SEASONAL VARIATION AND PARTITIONING OF NOCTURNAL FOREST LEVEL RESPIRATION IN A MIXED BROADLEAVED FOREST

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ABSTRACT
Seasonal variations in nocturnal aboveground forest level respiration were measured using static, automated foliage and stem chambers in the Yamashiro Experimental Forest (YEF), a broadleaved secondary forest in Kyoto, Japan. The growth component of the respiration during the growing season equaled 12% of the total annual aboveground nocturnal forest level respiration in the YEF. These findings suggest that growth respiration is an important component of total respiration in similar forests.

INTRODUCTION
To understand how deciduous and evergreen trees control nocturnal CO_2 flux in Yamashiro Experimental Forest (YEF), we measured the seasonal variation in the nocturnal foliar and woody-tissue respiration of the deciduous and evergreen trees using a static automated chamber method. The present paper describes the seasonal patterns of foliar respiration for *Quercus serrata Murr.* and *Ilex pedunculosa Miq.* in the upper and lower canopies, which were chosen to represent deciduous and evergreen trees [*Miyama et al.*, 2005]. In the present study, foliar respiration was measured using automated foliage chambers, including periods when growth respiration was occurring. In this study, we measured nocturnal stem respiration of *Q. serrata* and *I. pedunculosa* using automated stem chambers, and used this data and to estimate respiration by woody tissue in the YEF. We then estimated the ratio of growth respiration to total annual nocturnal respiration.

SITE DESCRIPTION AND METHODS
The YEF is located in a valley in Yamashiro-cho (34°47'N, 135°51'E), Soraku-gun, Kyoto, in a hilly, mountainous region of central Japan and at an elevation of about 220 m asl. The study site occupied 1.6 ha. The valley is underlain by weathering granites, and the soil layer is generally thin, immature, and sandy. The forest consists of deciduous broadleaved species (mainly *Q. serrata*) and evergreen broadleaved species (mainly *I. pedunculosa*). We measured the leaf area index (LAI) of the forest once per week with an LAI-2000 (Li-Cor).Based on the seasonal variation in the LAI, and the measured foliar respiration, we were able to estimate total foliar respiration for the forest (Miyama et al., 2005). We also measured the diameter at breast height (DBH) of all trees in the YEF every 5 years [*Goto et al*., 2003].

In this study, we measured seasonal variations in nocturnal stem respiration using static, automated stem chambers in the YEF. The chamber automatically measured nocturnal stem respiration at 30-min intervals. In most studies, estimates of whole-tree respiration rates for woody tissue are obtained by scaling up small sample measurements acquired using chambers at one or more positions on the tree stems. In addition, the stem surface area beneath the chamber has often been used as an index of the amount of living tissue associated with the measured respiration rate. This rate can then be extrapolated to the entire surface area of the stem and from there to the whole forest. Thus, we measured the relationship between DBH and the surface area of woody tissue in the trees, estimated total surface area in the YEF, and scaled up stem respiration to the whole forest level to estimate respiration by woody tissue. We attached the stem chambers to stems of *Q. serrata* and *I. pedunculosa* (DBH, 20.7 and 17.9 cm, respectively) at breast height. The air temperature within the stem chamber was measured with a copper-constantan thermocouple. Nocturnal respiration of woody tissue per unit surface area of *I. pedunculosa* and *Q. serrata* (F_{wI} and F_{wQ}, respectively) were calculated from the difference in CO_2 concentrations between 30 and 210 sec (3 min) in chambers. We collected data continuously from 1 May to 31 December 2003. We measured the relationship between DBH and the surface area of woody tissue on the sample trees. We defined surface areas of trees from the sum of twig surface areas, and measured twig surface areas using slide gauges directly. We used F_{wE} and F_{wD}, respectively, to represent the whole-tree respiration of woody tissue for evergreen and deciduous trees. We used the following equations to express nocturnal respiration:

$$F_{wE} = F_{wI}\, S_E,$$

$$F_{wD} = F_{wQ}\, S_D,$$

and

$$F_{tree} = F_{wE} + F_{wD} + F_{fE} + F_{fD},$$

where S_E and S_D are the whole-tree surface area of woody tissue for the evergreen and deciduous species, respectively, estimated using a database of DBH values for the YEF, and F_{fE} and F_{fD} are the corresponding whole-tree nocturnal foliar respiration rates for the evergreen and deciduous species. F_{tree} thus equals the nocturnal whole-tree aboveground respiration by these trees in the YEF.

RESULTS AND DISCUSSION

The relationship between DBH(cm) and stand-level surface area of woody tissue (SA, cm^2) was expressed by the following allometric equation ($SA = 247\ DBH^{2.24}$, $R^2 = 0.949$). We confirmed the linearity of the relationship between surface area and the respiration rate of woody tissue using destructive stem samples. The ambient air temperature was strongly correlated with respiration by foliage and woody tissue, except during the growing season, when there was relatively high growth respiration. The growing season for stems of *Q. serrata* was 1 month longer than that for *I. pedunculosa*. Thus, we estimated annual F_{tree} by adding the influences of growth respiration and of seasonal variation in air temperature. The proportions of annual F_{tree} accounted for by F_{wE}, F_{wD}, F_{fE}, and F_{fD} were estimated to be 8, 16, 34, and 42%, respectively. The rate of growth component of F_{wE}, F_{wD}, and F_{fD} in annual F_{tree} were estimated as 1, 2, and 9%, respectively. F_{fE} also includes a growth component, but that component seems to be divided among the seasons, and it's difficult to define the component. The total growth respiration component and the total woody tissue respiration thus equaled 12 and 24%, respectively, of annual F_{tree}. These results suggest the importance of exact estimation of growth respiration and woody tissue respiration in similar forests.

REFERENCES

Miyama, T., Kominami, Y., Tamai, K. and Goto, Y.(2005), Seasonal change in nocturnal foliar respiration in a mixed deciduous and evergreen broadleaved forest, *J. Agric. Meteorol.*, 60(5), 753-756.

Goto, Y., Kominami, Y., Miyama, T., Tamai, K., and Kanazawa, Y. (2003), Above ground biomass and net primary production of broad-leaved secondary forest in the southern part of Kyoto prefecture, central Japan. *Bull. FFPRI*, 387, 115-147. (in Japanese, with English summary).