v-notch weir for monitoring runoff at each nested of catchment. 50% of strip thinning was applied in treated catchment K2 from June to September, 2011 (Fig. 1). Most of the timbers were removed from the site for the commercial productions. Therefore, skid trail with 52.8 m ha^{-1} was newly installed. Catchment K3 was remained as the control. We defined pre-treated period from April 2010 to May 2011, while the post-thinning period was from June 2011 to December 2012. Estimation of quick, delayed, and base flows using hydrograph separation analysis was conducted based on methods of Hewlett and Hibbert (1967).

We applied statistical analysis for paired-catchment data between treated and control catchments based on their drainage areas (K2-1 and K3-1, K2-2 and K3-1, K2-3 and K3-2, and K2-4 and K3-2) using Generalized Linear Model. Post-thinning runoff was predicted based on pre-thinning calibration model. Finally, we conducted t-test for examining the significant difference of residual estimated (observed values minus predicted values). All of the statistical analysis was conducted using *R* package.

3. RESULTS AND DISCUSSION

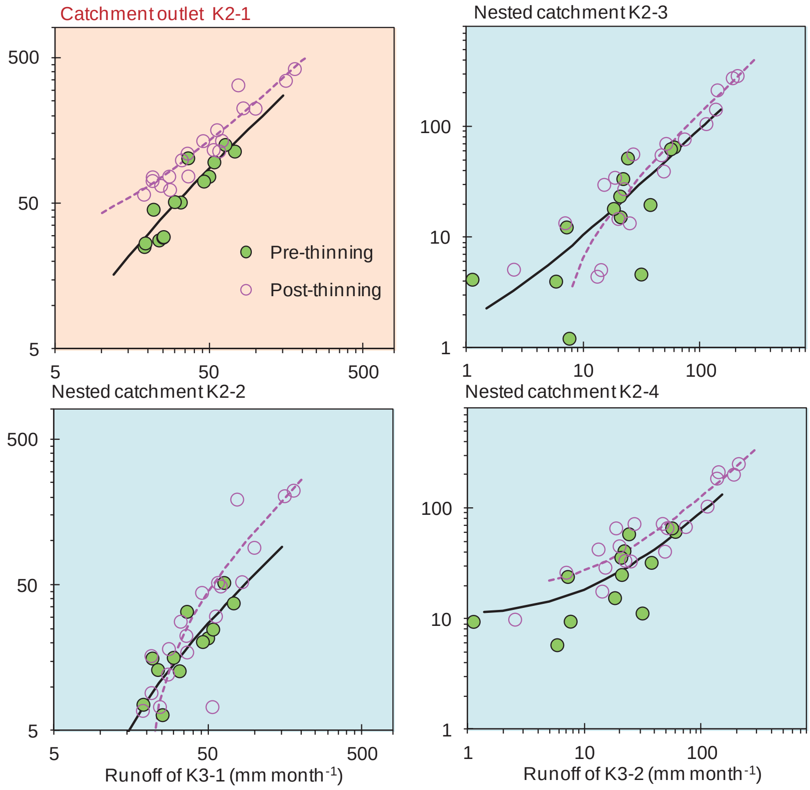

Figure 2. The relationship between monthly runoff of treated and control catchments in the pre- and post-thinning

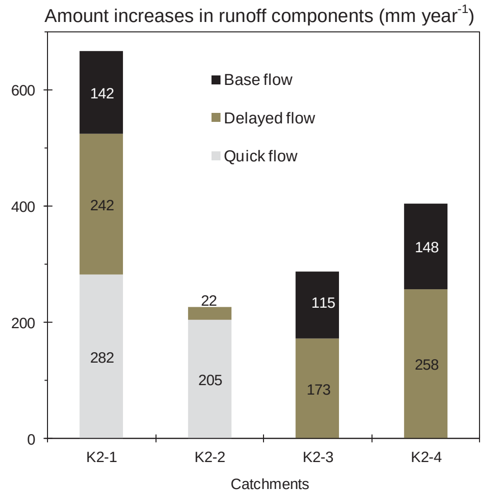

Figure 3. Increases in annual runoff components after thinning

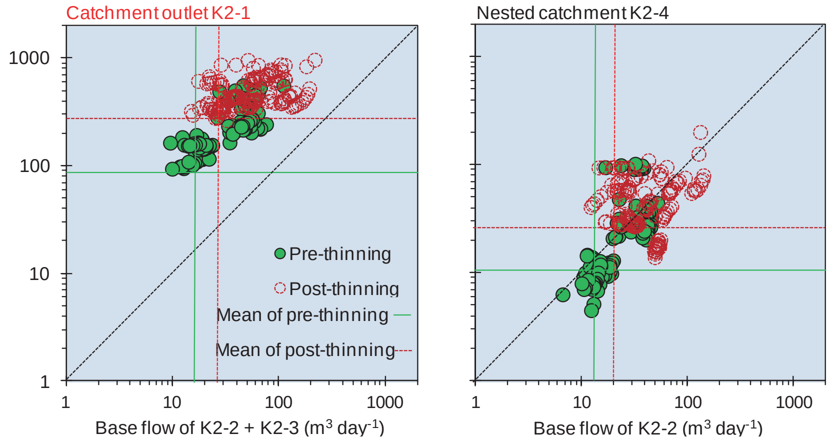

Figure 4. Base flow volumes in nested catchments in pre-and post-thinning

Paired-catchment analysis for monthly catchment runoff between treated and control catchments showed that runoff statistically significant increases after thinning at both outlet and nested catchments (Fig. 2). Increases in annual runoff in the catchment outlet were 667 mm year^{-1}, while the annual runoff increased in the nested catchment was 227 to 406 mm year^{-1} (Fig. 3).

Rate for the increases in runoff was the smallest in K2-2 site. 42% of increases in annual runoff in catchment outlet were contributed by quick flow component, while 36% of them were delayed flow component (Fig. 3). Because the runoff of K2-1 was consisted by sum of K2-2 and K2-3, contributions of quick and delayed flow components in K2-2 and K2-3 agreed to the values of quick and delayed flow components of K2-1.

Although the drainage area became greater from 5 to 10 ha in K2-4 and K2-2, base flows were similar in both pre- and post-thinning periods. Base flow volume in K2-1 was substantially greater than the sum of runoff volumes in K2-2 and K2-3. This suggested that groundwater gain may occur in the channel reach from the tributary between K2-2 and K2-4 to the catchment outlet (Fig. 4).

4. CONCLUSION

Based on our field observations and analysis, we concluded that (1) increases in water yields after logging differed depending on catchment scales, especially related to groundwater inflow, (2) Drawing conclusions for the changes in runoff after harvesting depends on the selection of monitoring sites.

References

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