

# Evaluation of CO<sub>2</sub> Uptake Amount by a Deciduous Forest by Advanced Flux Measurement Technique

## Background

Evaluation of CO<sub>2</sub> uptake amount by forests is necessary to use carbon sinks for greenhouse gas removal according to the Kyoto Accord's mechanism. The carbon cycling process in a forest contains complicated processes (photosynthesis by vegetation, decomposition of soil organic matter, and respiration by plants), and the method of evaluating each contribution has not been established. We conducted synthetic investigation about the carbon cycling from 2001 to 2004 in a deciduous broad-leaved forest on flat terrain in central Nagano Prefecture.

## Objectives

To develop a precise evaluation technique of CO<sub>2</sub> uptake amount by a forest; to distinguish the contribution of soil and plants to CO<sub>2</sub> cycle in a forest.

## Principal Results

### 1. Development of advanced CO<sub>2</sub> flux measurement technique

Precise amounts of CO<sub>2</sub> sequestered by forests are obtainable directly using the CO<sub>2</sub> flux data observed over a forest canopy. Since the conventional eddy-covariance method (EC)<sup>\*1</sup> is operated at single point, it has been often pointed out that the observed flux is not necessarily a representative value of the area. Accordingly, we developed the spatial-averaged flux measurement technique, which can provide long-term steady measurements even under bad weather conditions, by combination of the optical scintillometer<sup>\*2</sup> and the eddy-covariance. As a result, the underestimation problem of the flux evaluation was improved.

### 2. Development of measuring method of CO<sub>2</sub> flux on forest floor

CO<sub>2</sub> emission from the forest floor, soil respiration<sup>\*3</sup>, shows great spatial variance. To obtain the representative soil respiration in the forest, we devised the technique combining the soil-flux chamber (precise) and the alkali-absorption method (simple and many points). The content of the fulvic acid that is an easy decomposing ingredient of soil organic matter turned out to be effective as the index of organic matter decomposition of soil.

### 3. Discrimination of CO<sub>2</sub> source in forest

The respiration by roots was distinguished from the soil respiration. The ratio of stable isotope of Carbon in CO<sub>2</sub>, which is the ratio of carbons of mass number 12 and 13 ( $\delta^{13}\text{C}$ ), is different at atmospheric CO<sub>2</sub>, at CO<sub>2</sub> of respiration by plants and at CO<sub>2</sub> emitted by the decomposition of soil organic matter, respectively. By the relationships at  $\delta^{13}\text{C}$  and the respiration, and the separation of the root respiration from the soil respiration, we clarified the contribution of CO<sub>2</sub> sources in the forest.

As a result of comprehensive investigation, the amounts of carbon accumulated into plants and soil were 2.2 t C ha<sup>-1</sup>yr<sup>-1</sup> and 0.5 t C ha<sup>-1</sup>yr<sup>-1</sup>, respectively, and it turned out equivalent or a little larger than the value acquired in a domestic deciduous broad-leaved forest or coniferous forest. The amount of CO<sub>2</sub> uptake by a deciduous forest could be estimated more precisely, and the contribution of plants to CO<sub>2</sub> emission in a forest was clarified. The generalization of these techniques will be further performed to be able to apply them to other forests.

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## Reference

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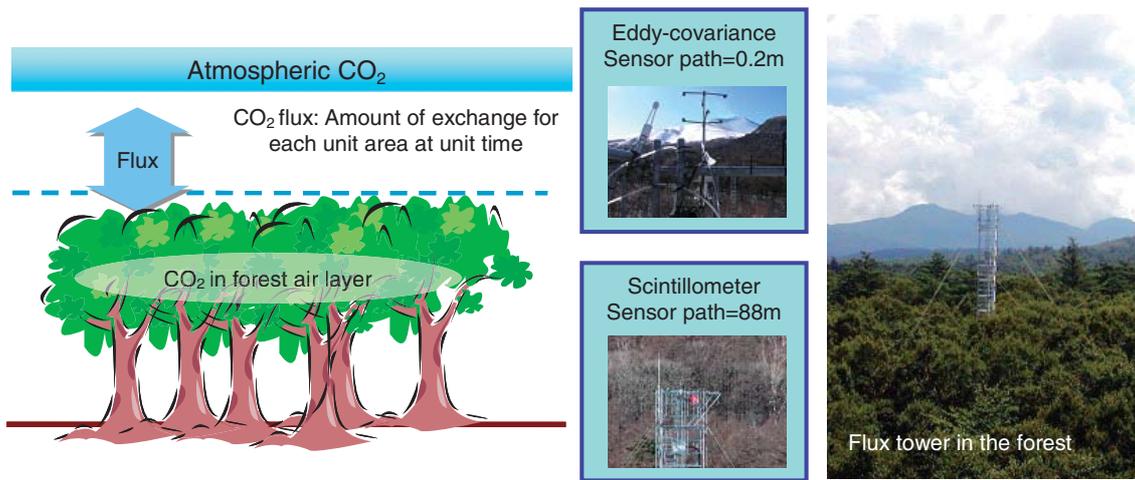
T. Kobayashi, et.al., 2005, "Stable isotopic determination of composition of respired CO<sub>2</sub> in a forest", Technical Report V04028 (in Japanese)

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\* 1 : Flux evaluation method based on the co-variance of vertical wind speed and mass density, measured by the sonic anemometer and the CO<sub>2</sub>/H<sub>2</sub>O analyzer.

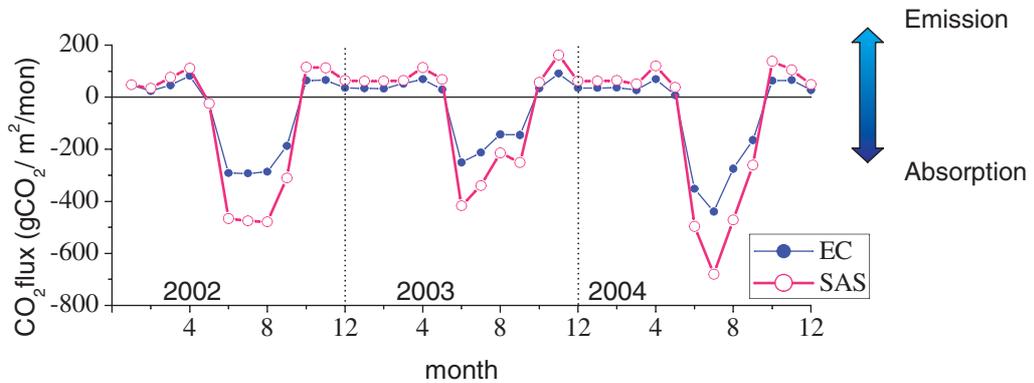
\* 2 : Equipment which measures the parameter necessary for flux calculation from the refractive dispersion of light in atmosphere. The measurement path can be extended to several hundred m.

\* 3 : the soil respiration consists of the respiration by plants root and the decomposition of soil organic matter.



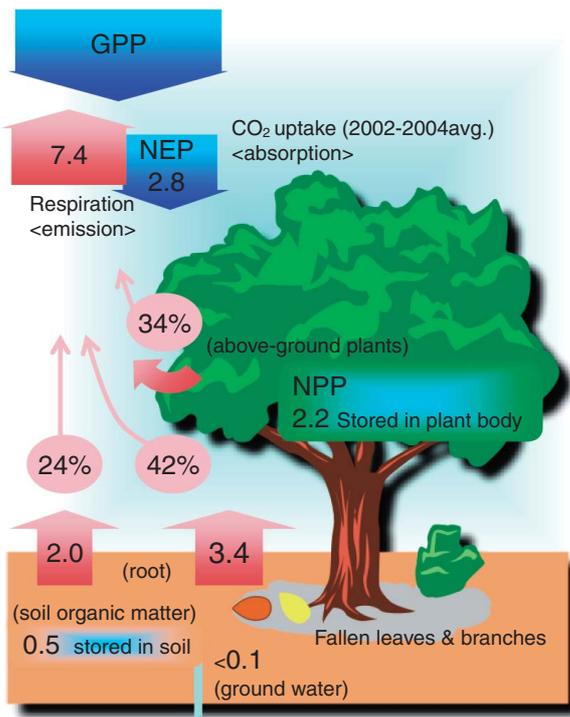
**Fig.1** Definition of CO<sub>2</sub> flux and its measurement method

CO<sub>2</sub> uptake amount by forest is obtainable by accumulation of the CO<sub>2</sub> flux.



**Fig.2** CO<sub>2</sub> uptake amount from 2002 to 2004

By combining the eddy-covariance and the scintillometer (SAS) the underestimation problem of the flux evaluation was improved.



**Fig.3** The composition of carbon cycle in the forest

By accumulating the CO<sub>2</sub> flux measured above a forest, the exact amount of CO<sub>2</sub> uptake reflecting the respiration and the photosynthesis can be evaluated.

Contribution of the plant (roots and aboveground part) to the respiration can be clarified by measuring the amount of respiration and by analysis of the stable isotope ratio of carbon.

[Unit: tCha<sup>-1</sup>yr<sup>-1</sup>]