Dead organic matter (coarse woody debris and leaf litter) decomposition respiration rate in a fire disturbed boreal forest in Wood Buffalo National Park, NWT, Canada

Mayuko Jomura1 Akira Osawa2 Yojiro Matsuura3

1 Nihon University, Fujisawa, Japan; 2 Kyoto University, Kyoto, Japan; 3 Forestry and Forest Product Research Institute, Tsukuba, Japan

Introduction

Heterotrophic respiration is a crucially important flux in the forest carbon cycle. Soil fauna, bacteria, and fungi decompose dead organic matter arising from tree senescence, litter fall, and fine-root turnover, releasing CO2 to the atmosphere. Because the soil in boreal forests is a large carbon pool on a global carbon-cycle scale, there is worldwide concern over the sensitivity of this dead organic carbon pooled in boreal forests to changes in environmental factors caused by global climate change or by disturbance.

The objective of this study was to determine the carbon dynamics through the decomposition process of dead organic matter such as coarse woody debris (CWD) and leaf litter in a fire-disturbed boreal forest.

Materials and methods

The decomposition respiration of CWD and leaf litter was measured in a quaking aspen (Populus tremuloides QA) forest (Plot No. Q31) and jack pine (Pinus banksiana) JP forests (P40, P22, P2000, P2004) in Wood Buffalo National Park, NWT, Canada in 2010 and 2011. Both snags and log samples of QA and JP were obtained in each site (Fig. 2). Sub samples were also obtained to estimate wood density and water content (θ= fresh weight-dry weight/dry weight of sub sample). Leaf litter samples (about 1 to 2 g dry weight) were obtained from the upper (new leaf litter) and lower (old leaf litter) parts of the organic layer in the forest. The respirations of CWD and leaf litter were measured using a closed dynamic chamber system with infrared gas analyzer (Fig. 3). The measurement system comprised an IRGA meter (GMP-343, Vaisala Inc., Sweden) and a chamber (made of acrylic resin). Simultaneously, the temperature in the chamber was measured by a thermometer (TR-52, T and D Inc., Tokyo, Japan). The fresh weight of samples was weighed to estimate water content. The measurement was conducted from 18 Sept., 2010 and 11 to 5 Sept., 2011.

Results and discussion

In the QA site, the respiration rate of CWD and leaf litter of QA was 12.8 and 251.6 mgCO2/kg/h, respectively (Table 1). The respiration rate of log was 3.2 times larger than that of snag according to the change in water content of CWD. The respiration rate of new leaf litter was 5.5 times larger than that of old leaf litter, probably due to the difference in the amount of decomposable organic carbon. In the JP site, the respiration rate of CWD and leaf litter of JP was 9.7 and 50.3 mgCO2/kg/h, respectively (Table 1). Although snag was not sampled in the JP site, there were many logs not in contact with the ground and such logs were sampled. The respiration rate of new leaf litter was 1.4 times larger than that of old leaf litter.

One experiment was conducted in 2010. CWD samples obtained from QA snag were set on the forest floor in 2010 and their respiration rate and water content were re-measured in 2011. The respiration rate and water content of the “artificial” log samples in 2011 increased to similar values as the “normal” log samples. These results showed that contact with the ground is an important factor for the process of decomposition of CWD.

In the JP forest, the respiration rate of CWD was measured chronologically (Fig. 4) and a gradual increase with number of years elapsed since the last fire was observed. This is likely due to two main mechanisms.

First, the temporal change in the amounts of snag and log would be important because respiration rate differs between snag and log. In most cases, the fire creates a large amount of snag and then the snag breaks down and becomes log as time progresses. Therefore, the ratio of falling down of snag would affect heterotrophic respiration over time. However, the situation in the field is complex. In the JP forest, three or four logs tended to lie over one another in the plots probably due to the difference in timing of the change from snag to log. The logs that had fallen down recently existed higher up and were not in contact with the ground (low water content). Decomposition progresses from the bottom of the log, and after the bottom has broken down, it becomes the main contributor to decomposition.

Second, the moss layer develops over time and the ground level rises, resulting in increased water content of logs. These two phenomena can be evaluated and modeled, so we can estimate the change in heterotrophic respiration of CWD over time. In a future study, I intend to determine (1) the ratio of the change from snag to log, (2) the decomposition (mineralization and fragmentation) rate of snag and log, and (3) the rate of moss developing. Finally, I would like to model the carbon dynamics through the process of decomposition of CWD in a fire-disturbed boreal forest.