

Decomposition rate of woody debris in a burnt forest: Results of a preliminary study at Poker flat research range

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0. ABSTRACT

This study examined the decomposition respiration of woody debris (WD) occurred by forest fire in a black spruce forest at Poker flat research range, which was burned in June 2004. We measured decomposition respiration (R_{WD}) of standing and downed WD and temperature and water content of WD in August 2005. WD samples (diameter: 3-10cm) were obtained from standing dead wood (snag) and downed dead wood (log) of black spruce. Temperature of WD was high (about 25°C), nevertheless R_{WD} was very low (snags: 0.21 ± 0.18 , logs: $0.40 \pm 0.26 \text{ mgCO}_2 \text{ kg}^{-1} \text{ h}^{-1}$). Decomposition rate of snags and logs was estimated to be 0.001 and 0.002 y^{-1} , and mean residence time was about 1000 and 500 years, respectively. The low decomposition rate may be mostly induced by the extremely low water content of WD (both snags and logs: 0.18 g g^{-1}). The slope facing to the south, well-drained soil, the lack of the crown of living trees and little precipitation may cause soil drying in the experimental site in summer season. Similarly, WD water content became low resulting in low microbial activity. R_{WD} was significantly different between snags and logs (t -test, $P < 0.05$), however, water content and wood density were almost similar (t -test, $P = 0.53$, $P = 0.49$, respectively). This difference was induced by low R_{WD} of snag samples located at the high position (more than 4m) and all of these samples did not expose CO_2 . Thus, the height of the WD position affects microbial invasion resulting in low decomposition rate. The vertical position of WD may affect decomposition rate of WD due to both the differences in microbial invasion and water content of WD. Therefore, the vertical position of WD may be a significant factor to determine decomposition dynamics of WD.

1. INTRODUCTION

Woody debris (WD) is an important component of all forest ecosystems. WD influences carbon storage, nutrient and water cycles, maintaining biodiversity and serves as a habitat for forest organisms (e.g. Harmon *et al.* 1986, Krankina *et al.* 2002). Recent studies analyzed the amount, structure, and dynamics of WD in natural and managed forest (e.g. Siitonen *et al.* 2000; Busing 2005). WD dynamics affects long-term carbon cycle (Janisch and Harmon 2002). However, WD have generally not been quantified in the carbon budgets in forest ecosystems. WD is an important wildfire fuel and respiratory sources of carbon through decomposition process in boreal forest (Bond-Lamberty *et al.* 2003). Thus, more accurate estimate of the amount of WD and decomposition

rate will help to advance long-term boreal carbon cycle. Global climate change will cause an increase in the fire and disturbance frequency in boreal forest (Kasischke 1999).

In this study, we focused on WD postfire decomposition rate and examined control factors and characteristics of the decomposition processes.

2. FIELD SURVEY METHODS

This study examined the amount and decomposition respiration of woody debris (WD) in a burnt black spruce forest at Poker flat research range in August 2005. The forest was burnt in June 2004. We defined WD as aboveground dead wood. We established two plots and measured diameter at breast height (DBH) and height (H) and identified the state of WD (standing dead wood: snags and downed dead wood: logs). We selected each three WD for snags and logs for the estimate of stem biomass. We measured diameter and length from the base at three or four points of stem and stem volume was calculated as a cylinder. We also cut samples at these points for wood density estimate. WD biomass was estimated by multiplying WD volume and wood density. An allometric relationship between DBH^2H and WD biomass was used to estimate WD biomass for plot basis. WD samples for respiration measurements were obtained from snags and logs of black spruce existing in the forest. WD samples ranged 3-10cm in diameter and 20-28cm in length. Snag and log samples were obtained from the position at 8-700cm and 3-50cm from the ground, respectively. The cut surfaces of WD samples were sealed with silicone sealant to eliminate the emission of CO_2 . Sub-sample was cut from the same WD to estimate wood density. Diameter and length of sub-samples were measured to calculate the volume and dried at $95^\circ C$ for 48 hours. Wood density was estimated by the dry weight divided by the volume of sub-samples. We measured decomposition respiration of WD (R_{WD}) using a closed dynamic chamber system with infrared gas analyzer (IRGA). The measurement system was composed of an IRGA meter (LI-800, LI-COR Inc., Lincoln, NE, USA), a chamber (made of acrylic resin $W18 \times D18 \times H10$ cm), tubes, a pump (CM-15, Enomoto Micro Pump, Tokyo, Japan), filters, and a flow meter. Simultaneously, temperature of WD was measured by thermometer (TR-52, TandD Inc., Tokyo, Japan). The position which temperature measured was 3cm in depth from the bark or the center of WD in case of the diameter less than 6cm. Fresh weight of WD samples was weighed to estimate gravimetric water content.

3. RESULTS and DISCUSSION

We obtained the allometry relationship between DBH^2H and WD biomass ($WD\ mass = 0.0202\ DBH^2H^{0.9897}$, $R^2=0.97$). The relationship was not different between snags and logs. Outlines of the plots were shown in Table 1. There was no living wood in the plots. DBH and height of plot 1 was little smaller than those of plot 2. Thus, WD biomass of plot 1 was smaller than that of plot 2. The ratio of logs was different between plot 1 and 2 (4 and 67%, respectively).

Table 1. Outlines of the plots.

			Plot 1	Plot 2
area	(m ²)		256.5	256.5
slope	(degree)		18.0	18.0
DBH	(cm)		4.1	5.3
Height	(m)		3.7	4.7
WD mass	total	(t ha ⁻¹)	5.55	8.44
	snag		5.32	2.80
	log		0.22	5.64

R_{WD} was very low ($n=10$, snags: 0.21 ± 0.18 , logs: 0.40 ± 0.26 mgCO₂ kg⁻¹ h⁻¹). If the respiration rate continues year-round, decomposition rate constant of snags and logs was 0.001 and 0.002 y⁻¹, respectively and mean residence time of snags and logs was calculated about 1000 and 500 years. At the measurement time, temperature of WD was high of 25°C. Nevertheless R_{WD} was very low for both snags and logs. The low decomposition rate may be mostly induced by the low water content of WD (snags and logs: 0.18 ± 0.07 , 0.18 ± 0.05 g g⁻¹, respectively). Compared to water content of logs in a tropical rain forest (Chambers *et al.*, 2001; ranged from 0.1 to 2.3 g g⁻¹), boreal forest (Bond-Lamberty *et al.*, 2003; decay class 1: 0.44 ± 0.04 g g⁻¹), temperate forest (Jomura, unpublished data; 0.65 ± 0.59 g g⁻¹), in this area WD water content was extremely low. The slope facing to the south, well-drained soil, the lack of the crown of living trees by fire, high temperature and little precipitation in summer season may cause surficial soil drying resulting in the extremely low water content of snags and logs. In spring, snow melt and permafrost degradation due to temperature increase increases water content of soil (Richter *et al.* 1999). Increase in water content of WD will occur with the changes and stimulate microbial activity of WD. Thus, to determine decomposition dynamics of WD after forest fire in this area, seasonal changes in decomposition rate should be measured. Low water content limits the activity of organisms and below 0.3g g⁻¹, water is generally not available to microbes (Griffin, 1977). In this study, respiration was observed below this point indicating that microbes can decompose WD even under the extremely low water content condition. However, decomposition rate was fairly low. Because of only one year after the forest fire, microbes have not developed sufficiently in WD and this may be the initial stage of decomposition.

Table 2. Mean wood density, gravimetric water content, and R_{WD} by state.

state	density		gravimetric water content		R_{WD}	
	g cm ⁻³		g g ⁻¹		mgCO ₂ kg ⁻¹ h ⁻¹	
snag	0.46	(0.06)	0.18	(0.07)	0.21	(0.18)
log	0.45	(0.03)	0.18	(0.05)	0.40	(0.26)

R_{WD} was significantly different between snags and logs (t -test, $P < 0.05$), however, water content and wood density were almost similar (t -test, $P = 0.53$, $P = 0.49$, respectively, Table 2). This difference was mostly induced by the low R_{WD} of snag samples located at the high position (more than 4m) and all of these samples did not expose CO_2 (Figure 1). Thus, the height of the WD position affects microbial invasion resulting in low decomposition rate. The vertical position of WD may affect decomposition rate of WD due to both the differences in microbial invasion and water content of WD. Therefore, the vertical position of WD may be a significant factor to determine decomposition dynamics of WD.

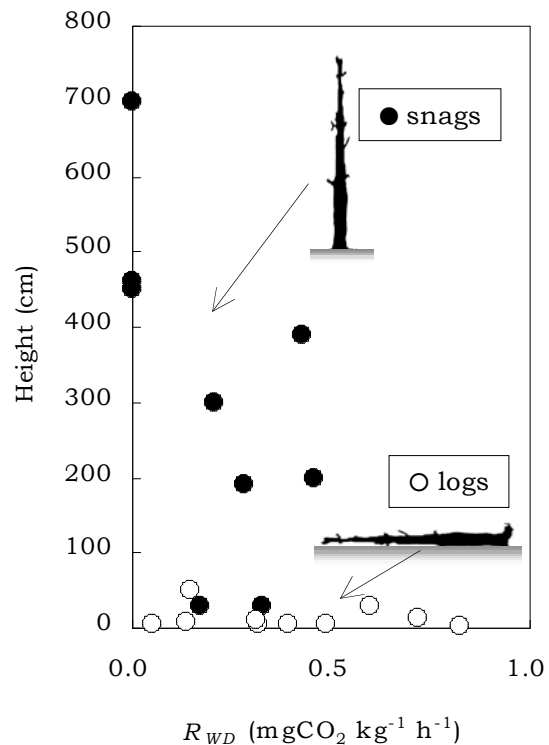


Figure 1. Vertical distribution of R_{WD}

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