Flood simulation model coupled with woody vegetation wash-out in the lower Asahi River, Japan

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INTRODUCTION

In recent years, forestation is progressing in the downstream Asahi river area. The trees are densely grown in the river channel, and the effects of impeded water flow are being studied. For this study, in order to elucidate the wash-out mechanism of vegetation during flooding, the field surveys and flood flow analysis were conducted for both areas. The numerical results of this study particularly provide useful information to improve the reproducibility of the vegetation wash-out phenomenon by setting the wash-out limit condition through focusing on vegetation height and tractive force and incorporating the resistance reduction due to vegetation wash-out in the flood flow analysis.

STUDY SITE AND METHODOLOGY

Study site and data collection

The target reach was measured using the present ALB system with laser sensors (Leica Chiroptera II; Leica Corp.) during a time with a normal water level in a normal water season (November , 2017, and January , 2018). Figure 1 presents ALB data acquisition range in Asahi river and Hyakken river, shows analysis area.

Classification by ALB data and Ortho-image before and after flooding

Clustering was performed on the ALB point cloud data contained in the 2 m mesh, and the river was divided into 4 labels. Figure 2 depicts a comparison on the classification of ground covers and vegetation species based on ALB data, and ortho-image taken by drone before flooding, and it was observed that vegetation classifications were almost consistent. Figure 3 shows the ortho-image, taken by drone, of the wash-out situation of the Asahi River after flooding (July 2018). Comparing with Ortho-image before and after flooding, we can make sure the situation of wash-out vegetation.

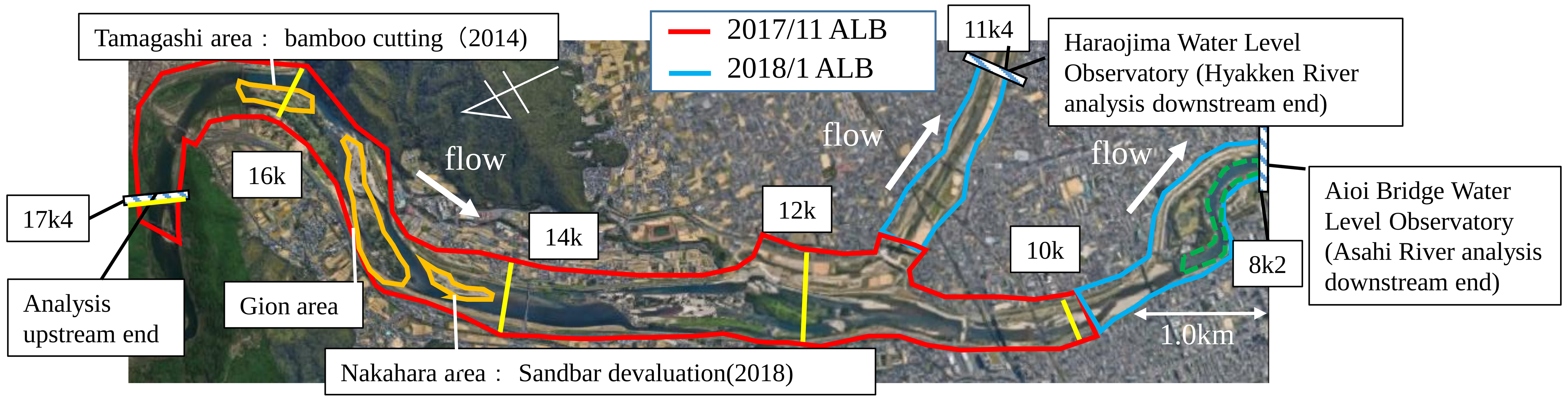

Figure 1. ALB data acquisition range in the target study area.

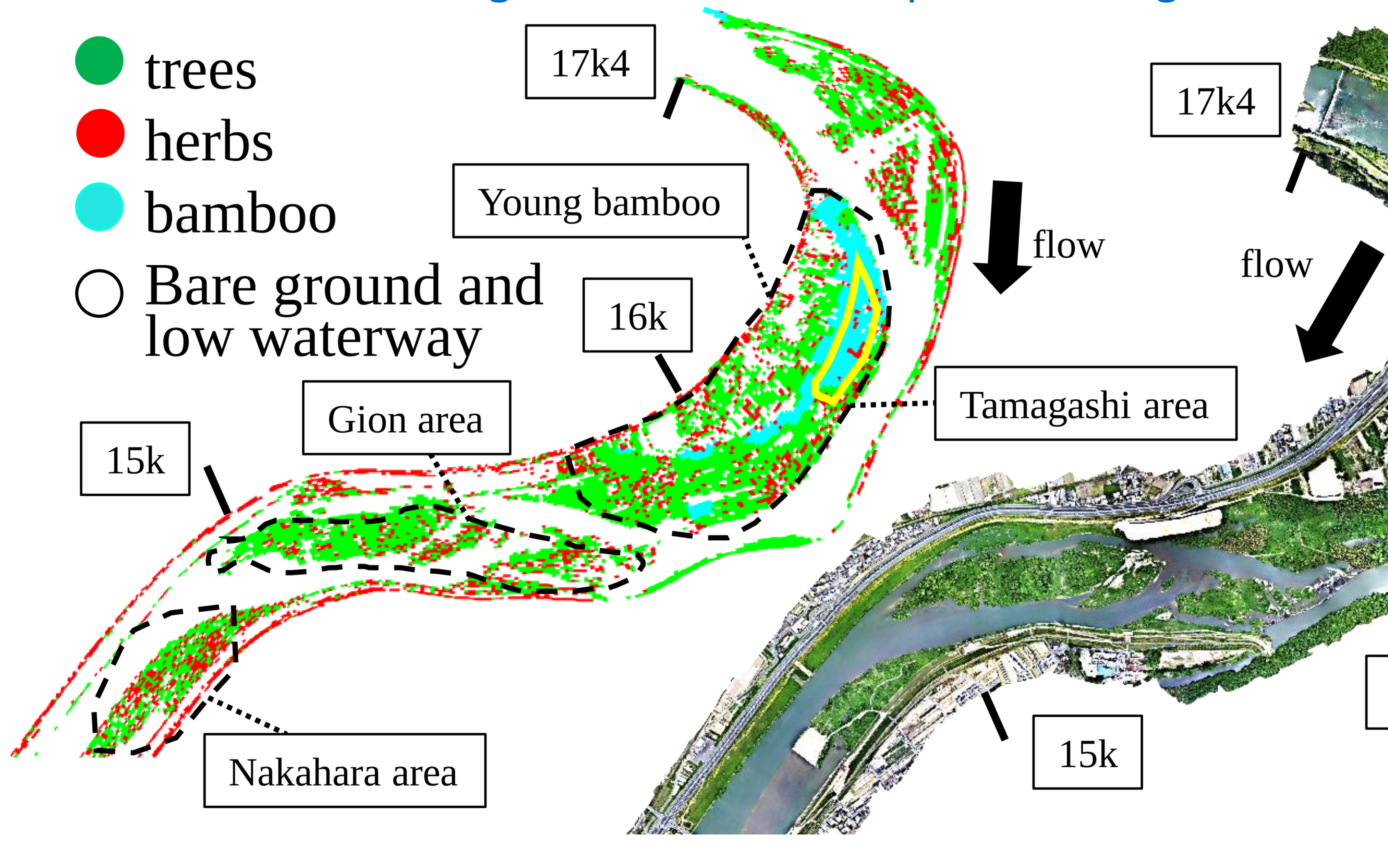

Figure 2. Classification by ALB data (left), and ortho-image (right) before flooding (May 2018) in Asahi River (14.5 KP-17.4 KP).

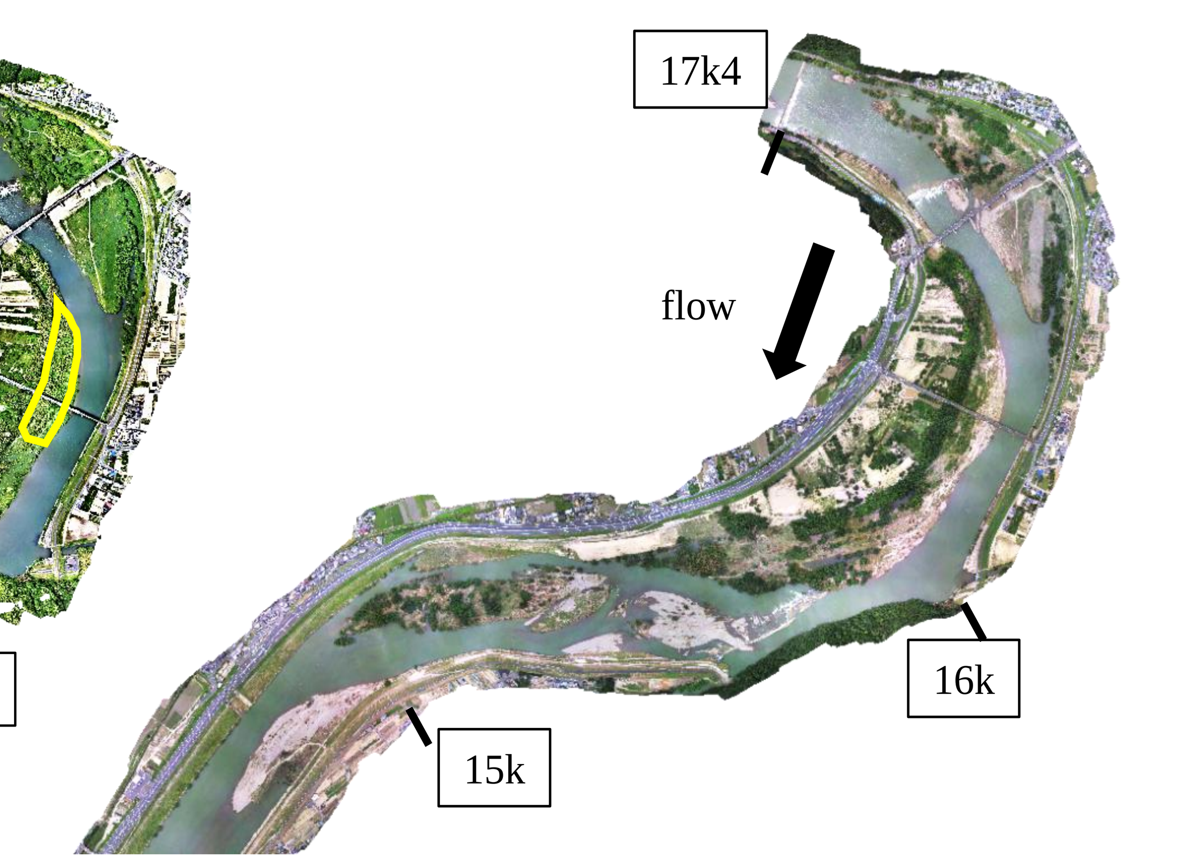

Figure 3. The wash-out situation of the Asahi River after flooding

RESULTS AND DISCUSSION

Examination of residual and wash-out conditions of vegetation

Firstly, unsteady flood flow analysis without vegetation wash-out was performed within the analysis range shown in Figure 1. As a result, it was found that it is desirable to use the share force to judge the vegetation residual. Figure 4. shows variation of the non-dimensional tractive force by particle size. From the figure 4., it can be seen that the 85% particle size is easier to consider for the residual judgment. In addition, when the value of $\tau*85/\tau*c85$ exceeds 2, it was confirmed as the vegetation wash-out.

Flood flow analysis considering resistance change caused by vegetation wash-out

The model diagram of the limit condition for the residual and wash-out of vegetation, considering 85% particle size as a representative value, is shown in Figure 5. Case 1 is a condition in which the limit of the wash-out is constant of 2 ($=\tau*85/\tau*c85$) regardless of vegetation height, and Case 2 changes the limit value gradually depending on the vegetation height. It was taken into consideration that the herbs were not dependent on vegetation height, and a certain value of 2 was imposed as a limit condition. The condition of vegetation species and ground covers based on the flood flow analysis as depicted in Figure 6. The simulated results demonstrated that the proposed model can improve the reproducibility of the wash-out situation after the flooding (figure 3.), compared with models that did not incorporate both the woody vegetation height distribution and transition process of woody vegetation wash-out during flooding. In addition, in Figure 6, using this model could show the possibility of vegetation wash-out before flood peak time.

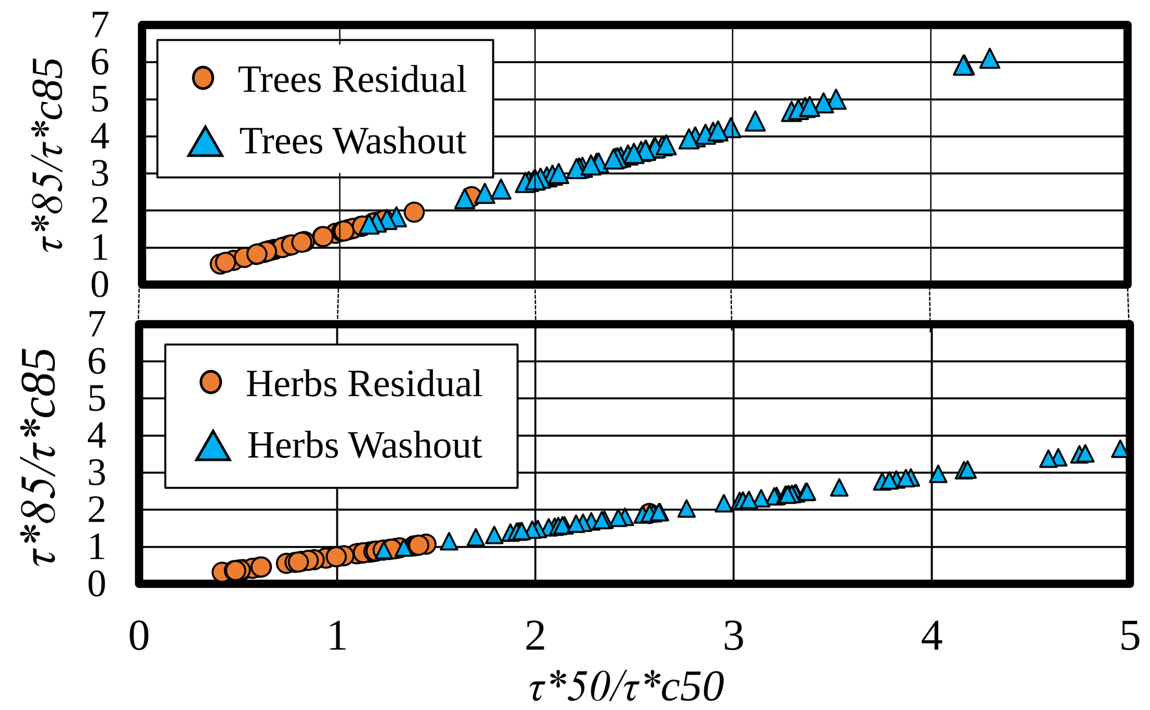

Figure 4. Variation of the non-dimensional tractive force by particle size (Nakahara, figure 2 .).

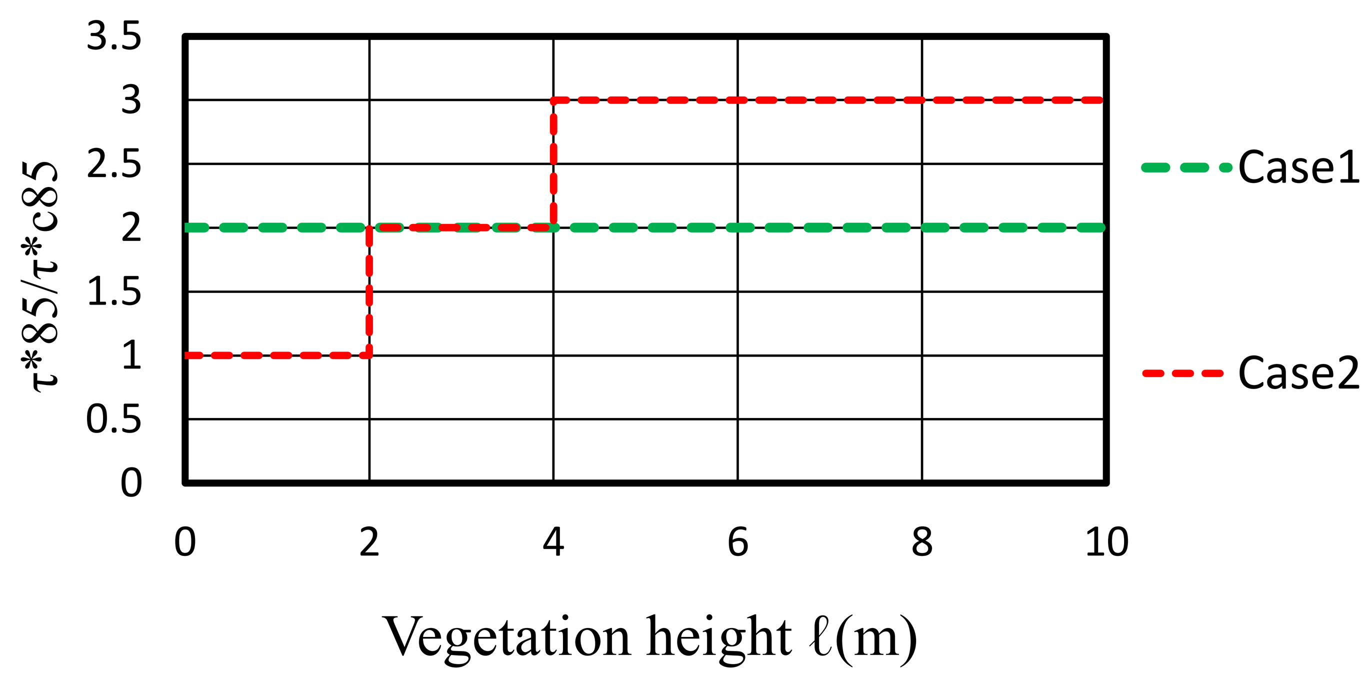

Figure 5. Model diagram (only wood) of the limit condition for the residual and wash-out considering vegetation height .

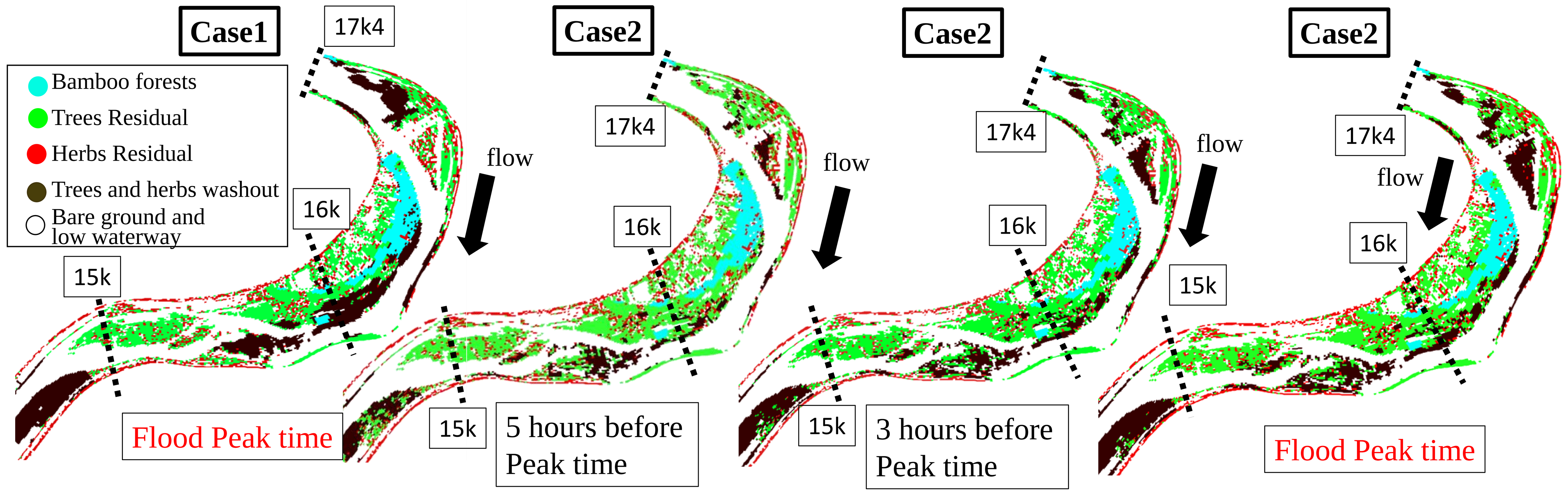

Figure 6. The condition of vegetation species and ground covers based on the flood flow analysis.

CONCLUSIONS

In this study, taking the 2018 Asahi River flood as an example, the local topography, ground cover, and vegetation conditions were reproduced with ALB data, and the residual and wash-out conditions of vegetation during the flooding were confirmed. In addition, although the relationship between the wash-out situation and the drag of vegetation at the peak of flood flow and the tractive force acting on the ground was considered, it was difficult to organize the limit conditions of vegetation wash-out. Therefore, a simple model was developed considering vegetation height in addition to the tractive force, and the flood flow analysis was performed taking into account the resistance reduction due to vegetation wash-out.