Comparison of soil respiration among three temperate forests in Changbai Mountains, China

Xu Wang, Yanling Jiang, Bingrui Jia, Fengyu Wang, and Guangsheng Zhou

Abstract: CO_2 efflux from forest soils is an important process in the global carbon cycle; however, effects of stand age and successional status remain uncertain. We compared soil respiration and its relationship to soil carbon content, forest floor mass, root biomass, soil temperature, and soil moisture content among three temperate forest ecosystems in Changbai Mountains, northeastern China, from 2003 to 2005. Forest types included an old-growth, mixed coniferous and broad-leaved primary forest (MN), a middle-aged, broad-leaved secondary forest (BL), and a young coniferous plantation forest (CP). Average annual soil CO_2 efflux at BL (1477.9 ± 61.8 g $C{\cdot}m^{-2}{\cdot}year^{-1}$) was significantly higher than at CP (830.7 ± 48.7 g $C{\cdot}m^{-2}{\cdot}year^{-1}$) and MN (935.4 ± 53.3 g $C{\cdot}m^{-2}{\cdot}year^{-1}$). Differences in soil temperature among those sites were not statistically significant but contributed to the differences in annual CO_2 efflux. In addition, the temperature response of soil CO_2 efflux was higher at MN (Q_{10} = 2.78) than that at BL (Q_{10} = 2.17) and CP (Q_{10} = 2.02). Our results suggest that successional stage affects soil respiration by the differences in substrate quantity and quality, environmental conditions, and root respiration.

Résumé : L'émission de CO_2 par les sols forestiers est un processus important dans le cycle global du carbone. Cependant, les effets de l'âge et du statut successionnel du peuplement demeurent incertains. Nous avons comparé la respiration du sol et sa relation avec le contenu en carbone du sol, la masse de la couverture morte, la biomasse des racines, la température du sol et la teneur en humidité du sol dans trois écosystèmes de forêt tempérée dans les monts Changbai, dans le nord-est de la Chine, de 2003 à 2005. Les types de forêt incluaient une vieille forêt vierge mixte composée de conifères et de feuillus (MN), une forêt feuillue secondaire d'âge intermédiaire (BL) et une jeune plantation de conifères (CP). Les émissions annuelles moyennes de CO_2 de BL (1477,9 ± 61,8 g $C{\cdot}m^{-2}{\cdot}an^{-1}$) étaient significativement plus élevées que celles de CP (830,7 ± 48,7 g $C{\cdot}m^{-2}{\cdot}an^{-1}$) et de MN (935,4 ± 53,3 g $C{\cdot}m^{-2}{\cdot}an^{-1}$). Les différences de température du sol entre ces sites n'étaient pas statistiquement significatives mais contribuaient aux différences entre les émissions annuelles de CO_2. De plus, la réponse des émissions de CO_2 à la température du sol était plus forte à MN (Q_{10} = 2,78) qu'à BL (Q_{10} = 2,17) et CP (Q_{10} = 2,02). Nos résultats indiquent que le stade de succession influence la respiration du sol parce que la quantité et la qualité du substrat, les conditions environnementales et la respiration racinaire diffèrent.

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Introduction

Soil respiration in forest ecosystems is an important flux in the global carbon cycle, accounting for approximately 70% of ecosystem respiration in temperate forests (Law et al. 1999). As the second largest carbon flux between the biosphere and the atmosphere, soil respiration plays a critical role in the global carbon budget (Raich and Schlesinger 1992; Law et al. 2002). Small increases in soil respiration can result in significant changes in atmospheric CO_2 concentration (Schlesinger and Andrews 2000).

Forest types, successional stages, and human activities, such as deforestation and reforestation, affect soil respiration (Raich and Schlesinger 1992; Houghton and Hackler 1999; Law et al. 2001). Soil carbon pools tend to increase in size during stand development, thereby increasing soil heterotrophic respiration (Pregitzer and Euskirchen 2004; Gough et al. 2007). Changes in forest species composition and litter quality with change of succession stages affect root respiration and heterotrophic respiration (Raich and Tufekciogul 2000; Tedeschi et al. 2006). Variation in soil temperature and soil moisture status explains much of the short-term variation in soil respiration at individual sites (Maier and Kress 2000; O'Neill et al. 2002). The relationship between soil respiration and temperature is often described by an exponential function (Lloyd and Taylor 1994; Fang and Moncrieff 2001), and its relationship with soil moisture status, however, has been described by linear, logarithmic, quadratic, and parabolic equations, with soil moisture status expressed as matric potential, gravimetric, and volumetric water content (Orchard and Cook 1983; Schlentner and Van Cleve 1985; Raich and Potter 1995; Davidson et al. 1998, 2000). Differences in forest floor mass, root biomass, soil microbial biomass, and soil chemical properties cause soil

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X. Wang. State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, the Chinese Academy of Sciences, Beijing 100093, China; Graduate University of Chinese Academy of Sciences, Beijing 100039, China.
Y. Jiang, B. Jia, F. Wang, and G. Zhou.[1] State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, the Chinese Academy of Sciences, Beijing 100093, China.

[1]Corresponding author (e-mail: gszhou@ibcas.ac.cn).