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Long-term Temporal Variation of Mean Residence Time in Spring and Groundwater After Thinning at a Forested Headwater Catchment

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Treatments on plantation forests, such as thinning, have a significant effect on the quality and quantity of water resources in the watersheds in Japan. However, few studies have performed intensive observations regarding the effects of thinning on the groundwater flow process with combined use of tracers, specially over a long period of time.

In this study, stable isotope analysis and hydrological observations were applied to investigate the temporal variation of spring water and groundwater mean residence time in a small watershed at Mount Karasawa, Tochigi Prefecture, Japan. We have monitored the research area since 2010, with periodical sampling once a month for 9 years, with a lack of data in some years after the thinning. We analyzed the date for three different time periods, those are: Before Thinning, from July 2010 to September 2011, Soon After Thinning, from November 2011 to October 2013 and Long After Thinning, from September 2017 to August 2019.

The mean residence time of spring water and groundwater were evaluated by using the stable isotopes of hydrogen and oxygen as tracers, then estimating their d-excess variations using two Lumped-Parameter Models, Exponential-Piston Flow Model and Dispersion Model. The SF_6 concentrations were used as an Apparent Age analysis for determination of the model's parameters. Both models show a tendency of the mean residence time getting older Soon After Thinning and then getting younger again Long After Thinning.

According to a selection of the best model for this area, the Exponential-Piston Flow Model shows that the spring water mean residence time was 25 months Before Thinning, 30 months Soon After Thinning and 26 months Long After Thinning; the groundwater at 15m deep mean residence time was 39 months Before Thinning, 46 months Soon After Thinning and 38 months Long After Thinning and the groundwater at 30m deep mean residence time was 38 months Before Thinning, 47 months Soon After Thinning and 45 months Long After Thinning. These results suggest that Soon After Thinning there is a reduction of forest interception and tree evapotranspiration, leading to an increase in infiltration and groundwater storage. Then, Long After Thinning, the forest interception and tree evapotranspiration rise back again with the recovery of the understory

vegetation, which leads to a decrease in infiltration and groundwater storage.