NOTE

Estimating net ecosystem production of tropical forest

(Laboratory of Radar Atmospheric Science, RISH, Kyoto University)

Tran Van Do

Abstract

In recent years, ecologists have focused on estimating Net Ecosystem Production (NEP) to understand the role of forest against increasing concentration of CO_2 in the atmosphere, a major concern in research and debates on global warming. This is due to the fact that NEP of a forest is the amount of carbon accumulated in a unit of area and time. In this study, NEP was estimated for tropical evergreen broadleaved forest in Northwestern Vietnam. The results indicated that one hectare of old-growth broadleaved forest can accumulate 2.59 Mg C ha^{-1} year^{-1}, which is higher than some other forests around the world.

Introduction

NEP is a fundamental property of ecosystems. It was originally defined as the difference between the amount of CO_2 fixed by photosynthesis in an ecosystem (gross primary production) and total ecosystem respiration (the sum of autotrophic and heterotrophic respiration). Based on this definition, NEP represents the organic carbon available for storage within the system or loss from it by export or non-biological oxidation. In other ways, NEP is usually described as the balance between Net Primary Production (NPP) and heterotrophic respiration in an ecosystem. Therefore, NEP is known as the rate of carbon accumulation in forest ecosystem. Estimating NEP is a gap in many forests. This study was conducted in Vietnam to understand capacity of tropical forests in sequestrating CO_2 against global warming and climate change.

Materials and methods

Study was conducted in a tropical evergreen broadleaved forests of Copia Natural Reserve, Northwest Vietnam at 21°23'N and 103°38'E. In the research area, mean annual rainfall was 1,277 mm, and mainly fell in the summer season between May and July. Mean monthly temperature ranged from 21 to 23°C in summer, and from 12 to 16°C in winter. The annual relative humidity is 80%.

On the site, a plot of 30 m × 30 m was established in old-growth forest for NEP estimation. The NEP or rate of carbon accumulation in a forest ecosystem is estimated as NEP = ΔM + ΔCr + Lf + Fp – Rs, where ΔM is aboveground biomass increment, ΔCr is coarse root increment, Lf is aboveground litterfall, Fp is fine root production, and Rs is heterotrophic respiration (soil respiration). ΔM was estimated basing on measuring diameter at breast height (*DBH*) of all living stems at time t_i and t_j ($t_j > t_i$), and applying allometry for AGB (aboveground biomass) in Eq. 1 [1];

$$\mathrm{AGB} = \rho\mathrm{E}\exp\begin{bmatrix} -1.499 + 2.148\,ln(DBH) + \\ 0.207(ln(DBH))^2 - 0.0281(ln(DBH))^3 \end{bmatrix} \qquad (\mathbf{1})$$

with ρ is wood specific gravity.

ΔCr was estimated basing on alloemtry between CRB (coarse root biomass; root with φ > 2 mm) and AGB as CRB = $0.489 \cdot AGB^{0.890}$ [2]. Lf was estimated basing on litter trap technique, which was set up systematically under forest canopy. Fp was estimated basing on continuous inflow method using sequence soil core sampling and litter bag technique [3]. Rs was estimated basing on a closed chamber method (CC-method) using an infra-red gas analyzer – IRGA [4].

Results and discussion

Decomposition of dead fine roots was 0.03 g m^{-2} d^{-1}, mortality was 0.07 g m^{-2} d^{-1}, and fine root production was 1.00 g m^{-2} d^{-1} in old-growth forest (Figure 1). Very small amount of fine roots died, indicating

NOTE

longevity of fine roots in the study site is long. Meanwhile, half of dead fine roots was decomposed to release CO_2 to the atmosphere. It may indicate that after two years all dead fine roots will be decomposed completely. Therefore, soil nutrient in tropical old-growth forest Vietnam is high.

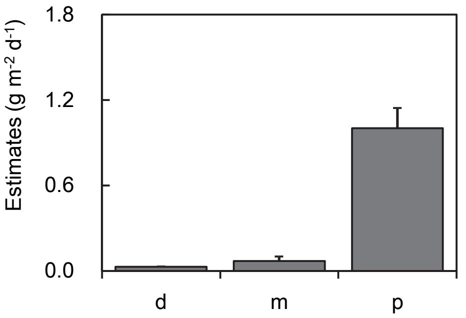

Figure 1. Fine root production (p), mortality (m), and decomposition (d), bars indicated ±SE (Standard error).

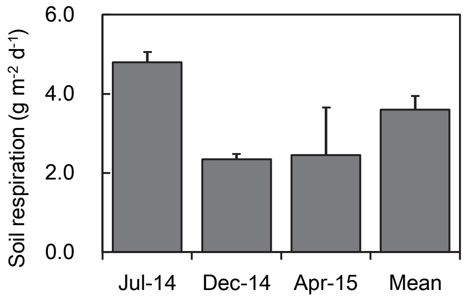

Figure 2. Soil respiration in different seasons, bars indicated ±SE (Standard error).

Total NPP in the present study area was 8.61 g m^{-2} d^{-1} (Table 1). In which, aboveground litterfall contributed 46.7%, reduced to AGB increment (37.1%), to fine root production (11.6%), and to coarse root increment (4.6%). Belowground NPP accounted for 16.2%, which was much lower than that of aboveground NPP (83.8%)

Table 1. Contribution of each compartment to total NPP

	Belowground NPP		Aboveground NPP		Total
	ΔCr	Fp	Lf	ΔM	
g biomass m^{-2} d^{-1}	0.40 ± 0.10	1.0 ± 0.14	4.02 ±0.45	3.19 ± 0.24	8.61
g C m^{-2} d^{-1}	0.2	0.5	2.01	1.595	4.31
Ratio (%)	4.6	11.6	46.7	37.1	

Soil respiration was seasonal dependent, which was higher in summer and lower in winter. In summer, soil respiration was nearly 5 g m^{-2} d^{-1}, while in winter was 2.2 g m^{-2} d^{-1} with annual mean of 3.6 g m^{-2} d^{-1} (Figure 2). In the summer, there are higher temperature and humidity leading to higher activities of soil microorganisms, which decompose organic matter to release CO_2. Meanwhile, in winter temperature may drop to 7^{o}C and it is very dry. Therefore, activities of soil microorganisms reduce. There was high variation of soil respiration in April, which is known as season transition between winter and summer. In this time, daily fluctuation of temperature between day and night is high, leading to much higher soil respiration in day time compared to that of night time.

Total NEP in evergreen broadleaved old-growth forest in Northwestern Vietnam was 0.71 g C m^{-2} d^{-1}, equaling to 2.59 Mg C ha^{-1} $year^{-1}$.

References

[1] Chave J, Andalo C, Brown S, Cairns M A, et al. (2005) Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145:87-99.
[2] Mokany K, Raison RJ, Prokushkin A S (2006) Critical analysis of root: shoot ratios in terrestrial biomes. Global Change Biology 12:84-96.
[3] Tran VD, Akira O, Tamotsu S (2016) Estimation of fine-root production using rates of diameter-dependent root mortality, decomposition and thickening in forests. Tree Physiology 36:513-523.
[4] Bekku Y, Koizumi H, Nakadai T, Iwaki H (1995) Measurement of soil respiration using closed chamber method: An IRGA technique. Ecological Research 10:369-373.