Global Warming Stimulates CO_2 Emissions from Forest Soil in Shirakami-Sanchi

-Increased soil organic carbon decomposition based on a soil warming experiment-

Globally, 360 Gt of CO_2 is emitted from soils (soil respiration) and released to the atmosphere every year. About 70% of soil respiration is derived from decomposition of Soil Organic Carbon (SOC) by soil microbiota (heterotrophic respiration). Heterotrophic respiration exponentially increases with increasing temperature; consequently, the carbon released to the atmosphere by increased heterotrophic respiration could cause positive feedback that further accelerates global warming. However, long-term response of heterotrophic respiration to global warming remains obscure and observation data that verify the response are limited.

The National Institute for Environmental Studies (NIES) and Hirosaki University have collaboratively conducted a soil warming experiment in a cool-temperate broad-leaved deciduous forest in Shirakami-Sanchi since September 2011 as a part of a project to evaluate the potential carbon sink or source strength of Japanese forest soils and its response to climate change. Shirakami-Sanchi is a mountain range (one of UNESCO world heritage sites in Japan) where cool-temperate forest ecosystems in the region are kept from human disturbance.

We concluded that global warming will long-term enhance SOC decomposition in humid cool-temperate forest ecosystems such as that in Shirakami-Sanchi. Abundant SOC and humid environment were the primary factors contributing to the long and high level of the warming effect. Our results also suggest that existing models and global estimations of terrestrial carbon-cycle feedbacks for global warming in the Asian monsoon region might be underestimated.

We increased the soil temperature at a depth of 5 cm by about 2.5 °C using infrared carbon-filament heat lamps, and continuously monitored CO_2 efflux from the soil surface and related environmental parameters with a multichannel automated chamber system. Based on a soil warming experiment from the end of 2011 to the end of 2016, we observed that heterotrophic respiration increased by 6.2 to 17.7% (10.9% for 5-year average) per 1^{o}C temperature rise (warming effect, Figure 1). In addition, the inter-annual variation of the annual warming effect on heterotrophic respiration was positively related with the number of rainy days (Figure 1), suggesting the importance of humid environment for sustained stimulatory warming effect. Furthermore, the Q_{10} values for heterotrophic respiration (the temperature sensitivity of heterotrophic respiration that expresses the magnification per 10 °C temperature increase) ranged from 2.40 to 2.85 (2.66 for 5-year average), larger than 2.0 that is used in many models for estimating future climate change.

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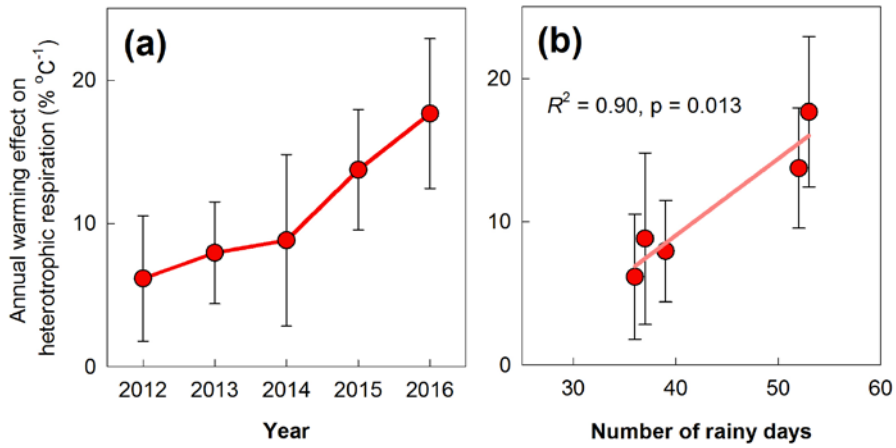

Figure 1. (a) Annual warming effect on heterotrophic respiration by 1ºC artificial soil warming, (b) Relationship between annual warming effect on heterotrophic respiration and number of rainy days

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