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Homeostasis of evapotranspiration measured during the succession from Japanese red pine to evergreen oak

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Introduction

The succession from Japanese red pine (*Pinus densiflora*) to evergreen broadleaved forest comprising mainly evergreen oak (*Quercus myrsinaefolia*) are widely observed (Yamashita and Hayashi, 1987). During the succession causing the change in forest structure, the change in evapotranspiration process would occur. Delzon and Loustau (2005) measured the transpiration and the evapotranspiration for several stands which have different ages, and reported that the transpiration decreased with the increase in age, but the evapotranspiration was not changed, "homeostasis of evapotranspiration". Similar homeostasis might occur during the succession. We measured the evapotranspiration at the beginning and the end of a 17-year period from 1985 to 2002 during which the forest changed from the pure red pine forest to the multi-layered forest of red pine and evergreen oak.

Method

We measured the evapotranspiration with energy-balance and eddy-covariance method in a secondary forest of Japanese red pine in the Terrestrial Environment Research Center, University of Tsukuba. The interception loss was calculated as the difference between the gross rainfall (P) and the sum of throughfall (TF) and stemflow (SF). Based on the sap flux density measurements, the transpiration from red pines (TR_P) and the transpiration from lower-layered evergreen trees (TR_L) were estimated in 2002. To estimate the depth of water uptake by root system, we measured soil water potentials by the tensionmeter nests around trees in 2004. We described the details of the forest structure in Iida et al. (2001 and 2003) and of the hydrological measurements in Iida et al. (2005, 2006 and 2008).

Results and Discussion

We show the annual values, for example ET, I, TR_P, TR_L and so on, as the proportion to P (%). Decline in the stand density of red pine caused decreases in TR_P from 28% in 1985 to 10% in 2002 and in I from 17% to 9%, while ET was 53 and 52% in 1985 and 2002, respectively: ET did not change and the homeostasis was found. The decreases in TR_P and I were counterbalanced by TR_L.

The throughfall (TF) did not change: the decrease in I was resulted from the significant increase in SF. More vertical branches and smoother bark of the lower canopy trees enhanced SF. Concentrated input of SF infiltrates around the tree base. Smaller SF of red pines suggested smaller available water for the uptake by the root system. We found that the lower soil water around the red pine after the rainfall events, and that the red pines uptake water from deeper soil in summer. These results corresponded with the report by Yamanaka et al. (2006).

These results indicated that lower-layered evergreen trees concentrated larger amount of water to their root systems to use for larger transpiration compared with red pines, and could imply that the evergreen trees had the advantage for the competition of soil water. However, the lower canopy trees had worse radiation condition which could adjust TRL and resulted in the counter-balancing effect on ET. The conditions of soil water and radiation will change with proceed of the succession: predicting the homeostatic control of ET by the ecosystem is very difficult. If the evergreen trees would have the closed canopy, the competition of water and radiation among the evergreen trees would be very severe and ET may not continue increasing. The future measurements must be need to predict that the ecosystem keep the homeostasis of ET in the climax or not.

References

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